Assessment of anthropogenic threats to New Zealand marine habitats

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EXECUTIVE SUMMARY

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The effects of fishing on fish stocks and other components of the ecosystem are increasingly coming under scrutiny, yet fishing is only one effect that humans have on marine ecosystems. We have undertaken an assessment of the relative impact of sixty-five potentially hazardous human activities that may affect sixty-two identifiable marine habitats in New Zealand's territorial seas and 200 nautical mile exclusive economic zone (EEZ). In the absence of extensive published information for all but a small subset of the potential approximately 4000 interactions of hazardous activities and marine habitats, we adopted a methodology that used expert knowledge in a quantifiable way to assess the relative impacts of threats for which the experts have direct experience, have knowledge of the specialist literature, and/or have access to relevant data that does not exist in the public domain. We also compiled information on the spatial distribution of thirteen of the top threats for which information is currently available in an electronic format at a scale amenable to linking to particular areas of habitat. Our assessment is equivalent to a Level 1 assessment within an environmental risk assessment for effects of fishing (ERAEF) framework but considered all threats to marine habitats, not just those stemming from fishing activities.

This research addressed the vulnerability of each habitat type to each particular threat. Each habitat-by-threat combination was given a vulnerability score based on the assessment by experts of five factors including the spatial scale, frequency and functional impact of the threat in the given habitat as well as the susceptibility of the habitat to the threat and the recovery time of the habitat following disturbance from that threat. We also included a measure of certainty that allowed the respondents to qualify their response with the level of confidence they had in the supporting information for each threat/habitat interaction. We used this measure of certainty to weight the response of each participant to a particular threat/habitat interaction. For each habitat and threat combination, the mean of the five weighted average vulnerability factors was calculated, giving a grand mean value. For each habitat, the mean across the grand mean threat values was calculated, giving the mean vulnerability for a habitat. For each threat, the mean across the grand mean habitat threat values was calculated, giving the mean impact of a threat. In compiling mean vulnerability scores per habitat we assumed interactions among threats were additive.

We also characterised each threat as largely stemming from global human activities, catchment based activities, human activity directly in the sea or stemming from a mixture of two or more of these. We found the two top threats, 83% of the top six threats, 67% of the top twelve threats and over half of the twenty-six top threats fully, or in part, stemmed from human activities external to the marine environment itself.

A number of threats to the marine environment derive from the net accumulation of greenhouse gases in the earth's atmosphere caused by the global burning of fossil fuels and reductions in forest cover. By a considerable margin, the highest scoring threat over all marine habitats was considered to be ocean acidification, a consequence of higher CO_2 levels in the sea. The second highest overall scoring threat was rising sea temperatures resulting from global climate change. The other seven threats deriving from global climate change all ranked 19= or higher in our study and indicated the importance of international threats to New Zealand's marine ecosystems.

Threats deriving from human activities in catchments that discharge into the coastal marine environment were among some of the highest scoring threats to New Zealand's marine habitats. Foremost was increased sedimentation resulting from changes in land-use. It was the

third equal highest ranked threat over all habitats and was the highest ranked threat for five coastal habitats including harbour intertidal mud and sand, subtidal mud, seagrass meadows and kelp forest. Other threats deriving from human activities in catchments ranking 19= or higher include sewage discharge, increased nitrogen and phosphorus loading and heavy metal pollution. Three other highly ranked (threats, algal blooms, increased turbidity, and oil pollution) stem in part from human activities in catchments.

Seven of the threats to New Zealand marine habitats ranking 19= or higher were directly related to human activities in the marine environment including fishing, invasive species, coastal engineering and aquaculture. The most important of these was bottom trawling which overall was the third equal highest ranking threat. The second highest ranking marine activity was dredging for shellfish which although destructive usually operates over a smaller spatial scale than bottom trawling. The third highest ranking threat caused by direct human activity in the marine environment was considered to be that posed by invasive species. The responding experts indicated that invasive species threaten forty-five New Zealand coastal and shelf marine habitats. Intertidal reefs in harbours are particularly vulnerable to invasive species and two further harbour and sheltered coast reef habitats are substantially affected. No benthic habitats on the slope or in the deep ocean are threatened by invasive species.

Our study indicates that generally, the number of threats to New Zealand's marine habitats declines with depth, particularly below mean depths of about 50 m. Shallow coastal habitats are impacted by up to fifty-two non-trivial threats deriving from human activities, while deep water habitats are threatened by as few as four or five. Likewise, the estimated magnitude or severity of those effects declines steeply with mean depth of the habitat. CLUSTER analysis indicated there was a strong tendency for habitats to group on the basis of their depth and exposure and to a weaker extent by their substrate. Coastal and shelf benthic habitats and all pelagic habitats formed one large cluster and all slope and deep-ocean benthic habitats formed another.

Reef, sand, and mud habitats in harbours and estuaries and along sheltered and exposed coasts were considered to be the most highly threatened habitats. The least threatened estuarine and harbour habitats were saltmarsh and mangrove forests. Slope and deep water habitats were among the least threatened and lowest ranked. The most threatened habitats were considered to be generally impacted by many threats and the least threatened habitats confronted by the fewest threats.

Over all threats, the functional impact of a threat, whether just one or a few species were affected, or the whole ecosystem was impacted, was judged to have the greatest contribution to habitat vulnerability scores. Threat frequency, whether the threat was pulsed and the timing of those pulses, or whether it was persistent, was the second greatest contribution to the vulnerability scores. Judged less important to the overall scores were habitat susceptibility and the area affected by a threat event. Recovery time was judged to have the smallest contribution to vulnerability as habitats were expected to recover from most threats relatively quickly once they ceased.

Detailed information on the spatial intensity of threats in New Zealand waters is readily available for only 20% of threats. For many threats the information remains dispersed among different institutions and/or is not available in an electronic format. Lack of detailed habitat maps for most of New Zealand's territorial seas and EEZ prevents the matching of threat intensity information to habitat locations.

The results of our study may be useful in identifying which threats to New Zealand's marine ecosystems require the first and greatest management response and which habitats should be the first focus for management action. Because so many of the top threats to New Zealand marine habitats stem from human activities external to the marine environment reducing their impact is likely to be complex and difficult. There is likely to be little or nothing New Zealand marine managers can do to directly control ocean acidification or any of the threats stemming from global climate change. However, we can and should document their impacts on marine habitats and deliver these results not only to the science community but also to our politicians and bureaucrats negotiating the global control of greenhouse gases.

There is more hope for better management and control of catchment and marine based threats to marine habitats as these are under New Zealand’s jurisdiction, and were judged to affect fewer habitats, to be mostly pulsed rather than persistent, and may recover in a few years once the threat is removed. Regional councils and unitary authorities have responsibility for management of catchments and territorial seas under the Resource Management Act (RMA), the Ministry of Fisheries has responsibility for mitigating the effects of fishing, the Department of Conservation has responsibility for management of protected and threatened species and protected areas, and hapu and iwi have a long-standing interest in the well-being of both land and sea environments. These agencies need to work collaboratively in order to reduce the threat status of marine habitats. Success in this area may enable marine ecosystems to better withstand the global threats of ocean acidification and climate change that are highly likely to intensify throughout this century.

OBJECTIVES

OVERALL OBJECTIVE:

To develop a risk assessment framework for balancing the environmental effects of fishing on coastal seafloor ecosystems against other threats to coastal ecosystems that may influence the productivity and sustainability of fisheries.

Note that after discussion with MFish it was agreed to extend the overall objective to include all marine habitats within New Zealand’s EEZ within the existing budget.

SPECIFIC OBJECTIVES:

1. To collate existing information on the distribution, intensity, and frequency of anthropogenic disturbances in the coastal zone that could be used in a risk assessment model to estimate their likely aggregate effect on ecosystem function across habitats and over different scales of ecosystem functioning and biological organisation.

2. To develop a risk assessment framework in conjunction with a variety of stakeholders and environmental scientists.

INTRODUCTION

1.1 Overview

The effects of fishing on fish stocks and other components of the ecosystem are increasingly coming under scrutiny (Dayton et al. 1995, Hall 1999, Kaiser et al. 2002, Millennium Ecosystem Assessment, 2005a & b, Dulvy et al. 2006, Myers et al. 2007, Donaldson et al. 2010, Williams et al. 2010). These effects may occur directly through removal of fished species and the destruction of habitat or indirectly through species interactions and/or the disruption of biogeochemical processes (Jennings & Kaiser 1998, Thrush et al. 1998, Tegner & Dayton 1999, Jennings et al. 2001, Hiddink et al. 2006, Clark & Rowden 2009). Yet fishing is only one effect that humans have on marine ecosystems. Many other threats derive from activities such as pollution, reclamation, dredging, sand and gravel abstraction, mining, sedimentation, eutrophication, aquaculture, changes in freshwater input, ocean acidification, climate change, the introduction of alien species or the displacement of fishing after establishment of marine reserves may also affect various aspects of the coastal ecosystem (Pearson & Rosenberg 1978, Constantine 1999, Derraik 2002, Hewitt et al. 2004a, Thrush & Hewitt 2004, Millennium Ecosystem Assessment 2005 ab, Hobday et al. 2006, Lohrer et al. 2006, Norkko & Hewitt 2006, Ford & Anderson 2007, Sale et al. 2008, Brierley & Kingsford 2009, Keeley et al. 2009, Savage 2009, Hoegh-Guldberg & Bruno 2010). The effect of these activities may act independently and additively, or interact synergistically and may compound over long time scales (Lotze et al. 2006, Worm et al. 2006, Crain et al. 2008, Darling & Cote 2008).

It is likely that these effects are most intense in coastal areas close to human population centres where many of them co-occur and impact upon the same habitats, and least intense in the deepwater habitats far offshore (Millennium Ecosystem Assessment 2005 ab, Teck et al. 2010). For example, New Zealand’s shallow coastal zone, because of its proximity to human population centres, ease of access, and variety of “desirable” species for harvest has sustained intensive fisheries for many years as well as the effects of sedimentation, pollution and reclamation (Thrush et al. 1998, Derraik 2002, Hewitt et al. 2004b, MacDiarmid et al. 2009, Morrison et al. 2009). In contrast at the other extreme, there is little fishing effort and few other direct human impacts in habitats at water depths greater than 1500 m although these comprise over 50% of the area of New Zealand’s EEZ (O’Driscoll & Clark 2005, Clark & Rowden 2009).

The effect of human activities in the marine environment is influenced by factors relating to both the threat and the habitat. The threat's magnitude, distribution and frequency of occurrence and the habitat's associated species assemblage affecting its susceptibility to a particular threat, the functional impact of the threat on the habitat, and the time that the habitat takes to recover from the threat can all be critical (Hughes et al. 2005, Halpern et al. 2007, Lundquist et al. 2010). If a threshold is reached in terms of the size or frequency of an impact then an ecosystem may never recover and could persist in an alternative stable state (Hewitt & Thrush 2010, Norkko et al. 2010, Pretraitis & Hoffman 2010).

There has been no previous attempt to determine the relative impact of fishing and other anthropogenic effects on New Zealand's marine ecosystems. This is essential, however. If other human influences on an ecosystem are equally or more important than fishing, then their joint management, rather than regulating only fisheries, is the key to successful mitigation of the effects on the ecosystem and the fisheries it sustains. This is consistent with the Ministry of Fisheries 2005 Strategy for Managing the Environmental Effects of Fishing (SMEEF) and with the Ministry's fisheries resources goal in its Strategic Research Directions; Statement of Intent for 2005-2008 as well as New Zealand's Biodiversity Strategy.

1.2 Risk Assessment

Risk assessment procedures provide a framework appropriate for decision making in the face of uncertainty and thus provide a good opportunity for the practical implementation of an ecosystem approach to management that incorporates fisheries management into a broader environmental context (Francis & Shotton 1997).

The Australian/New Zealand risk assessment standard, as specified in AS/NZS 4360 (2004), is a general assessment framework and consists of a four-step process:

1. Establish the context. In this step the question to be addressed is clearly stated.
2. Identify the hazards or threats.
3. Assess the risk. This step is broken into four substeps.
    a) Determine likelihood - typically the probability of an event occurring. Qualitative or quantitative data can be used at this point.
    b) Determine consequence. This step assesses the magnitude of the impact of the hazard on the environmental variables of interest.
    c) Determine risk. Risk is determined by multiplying likelihood by consequence.
    d) Assess and state uncertainties. These include measurement error, natural variation and lack of knowledge.
4. Treat and/or mitigate the risk (if warranted)

Smith et al. (2007) advocate a slightly different approach for evaluating the effects of fisheries on components of the ecosystem and argue for an exposure – effects model rather than a likelihood – consequence approach because most fishing activities are common and deliberate rather than rare and accidental.

Smith et al. (2007) and Hobday et al. (in press), based on original work by Hobday et al. (2006), describe a hierarchical framework for environmental risk assessment for effects of fishing (ERAEF), including a scoping stage and then up to three levels of assessment, spanning expert-based (Level 1), through semi-quantitative or empirical (Level 2), to fully quantitative methods (Level 3), with explicit links between them. These are similar to the approaches identified in reviews by Rowden et al. (2008) and Baird & Gilbert (2010). A number of studies have carried out Level 1 (Crawford 2003, Fletcher 2005, Astles et al. 2006, Furlani et al. 2007), Level 2 (Ling & Hobday 2004, Clark & Tittensor 2010) and Level 3 studies (Zhou et al. 2007) of the effects of fishing on components of an ecosystem.

Rowden et al. (2008) and Baird & Gilbert (2010) reviewed risk assessment approaches for application to assessing risks of fishing to New Zealand seamounts and seabirds respectively. Three main approaches were identified that generally progress from qualitative to highly quantitative assessments. 1). A general assessment framework - this is frequently used as the basis for 'expert' decision making, sometimes using quantitative or semi-quantitative data and a structured Delphic process to ensure independent input by participating experts; 2). Semi-quantitative - Rowden et al. (2008) suggested that fuzzy logic expert systems provide a way of processing imprecise information about the impact of a threat and incorporating expert knowledge into a classification scheme. Alternatively, qualitative modeling can be used. This technique focuses on the direction of the interaction among threats and components of the ecosystem and is thus useful when there is a lack of quantitative knowledge of the interactions between many of the components; 3). Fully quantitative approaches - Rowden at al. (2008) highlighted sensitivity analysis that uses a size-based model of species vulnerability and recovery times to predict impacts of different fishing scenarios on benthic habitats. But, as Baird & Gilbert (2010) point out, a variety of other quantitative techniques can be used where there is sufficient empirical information to draw upon.

In New Zealand the risk assessment models used thus far assess one threat (typically bottom or mid-water trawling) to single or multiple components of a fishery or ecosystem (Campbell & Gallagher 2007, Baird & Gilbert 2010, Clark & Tittensor 2010, Clark et al. in press. New Zealand marine environments are in fact threatened by multiple human activities (Ministry for the Environment 1997, New Zealand Biodiversity Strategy 2000, Department of Conservation 2007, Gordon et al 2010) and the amount of published information about these threats is highly variable with the impacts of some threats just beginning to be investigated (e.g., the effects of ocean acidification). We therefore decided to use an approach that had a proven record in assessing multiple threats to multiple habitats where there was a distinct unevenness in available published information to draw upon.

1.3 Our approach

For this project, we built upon efforts by Halpern et al. (2007, 2008) who created a global map of human influence on particular ecosystems in part by soliciting expert opinion from around the world. While very useful from a global perspective, the focus of Halpern et al.'s (2007, 2008) research was too large to be useful at a New Zealand scale, did not include all marine habitats of New Zealand interest, and only two New Zealand experts (one on rocky reefs and one on soft sediments) participated in their survey. Consequently, we largely reused Halpern et al.'s (2007, 2008) assessment criteria, but applied them to the New Zealand situation and sought input on threats to New Zealand marine habitats from New Zealand experts and overseas experts with substantial New Zealand experience. This approach is equivalent to an ERAEF Level 1 assessment (Smith et al. 2007), but over a broad range of threats.

We identified sixty-five potentially hazardous human activities in New Zealand's marine waters that may affect sixty-two identifiable marine habitats. In the absence of extensive published information for all but a small subset of the potential approximately 4000 interactions of hazardous activities and marine habitats we adopted a methodology that used expert knowledge in a quantifiable way to assess the relative impacts of threats for which the experts have direct experience, have knowledge of the specialist literature, and/or have access to relevant data that does not exist in the public domain. Guidelines and a standardised spreadsheet questionnaire supplied to each expert contributing to the evaluation were intended to make the process quantifiable, repeatable, and transparent.

We focused on the vulnerability of each habitat type to each particular threat. Each habitat-by-threat combination was given a vulnerability score, devised according to the variables described in section 2.2 below. Those scores ultimately could be used as multipliers to modify

New Zealand maps of threat intensity/ frequency by habitat type, reflecting the relative impact of particular threats across different habitats. This project collated information about the spatial intensity of some threats but for many the relevant information is scattered, in paper copy only, or non-existent. Another problem hindering mapping of threat intensity by habitat is that the distribution of marine benthic habitats is known accurately for only about half the habitats considered in this study.

METHODS

2.1 Specific Objective 2

2.1.1 Habitats

At an initial workshop of habitat experts held in Wellington on 26 May 2008 and during further discussion with specialists not at the original workshop, we identified sixty-two distinct marine habitats occurring within New Zealand's territorial seas and EEZ (Table 1). We started with Halpern et al.'s (2007) list of marine habitats, eliminated those not relevant to New Zealand (e.g. coral reefs and sea ice), subdivided others into finer categories (e.g. rocky intertidal reef was divided into those bordering harbours, sheltered coasts and exposed coasts) because it was expected that a different suite of threats would affect similar habitats in different areas, and added in others relevant to New Zealand (e.g. fiord rock walls). We also took into account feedback from a small group of initially consulted experts indicating that they fell into habitat 'lumper' and 'splitter' camps. To address the needs of both groups we ensured that habitat categories were divided into fine divisions but gave participating experts the option of combining them on the survey form if they thought the same suite of threats affected a number of habitats and if they responded identically to these threats. Our list of habitats is dominated by coastal and shelf habitats (46) rather than slope and deepwater habitats (16) because of the greater changes in physical habitat attributes with depth and exposure on the coast and shelf and because we know much more about biogenic habitats in shallow water areas.

We avoided use of the Marine Environmental Classification System (Snelder et al. 2006) to define habitats for three reasons. First, it does not apply to shallow coastal habitats nationwide, second its definition does not include substrate type or dominant biological structural element, and lastly the definitions are too complex and are not well understood or used within New Zealand's broader marine ecology community. The habitats we used were defined by the type of benthic substrate (rock, sand, mud, calcareous rubble etc) or the dominant biological structural element (saltmarsh, mangrove forest, seagrass, cockle bed, pipi bed, kelp forest, turfing algae, biogenic calcareous reef), by depth and degree of exposure (harbour, sheltered coast, exposed coast, slope habitats, deepwater habitats).

2.1.2 Threats

At the initial workshop and follow-up discussions described above, we identified eleven general categories of threats to marine environments deriving from human activities either in the marine environment (e.g. fishing, pollution, coastal engineering), in catchments that discharge into the marine environment (e.g. sedimentation, eutrophication) or indirectly through global burning of fossil fuels, forest destruction, methane production resulting in increased greenhouse gases manifest in the oceans as an increase in sea temperature, increase in sea level, or acidification, etc. We subdivided all general categories into finer categories to give sixty-five threats in total (Table 2).

Eight general categories of threats stemming from human activities in the marine environment were subdivided into a total of forty-seven threats. Fishing was divided into thirteen threats based on gear type because these are largely used in different habitats and their impacts vary widely. The displacement of fishing activities due to spatial closures (e.g. creation of marine reserves) was also included in this general category. Three threats posed by aquaculture activities were considered; benthic accumulation of debris (shells, faeces, food material), a decrease in the availability of primary production downstream of the marine farm (particularly mussel farms) and an increase in habitat complexity that may be detrimental to some species[1]. We identified twelve threats under the general category of engineering because they vary from complete and permanent alteration of a habitat (reclamation) to modification of some physical factors (e.g. piled wharves and sheds decrease light levels and current velocities but may increase the area of hard surfaces), and impact either on the coast (causeways), on the shelf (e.g. mining – deep hole extraction of iron sands), or in deep water (mining – surface suction of phosphorite nodules). We considered five threats from pollution occurring at sea but note that oil pollution, plastic pollution and sewage derive from a mix of both land and marine based activities. Effects of invasive species were divided into their impacts as space occupiers or competitors and diseases. Shipping was divided to reflect the impacts of direct strikes on surface animals, particularly whales, dolphins and penguins but also large fish and invertebrates, the noise from engines and propeller cavitations that may affect marine mammals, fish and diving birds over a wider distance, and also effects on benthic communities from shipping disasters resulting in ship groundings or sinking. Lastly, we subdivided ecotourism to reflect the differing effects that these activities can have on habitats or the species that inhabit them.

Human activities in catchments, including urban environments, can threaten marine habitats. Engineering works on rivers, including dams, channel hardening, stop-banking and straightening and river diversion, as well as changes in land use patterns in catchments can drastically change freshwater and sediment inputs to estuaries, harbours and coastal waters. For this reason we have five categories of altered river inputs to take into account increases as well as decreases in river flows and sediment loading, as well as dampening in flows. We included seven distinct threats from pollution as the different pollutants may affect the various habitats in different ways.

A number of threats to the marine environment derive from the net accumulation of greenhouse gases in the earth's atmosphere caused by the global burning of fossil fuels and reductions in forest cover. We considered nine distinct threats as these may each affect an ecosystem differently or may work together.

[1] Possible impacts of fish-farming that differ from those listed, e.g. nutrient additions, have not been included here, but due to recent law changes may become more of a threat in the future.

Table 1: Marine habitats used in the expert assessment of habitat vulnerability. The mean, or approximate mean depth of the habitat below high water spring tide level is also indicated.

Habitat	Mean Depth	Habitat	Mean Depth
Harbour & Estuaries:		*Exposed Coasts:*	
Salt marsh	0	Sandy beaches	1
Mangrove forest	0.5	Cobble beaches	1
Intertidal mud	1	Intertidal reefs	1
Intertidal sand	1	Gravel/pebble/shell 2–9 m	4.5
Intertidal reef	1	Sand 2–9 m	4.5
Subtidal mud	5	Subtidal reefs 2–9 m	4.5
Subtidal sand	5	Turfing algal reefs	7
Subtidal reef	5	Kelp Forest	10
Cockle bed	2	Biogenic calcareous reefs	15
Pipi bed	2	Gravel/pebble/shell 10–29 m	19.5
Seagrass	3	Mud 10–29 m	19.5
		Sand 10–29 m	19.5
Sheltered Coast:			
Sandy beaches	1	Subtidal reefs 10–30 m	19.5
Cobble Beaches	1	Gravel/pebble/shell 30–200 m	115
Intertidal reef	1	Mud 30–200 m	115
Gravel/pebble/shell 2–9 m	4.5	Sand 30–200 m	115
Mud 0–9 m	4.5	Subtidal reefs 30–200 m	115
Sand 2–9 m	4.5		
		Slope habitats:	
Subtidal reefs 2–9 m	4.5	Hard canyon	400
Kelp Forest	10	Soft canyon	400
Gravel/pebble/shell 10–29 m	19.5	Gravel/pebbles/shells 200–2000 m	1100
Mud 10–29 m	19.5	Slope Habitats : Mud 200–2000 m	1100
Sand 10–29 m	19.5	Slope Habitats : Reef 200–2000 m	1100
Subtidal reefs 10–29 m	19.5	Slope Habitats : Sand 200–2000 m	1100
Fiord Habitats:		*Deep Habitats:*	
Inner fiord rockwalls	50	Vent (hot and cold)	800
Outer fiord rockwalls	50	Seamount < 2000 m	1000
Fiord sediments	100	Seamount > 2000 m	3500
Fiord water column	50	Soft abyssal 2000 m+	3500
		Hard abyssal 2000 m+	3500
Pelagic Habitat:			
Coastal -water column inside 50 m contour	25	Trench	5000
Shelf - water column from 50–200 m contour	125		
Slope - water column in photic zone	50		
Slope - water column below photic zone	1500		

Deep ocean water column in photic zone	50
Deep ocean water column below photic zone	3000

Table 2: Threats to New Zealand marine habitats deriving from potentially hazardous human activities in the marine environment, on land, and globally that were assessed in this study. Note that some threats such as oil pollution, plastic pollution and sewage derive from a mix of both land and marine based activities.

Threats

Marine Based Threats

Fishing
- Bottom trawling
- Scallop or oyster dredging
- Trapping fish or crayfish
- Paua gathering/ diving
- Seaweed gathering
- Spear fishing
- Set netting
- Pelagic low bycatch (e.g. squid jigging)
- Pelagic high bycatch
- Long-lining
- Shellfish fishing / gathering
- Recreational line fishing
- Displacement of fishing activity

Aquaculture
- Benthic accumulation of debris
- Decreased available I^{o} production
- Increase in habitat complexity

Engineering
- Sand / gravel abstraction
- Dredging
- Mining - surface suction
- Mining - deep hole extraction
- Mining - other methods
- Dumping of dredge spoils
- Coastal reclamation
- Causeways
- Pontoons
- Piled wharfs/sheds
- Pile moorings/markers
- Seawalls

Pollution (at sea)
- Oil or oil products
- Plastic
- Sewage
- Acoustic discharges / guns
- Electromagnetic discharges

Invasive species
- Space occupiers, competitors
- Disease

Shipping
- Animal strikes
- Noise pollution
- Ship grounding, sinking

Ecotourism
- Marine mammal watching
- Diving
- Reef trampling
- Noise
- Feeding wildlife
- Vehicles

Other threats
- Anchoring
- Algal blooms - toxic and massive
- Increased turbidity

Land based Threats

River inputs
- Decreased sediment loading
- Increased sediment loading
- Decreased freshwater discharge
- Increased freshwater discharge
- Dampening of flows

Pollution (in catchments)
- Oil or oil products
- Plastic
- Sewage
- Heavy metals
- Nitrogen and phosphorus
- Pesticides including PCBs
- Herbicides

Global Threats

Increasing greenhouse gases
- Increase in sea-level
- Increase in sea temperature
- Increased intertidal temperatures
- Increase in UV radiation
- Ocean acidification
- Change in currents
- Increased storminess
- Altered rainfall
- Increased stratification

2.1.3 Vulnerability Factors

Rather than ask each expert to provide a single score for the vulnerability of a habitat to a particular threat, we followed Halpern et al. (2007) and asked them to assess five distinct vulnerability criteria which we would later combine into a single weighted score. These criteria included the spatial scale, frequency and functional impact of the threat in the given habitat as well as the susceptibility of the habitat to the threat and the recovery time of the habitat following disturbance (Table 3). We also included a measure of certainty that allowed the respondents to qualify their response with the level of confidence they had in the supporting information for each threat/habitat interaction. We would use this measure of certainty to weight the response of each participant to a particular threat/habitat interaction. For each vulnerability criteria we provided an assessment scale (Table 3) that was explicitly or approximately logarithmic as well as, where appropriate, descriptive notes and examples.

Experts were first asked to assess the average spatial scale at which a particular threat acts within a specified habitat in the New Zealand region. This includes both direct and indirect impacts in six steps ranged from less than 1 km^2 to more than 10 000 km^2 (Table 3). The instructions to each participant emphasized that this criteria focused on the scale of a single event of a threat such as one pass of a bottom trawl that may impact 1–10 km^2, not the spatial scale over which the cumulative threat of bottom trawling operates (perhaps thousands of square kilometres for a particular habitat).

Next we asked experts to describe how often discrete threat events occurred within a particular habitat. This event frequency ranged in scale from rare or very infrequent events such as a major oil spill, to persistent, being more or less constant year round (Table 3). For example, the shading effects of a piled wharf are more or less the same every day and may be expected to last for the lifetime of the structure which may be many years, perhaps decades. It is important to note that frequency does not necessarily imply anything about severity. Major oil spills are rare but their impacts on a particular habitat may be extreme as well as long lasting.

To capture the magnitude of an impact we also asked participating experts to assess the functional impact of the threat on the habitat by indicating over a four step scale whether a single species or the entire ecosystem was affected (Table 3). We modified Halpern et al.'s (2007) vulnerability criteria 'habitat resistance' to 'habitat susceptibility' as we thought this term was more widely understood, would help differentiate the measure from resilience and more logically increased in step with the threat level (Table 3). In fact this measure is close to Teck et al.'s (2010) measure of "percentage change" used in the assessment of threats to US west coast marine ecosystems. Susceptibility was estimated in four steps from low where there was no significant change in biomass, structure or diversity until extreme threat levels, to extreme where the slightest occurrence of the threat causes a major change.

Experts were asked to assess recovery time, the average time required for the affected species, trophic level(s), or entire community to return to its former state following disturbance by a particular threat. This was estimated in years with the scale ranging in four steps from <1 year to >100 years.

Lastly, we included a measure of certainty to allow participating experts to indicate the quality of the knowledge available to them to make judgements in relation to each of the above criteria for a particular threat to a specific habitat. The certainty scale ranged from no certainty at all in the absence of any documented or personal evidence to absolutely certain when extensive empirical work exists or the expert has extensive personal research knowledge (Table 3). For each vulnerability criteria we also provided a 'don't know' option.

Table 3: Ranking system for each vulnerability measure used to assess how threats affect NZ marine habitats (based on Table 2 in Halpern et al. 2007).

Vulnerability Criteria	Category	Rank	Descriptive Notes	Example
Area (km^2) of consequence of a threat event				
	No threat	0		
	<1	1		Damage from a single anchor; small oil/ diesel spill
	1–10	2	About the size of the Leigh Marine Reserve	Single bottom trawl tow
	10–100	3		Sediment run-off from deforestation event
	100–1 000	4		Major pollution event in river enters coastal waters
	1 000–10 000	5		Invasive species arrives; major oil spill
	>10 000	6	The size of the Hauraki Gulf or larger	Sea surface temperature change
Frequency				
	Never occurs	0		
	Rare	1	Very infrequent	Major oil spill
	Occasional	2	Frequent but irregular in nature	Toxic algal bloom
	Annual or regular	3	Frequent and often seasonal or periodic	Runoff events due to seasonal rains
	Persistent	4	More or less constant year round, lasting through multiple years or decades	Reclamation or shading effects of pile wharf
Functional Impact[2]				
	No impact	0		
	Species (single or multiple)	1	One or more species in a single or different trophic level	Ship strikes on whales
	Single trophic level	2	Multiple species affected; entire trophic level changes	Over-harvest of multiple species within the same trophic guild
	>1 trophic level	3	Multiple species affected; multiple trophic levels change	Over-harvest of key species from multiple trophic guilds
	Entire ecosystem	4	Cascading effect that affects entire ecosystem	Increase in ocean temperature or acidification
Susceptibility				
	Not susceptible	0		
	Low	1	No significant change in biomass, structure or diversity until extreme threat levels	Trawling on shallow sediment communities on an exposed coast
	Medium	2	Moderate intensities or frequencies causes change	Effects of industrial pollution discharges on coastal habitats
	High	3	Threat causes significant but not catastrophic effects; some capacity for adaptation	Effects of acidification on growth of calcareous biogenic reef organisms
	Extreme	4	Slightest occurrence causes a major change	Bottom trawling on deep-sea corals
Recovery time (yrs)				
	No impact	0		
	<1	1		Kelp forest recovery after disturbance
	1–10	2		Short lived species recover from episodic toxic pollution
	10–100	3		Long-lived species recover after over-harvesting e.g. right whales
	>100 or permanent	4		Deep-sea coral recovery after trawl damage; reclamation
Certainty				
	None	0	Vague hunch or gut-feeling only	
	Low	1	No empirical work exists of this interaction specifically, perhaps some general knowledge	
	Medium	2	Some empirical work exists or expert has some personal knowledge	
	High	3	Body of empirical work exists or the expert has direct personal research experience	
	Absolutely certain	4	Extensive empirical work exists or the expert has extensive personal research knowledge	

[2] Note that functional impact would be expected to be low if recovery time was short

2.1.4 Experts

During the initial workshop and follow up conversations with New Zealand based habitat researchers we identified 105 researchers with considerable ecological knowledge and experience of one or more New Zealand marine habitats and with whom we had sufficient professional contact to judge their competency in fairly completing an assessment. We attempted to identify at least five experts for each of the sixty-two marine habitats. For coastal habitats with many active researchers, the experts identified were a subset of all researchers working in the field. For deepwater habitats the experts identified were likely to be all or most of the experts working on that New Zealand habitat. We did not approach those individuals whose agency, current work or experience was likely to be focused on one or a narrow range of threats as we required respondents to be able to fairly assess all threats to a habitat in the absence of a conflict of interest.

The identified experts were then approached via email, invited to participate in the study and provided with a document that provided background to the project and a detailed explanation on how threats to habitats should be scored (see Appendix 1). Often researchers were expert in more than one habitat and they were invited to submit an evaluation of vulnerability for each habitat they felt they were expert in. Experts were invited to pass along the questionnaire to colleagues they judged to be expert in one or more habitats.

Of the 105 habitat experts invited to take part in the survey most (90%) were resident in New Zealand with the remainder based in five other countries, especially in Australia (Table 4). Of the New Zealand based experts most (64%) worked for NIWA as collectively they worked across all habitat types and for many of the outer shelf, slope, and deepwater habitats were the majority of New Zealand based experts working in these habitats. The remainder of experts invited to participate in the assessment were either independent researchers (7%) or worked for universities (16.8%), government departments (6.3%) regional councils (3.2%), or private research institutions (2%).

Table 4: Country of residence and for New Zealand the institutional affiliation of marine habitat experts contacted to take part in the habitat vulnerability assessment.

Country/Institution	Number	
New Zealand	95	
NIWA		61
University of Otago		7
Independent		7
University of Auckland		4
Department of Conservation		3
Ministry of Fisheries		3
Regional Councils		3
Victoria University of Wellington		2
Cawthron Institute		2
University of Waikato		1
University of Canterbury		1
Auckland University of Technology		1
Australia	4	
Germany	2	
USA	2	
UK	1	
Norway	1	
TOTAL	105	

2.1.5 Questionnaire

An Excel spreadsheet with embedded pull down lists of the levels of each vulnerability factor was provided to each participant (Figure 1). Note that the spreadsheet was set up so that each vulnerability criteria for each threat was set to zero (no threat) except for the certainty factor that was set at the highest level (absolutely certain). Each expert was then asked to alter the level for those threats they considered affected a particular habitat and to indicate their degree of certainty about the knowledge available for every threat. We arranged the spreadsheet in this way so that participating experts needed to concentrate only on threats affecting their particular habitat, thereby reducing their workload and hopefully increasing the likelihood of assessment completion and submission. However, this did potentially upwardly bias the overall level of certainty for each assessment and this possibility is investigated in the results (see section 3.1.4).

Reminder emails were sent out twice to the original 105 researchers over a four month period and then follow up phone calls were made to individual habitat experts to encourage them to complete and submit their assessments, particularly those experts with expertise in habitats for which fewer than five assessments had been received.

2.1.6 Analysis

The vulnerability data was returned by the participating experts in the form of Excel spreadsheets, with a sheet for each habitat evaluation by an expert. For each of the sixty-five threats in an Excel sheet the participating expert provided vulnerability estimates for each of five vulnerability criteria (area, frequency, impact, susceptibility, recovery) as well as an estimate of the certainty associated with the vulnerability estimates (so for a sheet there are 65 associated certainty values).

The methodology for the data analysis closely followed Halpern et al. (2007). The analysis was done in four steps:

(a) The vulnerability estimates for the five vulnerability factors were put onto a common scale.
(b) The vulnerability estimates were averaged across respondents by taking a weighted average with respect to the certainty values. This resulted in, for each habitat and threat, a weighted average value for each of the five vulnerability factors.
(c) For each habitat and threat combination, the mean of the five weighted average vulnerability factors was calculated, giving a grand mean value.
(d) For each habitat, the mean across the grand mean threat values was calculated, giving the mean vulnerability for a habitat. For each threat, the mean across the grand mean habitat threat values was calculated, giving the mean impact of a threat.

Some of these steps are explained in more detail below.

Scaling

In the Halpern et al. (2007) paper the five vulnerability factors and the certainty were ranked on a scale from 0 to 4. In the assessments undertaken by the experts in this project the rankings are on the scales as shown in Table 3. To put the rankings on the same scale as used for Halpern et al. (2007) the Area factor vulnerability estimates were multiplied by 4/6; other vulnerability measures already on a scale from 0 to 4 were left unchanged.

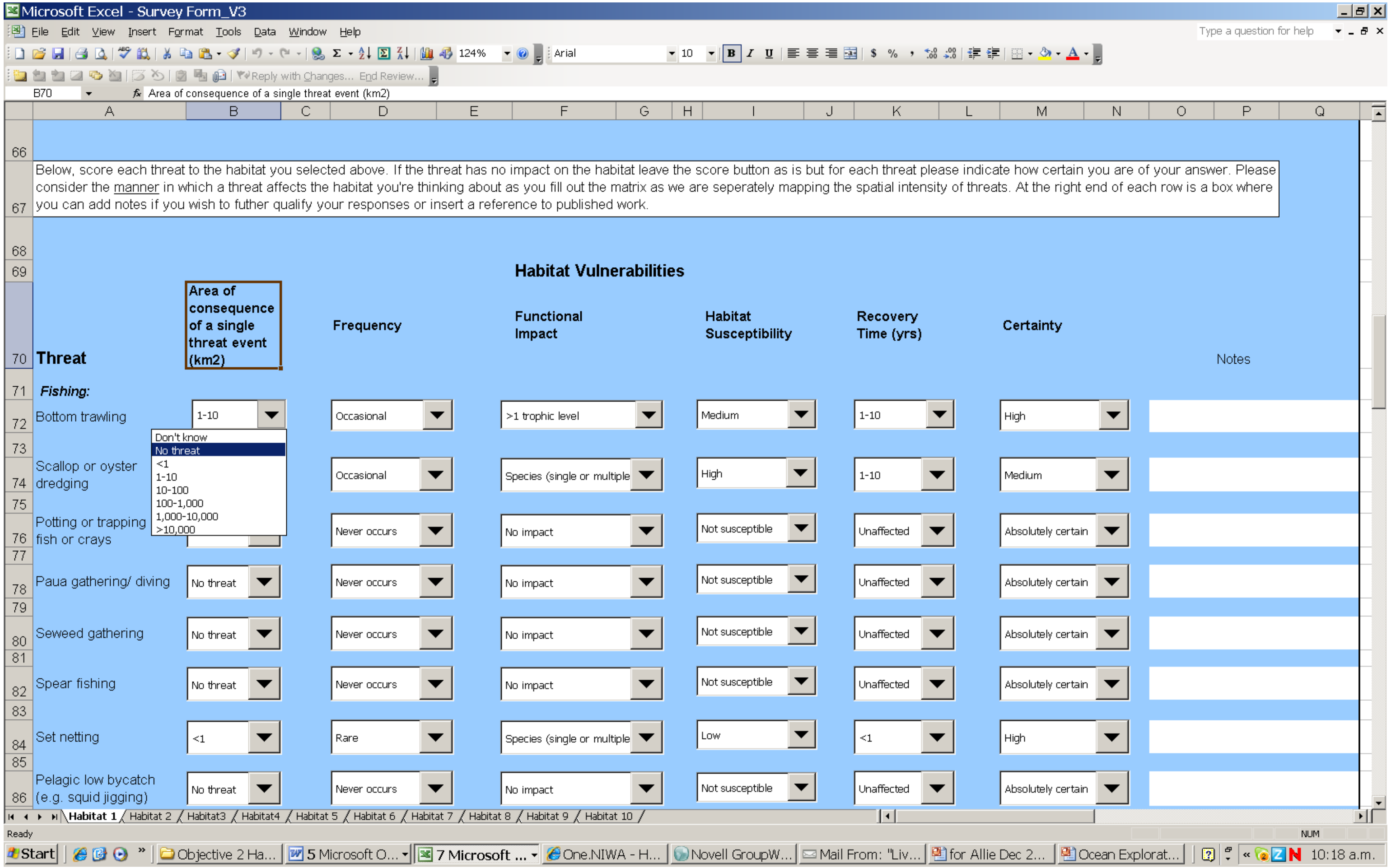


Figure 1: Screenshot of the Excel worksheet provided to each participant showing some of the threats and response options.

Weighting

For each threat and habitat combination, the vulnerability criteria score (0-4) was multiplied by its certainty estimate and the sum of these estimates across replicate survey responses was divided by the sum of the certainty estimates. A short example of this weighted average vulnerability calculation is given in Table 5. In this example, the Area criteria score from respondent one is multiplied by 2 (=2) and that from respondent two is multiplied by 3 (=9). The sum of these (11) is divided by the sum of the certainty scores (5) to produce a weighted average vulnerability of 2.2. This same procedure is undertaken for each of the other four vulnerability criteria scores and then summed and divided by the number of vulnerability criteria (5) to calculate the grand mean vulnerability score (for the given habitat and threat). In the example below the grand mean is (2.2 + 2.4 + 3.6 + 1.4 + 3.0)/5 = 2.52.

Table 5: The weighted average for two respondents (for a given habitat and threat)

	Area	Frequency	Impact	Susceptibility	Recovery	Certainty	Grand Mean
Respondent One	1	0	3	2	3	2	
Respondent Two	3	4	4	1	3	3	
Weighted average	2.2	2.4	3.6	1.4	3.0		2.52

Vulnerability score interpretation

The weighted average vulnerability score represents the vulnerability of a habitat to a particular threat over a range of 0–4. These scores are equivalent to responses to threats over several orders of magnitude. For instance, an average score of 0 indicates that the particular human activity does not threaten a specific habitat. An average score of 1.0 would indicate that typically a threat event has a spatial impact of approximately 1 km^2, is very infrequent over the course of a year and affects only one or a few species, and that the habitat in question has low susceptibility to the threat and recovers in less than a year. An average score of 2.0 would indicate that typically a threat event has a spatial scale of 10–100 km^2, is frequent but irregular in nature, multiple species or an entire trophic level is affected, that moderate intensities or frequencies of the threat causes change and that the habitat takes 1–10 years to recover. An average score of 3.0 would indicate that typically a threat event has a spatial scale of just over 1000 km^2, is frequent and often seasonal or periodic, affects multiple species in multiple trophic levels, causes significant but not catastrophic effects and that the habitat takes between 10 and 100 years to recover. An average score of 4.0 would indicate that typically a threat event is very widespread, persistent, affects the entire ecosystem, the slightest occurrence of the threat causes a major change to the habitat, and that the habitat recovery time is more than 100 years. To reach a score of 4.0 score all experts assessing the threat/habitat interaction would need to provide identical maximum scores. In practice this is unlikely so the maximum vulnerability estimates may lie between 3 and 4.

We categorised threats as extreme if the mean weighted score was 3 or more, major if the score was 2–2.9, moderate if the score was 1–1.9, minor if the score was 0.5 – 1.0, and trivial if the score was less than 0.5.

It is important to note that threats may score more highly for some vulnerability criteria than others. While the average score is a useful summary of the overall vulnerability, in section 3.1.6 we describe the variation in vulnerability among the five different criteria used.

Hierarchical Cluster Analysis

We undertook a cluster analysis of threats by habitat using the Bray Curtis similarity index to determine whether there was any tendency for threats stemming from the same underlying cause (e.g. fishing, engineering, increasing greenhouse gases, etc) to group together on the basis of their mean weighted vulnerability score. Similarly, we undertook a cluster analysis of habitats by threat using the Bray Curtis similarity index to determine whether there was any tendency for habitats to group by depth, exposure and/or substrate on the basis of mean weighted vulnerability scores. The cluster analyses were undertaken using Primer 6.0.

2.2 Specific Objective 1

During the initial project workshop and follow-up conversations we also identified potential sources and owners of existing information that would enable the spatial intensity of threats to marine habitats in New Zealand’s EEZ to be mapped. These data owners were then approached to gain permission to access specific data sets, especially for those threats identified as high ranking as a consequence of work carried out using the approach specified in section 2.1 above. For each threat we summarised the key contacts, described the data and the methods used to generate it, described the key models and or datasets, indicated the limitations of the data and/or models, described future development of data collection or modelling pertinent to the threat, listed relevant references and provided a figure or figures that illustrate the data and or modelling output. We sought this information for the whole of the territorial seas and EEZ.

RESULTS

3.1 Habitat vulnerability assessment

3.1.1 Responding experts

We received responses from forty-nine marine habitat experts (47% response rate) but had to discard the responses of two experts because they placed their assessments for very dissimilar habitats on a single worksheet thereby making it impossible to separate the effects of the same threat on different habitats. Another two people made a joint response on one form and this was treated as a single response. The effective response rate was thereby reduced to 44%.

Most respondents were based in New Zealand (96%), with only two of the twelve overseas based experts responding (Figure 2). Most New Zealand based respondents were from NIWA (69%) with the reminder affiliated to universities (11%), government departments (8.9%), and private research institutes (4.4%) or were independent researchers (6.7%). These proportions were similar to the proportions invited to participate except that no regional council scientists responded. Two respondents were passed the questionnaire by their colleagues.

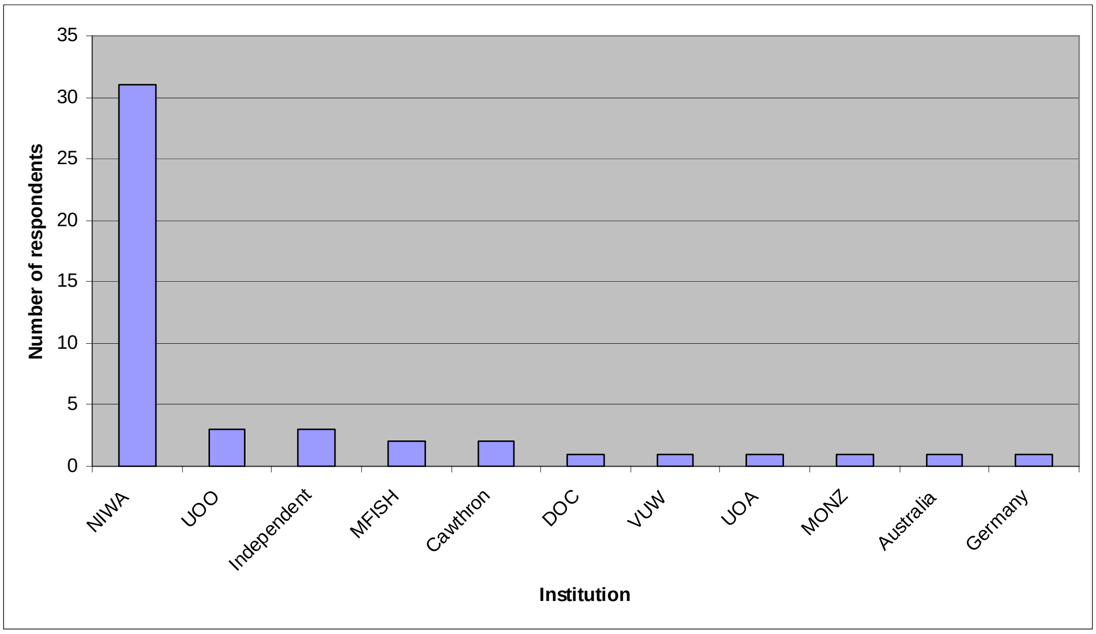


Figure 2: Number of responding experts per New Zealand institution or country. Abbreviations are as follows: UOO, University of Otago; MFish, Ministry of Fisheries; DOC, Department of Conservation; VUW, Victoria University of Wellington; UOA, University of Auckland; MONZ, Museum of New Zealand Te Papa.

Seven of the responding experts assessed only one habitat and half the responding experts assessed fewer than five habitats each (Figure 3a and Table 6a & b). At the other extreme four respondents assessed more than twenty habitats each; one expert assessed thirty-six coastal and shelf habitats.

In total these forty-five habitat experts provided 343 usable assessments (Figure 3b) but these were unevenly distributed across habitats (Figure 4 and Table 7). Up to ten experts assessed some habitats. But for three habitats, cobble beaches on sheltered coasts, cobble beaches on exposed coasts, and hard abyssal habitats, we received no expert assessment and so dropped these from our analysis (Table 7). Twelve outer shelf, slope, deepwater, fiord and pelagic habitats were assessed by between two and four experts, fewer than our target minimum of five. We included these in our analysis but results for these habitats should be interpreted cautiously.

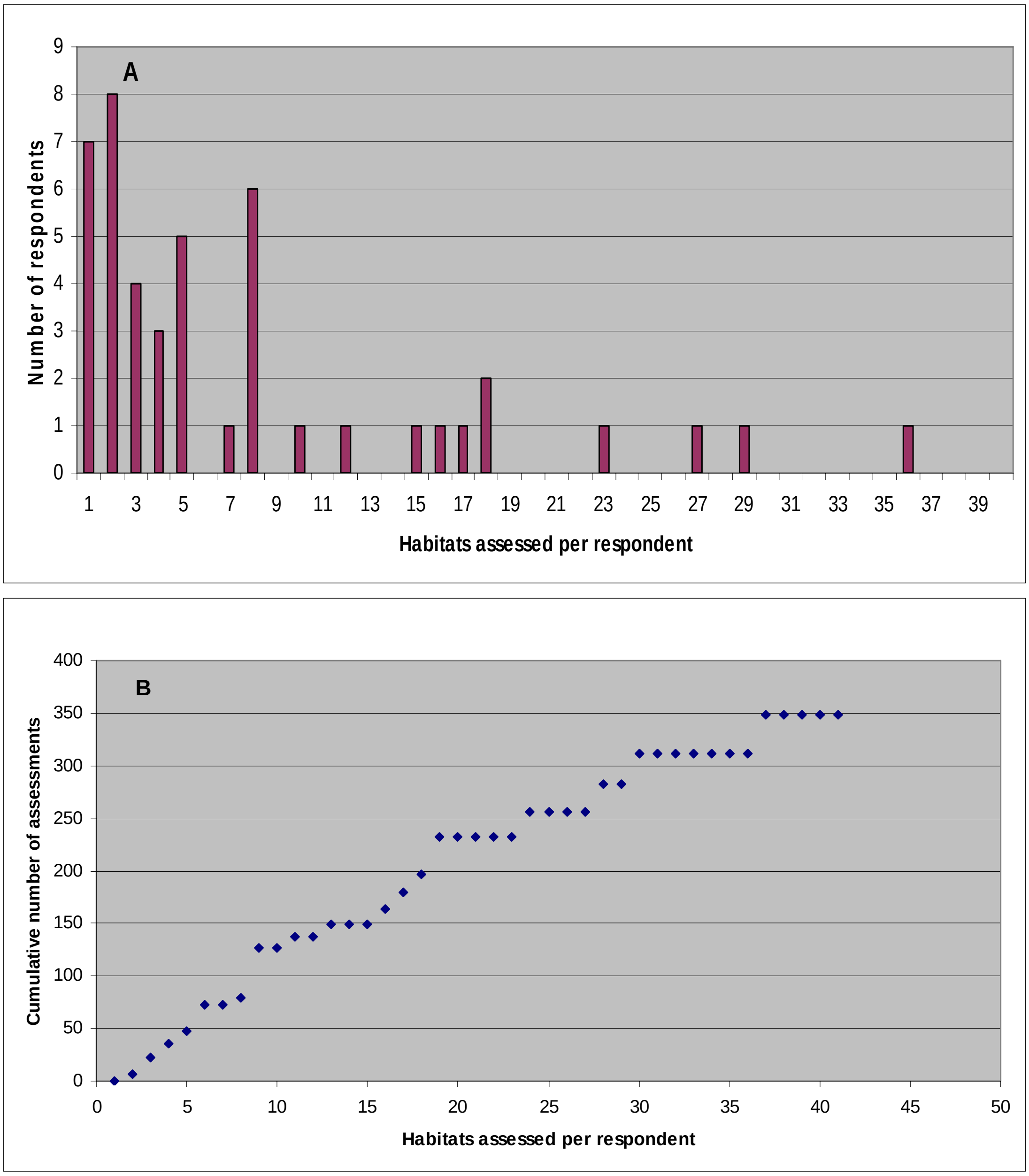


Figure 3: Habitat assessments per expert returned during the New Zealand marine habitat vulnerability assessment. A) number of experts, B) cumulative number of assessments.

Table 6a: Habitats assessed by responding experts 1-23. Experts are arranged in order of response to the initial invitation to participate. Each 1 indicates a response to this habitat category.

	Responding experts																						
Habitats	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Harbour & Estuaries : Saltmarsh	1	1			1		1																
Harbour & Estuaries : Mangrove forest	1	1			1		1																
Harbour & Estuaries : Intertidal sand	1	1		1			1	1		1	1									1			
Harbour & Estuaries : Intertidal mud	1									1	1									1			
Harbour & Estuaries : Seagrass meadows	1	1					1			1									1	1			
Harbour & Estuaries : Subtidal mud	1									1					1					1		1	1
Harbour & Estuaries : Subtidal sand	1									1										1		1	1
Harbour & Estuaries : Cockle bed	1	1					1			1	1												
Harbour & Estuaries : Pipi bed	1	1					1			1	1												
Harbour & Estuaries : Intertidal reef	1			1			1	1			1		1										
Harbour & Estuaries : Subtidal reef	1	1		1			1	1					1									1	
Sheltered Coast : Sandy beaches	1			1			1	1		1	1												
Sheltered Coast : Mud 0–9 m	1				1	1			1	1					1								
Sheltered Coast : Sand 0–9 m	1		1	1	1	1			1	1													
Sheltered Coast : Gravel/pebble/shell 0–9 m	1		1	1	1	1			1														
Sheltered Coast : Mud 10–29 m	1		1		1	1			1	1		1			1								
Sheltered Coast : Sand 10–29 m	1		1		1	1			1	1		1											
Sheltered Coast : Gravel/pebble/shell 10–29 m	1		1	1	1	1			1			1											
Sheltered Coast : Intertidal reef				1			1	1			1		1										
Sheltered Coast : Subtidal reefs 0–9 m	1	1		1		1	1	1	1				1								1		
Sheltered Coast : Subtidal reefs 10–29 m	1	1		1		1	1	1	1				1								1		
Sheltered Coast : Kelp Forest	1			1		1	1	1	1														
Exposed Coasts : Sandy beaches	1			1				1			1	1											
Exposed Coasts : Sand 0–9 m	1		1	1		1						1										1	
Exposed Coasts : Gravel/pebble/shell 0–9 m	1		1	1	1	1																	
Exposed Coasts : Mud 10–29 m	1		1		1	1					1												
Exposed Coasts : Sand 10–29 m	1		1		1	1						1										1	
Exposed Coasts : Gravel/pebble/shell 10–29 m	1		1	1	1	1						1											
Exposed Coasts : Mud 30–200 m	1		1		1						1												
Exposed Coasts : Sand 30–200 m	1		1		1																		
Exposed Coasts : Gravel/pebble/shell 30–200 m	1		1	1	1																		
Exposed Coasts : Intertidal reefs	1			1				1					1										
Exposed Coasts : Subtidal reefs 0–9 m	1		1	1		1	1	1	1				1								1		

Habitats	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Exposed Coasts : Subtidal reefs 10–30 m	1		1	1		1	1	1	1				1								1		
Exposed Coasts : Subtidal reefs 30–200 m				1				1	1												1		
Exposed Coasts : Biogenic calcareous reefs	1		1	1			1	1				1											
Exposed Coasts : Kelp Forest	1			1		1	1	1	1														
Exposed Coasts : Turfing algal reefs	1			1		1		1															
Slope Habitats : Mud 200–2000 m		1	1		1									1	1		1	1					1
Slope Habitats : Sand 200–2000 m		1	1		1									1				1					
Slope Habitats : Gravel/pebbles/shells 200–2000 m		1	1		1													1					
Slope Habitats : Reef 200–2000 m		1	1															1					1
Deep Habitats : Soft canyon		1														1							
Deep Habitats : Hard canyon		1	1													1							
Deep Habitats : Seamount < 2000 m		1	1													1		1					
Deep Habitats : Seamount > 2000 m		1	1													1		1					
Deep Habitats : Vent (hot and cold)		1	1											1		1	1						
Deep Habitats : Soft abyssal 2000 m+		1	1											1		1		1					1
Deep Habitats : Trench																							
Fiord Habitats : Inner fiord rockwalls		1	1													1	1						
Fiord Habitats : Outer fiord rockwalls									1										1				
Fiord Habitats : Fiord sediments									1										1				
Fiord Habitats : Fiord water column		1																	1				
Pelagic Habitat : Coastal - whole water column inside 50 m contour		1																	1				
Pelagic Habitat : Shelf - whole water column between 50–200 m contour		1													1		1						
Pelagic Habitat : Slope - water column in photic zone		1													1		1						
Pelagic Habitat : Slope - water column below photic zone		1												1	1								
Pelagic Habitat : Deep ocean water column in photic zone		1												1	1								
Pelagic Habitat : Deep ocean water column below photic zone		1												1			1						

Table 6b: Habitats assessed by responding experts 24-45. Experts are arranged in order of response to the initial invitation to participate. Each 1 indicates a response to this habitat category.

Responding experts

Habitats	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Harbour & Estuaries : Saltmarsh																		1	1		1	1
Harbour & Estuaries : Mangrove forest		1				1											1					
Harbour & Estuaries : Intertidal sand																						
Harbour & Estuaries : Intertidal mud						1							1									
Harbour & Estuaries : Seagrass meadows																1						
Harbour & Estuaries : Subtidal mud						1																
Harbour & Estuaries : Subtidal sand																						
Harbour & Estuaries : Cockle bed													1									
Harbour & Estuaries : Pipi bed		1																				
Harbour & Estuaries : Intertidal reef																						
Harbour & Estuaries : Subtidal reef																						
Sheltered Coast : Sandy beaches																						
Sheltered Coast : Mud 0–9 m																						
Sheltered Coast : Sand 0–9 m																						
Sheltered Coast : Gravel/pebble/shell 0–9 m																						
Sheltered Coast : Mud 10–29 m																						
Sheltered Coast : Sand 10–29 m																						
Sheltered Coast : Gravel/pebble/shell 10–29 m																						
Sheltered Coast : Intertidal reef		1																				
Sheltered Coast : Subtidal reefs 0–9 m																						
Sheltered Coast : Subtidal reefs 10–29 m																						
Sheltered Coast : Kelp Forest																						
Exposed Coasts : Sandy beaches																						
Exposed Coasts : Sand 0–9 m					1																	
Exposed Coasts : Gravel/pebble/shell 0–9 m																						
Exposed Coasts : Mud 10–29 m																						
Exposed Coasts : Sand 10–29 m																						
Exposed Coasts : Gravel/pebble/shell 10–29 m														1								

Habitats	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Exposed Coasts : Mud 30–200 m																						
Exposed Coasts : Sand 30–200 m					1																	
Exposed Coasts : Gravel/pebble/shell 30–200 m														1								
Exposed Coasts : Intertidal reefs		1																				
Exposed Coasts : Subtidal reefs 0–9 m				1																		
Exposed Coasts : Subtidal reefs 10–30 m				1																		
Exposed Coasts : Subtidal reefs 30–200 m																						
Exposed Coasts : Biogenic calcareous reefs																						
Exposed Coasts : Kelp Forest				1																		
Exposed Coasts : Turfing algal reefs																				1		
Slope Habitats : Mud 200–2000 m					1																	
Slope Habitats : Sand 200–2000 m																						
Slope Habitats : Gravel/pebbles/shells 200–2000 m																						
Slope Habitats : Reef 200–2000 m																						
Deep Habitats : Soft canyon																						
Deep Habitats : Hard canyon																						
Deep Habitats : Seamount < 2000 m			1																			
Deep Habitats : Seamount > 2000 m			1																			
Deep Habitats : Vent (hot and cold)			1																			
Deep Habitats : Soft abyssal 2000 m+									1													
Deep Habitats : Trench																						
Fiord Habitats : Inner fiord rockwalls									1													
Fiord Habitats : Outer fiord rockwalls										1	1	1										
Fiord Habitats : Fiord sediments											1	1										
Fiord Habitats : Fiord water column										1												
Pelagic Habitat : Coastal - whole water column inside 50 m contour																						
Pelagic Habitat : Shelf - whole water column between 50–200 m contour							1								1							
Pelagic Habitat : Slope - water column in photic zone							1								1							
Pelagic Habitat : Slope - water column below photic zone	1						1	1														
Pelagic Habitat : Deep ocean water column in photic zone	1							1														
Pelagic Habitat : Deep ocean water column below photic zone	1																					

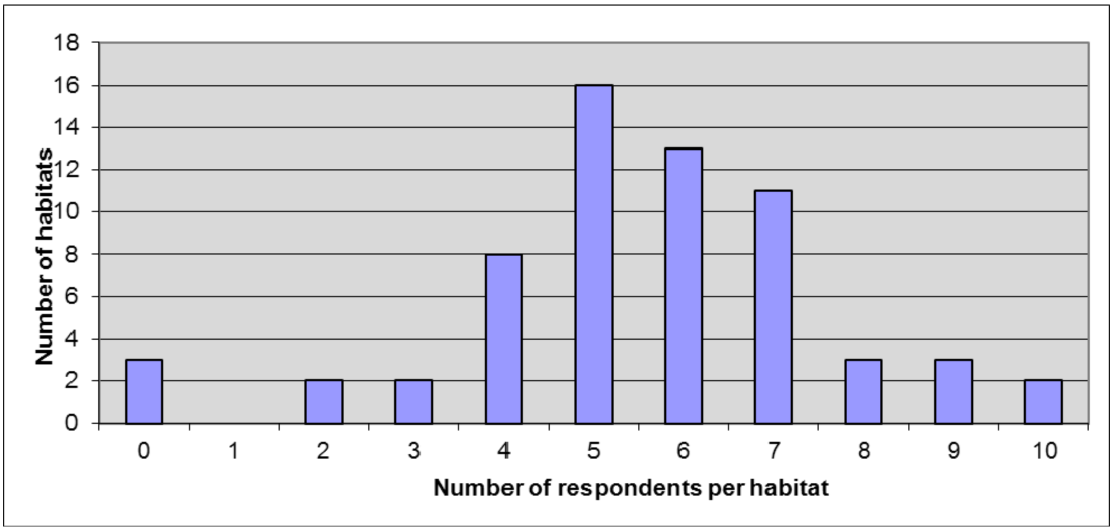


Figure 4: Number of respondents per habitat for the New Zealand marine habitat vulnerability assessment.

Table 7: Habitats in descending order of the number of expert assessments completed in the New Zealand habitat vulnerability assessment.

Habitat	Number of expert assessments
Exposed Coasts : Subtidal reefs 10–30 m	10
Exposed Coasts : Subtidal reefs 2–9 m	10
Sheltered Coast : Subtidal reefs 2–9 m	9
Sheltered Coast : Subtidal reefs 10–29 m	9
Slope Habitats : Mud 200–2000 m	9
Harbour & Estuaries : Intertidal sand	8
Sheltered Coast : Mud 10–29 m	8
Harbour & Estuaries : Saltmarsh	8
Harbour & Estuaries : Subtidal reef	7
Harbour & Estuaries : Subtidal mud	7
Harbour & Estuaries : Seagrass	7
Sheltered Coast : Sand 2–9 m	7
Sheltered Coast : Sand 10–29 m	7
Sheltered Coast : Gravel/pebble/shell 10–29 m	7
Exposed Coasts : Kelp Forest	7
Exposed Coasts : Sand 2–9 m	7
Harbour & Estuaries : Mangrove	7
Exposed Coasts : Gravel/pebble/shell 10–29 m	7
Deep Habitats : Soft abyssal 2000 m+	7
Harbour & Estuaries : Intertidal reef	6
Harbour & Estuaries : Intertidal mud	6
Harbour & Estuaries : Pipi bed	6
Sheltered Coast : Intertidal reef	6
Sheltered Coast : Mud 2–9 m	6
Sheltered Coast : Gravel/pebble/shell 2–9 m	6
Harbour & Estuaries : Cockle bed	6
Sheltered Coast : Kelp Forest	6
Exposed Coasts : Biogenic calcareous reefs	6
Sheltered Coast : Sandy beaches	6
Exposed Coasts : Sand 10–29 m	6
Pelagic Habitat : Slope - water column in photic zone	6
Deep Habitats : Vents and seeps	6

Harbour & Estuaries : Subtidal sand	5
Exposed Coasts : Intertidal reefs	5
Exposed Coasts : Turfing algal reefs	5
Exposed Coasts : Gravel/pebble/shell 2–9 m	5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	5
Exposed Coasts : Sandy beaches	5
Fiord Habitats : Inner fiord rockwalls	5
Exposed Coasts : Mud 10–29 m	5
Pelagic Habitat : Shelf - whole water column between 50–200 m contour	5
Pelagic Habitat : Slope - water column below photic zone	5
Exposed Coasts : Gravel/pebble/shell 30–200 m	5
Slope Habitats : Sand 200–2000 m	5
Deep Habitats : Seamount < 2000 m	5
Deep Habitats : Seamount > 2000 m	5
Deep Habitats : Trench	5
Exposed Coasts : Subtidal reefs 30–200 m	4
Exposed Coasts : Mud 30–200 m	4
Fiord Habitats : Outer fiord rockwalls	4
Pelagic Habitat : Deep ocean water column in photic zone	4
Exposed Coasts : Sand 30–200 m	4
Pelagic Habitat : Deep ocean water column below photic zone	4
Slope Habitats : Gravel/pebbles/shells 200–2000 m	4
Slope Habitats : Reef 200–2000 m	4
Fiord Habitats : Fiord sediments	3
Deep Habitats : Hard canyon	3
Deep Habitats : Soft canyon	2
Fiord Habitats : Fiord water column	2
Deep habitats: Hard abyssal	0
Sheltered coasts: Cobble beaches	0
Exposed coasts: Cobble beaches	0

3.1.2 Habitat vulnerability scores

For each habitat and threat a weighted average vulnerability score was calculated. These scores could then be summarised as the mean or sum of scores across habitats or threats. The sum of scores effectively ignores zero values and provides a ranking based only on those threats that have an impact in a habitat. In contrast, the mean takes into account zero scores. In practice there was a strong positive relationship between the two measures (r^2= 0.99) so we report only the mean score across habitats or threats.

3.1.3 Certainty versus vulnerability scores for the raw values

Vulnerability scores ranged from 0 (low) to 4 (high) in steps of one for the vulnerability factors frequency, impact, susceptibility, and recovery. For the area vulnerability factor the scores after rescaling were from 0 to 4, but in steps of 2/3 (before rescaling they went from 0 to 6 in steps of one). To compare certainty records across unweighted vulnerability scores we rounded the area values (e.g. scores of 2 and 1 when multiplied by 2/3 become 1.33 and 0.66 respectively, which both get rounded to 1) so that all vulnerability values were either 0, 1, 2, 3, or 4.

The majority of certainty records were either 3 or 4 (High or Absolutely Certain) for all estimated vulnerability values (Figure 5). The pattern is the same for each vulnerability factor (Figure 6).

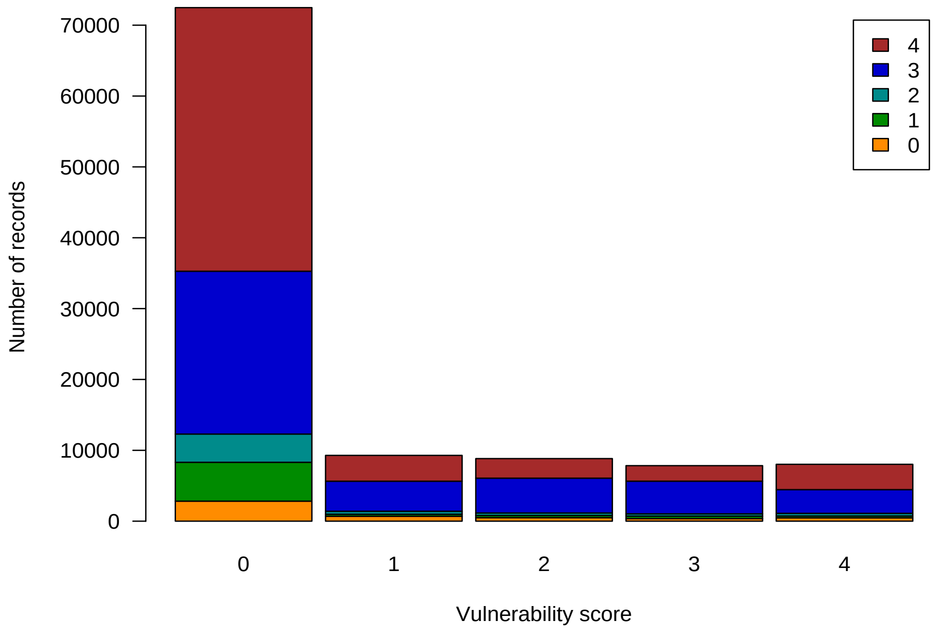


Figure 5: Number of records by vulnerability score and certainty. Vulnerability scores are rounded to integers for the vulnerability category Area (see text). For each vulnerability score the number of records for each level of certainty is indicated by the coloured portions (Orange represents zero certainty, and red/brown absolutely certain).

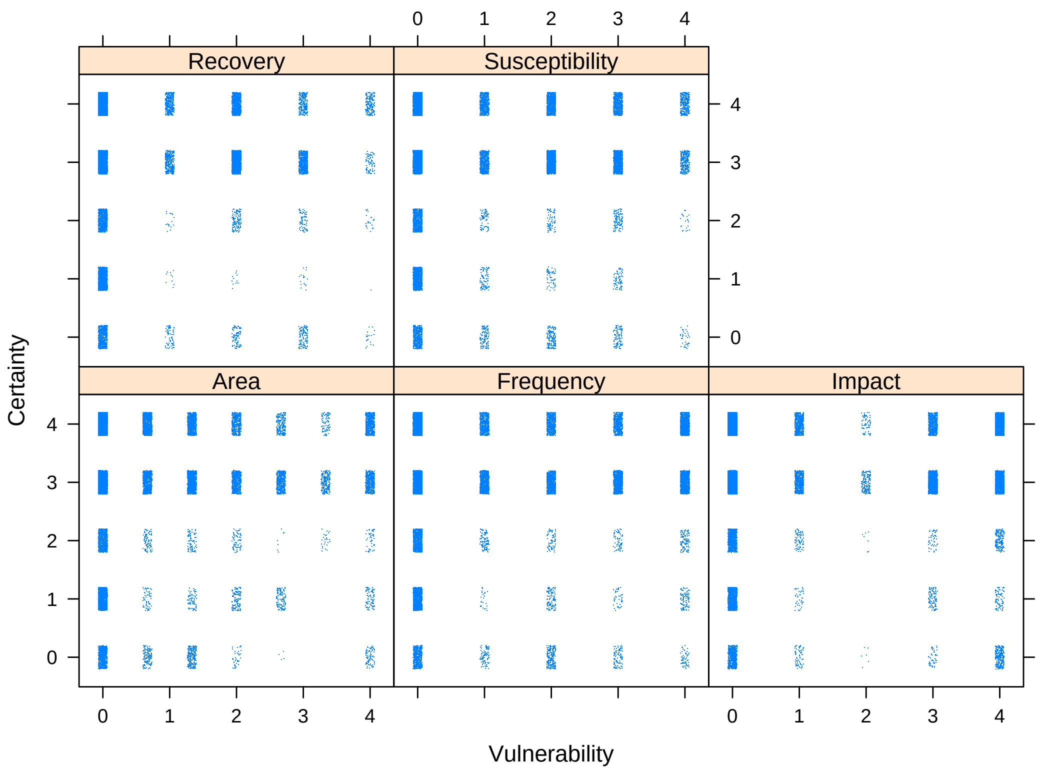


Figure 6: Certainty by vulnerability category. Both the vulnerability and certainty values are jittered (expanded spatially) so as to separate out points to some extent. Note that there was an uneven distribution of records across vulnerability scores and certainty scores so that the blue rectangles in many cases are incomplete.

3.1.4 Consistency of respondent vulnerability estimates

The number of habitat by threat by vulnerability categories = 59 x 65 x 5 = 19 175. The total number of estimates for these 19 175 categories from participating experts is 114 725, so the mean number of estimates per category is six. About 2% of the categories had just one estimate, but most had four or more (Figure 7).

An important question is to what extent are these vulnerability estimates consistent with each other? Note that one aspect in addressing this is the certainty associated with the vulnerability estimates. For example, disparate vulnerability estimates that are highly uncertain are more consistent then disparate vulnerability estimates that are very certain. However, as most (84%) of the certainty estimates are either "High" or "Absolutely Certain", (see Figure 5) then as a simplifying approximation the certainty values can be ignored.

To measure the consistency of the vulnerability estimates the standard deviation could be calculated for each vulnerability category. However for a small quantity of discrete data this is not a good measure of consistency. Instead, the percentage of vulnerability estimates in the modal score was calculated. For example, for the data set 2, 3, 3, 3, 4, 5, 6 the modal score is three and the percentage of estimates in the mode is 3/7*100 = 43%. When there is no modal score the percentage is zero.

For each habitat there are 325 threat by vulnerability combinations (i.e. 65 threats x 5 vulnerability criteria). For each of these combinations for a habitat, the percentage of the vulnerability estimates in the mode was calculated, then the mean taken across the 325 combinations. All mean values for the percentage in the mode were greater than 50% (Figure 8).

Many vulnerability estimates are zero with high or greater certainty, reflecting that the experts believe that particular threats do not occur in certain habitats. Because of this, the vulnerability estimates for these particular habitats and threats are expected to be highly consistent. Dropping these zero vulnerability estimates brought the minimum mean value across habitats down to about 30% (Figure 9) indicating that in habitats where threats operate, there is less consistency in estimates of the magnitude of the threat.

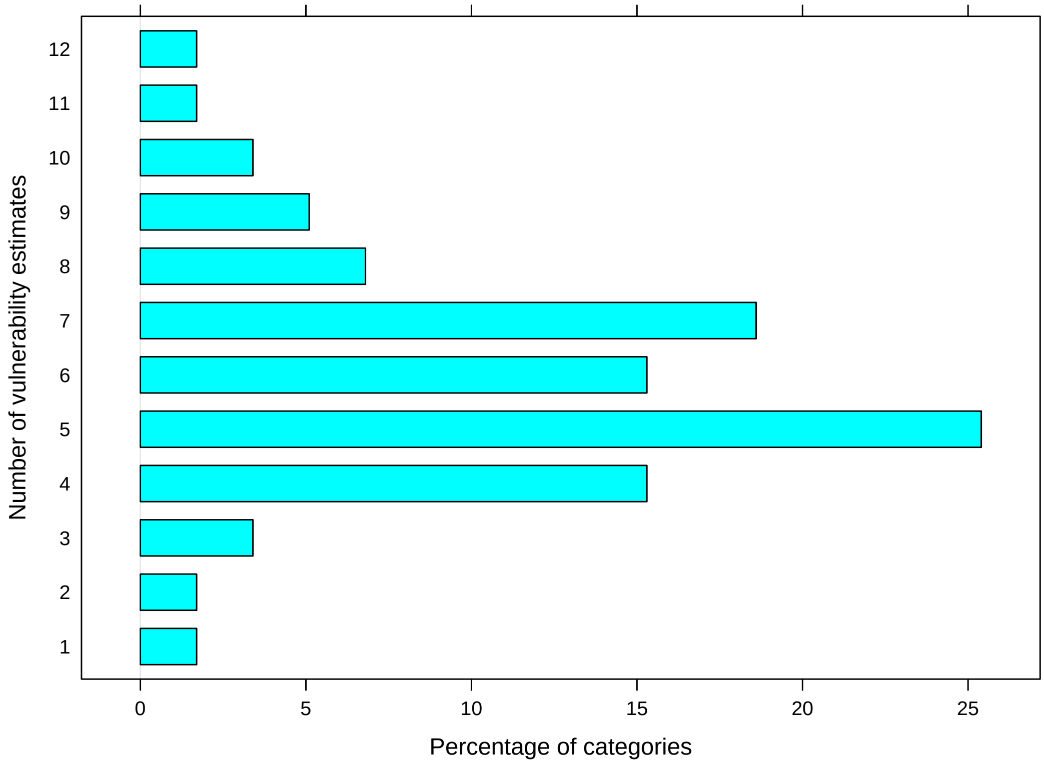


Figure 7: Percentage distribution for the number of categories with a given number of vulnerability estimates.

Figure 8: Percentage of vulnerability estimates in the mode. Mean across threat by vulnerability criteria combinations for each habitat.

Figure 9: Percentage of vulnerability estimates in the mode, but with vulnerability estimates of zero with certainty "High" or "Absolutely Certain" dropped from the data. Mean across the threat by vulnerability criteria combinations for each habitat.

3.1.5 Threats to marine habitats

By a large margin, the highest ranked threat to marine habitats overall by the participating experts was ocean acidification with a score of 2.6 (Table 8). However, the certainty score for this threat was the lowest indicating that the potential for widespread change is high but that full knowledge of impacts is yet to emerge. The second highest scoring threat, with a score of 1.6 (about an order of magnitude lower impact than ocean acidification), was increased sea temperature due to climate change followed closely by bottom trawling and sedimentation. Two other impacts of climate change, change in currents and increased storminess, ranked fifth equal with scallop and oyster dredging the only other threat with a score of 1 or more.

The threat of invasive species occupying space or competing with native species across all habitats scored 0.9 and overall ranked eighth equal, but was the third highest ranking marine based threat along with the dumping of dredge spoils. Algal blooms and increased turbidity had the same score and ranking, but originated from a mixture of climate change, catchment and marine human activities (Table 8). All the remaining effects of climate change ranked higher than 20 as did six forms of fishing including line fishing, trapping, longlining, and shellfish gathering, as well the bottom trawling and dredging already mentioned. The only threats from engineering to rank in the top 20 were dumping of dredge spoils (8=) and reclamation (13=). Surprisingly, extraction of minerals by surface suction ranked 47= with a score of 0.3, with other forms of mineral extraction even more lowly ranked and scored.

The highest ranking threats from pollution across all habitats were for sewage, nitrogen and phosphorus loading, and oil and oil products (13=), all with a score of 0.8. Heavy metal pollution ranked in the top 20.

The benthic accumulation of shells, food and faeces from aquaculture ranked 19= with a score of 0.7. Other impacts of aquaculture were mid ranked (36=) with a score of only 0.4.

The effects of ecotourism all ranked in the bottom half of threats with the highest being damage from diving (36=) with a score of 0.4.

The lowest ranked form of fishing (52=) was low by-catch pelagic fishing, such squid jigging, with a score of only 0.2.

Among the lowest ranked threats across all habitats by the participating experts were various forms of ocean bed mining, animal strikes from ships, marine mammal watching, electrical and acoustic discharges and dampening of river flows. The lowest rank threat was noise from people which had a weighted mean vulnerability score across all habitats of zero.

Many of the top ranked threats to New Zealand marine habitats originate wholly or in part from human activities external to the marine environment (Table 8). The nine threats stemming from increasing greenhouse gases originate from global human activities and all ranked in the top twenty threats with ocean acidification and increased sea temperature the top two ranking threats. Four of the ten threats originating from catchment based activities (increased sediment loading, sewage discharges, nitrogen and phosphorus loading, and heavy metal pollution) were among the top twenty threats. Threats stemming from a mixture of catchment, global and/or marine based activities made up three of the top twenty threats. Threats originating from marine based activities, though comprising the majority of all threats to New Zealand marine habitats made up only a third of the top 20 threats (Table 8).

The mean certainty score assigned to threats by participating experts declined moderately with mean threat score across all habitats ($r^2 = 0.34$) (Table 8). Participating experts were more confident in the supporting information for threats with little impact and somewhat less confident in the information available to assess high impact threats.

Table 8: Threats to New Zealand marine habitats and threat source in decreasing order of mean impact of a threat across all habitats. Note the maximum possible mean weighted habitat impact score = 4.0. The mean certainty score for each threat is also shown.

Threat	Threat source	Mean impact of threat across all habitats	Rank	Mean certainty score
Ocean acidification	Global	2.6	1	2.2
Climate change: Increased sea temperature	Global	1.6	2	2.9
Fishing: Bottom trawling	Marine	1.5	3=	3.1
River inputs: Increased sediment loading	Catchment	1.5	3=	3.0
Climate change: Change in currents	Global	1.2	5=	2.6
Climate change: Increased storminess	Global	1.2	5=	2.8
Fishing: Dredging	Marine	1.0	7	3.4
Invasive species: Space occupiers, competitors	Marine	0.9	8=	3.2
Engineering: Dumping of dredge spoils	Marine	0.9	8=	3.1
Climate change: Rise in sea-level	Global	0.9	8=	2.9
Algal blooms - both toxic and massive	Mixed	0.9	8=	2.9
Increased turbidity	Mixed	0.9	8=	3.2
Fishing: Line fishing	Marine	0.8	13=	3.2
Engineering: reclamation	Marine	0.8	13=	3.6
Climate change: Increased stratification	Global	0.8	13=	2.9
Pollution: Sewage	Catchment	0.8	13=	3.1
Pollution: Nitrogen & phosphorus load	Catchment	0.8	13=	2.8
Pollution: Oil or oil products	Mixed	0.8	13=	2.9
Fishing: Trapping	Marine	0.7	19=	3.1
Fishing: Long-lining	Marine	0.7	19=	3.1
Fishing: Shellfish gathering	Marine	0.7	19=	3.4
Climate change: Increased intertidal temperatures	Global	0.7	19=	3.4
Climate change: Increase in UV	Global	0.7	19=	3.0
Climate change: Altered rainfall	Global	0.7	19=	3.0
Pollution: Heavy metals	Catchment	0.7	19=	2.7
Aquaculture: Benthic accumulation of shells, food, faeces	Marine	0.7	19=	3.2
Fishing: Set netting	Marine	0.6	27=	3.0
Engineering: Sand / gravel abstraction	Marine	0.6	27=	3.3
Engineering: Dredging	Marine	0.6	27=	3.4
Altered river inputs: Increased freshwater discharge	Catchment	0.5	30=	3.1
Engineering: Causeways	Marine	0.5	30=	3.3
Pollution: Plastic	Mixed	0.5	30=	2.9
Pollution: Pesticides including PCBs	Catchment	0.5	30=	2.9
Pollution: Herbicides	Catchment	0.5	30=	2.8
Anchoring	Marine	0.5	30=	3.3
Fishing: Abalone gathering	Marine	0.4	36=	3.4
Fishing: Seaweed gathering	Marine	0.4	36=	3.4
Fishing: Spear fishing	Marine	0.4	36=	3.3
Fishing: Pelagic high bycatch	Marine	0.4	36=	3.3
Engineering: Piled wharfs/sheds	Marine	0.4	36=	3.5
Engineering: Pile moorings/markers	Marine	0.4	36=	3.5
Aquaculture: Decrease in primary production	Marine	0.4	36=	3.2
Aquaculture: Increase in habitat complexity	Marine	0.4	36=	3.2
Spatial closures	Marine	0.4	36=	3.3
Shipping: Ship grounding, sinking	Marine	0.4	36=	3.1
Ecotourism: Diving	Marine	0.4	36=	3.4
River inputs: Decreased sediment loading	Catchment	0.3	47=	3.2

River inputs: Decreased freshwater discharge	Catchment	0.3	47=	3.2
Engineering: Mineral extraction - surface suction	Marine	0.3	47=	3.3
Engineering: Seawalls	Marine	0.3	47=	3.5
Invasive species: Disease	Marine	0.3	47=	2.7
Fishing: Pelagic low bycatch	Marine	0.2	52=	3.3
Engineering: Pontoons	Marine	0.2	52=	3.5
Shipping: Underwater noise	Marine	0.2	52=	3.2
Ecotourism: Reef trampling	Marine	0.2	52=	3.7
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2	52=	3.4
Ecotourism: Vehicles on beaches	Marine	0.2	52=	3.7
River inputs: Dampening of flows	Catchment	0.1	58=	3.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.1	58=	3.5
Engineering: Minerals extraction - other methods	Marine	0.1	58=	3.3
Engineering: Acoustic discharges / guns	Marine	0.1	58=	2.8
Engineering: Electromagnetic discharges from cables	Marine	0.1	58=	2.9
Shipping: Animal strikes	Marine	0.1	58=	3.4
Ecotourism: Marine mammal watching	Marine	0.1	58=	3.6
Ecotourism: Noise from people	Marine	0.0	65	3.4

3.1.6 Habitat vulnerability across all threats

Reef, sand and mud habitats in harbours and estuaries and along exposed coasts were ranked the most highly threatened habitats, with threat scores of 1 or more (Table 9). The least threatened estuarine and harbour habitats were saltmarsh and mangrove forests with a mean threat score of 0.5 and a rank of thirty-second equal. Slope and deep water habitats were among the least threatened and lowest ranked. The most threatened habitats were generally considered to be impacted by many threats and the least threatened habitats confronted by the fewest threats (Table 9 and Figure 10).

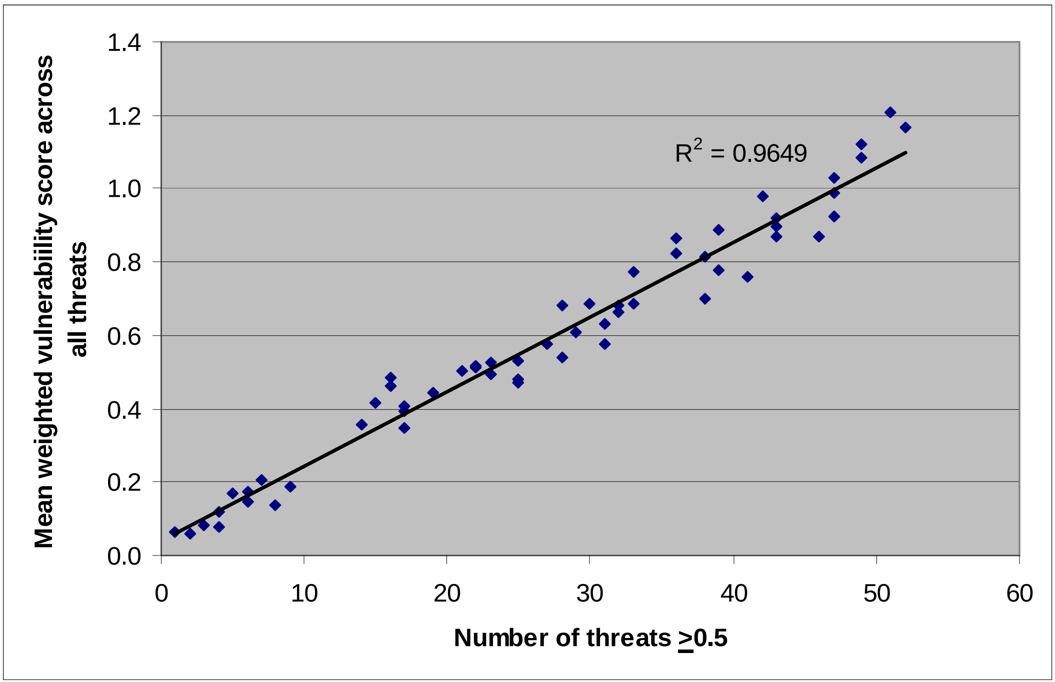


Figure 10: The number of threats scoring at least 0.5 and the mean weighted vulnerability score across all threats for 59 New Zealand marine habitats.

Table 9: New Zealand marine habitats in order of decreasing mean weighted vulnerability score and rank across all threats. The number of threats with scores ≥0.5 affecting a habitat is also provided.

Habitat	Number of threats with scores ≥0.5	Mean weighted vulnerability score	Rank
Harbour & Estuaries : Intertidal reef	51	1.2	1=
Harbour & Estuaries : Subtidal reef	52	1.2	1=
Harbour & Estuaries : Subtidal mud	49	1.1	3=
Exposed Coasts : Subtidal reefs 30–200 m	49	1.1	3=
Harbour & Estuaries : Subtidal sand	47	1.0	5=
Exposed Coasts : Intertidal reefs	47	1.0	5=
Harbour & Estuaries : Intertidal mud	42	1.0	5=
Harbour & Estuaries : Pipi bed	43	0.9	8=
Sheltered Coast : Subtidal reefs 2–9 m	47	0.9	8=
Sheltered Coast : Subtidal reefs 10–29 m	47	0.9	8=
Sheltered Coast : Intertidal reef	43	0.9	8=
Harbour & Estuaries : Seagrass	39	0.9	8=
Sheltered Coast : Mud 2–9 m	43	0.9	8=
Exposed Coasts : Subtidal reefs 10–30 m	46	0.9	8=
Sheltered Coast : Gravel/pebble/shell 2–9 m	36	0.9	8=
Sheltered Coast : Sand 2–9 m	36	0.8	16=
Harbour & Estuaries : Cockle bed	38	0.8	16=
Sheltered Coast : Kelp Forest	39	0.8	16=
Sheltered Coast : Sand 10–29 m	33	0.8	16=
Exposed Coasts : Subtidal reefs 2–9 m	41	0.8	16=
Exposed Coasts : Turfing algal reefs	38	0.7	21=
Sheltered Coast : Gravel/pebble/shell 10–29 m	30	0.7	21=
Harbour & Estuaries : Intertidal sand	32	0.7	21=
Exposed Coasts : Gravel/pebble/shell 2–9 m	33	0.7	21=
Sheltered Coast : Mud 10–29 m	28	0.7	21=
Exposed Coasts : Biogenic calcareous reefs	32	0.7	21=
Pelagic Habitat : Coastal - water column inside 50 m contour	31	0.6	27=
Exposed Coasts : Sandy beaches	29	0.6	27=
Sheltered Coast : Sandy beaches	27	0.6	27=
Exposed Coasts : Kelp Forest	31	0.6	27=
Fiord Habitats : Fiord water column	39	0.6	27=
Exposed Coasts : Sand 2–9 m	28	0.5	32=
Harbour & Estuaries : Mangrove	25	0.5	32=
Harbour & Estuaries : Saltmarsh	23	0.5	32=
Fiord Habitats : Inner fiord rockwalls	22	0.5	32=
Exposed Coasts : Mud 10–29 m	22	0.5	32=
Exposed Coasts : Sand 10–29 m	21	0.5	32=
Exposed Coasts : Gravel/pebble/shell 10–29 m	23	0.5	32=
Pelagic Habitat : Slope - water column in photic zone	16	0.5	32=
Pelagic Habitat : Shelf - water column between 50–200 m contour	25	0.5	32=
Exposed Coasts : Mud 30–200 m	25	0.5	32=
Pelagic Habitat : Slope - water column below photic zone	16	0.5	32=
Fiord Habitats : Outer fiord rockwalls	19	0.4	43=
Pelagic Habitat : Deep ocean water column in photic zone	15	0.4	43=
Exposed Coasts : Gravel/pebble/shell 30–200 m	17	0.4	43=

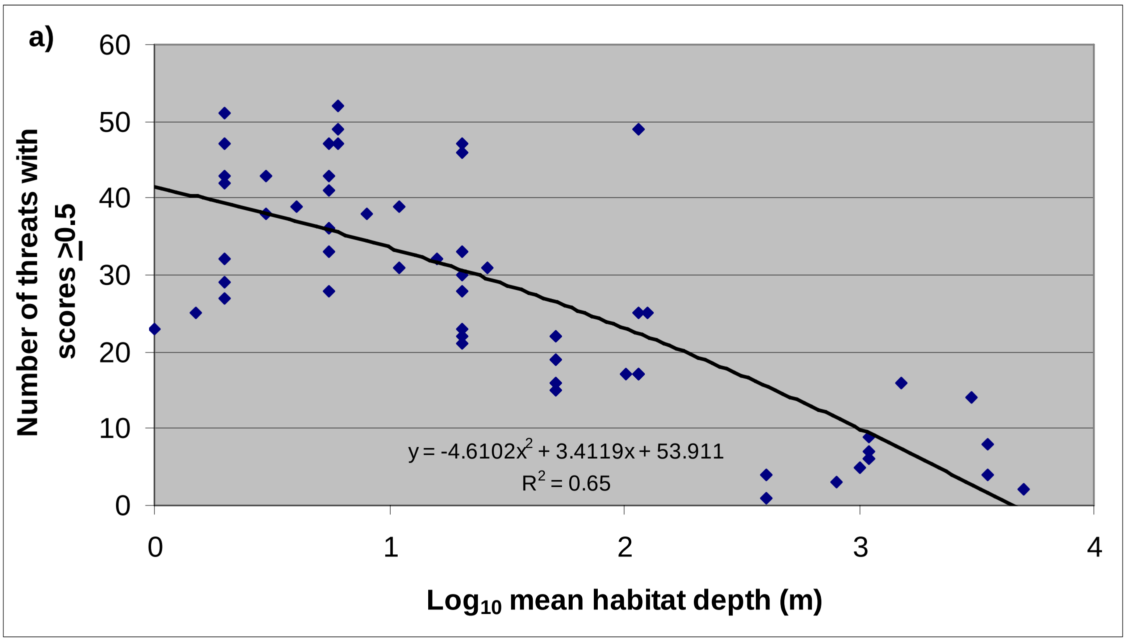
Exposed Coasts : Sand 30–200 m	17	0.4	43=
Pelagic Habitat : Deep ocean water column below photic zone	14	0.4	43=
Fiord Habitats : Fiord sediments	17	0.4	43=
Slope Habitats : Sand 200–2000 m	7	0.2	48=
Slope Habitats : Gravel/pebbles/shells 200–2000 m	9	0.2	48=
Deep Habitats : Seamount < 2000 m	5	0.2	48=
Slope Habitats : Reef 200–2000 m	6	0.2	48=
Slope Habitats : Mud 200–2000 m	6	0.2	48=
Deep Habitats : Soft abyssal 2000 m+	8	0.1	53=
Deep Habitats : Hard canyon	4	0.1	53=
Deep Habitats : Vents and seeps	3	0.1	53=
Deep Habitats : Seamount > 2000 m	4	0.1	53=
Deep Habitats : Soft canyon	1	0.1	53=
Deep Habitats : Trench	2	0.1	53=

Generally, the number of threats to marine habitats declined with depth (Figure 11a). Shallow habitats were impacted by up to fifty-two non-trivial threats (those with scores $\geq$0.5) deriving from human activities, while deep-water habitats were threatened by as few as two or three. Likewise, the estimated magnitude or severity of those effects declined exponentially with mean depth of the habitat (Figure 11b). Shallow habitats had mean weighted vulnerability scores up to 1.2 while some habitats deeper than 1000 m had scores of 0.2 or less, over an order of magnitude difference in severity.

There was a weak positive relationship between the number of respondents and habitat mean vulnerability score (Figure 12a). This was almost certainly because the number of respondents declined with the depth of the habitat (Figure 12b) as did the mean vulnerability score (Figure 11b). The decline in number of respondents with depth generally reflects that in New Zealand, as elsewhere, there are more scientists engaged in shallow water research than engaged in deepwater research for which large expensive ships and specialised equipment is required.

The mean scores across all habitats for each vulnerability measure indicate how each threat impacts the environment (Table 10). For instance, the highest ranking threat, ocean acidification, had the highest scores across all five vulnerability measures, indicating its large spatial impact, its persistence, its broad functional impact, the susceptibility of many habitats to its influence, and a recovery time of ten years or more. Area of consequence was the most important vulnerability measure for most other threats from climate change, invasive disease organisms, and underwater sound disturbance from acoustic devices. For most other threats the largest contributor to the overall threat score was either threat frequency, functional impact or both. Overall habitat susceptibility was the equal most important factor for only four threats; reef trampling, deep-hole extraction of minerals, other methods of mineral extraction, and animal strikes by ships. For no threat was recovery time the largest contributor to the overall habitat vulnerability score.

Over all threats, functional impact had the greatest contribution to habitat vulnerability scores (see bottom line in Table 10), followed by threat frequency, then habitat susceptibility and area of consequence. Recovery time had the smallest contribution.



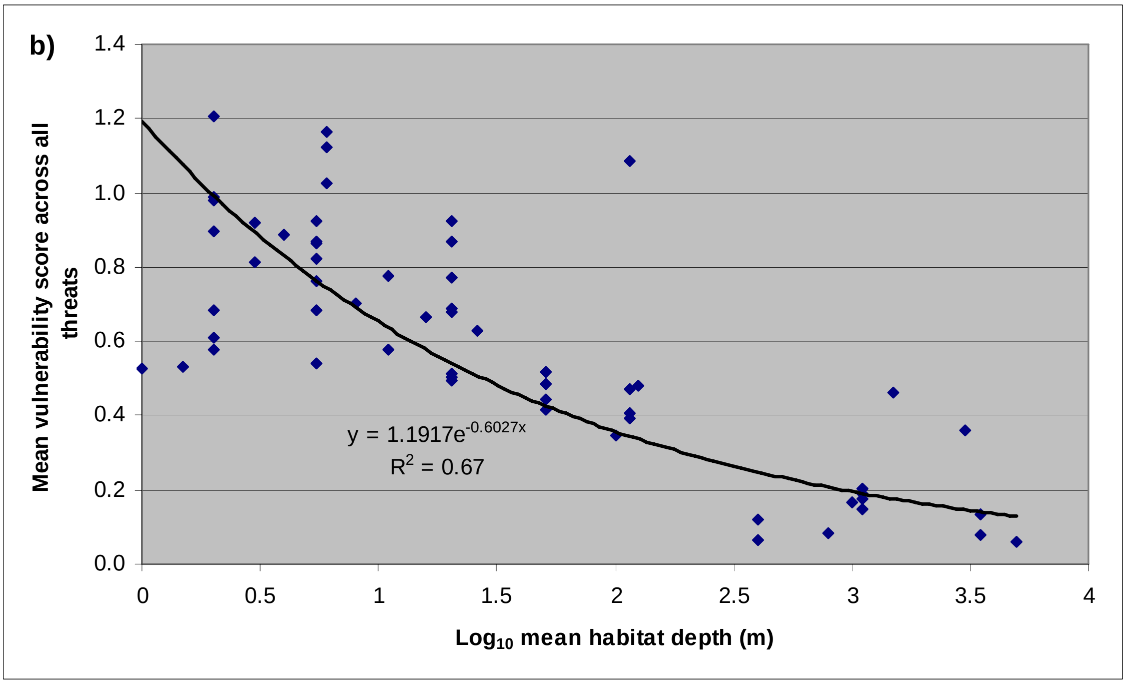
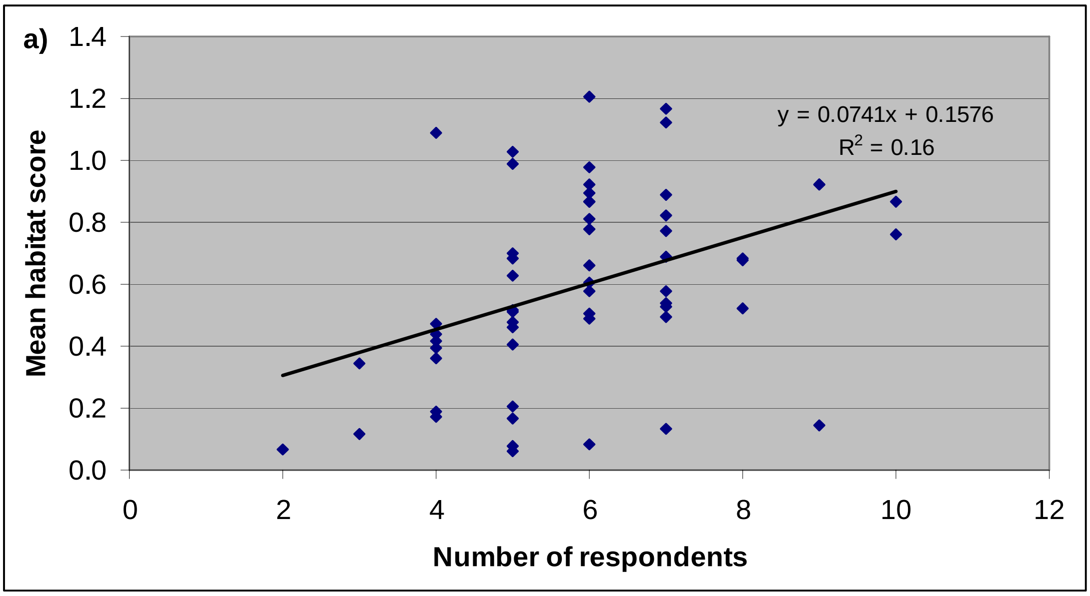


Figure 11: The relationship of $\log_{10}$ mean habitat depth with a) the number of threats with scores of at least 0.5 and b) the mean weighted vulnerability score across all threats.



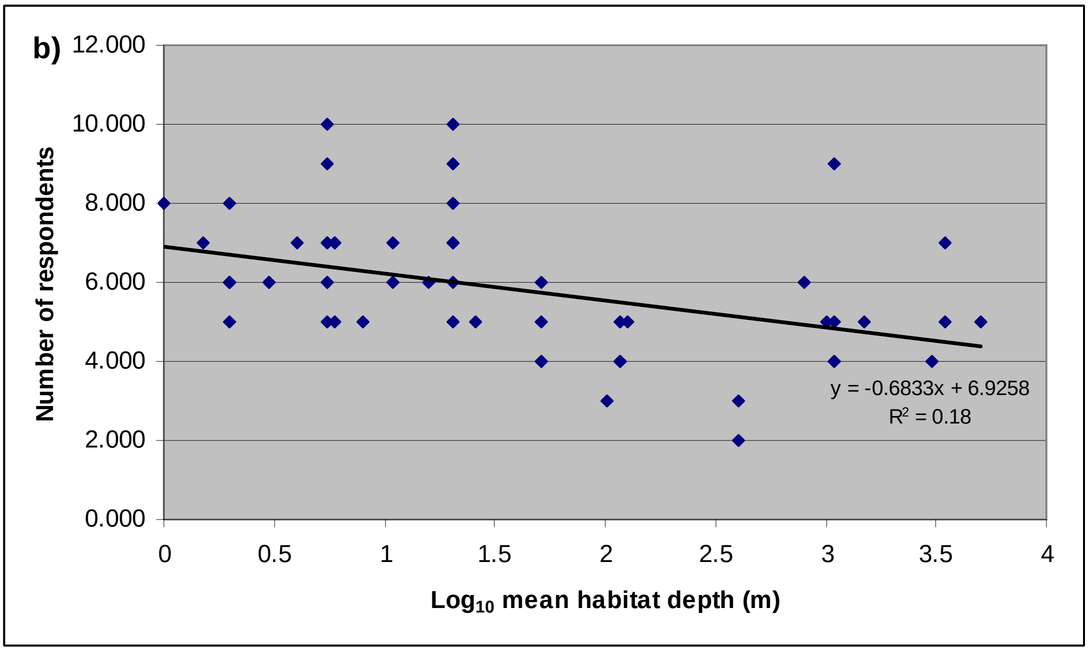


Figure 12: The relationship of number of respondents with a) mean habitat score across all threats and b) $\log_{10}$ mean habitat depth. The linear regression line and r^2 value is shown for each relationship.

Table 10: Average values across all marine habitats for each of the measures of ecosystem vulnerability for each anthropogenic threat, and the mean certainty of survey respondents on how threats affect marine ecosystems, in order of decreasing mean weighted vulnerability score across all habitats. Highlighted in black is the highest score for each vulnerability measure. Highlighted in grey is the highest vulnerability measure score(s) for each threat. Also included are the codes used in the CLUSTER analysis in Figure 13.

Threat	Code	Area of Consequence	Frequency	Functional Impact	Susceptibility	Recovery Time	Certainty	Mean weighted vulnerability score
Ocean acidification	CC OA	3.1	2.7	2.8	2.0	2.4	2.2	2.6
Climate change: Increased sea temperature	CC ST	2.1	1.9	2.0	1.2	1.1	2.9	1.6
Fishing: Bottom trawling	F BT	0.7	1.7	2.1	1.7	1.3	3.1	1.5
River inputs: Increased sediment loading	RI ISL	1.2	1.5	2.0	1.4	1.2	3.0	1.5
Climate change: Change in currents	CC CC	1.5	1.5	1.5	1.0	0.8	2.6	1.2
Climate change: Increased storminess	CC IS	1.4	1.3	1.5	1.0	0.8	2.8	1.2
Fishing: Dredging	F D	0.5	1.1	1.4	1.2	0.9	3.4	1.0
Engineering: Dumping of dredge spoils	E DDS	0.7	0.7	1.5	1.0	0.7	3.2	0.9
Climate change: Rise in sea-level	CC SL	1.3	1.2	0.9	0.7	0.5	3.1	0.9
Invasive species: Space occupiers, competitors	I C	0.9	0.8	1.2	0.8	0.6	2.9	0.9
Algal blooms - both toxic and massive	AB	1.0	0.6	1.3	1.0	0.7	2.9	0.9
Increased turbidity	T	0.8	0.9	1.4	0.9	0.6	3.2	0.9
Fishing: Long-lining	F LL	0.4	0.9	0.7	0.6	0.8	3.1	0.8
Fishing: Line fishing	F LF	0.3	1.2	0.8	0.7	0.8	3.2	0.8
Engineering: Reclamation	E R	0.5	0.7	1.1	1.0	0.8	3.6	0.8
Climate change: Increased stratification	CC IN	1.0	0.9	0.9	0.6	0.6	2.9	0.8
Pollution: Sewage	P S	0.7	0.9	1.2	0.8	0.6	3.1	0.8
Pollution: Nitrogen & phosphorus	P NP	0.7	0.9	1.0	0.6	0.6	2.8	0.8
Pollution: Oil or oil products	P O	0.8	0.6	1.3	0.9	0.7	2.9	0.8
Fishing: Trapping	F T	0.3	1.0	0.8	0.7	0.8	3.1	0.7
Fishing: Shellfish gathering	F SG	0.3	1.0	0.8	0.7	0.7	3.4	0.7
Climate change: Increased intertidal temperature	CC IT	0.9	0.9	0.8	0.6	0.4	3.4	0.7
Climate change: UV increase	CC UV	0.9	0.9	0.7	0.5	0.4	3.0	0.7
Climate change: Altered rainfall	CC AR	0.9	0.7	0.8	0.5	0.4	3.0	0.7
Pollution: Heavy metals	P HM	0.7	0.7	1.0	0.7	0.6	2.7	0.7
Aquaculture: Benthic accumulation of debris	AQ BA	0.4	0.9	1.0	0.8	0.6	3.2	0.7
Fishing: Set netting	F SN	0.3	0.8	0.7	0.6	0.6	3.0	0.6

Threat	Code	Area of Consequence	Frequency	Functional Impact	Susceptibility	Recovery Time	Certainty	Mean weighted vulnerability score
Engineering: Sand / gravel abstraction	E SA	0.4	0.5	1.0	0.7	0.5	3.3	0.6
Engineering: Dredging	E DR	0.4	0.5	0.9	0.6	0.5	3.4	0.6
River inputs: Increased flow	RI IF	0.4	0.6	0.7	0.4	0.4	3.1	0.5
Engineering: Causeways	E C	0.3	0.6	0.7	0.6	0.4	3.3	0.5
Pollution: Plastic	P PL	0.5	0.6	0.4	0.4	0.3	2.9	0.5
Pollution: Pesticides including PCBs	P PCB	0.5	0.5	0.8	0.4	0.4	2.9	0.5
Pollution: Herbicides	P HB	0.5	0.5	0.7	0.4	0.3	2.8	0.5
Anchoring	AG	0.3	0.7	0.5	0.5	0.4	3.3	0.5
Fishing: Abalone gathering	F AG	0.2	0.6	0.5	0.3	0.4	3.4	0.4
Fishing: Seaweed gathering	F	0.2	0.4	0.7	0.5	0.4	3.4	0.4
Fishing: Spear fishing	ST	0.2	0.5	0.5	0.3	0.4	3.3	0.4
Fishing: Pelagic high bycatch	F PHB	0.3	0.5	0.5	0.3	0.3	3.3	0.4
Engineering: Piled wharfs/sheds	E PWS	0.2	0.6	0.5	0.4	0.2	3.5	0.4
Engineering: Pile moorings/markers	E PMM	0.1	0.6	0.5	0.4	0.2	3.5	0.4
Aquaculture: Decrease in primary production	AQ PP	0.3	0.4	0.6	0.3	0.3	3.2	0.4
Aquaculture: Increase in habitat complexity	AQ HC	0.3	0.5	0.5	0.4	0.3	3.2	0.4
Spatial closures to fishing	C	0.3	0.6	0.5	0.4	0.2	3.3	0.4
Shipping: Grounding, sinking	SH G	0.3	0.3	0.7	0.4	0.4	3.1	0.4
Ecotourism: Diving	ET D	0.2	0.6	0.4	0.3	0.3	3.4	0.4
River inputs: Decreased sediment loading	RI DSL	0.2	0.4	0.4	0.3	0.2	3.2	0.3
River inputs: Decreased flow	RI DF	0.2	0.3	0.4	0.2	0.2	3.2	0.3
Engineering: Mineral extraction - surface suction	E MESS	0.3	0.2	0.5	0.4	0.2	3.3	0.3
Engineering: Seawalls	E SW	0.2	0.5	0.5	0.4	0.2	3.5	0.3
Invasive species: Disease	I D	0.6	0.2	0.3	0.2	0.2	2.7	0.3
Fishing: Pelagic low bycatch	F PLB	0.1	0.3	0.2	0.1	0.1	3.3	0.2
Engineering: Pontoons	E P	0.1	0.5	0.3	0.2	0.2	3.5	0.2
Shipping: Noise pollution	SH N	0.2	0.3	0.2	0.1	0.1	3.2	0.2
Tourism: Reef trampling	ET RT	0.1	0.2	0.2	0.2	0.1	3.7	0.2
Ecotourism: Changes in fish and invertebrate behaviour	ET FI	0.2	0.3	0.3	0.1	0.1	3.4	0.2
Ecotourism: Vehicles on beaches	ET V	0.1	0.3	0.2	0.2	0.1	3.7	0.2
River inputs: Dampening of flows	RI DoF	0.1	0.1	0.2	0.1	0.1	3.2	0.1

Threat	Code	Area of Consequence	Frequency	Functional Impact	Susceptibility	Recovery Time	Certainty	Mean weighted vulnerability score
Engineering: Mineral extraction - deep hole extraction	E MEDH	0.1	0.1	0.2	0.2	0.1	3.5	0.1
Engineering: Minerals extraction - other methods	E ME	0.1	0.1	0.2	0.2	0.1	3.3	0.1
Engineering: Acoustic discharges / guns	P A	0.2	0.2	0.1	0.1	0.0	2.8	0.1
Pollution: Electromagnetic discharges	P E	0.2	0.3	0.1	0.1	0.0	2.9	0.1
Shipping: Animal strikes	SH AS	0.1	0.2	0.1	0.2	0.1	3.4	0.1
Ecotourism: Marine mammal watching	ET MM	0.1	0.4	0.1	0.2	0.1	3.6	0.1
Ecotourism: Noise	ET N	0.0	0.1	0.0	0.0	0.0	3.4	0.0
Average		**0.51**	**0.68**	**0.76**	**0.55**	**0.46**		

3.1.7 Threats by habitat

The number and mix of threats a habitat was vulnerable to varied with depth, substrate, exposure and major biological element. Threats were categorised as extreme if the mean weighted score was 3 or more, major if the score was 2–2.9, moderate if the score was 1–1.9, minor if the score was between 0.5 and 1.0, and trivial if the score was 0.4 or less. Below we briefly summarise the most important threats to each New Zealand marine habitat from saltmarsh to trenches as judged by the experts participating in the survey. We indicate the number of threats scoring at least 0.5 only, as scores below this are trivial and unreliable. Appendix 2 lists the full range of threats affecting each habitat ordered by increasing depth of the habitats.

Harbour and Estuaries: Salt marsh

Salt marsh habitats were judged to be affected by twenty-three threats scoring at least 0.5 (Table A2.1). Two were judged to have extreme effects: reclamation (mean weighted vulnerability score = 3.4) and rise in sea level caused by climate change (3.3). Threats with a major impact were effects of causeway construction (2.6), increased sediment loading of rivers (2.3) and oil pollution (2.1). Another ten threats were judged to have moderate effects. A further eight threats had minor impacts. Two of the top ten threats to this habitat derived from the global threat of climate change, four were associated with human activities in catchments, three derived from activities in the marine environment itself and one derived from a mix of both catchment and marine activities.

Harbour and Estuaries: Mangrove forest

Mangrove forests were judged to be affected by twenty-five threats scoring at least 0.5 (Table A2.2). Two were judged to have extreme effects; rise in sea-level due to climate change (mean weighted vulnerability score = 3.3) and reclamation (3.0). Effects of causeway construction were major (2.0) while another 14 threats were judged to have moderate effects. A further eight threats had minor impacts. Two of the top ten threats to this habitat derived from the global threat of climate change, five were associated with human activities in catchments, two derived from activities in the marine environment itself and one derived from a mix of both catchment and marine activities.

Harbour and Estuaries: Intertidal mud

Intertidal muds in harbours and estuaries were judged to be affected by forty-two threats scoring at least 0.5 (Table A2.3) No threats had extreme effects but 12 had major impacts, including sedimentation and causeway construction (mean weighted habitat vulnerability scores = 2.8), heavy metal (2.5) and sewage pollution (2.5), shellfish gathering (2.4), four aspects of climate change - rise in sea-level, increased sea temperature (both 2.3), increased inter-tidal temperature and increased storminess (both 2.3), reclamation, increased river flows and benthic accumulation of debris from aquaculture . Another 16 threats had moderate impacts and 14 minor impacts. Four of the top ten threats to this habitat derived from the global threat of climate change, three were associated with human activities in catchments and three derived from activities in the marine environment itself.

Harbour and Estuaries: Intertidal sand

Intertidal sands in harbours and estuaries were judged to be affected by thirty-two threats scoring at least 0.5 (Table A2.4) No threats were judged to have extreme effects on this habitat. Five threats had a major impact including sedimentation, three consequences of rising greenhouse gases- acidification and rise in sea-level (both 2.6) and increased inter-tidal temperature (2.1) and causeway construction (2.0). Another 14 activities had moderate effects, and 13 had minor effects. Half the top ten threats to this habitat derived from the global threat of climate change, two were associated with human activities in catchments and only three were derived from activities in the marine environment itself.

Harbour and Estuaries: Cockle beds

Cockle beds were judged to be affected by thirty-eight threats scoring at least 0.5 (Table A2.5) This habitat is extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.2). Five threats had a major impact on this habitat; sedimentation, increased inter-tidal temperature, rise in sea-level, shellfish gathering and causeway construction. Fifteen threats had moderate impacts and 17 minor impacts. Half the top ten threats to this habitat derived from the global threat of climate change, two were associated with human activities in catchments, two were derived from activities in the marine environment itself and one derived from a mixture of catchment and marine based activities. Threats affecting cockle beds are very similar in order and magnitude to those affecting pipi beds.

Harbour and Estuaries: Pipi beds

Pipi beds were judged to be affected by forty-three threats scoring at least 0.5 (Table A2.6) This habitat is extremelly vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.4). Threats with a major impact include sedimentation (2.9), increased inter-tidal temperature (2.9), rise in sea-level (2.8), rise in sea temperature (2.4), shellfish gathering (2.3), causeway construction (2.1), increased storminess (2.0) and oil pollution (2.0). Another sixteen threats were of moderate impact and 18 of minor impact. Half the top ten threats to this habitat derived from the global threat of climate change, two were associated with human activities in catchments, two were derived from activities in the marine environment itself and one was a mixture of catchment and marine activities. Threats affecting pipi beds are very similar in order and magnitude to those affecting cockle beds.

Harbour and Estuaries: Intertidal reef

Intertidal reefs in harbours and estuaries were judged to be affected by fifty-one threats scoring at least 0.5 (Table A2.7). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5), sedimentation (3.3), invasive species (3.0) and reclamation (3.0). Major threats include rise in sea-level (2.4), increased sea temperature (2.3), shellfish gathering (2.3), increased storminess (2.2), altered rainfall (2.2), UV increase (2.2.), change in currents and causeway construction. Another 28 threats scored in the moderate range while 13 had minor impact. Six of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, and only three were derived from activities in the marine environment itself.

Harbour and Estuaries: Subtidal reef

Subtidal reefs in harbours and estuaries are affected by fifty-two threats scoring at least 0.5 (Table A2.8). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.6), sedimentation (3.2) and reclamation (3.0). Major threats include invasive species (2.5), increased sea temperature (2.2), heavy metal pollution (2.2), line fishing (2.2), set netting (2.1), and nitrogen and phosphorus loading (2.0). Another thirty-five threats had moderate impacts and nine threats had minor impacts. Two of the top ten threats to this habitat derived from the global threat of climate change, another four were associated with human activities in catchments and four were derived from activities in the marine environment itself. This habitat had the highest number of non-trivial threats and the highest scoring single threat; ocean acidification.

Harbour and Estuaries: Seagrass meadows

Seagrass meadows were judged to be affected by thirty-nine threats scoring at least 0.5 (Table A2.9). No threats had extreme effects but major threats included sedimentation (mean weighted vulnerability score = 2.9), reclamation (2.4) benthic accumulation of debris from marine farms (2.3), causeway construction (2.2), and nitrogen and phosphorus loading (2.0). Twenty-three threats had more moderate impacts and 11 threats had minor impacts Three of the top ten threats to this habitat derived from the global threat of climate change, another three were associated with human activities in catchments, while four were derived from activities in the marine environment itself and one derived from a mixture of catchment and marine activites.

Harbour and Estuaries: Subtidal sand

Subtidal sand habitats within harbours and estuaries were judged to be affected by forty-seven threats scoring at least 0.5 (Table A2.10). No threats had extreme effects. Major threats included increased sea temperature, ocean acidification (mean weighted vulnerability scores = 2.7), increased storminess (2.5), sedimentation (2.3), sewage (2.1), increased intertidal temperatures (2.1), and heavy metal pollution (2.0). Another twenty-eight threats had moderate impacts and 12 had minor impacts. Half the top ten threats to this habitat derived from the global threat of climate change, another four were associated with human activities in catchments, and one derived from activities in the marine environment itself.

Harbour and Estuaries: Subtidal mud

Subtidal mud habitats within harbours and estuaries were judged to be affected by forty-nine threats scoring at least 0.5 (Table A2.11). No threat had extreme effects. Major threats included sedimentation and heavy metal pollution (both with mean weighted vulnerability scores of 2.7), increased storminess (2.5), sewage (2.5), increased intertidal temperatures (2.2), increased sea temperature (2.2), nitrogen and phosphorus loading (2.1), pesticide pollution (2.1), benthic accumulation of debris under marine farms (2.1), and increased river flows (2.0). Another twenty-seven threats scored in the moderate range and 12 in the minor range. Three of the top ten threats to this habitat derived from the global threat of climate change, another six were associated with human activities in catchments, while one derived from activities in the marine environment itself.

Sheltered Coast: Sandy beaches

Sandy beaches on sheltered coasts were judged to be affected by twenty-seven threats scoring at least 0.5 (Table A2.12). They were assessed as being extremely vulnerable to three threats: effects of sea-level rise (mean weighted vulnerability score = 3.4), ocean acidification (3.2), and sedimentation (3.1). Major threats included reclamation (2.3) and increased storminess (2.1). Eight threats had moderate scores and 14 had minor scores. Half the top ten threats to this habitat derived from the global threat of climate change, another two were associated with human activities in catchments, while the remainder derived from activities in the marine environment itself.

Sheltered Coast: Intertidal reefs

Intertidal reefs on sheltered coasts were judged to be affected by forty-three threats scoring at least 0.5 (Table A2.13). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.4) and sedimentation (3.2). Major threats included reclamation (2.7), rise in sea level (2.2), shellfish gathering (2.1), invasive species (2.0), increased intertidal temperature (2.0), and causeway construction (2.0). Sixteen threats had moderate scores and another 19 had minor scores. Four of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, four were derived from activities in the marine environment itself and one derived from a mixture of catchment and marine based activities.

Sheltered Coast: Kelp forest

Kelp forests on sheltered coasts were judged to be affected by thirty-nine threats scoring at least 0.5 (Table A2.14). No threat had extreme effects. Major threats included sedimentation, (mean weighted vulnerability score = 2.5), increased turbidity (2.3), ocean acidification (2.2), set netting (2.1), and increased storminess (2.0). Fourteen threats had moderate impacts and 21 threats had minor impacts Two of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, six were derived from activities in the marine environment itself and one threat derived from a mixture of catchment and marine based activities.

Sheltered Coast: Subtidal reefs 2–9 m
Shallow subtidal reefs on sheltered coasts were judged to be affected by forty-seven threats scoring at least 0.5 (Table A2.15). No threat had extreme impacts. Major threats included ocean acidification (mean weighted vulnerability score = 2.9), increased sedimentation (2.7), set netting (2.1), increased turbidity (2.0), and line fishing (2.0). Another 21 threats had moderate impacts and 21 had minor impacts. One of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, seven were derived from activities in the marine environment itself and one threat derived from a mixture of catchment and marine based activities. Threats confronting this habitat were assessed as the same for deeper subtidal reefs on sheltered coasts.

Sheltered Coast: Gravel/pebble/shell 2–9 m
Shallow areas of gravel, pebbles and shell habitat on sheltered coasts were judged to be affected by thirty-six threats scoring at least 0.5 (Table A2.16). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5). Other major threats were bottom trawling (2.8) and scallop, oyster dredging (2.8), sedimentation (2.2), increased sea temperature (2.0), bottom dredging (2.0) and increased turbidity (2.0). Another seventeen threats were judged to have moderate impacts and 12 minor impacts. Three of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, five were derived from activities in the marine environment itself and one threat was derived from a mixture of catchment and marine based activities. Threats confronting this habitat were assessed as very similar to those in deeper areas of gravel, pebbles and shell habitat on sheltered coasts.

Sheltered Coast: Sand 2–9 m
Shallow areas of sand on sheltered coasts were judged to be affected by thirty-six threats scoring at least 0.5 (Table A2.17). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5). Threats with major impacts were sedimentation (2.4), bottom trawling (2.3), scallop and oyster dredging (2.3), increased sea temperature (2.1), sand and gravel abstraction (2.1), and increased turbidity (2.0). Another sixteen threats were judged to have moderate impacts and 13 threats minor impacts. Three of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, five were derived from activities in the marine environment itself and one from a mixture of catchment and marine based activities.

Sheltered Coast: Mud 2–9 m
Shallow areas of mud on sheltered coasts were judged to be affected by forty-three threats scoring at least 0.5 (Table A2.18). They were assessed as being extremely vulnerable to the effects of bottom trawling (mean weighted vulnerability score = 3.0). Major threats included scallop and oyster dredging (2.9), ocean acidification (2.7), benthic accumulation of debris under marine farms (2.6), sedimentation (2.2), increased sea temperature (2.1), change in currents (2.0), dumping of dredge spoils (2.0) and bottom dredging (2.0). Another thirteen threats were judged to have moderate effects and 21 minor impacts. Four of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments and half were derived from activities in the marine environment itself.

Sheltered Coast: Subtidal reefs 10–29 m
Subtidal reefs at depths of 10–29 m on sheltered coasts were judged to be affected by forty-seven threats scoring at least 0.5 (Table A2.19). No threats had extreme impacts. Major threats included ocean acidification (mean weighted vulnerability score = 2.9), increased

sedimentation (2.7), set netting (2.1), increased turbidity (2.0), and line fishing (2.0). Another 21 threats were judged to have moderate impacts and 21 minor impacts. One of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments while the majority were derived from activities in the marine environment itself. One threat derived from a mixture of catchment and marine based activities. Threats confronting this habitat were assessed as the same facing shallow subtidal reefs on sheltered coasts.

Sheltered Coast: Gravel/pebble/shell 10–29 m
Deeper areas of gravel, pebbles and shell habitat on sheltered coasts were judged to be affected by thirty threats scoring at least 0.5 (Table A2.20). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5). Major threats were bottom trawling (2.9), scallop and oyster dredging (2.8), sedimentation (2.2) and increased sea temperature (2.1). Another eleven threats were judged to have moderate impacts and 14 minor impacts. Four of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments and half were derived from activities in the marine environment itself. Threats confronting this habitat were assessed as very similar to those in shallow areas of gravel, pebbles and shell habitat on sheltered coasts.

Sheltered Coast: Sand 10–29 m
Deeper areas of sand on sheltered coasts were judged to be affected by thirty-three threats scoring at least 0.5 (Table A2.21). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5). Major threats included bottom trawling (2.9), scallop and oyster dredging (2.8), sedimentation (2.3), and increased sea temperature (2.1). Another fourteen threats were judged to have moderate impacts and 14 minor impacts. Three of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments while the majority were derived from activities in the marine environment itself.

Sheltered Coast: Mud 10–29 m
Deeper areas of mud on sheltered coasts were judged to be affected by twenty-eight threats scoring at least 0.5 (Table A2.22). No threat had an extreme impact. Major threats are bottom trawling (mean weighted vulnerability score = 2.9), scallop and oyster dredging (2.8), ocean acidification (2.7), and sedimentation (2.3). Eleven further threats were judged to have a moderate impact and 14 threats a minor impact. Four of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments while half were derived from activities in the marine environment itself.

Exposed Coasts: Sandy beaches
Sandy beaches on exposed coasts were judged to be affected by twenty-nine threats scoring at least 0.5 (Table A2.23). They were assessed as being extremely vulnerable to the three threats; increased storminess, ocean acidification and increased sea temperature (mean weighted vulnerability score = 3.1 for all three threats). Major threats include rise in sea level (2.8) and sedimentation (2.5). Eight threats were judged to have moderate impacts and fifteen minor impacts. Six of the top ten threats to this habitat derive from the global threat of climate change, another two are associated with human activities in catchments, and two derive from human activities in the marine environment itself.

Exposed Coasts: Intertidal reefs
Intertidal reefs on exposed coasts were judged to be affected by forty-seven threats scoring at least 0.5 (Table A2.24). They were assessed as being extremely vulnerable to the effects of increased storminess (mean weighted vulnerability score = 3.5). Threats judged to have a major impact include increased intertidal temperatures (2.8), ocean acidification (2.3),

increased sea temperature (2.3), sea level rise (2.1), sedimentation (2.0), change in currents (2.0), and UV increase (2.0). Twenty threats scored were judged to have moderate impacts and nineteen minor impacts. Seven of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, one was derived from activities in the marine environment itself and one was derived from a mixture of catchment and marine based activities.

Exposed Coasts: Turfing algal reefs
Turfing algal reefs on exposed coasts were judged to be affected by thirty-eight threats scoring at least 0.5 (Table A2.25). No threat had an extreme impact. Major threats include ocean acidification (mean weighted vulnerability score = 2.5) and increased storminess (2.0). Another nineteen threats were judged to have moderate impacts and seventeen threats minor impacts. Three of the top ten threats to this habitat derive from the global threat of increasing greenhouse gases, none are associated solely with human activities in catchments, seven derive from activities in the marine environment itself and one derives from a mixture of catchment and marine based activities.

Exposed Coasts: Kelp forest
Kelp forests on exposed coasts were judged to be affected by thirty-one threats scoring at least 0.5 (Table A2.26). None were judged to have extreme or major impacts. Sixteen threats had moderate impacts. The most important of these, increased storminess and seaweed gathering, both had a mean weighted vulnerability score of 1.7. This was closely followed by ocean acidification (1.6), trapping fish and lobsters (1.6), increased turbidity (1.6), increased sediment loading, line fishing (1.4), set netting (1.3), abalone gathering (1.3), and anchoring (1.3). Another fifteen were judged to have minor impacts. Two of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, six were derived from activities in the marine environment itself and one was derived from a mixture of catchment and marine based activities.

Exposed coasts: Subtidal reefs 2–9 m
Shallow subtidal reefs on exposed coasts were judged to be affected by forty-one threats scoring at least 0.5 (Table A2.27). No threat had an extreme impact. Two threats were judged to have a major impact; ocean acidification (mean weighted vulnerability score = 2.1) and trapping for fish and lobsters (2.1). Twenty threats were judged to have a moderate impact and 19 a minor impact. Two of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, six were derived from activities in the marine environment itself and one derived from a mixture of catchment and marine based activities.

Exposed Coasts: Gravel/pebble/shell 2–9 m
Shallow areas of gravel, pebbles and shell habitat on exposed coasts were judged to be affected by thirty-three threats scoring at least 0.5 (Table A2.28). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.4). Major threats were bottom trawling (2.8) and scallop and oyster dredging (2.8). Seventeen threats were judged to have moderate impacts and 13 minor impacts. Four of the top ten threats to this habitat derive from the global threat of climate change, none are associated with human activities in catchments while the majority derive from activities in the marine environment itself.

Exposed Coasts: Biogenic calcareous reefs
Biogenic calcareous reefs were judged to be affected by thirty-two threats scoring at least 0.5 (Table A2.29). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.5). Major threats were bottom trawling (2.8), scallop and oyster dredging (2.6), and massive and toxic algal blooms (2.4). Eleven threats were judged to have moderate impacts and 17 to have minor impacts. Three of the top

ten threats to this habitat derive from the global threat of increasing greenhouse gases; one is associated with human activities in catchments, and the majority derive from activities in the marine environment itself.

Exposed Coasts: Sand 2–9 m
Shallow areas of sand on exposed coasts were judged to be affected by twenty-eight threats scoring at least 0.5 (Table A2.30). No threat was judged to have an extreme impact on this habitat. Major impacts included ocean acidification (mean weighted vulnerability score = 2.6) and increased storminess (2.2). More modest are the effects of toxic and massive algal blooms (1.7), sedimentation (1.6), scallop and oyster dredging (1.6), sand and gravel abstraction (1.5), bottom trawling (1.4), increased turbidity (1.3), rise in sea temperature, and dredging (1.2). Ten threats were judged to have a moderate impact and 16 a minor impact. Three of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, six were derived from activities in the marine environment itself and one threat derived from a mixture of catchment and marine based activities.

Exposed coasts: Subtidal reefs 10–29 m
Subtidal reefs at depths of 10–29 m on exposed coasts were judged to be affected by forty-six threats scoring at least 0.5 (Table A2.31). No threat was judged to have an extreme impact. Major threats included ocean acidification (mean weighted vulnerability score = 2.4), trapping for fish and lobsters (2.3), increased storminess (2.2), sedimentation (2.1), and increased turbidity (2.0). Eighteen threats were judged to have moderate impacts and 22 threats minor impacts. Two of the top ten threats to this habitat derived from the global threat of climate change, another was associated with human activities in catchments, six were derived from activities in the marine environment itself and one threat was derived from a mixture of catchment and marine based activities.

Exposed Coasts: Gravel/pebble/shell 10–29 m
Shallow areas of gravel, pebbles and shell habitat on exposed coasts were judged to be affected by twenty-three threats scoring at least 0.5 (Table A2.32). They were assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.3). Major threats are bottom trawling (2.6) and scallop and oyster dredging (2.6). Five threats were judged to have moderate effects and 15 threats minor impacts. Four of the top ten threats to this habitat derive from the global threat of climate change; one is associated with human activities in catchments while the remainder derive from activities in the marine environment itself.

Exposed Coasts: Sand 10–29 m
Areas of sand at depths of 10–29 m on exposed coasts were judged to be affected by twenty-one threats scoring at least 0.5 (Table A2.33). No threat was judged to have an extreme impact on this habitat. Major threats include bottom trawling (mean weighted vulnerability score = 2.6), scallop and oyster dredging (2.6), and ocean acidification (2.6). Eight additional threats were judged to have moderate impacts and 10 threats minor impacts. Four of the top ten threats to this habitat derive from the global threat of climate change; none are associated with human activities in catchments while the remainder derive from activities in the marine environment itself.

Exposed Coasts: Mud 10–29 m
Areas of mud at depths of 10–29 m on exposed coasts were judged to be affected by twenty-two threats scoring at least 0.5 (Table A2.34). No threat was judged to have extreme impacts on this habitat. Major threats include bottom trawling (mean weighted vulnerability score = 2.9), scallop and oyster dredging (2.8), and ocean acidification (2.3). Ten other threats were judged to have a moderate impact and nine threats to have minor impacts. Four of the top ten threats to this habitat derive from the global threat of climate change; none are associated with

human activities in catchments while the majority derive from activities in the marine environment itself.

Exposed coasts: Subtidal reefs 30–200 m
Subtidal reefs at depths of 30–200 m on exposed coasts were judged to be affected by forty-eight threats scoring at least 0.5 (Table A2.35). They are extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.3). Other major threats include changing currents (2.3), bottom trawling (2.2), increased sea temperature (2.2), trapping for fish and lobsters (2.2), sedimentation (2.1), massive and toxic algal blooms (2.1) and increases storminess (2.0). Another thirty-two threats were judged to have moderate impacts and nine threats to have minor impacts. Half of the top ten threats to this habitat derive from the global threat of climate change, another is associated with human activities in catchments and the remainder derive from activities in the marine environment itself.

Exposed Coasts: Gravel/pebble/shell 30–200 m
Deep areas of gravel, pebbles and shell habitat on exposed coasts were judged to be affected by seventeen threats scoring at least 0.5 (Table A2.36). This habitat was assessed as being extremely vulnerable to the effects of ocean acidification (mean weighted vulnerability score = 3.0). Other major threats are bottom trawling (2.9) and scallop and oyster dredging (2.6). Four threats were judged to have moderate impacts and 10 threats minor impacts. Five of the top ten threats to this habitat derive from the global threat of climate change; none are associated with human activities in catchments while the remainder derive from activities in the marine environment itself.

Exposed Coasts: Sand 30–200 m
Deep areas of sand on exposed coasts were judged to be affected by seventeen threats scoring at least 0.5 (Table A2.37). This habitat was assessed as being extremely vulnerable to the effects of bottom trawling (mean weighted vulnerability score = 3.0), with scallop and oyster dredging (2.8) a major threat. Five threats were judged to have a moderate impact and 10 threats a minor impact. Five of the top ten threats to this habitat derive from the global threat of climate change; none are associated with human activities in catchments while the remainder derive from activities in the marine environment itself.

Exposed Coasts: Mud 30–200 m
Deep areas of mud on exposed coasts were judged to be affected by twenty-five threats scoring at least 0.5 (Table A2.38). This habitat was assessed as being extremely vulnerable to the effects of bottom trawling (mean weighted vulnerability score = 3.2). Major threats are scallop and oyster dredging (2.9), and dumping of dredge spoils (2.3). Seven threats were judged to have a moderate impact including ocean acidification (1.9), change of currents (1.8), increase in sea temperature (1.3), fish and lobster trapping (1.0), increased stratification (1.0), oil pollution (1.0) and increased storminess (1.0). Fifteen threats were judged to have a minor impact. Half of the top ten threats to this habitat derive from the global threat of climate change, none are solely associated with human activities in catchments and four derive from activities in the marine environment itself and one threat derives from a mixture of catchment and marine activities.

Fiord habitats: Inner fiord rock walls
Inner fiord rock walls were judged to be affected by twenty-two threats scoring at least 0.5 (Table A2.39). No threats were judged to have an extreme impact on this habitat. Major impacts include altered rainfall (mean weighted vulnerability score = 2.5) trapping of lobsters (2.2), increased river flows (2.0), increased turbidity (2.0), and diving damage (2.0). Twelve other threats were judged to have moderate impacts and five threats to have minor impacts. A quarter of the top twelve threats to this habitat derive from the global threat of climate change, one is associated with human activities in catchments seven derive from activities in the

marine environment itself and one derives from a mixture of catchment and marine based activities.

Fiord habitats: Outer fiord rock walls

Outer fiord rock walls were judged to be affected by nineteen threats scoring at least 0.5 (Table A2.40). No threats were judged to have an extreme impact on this habitat. Major impacts include increased river flows (mean weighted vulnerability score = 2.7), trapping of lobsters (2.3), and altered rainfall (2.2). Ten other threats were judged to have moderate impacts and six threats minor impacts. Two of the top eleven threats to this habitat derive from the global threat of climate change, two are associated with human activities in catchments, six derive from activities in the marine environment itself and one threat derives from a mixture of catchment and marine based activities.

Fiord habitats: Sediments

Fiord sediments were judged to be affected by seventeen threats scoring at least 0.5 (Table A2.41). This habitat was assessed as being extremely vulnerable to the effects of altered rainfall (mean weighted vulnerability score = 3.0). The only major threat was ocean acidification (2.5). Six threats were judged to have moderate impacts and nine threats to have minor impacts. Four of the top ten threats to this habitat derive from the global threat of climate change; none are associated with human activities in catchments, five derive from activities in the marine environment itself and one derives from a mixture of catchment and marine based activities.

Pelagic habitat: whole water column inside the 50 m contour

Inner shelf water column habitats were judged to be affected by thirty-one threats scoring at least 0.5 (Table A2.42). No threat was judged to have an extreme impact on this habitat. Major threats include ocean acidification (mean weighted vulnerability score = 2.7), toxic and massive algal blooms (2.3) and increased sea temperature (2.1). Fifteen threats were judged to have a moderate impact and 13 to have a minor impact. Three of the top ten threats to this habitat derive from the global threat of climate change, one is associated with human activities in catchments, five derive from activities in the marine environment itself and one derives from a mixture of catchment and marine based activities.

Pelagic habitat: whole water column between 50–200 m contours

Outer shelf water column habitats were judged to be affected by twenty-five threats scoring at least 0.5 (Table A2.43). This habitat is extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.1). Only one threat had a major impact; increased sea temperature (2.8). Eight threats were judged to have moderate impacts and 16 threats a minor impact. Four of the top ten threats to this habitat derive from the global threat of climate change, none are associated with human activities in catchments, five derive from activities in the marine environment itself and one derives from a mixture of catchment and marine based activities.

Pelagic habitat: slope water column in the photic zone

Slope water column habitats in the photic zone were judged to be affected by sixteen threats scoring at least 0.5 (Table A2.44). This habitat is extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.5), increased sea temperature (3.4), increased stratification (3.4), and change in currents (3.2). One threat had a major impact; UV increase (2.1). Four threats were judged to have a moderate impact and seven threats to have a minor impact. The top five threats to this habitat all derive from the global threat of climate change. One of the top ten threats is associated with human activities in catchments, three derive from activities in the marine environment itself and one derives from a mix of catchment and marine based activities.

Pelagic habitat: slope water column below the photic zone

Slope water column habitats below the photic zone were judged to be affected by sixteen threats scoring at least 0.5 (Table A2.45). This habitat is extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.4), increased sea temperature (3.4), increased stratification (3.4), and change in currents (3.2). There were no threats with a major impact. Five threats, high bycatch pelagic fisheries (1.7), UV increase (1.4), nitrogen and phosphorus loading (1.3), oil pollution (1.2) and long-lining (1.0) had a moderate impact. Seven threats were judged to have a minor impact. Of the top ten threats to this habitat, half derive from the global threat of climate change, one is associated with human activities in catchments, three derive from activities in the marine environment itself and one derives from a mixture of catchment and marine based activities.

Pelagic habitat: deep ocean water column in the photic zone

Deep ocean water column habitats in the photic zone were judged to be affected by fifteen threats scoring at least 0.5 (Table A2.46). This habitat is extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.5), increased sea temperature (3.5) and change in currents (3.5). Additional major threats include increased stratification (2.2), and high bycatch pelagic fisheries (2.2). Five threats were judged to have a moderate impact and a further five threats a minor impact. Half the top ten threats to this habitat derive from the global threat of climate change, none are solely associated with human activities in catchments, four derive from activities in the marine environment itself and one derives from a mix of catchment and marine based activities.

Pelagic habitat: deep ocean water column below the photic zone

Deep ocean water column habitats below the photic zone were judged to be affected by fourteen threats scoring at least 0.5 (Table A2.47). This habitat is extremely vulnerable to ocean acidification (mean weighted vulnerability score = 3.5), increased sea temperature (3.5), and change in currents (3.5). Other major threats are increased stratification (2.2), and high bycatch pelagic fisheries (2.0). Two threats were judged to have moderate impacts and seven to have minor impacts. Half the top ten threats to this habitat derive from the global threat of climate change, one is associated with human activities in catchments, three derive from activities in the marine environment itself and one threat derives from a mix of catchment and marine based activities.

Slope habitats: hard canyon habitats

Hard canyon habitats were judged to be affected by just four threats scoring at least 0.5 (Table A2.48); none were judged to have an extreme impact on this habitat. The only two major threats are bottom trawling (mean weighted vulnerability score = 2.9) and ocean acidification (2.8). Two threats (increase in sea temperature and change in currents) were judged to have a minor impact. Three of the four non-trivial threats to this habitat derive from the global threat of climate change; none are associated with human activities in catchments while one derives from activities in the marine environment itself.

Slope habitats: soft canyon habitats

Soft canyon habitats were judged to be affected by just one threat scoring at least 0.5 (Table A2.49) but this threat, bottom trawling, was judged to have an extreme impact on this habitat (mean weighted vulnerability score = 3.1).

Slope habitats: reefs 200–2000 m

Deep reefs at depths of 200–2000 m were assessed as being affected by six threats scoring at least 0.5 (Table A2.50). They are extremely vulnerable to bottom trawling (mean weighted vulnerability score = 3.1). There was one other major threat; ocean acidification (2.5). Only a single moderate threat was identified; long-lining (1.0). Three threats were judged to have a minor impact. Of the six threats to this habitat scoring at least 0.5, one derives from the global threat of climate change and the remainder derive from activities in the marine environment itself.

Slope habitats: gravel, pebbles, shells 200–2000 m
Deep gravel, pebble and shell habitats at depths of 200–2000 m were assessed as being affected by nine threats scoring at least 0.5 (Table A2.51). They are extremely vulnerable to bottom trawling (mean weighted vulnerability score = 3.3). There was only one major threat; ocean acidification (2.7). One moderate threat was identified; long-lining (1.0). Minor threats are change in currents (0.9), increased sea temperatures (0.9), dumping of dredge spoils (0.7), and three forms of mining the seabed (all 0.5). Of the nine threats to this habitat scoring at least 0.5, three derive from the global threat of climate change and six derive from activities in the marine environment itself.

Slope habitats: mud 200–2000 m
Deep mud habitats at depths of 200–2000 m were assessed as being affected by six threats scoring at least 0.5 (Table A2.52). They are extremely vulnerable to bottom trawling (mean weighted vulnerability score = 3.0). Moderate threats are ocean acidification (1.1) and dumping of dredge spoils (1.0). Minor threats include change in currents (0.7), increased sea temperatures (0.7), seabed surface suction during mining activities. Of the six threats to this habitat scoring at least 0.5, three derive from the global threat of climate change and three derive from activities in the marine environment itself.

Slope habitats: sand 200–2000 m
Sand habitats at depths of 200–2000 m were assessed as being affected by seven threats scoring at least 0.5 (Table A2.53). They are extremely vulnerable to bottom trawling (mean weighted vulnerability score = 3.1). More moderate threats include ocean acidification (1.8), dumping of dredge spoils (1.5), change in currents (1.3) and increased sea temperatures (1.0). Another two threats were judged to have minor impacts. Of the seven threats to this habitat scoring 0.5 or more, three derive from the global threat of climate change and four derive from activities in the marine environment itself.

Deep habitats: vents and seeps
Vents and seeps were assessed as being affected by just three threats scoring at least 0.5 (Table A2.54). None were judged to have an extreme impact on this habitat. Bottom trawling (mean weighted vulnerability score = 2.6) was judged to be a major threat to vents and seeps while mineral extraction (1.5) was a moderate threat and ocean acidification (0.6) a minor threat. Of the top three threats to this habitat one derives from the global threat of climate change and the other two derive from activities in the marine environment itself.

Deep habitats: seamounts shallower than 2000 m
Seamounts habitats less than 2000 m were assessed as being affected by just five threats scoring at least 0.5 (Table A2.55). They are extremely vulnerable to bottom trawling (mean weighted vulnerability score = 3.2) and ocean acidification (3.0). Other moderate include long-lining (1.7), other methods of mineral extraction (1.0). Surface suction of minerals (0.6) was judged to be a minor threat. Of the top five threats to this habitat, one derives from the global threat of climate change and the remainder derive from activities in the marine environment itself.

Deep habitats: seamounts deeper than 2000 m
Seamounts habitats greater than 2000 m were assessed as being affected by just four threats scoring at least 0.5 (Table A2.56). No threat was judged to have extreme or major impacts on this habitat. Ocean acidification (mean weighted vulnerability score = 1.4) was judged to be a moderate threat. Minor threats include long-lining (0.8), bottom trawling (0.7), and mineral extraction (0.6). Of the four threats to this habitat scoring at least 0.5, one derives from the

global threat of climate change and the remainder derive from activities in the marine environment itself.

Deep habitats: Soft abyssal habitats deeper than 2000 m
Soft abyssal habitats greater than 2000 m were assessed as being affected by just eight threats scoring at least 0.5 (Table A2.57). No threats were judged to have extreme impacts. Only one threat, ocean acidification (mean weighted vulnerability score = 2.9) was judged to have a high impact. All seven other threats had a low impact. Of the eight threats to this habitat scoring at least 0.5, three derive from the global threat of climate change and the remainder derive from activities in the marine environment itself.

Deep habitats: trenches
Trenches were assessed as being affected by just two threats scoring at least 0.5 but both fell below the extreme impact range (Table A2.58). Ocean acidification (mean weighted vulnerability score = 2.8) was judged to have a high impact on this habitat while change in currents due to climate change was judged to have a low impact (0.5). There were no effects of catchment or marine based activities on this remote habitat.

3.1.8 Affected habitats by threat

Although some threats substantially affected a great number of habitats, some had less of an impact. Below we briefly summarise the habitats most affected by each threat in alphabetical order of threats. Appendix 3 lists the mean weighted vulnerability scores for all habitats affected by a threat in descending order.

Algal blooms –toxic and massive
The effects of massive and toxic algal blooms were judged to be broad, affecting fifty one habitats (Table A3.1). The greatest effects are on biogenic calcareous reefs (mean weighted vulnerability score = 2.4), inner shelf pelagic habitats (2.3) and subtidal reefs on the outer shelf (2.1). A large group of habitats on exposed coasts, sheltered coasts, in harbours and estuaries and in fiords are only moderately affected by algal blooms, scoring between 1.0 and 1.8. Twenty-two habitats, including some very shallow and very deep habitats, were judged to be only slightly affected by algal blooms, scoring less than 1.0.

Anchoring
The effects of anchoring were judged to be broad, affecting forty-one habitats, though none severely (Table A3.2). Twelve reef habitats are the most strongly affected, though only moderately, with mean weighted vulnerability scores between 1.6 and 1.0. A group of shallow inshore sand, shell, mud, and seagrass habitats followed with vulnerability scores between 0.8 and 0.5.

Aquaculture
There are three potential important effects of aquaculture on marine habitats; the benthic accumulation of debris, increases in habitat complexity, and local decreases in primary production around farms because of filter feeding by mussels.

Benthic accumulation of debris was judged to most affect mud, seagrass, sand and gravel pebble, shell habitats in harbours and estuaries and on sheltered coasts reflecting where most aquaculture farms are situated at present (Table A3.3). A broader range of habitats will be affected once some large farms planned for the open coast come into operation.

Marine farms can increase local habitat complexity by virtue of the structures introduced into the habitat. This may be viewed as a positive or negative impact depending on the value placed on the original habitat present. Again the habitats most affected include muds, sands and gravels in harbours and estuaries and on sheltered coasts as well as rocky reefs (Table A3.4).

Local decreases in primary production around mussel farms were judged to most greatly affect mud and reef habitats in harbours and estuaries and on sheltered coasts and also the coastal pelagic habitat (Table A3.5). Note we had no fine scale division of pelagic habitats specifically for enclosed waters where most aquaculture facilities occur so the coastal pelagic habitat was rated as affected by this threat.

Increasing greenhouse gases

The burning of fossil fuels causing increasing greenhouse gas concentrations in the atmosphere and oceans is manifest in a variety of ways that may effect different habitats to a greater or lesser extent. Ocean acidification was the highest ranking threat overall and was judged by our experts to have the broadest impact of any threat (along with increasing sea temperature), affecting fifty-seven of fifty-nine habitats assessed (Table A3.6). Twenty-two habitats were judged to be particularly vulnerable to ocean acidification (all with mean weighted vulnerability scores of 3 or more). This group includes shallow reefs, sand and gravel, pebble and shell habitats, shellfish beds, seamounts and pelagic habitats. Ocean acidification has substantial affects on another broad group of twenty-one coastal, shelf, slope and deepwater habitats with vulnerability scores between 2.0 and 3.0. Another twelve habitats have vulnerability scores between 1.0 and 2.0. Only two habitats affected by ocean acidification, salt marsh and seeps and vents, have vulnerability scores less than 1.0.

Increasing sea temperatures were also judged to have broad effects, affecting fifty-seven habitats (Table A3.7). Five habitats are particularly vulnerable with mean weighted vulnerability scores of more than 3.0. Interestingly, four of these are slope and deepwater pelagic habitats within and below the photic zone and the fifth is sandy beach habitat on exposed coasts. Outer shelf pelagic habitat had a vulnerability score of 2.8, followed by reef, shellfish, sand, gravel/pebble/shell and mud habitats in harbours and estuaries and on sheltered coasts, inner shelf pelagic habitats and outer shelf reefs, all with a vulnerability score of 2 or more.

Increased storminess was judged to affect forty-four habitats (Table A3.8). Two habitats, intertidal reefs and sandy beaches on exposed coasts are particularly vulnerable with mean weighted vulnerability scores of 3.5 and 3.1 respectively. Eleven shallow sand, mud, shellfish, reef and algal habitats on harbour, sheltered and exposed coasts were less vulnerable to increased storminess, all with scores between 2.0 and 2.5. Interestingly, reefs between 30 and 200 m on exposed coasts were assessed as scoring within this group (2.0), closely followed by shallow subtidal reefs on exposed coasts (1.9).

Changing currents were judged to have broad effects, affecting fifty-five habitats (Table A3.9). Four slope and deep ocean pelagic habitats are particularly vulnerable with mean weighted vulnerability scores of 3.5 and 3.2. About an order of magnitude less affected are three reef habitats and one mud habitat on exposed coasts and in harbours with vulnerability scores between 2.0 and 2.3. Only moderately affected is a group of eleven mud, sand, shell and reef habitats in harbours, and on sheltered and exposed coasts, with vulnerability scores from 1.5 to 1.8.

Rising sea level was judged to affect forty-two habitats (Table A3.10) with the degree of vulnerability generally declining with increasing depth. Three shallow inshore habitats, sheltered sandy beaches, mangroves and saltmarsh are particularly vulnerable with mean weighted vulnerability scores of 3.3 to 3.4. Less, but still substantially affected are eight coastal intertidal beach, mud, shellfish and reef habitats with vulnerability scores between 2.0 and 2.9. Moderately affected is a group of shallow subtidal sand, mud, gravel/pebble/shell and reef habitats with vulnerability scores from 1.0 to 1.7. Deeper shelf habitats are only modestly vulnerable with scores from 0.1 to 0.9. No slope or deepwater habitats are considered vulnerable to this threat.

Increased stratification was judged to affect forty-seven habitats (Table A3.11). Slope pelagic habitats above and below the photic zone are particularly vulnerable with mean weighted vulnerability scores of 3.4. Less, but still substantially affected are two deep ocean pelagic habitats above and below the photic zone (2.2). Moderately affected is a group of twenty coastal and shelf, mud, sand, gravel/pebble/shell, reef and pelagic habitats with vulnerability scores from 1.0 to 1.9. Weakly vulnerable to increased stratification, with scores less than 1.0, is a broad group of twenty-three habitats ranging in depth from the intertidal to the abyss.

Increased intertidal temperatures were judged to affect forty-two habitats (Table A3.12). Surprisingly not all of these are intertidal. Shellfish beds, intertidal reefs, intertidal mud and sand, and shallow subtidal mud and sand are substantially affected with mean weighted vulnerability scores of 2.0 to 2.9. More moderately affected are beaches, seagrass meadows, saltmarsh, mangrove forest and subtidal reefs with vulnerability scores of 1.0 to 1.9. Presumably, experts judged subtidal reefs to be moderately affected because some ecosystem components may feed in adjacent intertidal habitats affected by increased temperature.

Increases in ultra-violet light were judged to affect forty-four habitats (Table A3.13). Intertidal reefs and surface pelagic habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.2. More moderately affected are shallow subtidal mud and sand, shellfish beds, seagrass meadows, and subtidal reefs with vulnerability scores between 1.0 and 1.8. Twenty-six coastal and shelf habitats were weakly affected with vulnerability scores less than 1.0

Altered rainfall was judged to affect forty-five habitats (Table A3.14). Fiord sediments are particularly vulnerable with a mean weighted vulnerability score of 3.0. Substantially affected are fiord rock walls and intertidal reefs in harbours and estuaries with scores from 2.2 to 2.5. More moderately affected are twelve shallow intertidal and subtidal mud and sand habitats, shellfish beds, seagrass meadows, mangrove forests, and subtidal reefs with vulnerability scores between 1.0 and 1.6. Twenty-nine coastal, shelf and slope habitats were weakly affected with vulnerability scores less than 1.0.

Ecotourism
Ecotourism encompasses six non-consumptive threats to marine ecosystems. Divers may inadvertently damage benthic species and this threat was judged to affect thirty-four habitats (Table A3.15). Inner fiord rock walls are substantially affected with a mean weighted vulnerability score of 2.0. Moderately affected are fiord sediments, outer fiord rock walls, subtidal reefs, kelp forests, and turfing algal reefs. A further twenty-three coastal and habitats were weakly affected with vulnerability scores less than 1.0.

Vehicles were judged to affect thirty-four habitats to a moderate or minor extent (Table A3.16). Sandy beaches, intertidal sand and saltmarsh habitats are moderately affected with mean weighted vulnerability scores from 1.0 to 1.8. A further seventeen habitats were weakly affected with vulnerability scores less than 1.0.

Changes in fish and invertebrate behaviour may occur when tourists feed or interact with them making them more vulnerable to predation or disease, or to becoming pests. This threat was judged to affect twenty-seven habitats to a minor extent (Table A3.17). Nine coastal reef habitats headed the ranks with scores from 0.6–1.0. The remaining affected habitats were all coastal.

Trampling damage by tourists was judged to affect twenty-one habitats to a moderate or minor extent (Table A3.18). Intertidal reefs are moderately affected with mean weighted vulnerability scores from 1.2 to 1.8. A further eighteen shallow coastal habitats were weakly affected with vulnerability scores less than 1.0. It is likely that at least one respondent confused trampling damage with diver damage as coastal subtidal reefs had trivial scores for this threat so scores for trampling for subtidal habitats should be ignored.

Marine mammal watching was judged to affect thirty-one habitats to a moderate or minor extent (Table A3.19). Fiord habitats topped the ranks, followed by shelf pelagic ecosystems, reflecting where most marine mammal watching takes place. A further twenty-six coastal, shelf and slope habitats were weakly affected with vulnerability scores less than 0.5.

Noise generated by tourists was judged to affect fifteen coastal shelf and slope habitats to a very minor extent with scores from 0.1 to 0.2 (Table A3.20). These scores are so low and close that there is no justification in discussing their order or ranking.

Engineering
Engineering included twelve human activities in the marine environment. Dumping of dredge spoils was judged to affect forty-nine habitats (Table A3.21). Shallow subtidal mud habitats on sheltered coasts and outer shelf mud habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.3. More moderately affected, with vulnerability scores from 1.0 to 1.9 are subtidal reefs, sand, gravel, and mud habitats as well as seagrass meadows, shellfish beds, and shelf pelagic habitats from the surface to the sea floor. An additional thirteen very shallow and deep ocean habitats with scores less than 1.0 are affected to a minor extent by dumping of dredge spoils.

Coastal reclamation was judged to affect thirty-seven habitats (Table A3.22). Saltmarsh, mangrove forests, and intertidal reefs fringing harbours and estuaries are particularly vulnerable with mean weighted vulnerability scores of 3.0 to 3.4. Also substantially affected are intertidal reefs and mud, beaches and seagrass meadows in harbours and along sheltered coasts. More moderately affected are intertidal sands and shellfish beds and subtidal habitats in harbours and intertidal reefs on exposed coasts. An additional sixteen habitats with scores less than 1.0 were judged to be affected to a minor extent by reclamation.

Sand and gravel abstraction was judged to affect forty-five habitats to a significant, moderate or minor extent (Table A3.23). Shallow subtidal sand habitat on sheltered coasts is the only habitat substantially affected with a mean weighted vulnerability score of 2.1. Moderately affected is a range of beach, gravel, sand, and mud habitats mainly along sheltered and exposed coastlines as well as biogenic calcareous reefs. An additional thirty habitats with scores less than 1.0 were judged to be affected to a minor extent.

Dredging shipping or access channels was judged to affect thirty-six habitats to a major, moderate or minor extent (Table A3.24). Shallow mud and gravel, pebble, shell habitats on sheltered coasts are substantially affected with mean weighted vulnerability scores of 2.0. More moderately affected are shallow coastal sand, gravel, and mud habitats as well as shellfish beds, seagrass meadows, biogenic calcareous reefs, and shallow subtidal reefs. An additional fifteen coastal habitats with scores 0.5–1.0 were judged to be affected to a minor extent by bottom dredging.

Causeway construction was judged to affect twenty-seven habitats to a significant, moderate or minor extent (Table A3.25). Eight intertidal or shallow subtidal harbour and estuarine habitats and sheltered intertidal reefs are substantially affected with mean weighted vulnerability scores of 2.0 to 2.8. More moderately affected are beaches, intertidal reefs, and shallow subtidal mud and sand habitats with scores between 1.1 and 1.3. An additional thirteen coastal habitats with scores less than 1.0 were judged to be affected to a minor extent by causeway construction.

Pile moorings and markers were judged to affect thirty-one habitats to a moderate or minor extent (Table A3.26). Eight harbour and one sheltered coast habitats are moderately affected with mean weighted vulnerability scores of 1.1 to 1.7. An additional twenty-two coastal habitats with scores less than 1.0 were judged to be affected to a minor extent by pile moorings and markers.

Piled wharfs and sheds were judged to affect thirty-one habitats to a moderate or minor extent (Table A3.27). Twelve shallow harbour habitats, and beaches on sheltered and exposed coasts are moderately affected with mean weighted vulnerability scores of 1.0 to 1.7. An additional nineteen coastal habitats with scores less than 1.0 were judged to be affected to a minor extent by piled wharfs and sheds.

Seawalls were judged to affect twenty-nine habitats to a moderate or minor extent (Table A3.28). Nine intertidal and shallow habitats in harbours and beaches on sheltered coasts are moderately affected with mean weighted vulnerability scores of 1.0 to 1.9. An additional twenty coastal habitats with scores less than 1.0 were judged to be affected to a minor extent.

Surface suction of minerals was judged to affect forty-four habitats to a moderate or minor extent (Table A3.29). Shallow mud habitat on sheltered coasts is the only habitat moderately affected with a mean weighted vulnerability score of 1.3. An additional forty-three coastal, shelf, slope, and deep water habitats with scores less than 1.0 were judged to be affected to a minor extent. Included in this latter group are hot vent, cold seep, and slope habitats where surface suction of minerals has not occurred but these habitats are currently being investigated for their surface mineral deposits.

Pontoons were judged to affect twenty-nine habitats to a moderate or minor extent (Table A3.30). Intertidal mud and reef, and subtidal sand and mud in harbours and estuaries are moderately affected with mean weighted vulnerability scores of 1.0 to 1.7. An additional twenty-five coastal habitats with scores less than 1.0 were judged to be affected to a minor extent.

Other methods for extraction of minerals were judged to affect twenty-three habitats to a moderate or minor extent (Table A3.31). Hot vents, cold seeps and seamounts less than 2000 m are moderately affected with a mean weighted vulnerability scores of 1.0 to 1.5. An additional twenty-one coastal, shelf, slope, and deep water habitats with scores 0.6 or less were judged to be affected to a minor extent.

Deep hole extraction of minerals was judged to affect twenty-five habitats to a minor extent (Table A3.32). Gravel, pebble & shell habitats, and deep reefs topped this list with mean weighted vulnerability scores of 0.5 to 0.6.

Fishing
Fishing encompasses twelve distinct threats to marine ecosystems. Bottom trawling was judged to affect fifty-one habitats (Table A3.33). Fourteen habitats, including mud, sand and gravel habitats on the shelf and slope, seamounts less than 2000 m, canyons, and deep reefs between 200 and 2000 m, are particularly vulnerable with mean weighted vulnerability scores of 3.0 to 3.3. Substantially affected is another group of fourteen shelf, slope and deepwater mud, sand, gravel reef, and vent habitats, all with vulnerability scores between 2.2 and 2.9. Moderately affected by bottom trawling are nine coastal mud, sand, and reef habitats less than 30 m deep. An additional nineteen coastal and deepwater habitats with scores 0.9 or less were judged to be affected to a minor extent.

Dredging for shellfish was judged to affect forty habitats (Table A3.34). Fourteen habitats, including shelf mud, sand and gravel habitats, and biogenic calcareous reefs, are substantially affected with mean weighted vulnerability scores of 2.3 to 2.9. Moderately affected are seven coastal mud, sand and reef habitats less than 30 m deep. An additional seventeen coastal mud, reef, shellfish, and seagrass habitats and slope muds and sands with scores 0.9 or less were judged to be affected to a minor extent by dredging for shellfish.

Line fishing was judged to affect forty-three habitats (Table A3.35). Three subtidal reef habitats in harbours and on sheltered coasts are substantially affected with mean weighted vulnerability scores of 2.0 to 2.2. Moderately affected with vulnerability scores between 1.0 to 1.7 are an additional ten coastal and shelf reef habitats as well as kelp forests, and turfing algal reefs and another ten mud, sand, gravel, and pelagic habitats on the coast, slope and in deepwater. An additional twenty coastal mud, sand, gravel/shell, reef, seagrass, mangrove, and shellfish habitats, and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent by line fishing.

Trapping or potting for fish and crustaceans such as lobsters was judged to affect forty-one habitats (Table A3.36). Five exposed coast and fiord reef or rockwall habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.3, reflecting where the rock lobster fishery predominately occurs. Moderately affected are sixteen coastal mud, sand, and reef habitats less than 30 m deep. An additional twenty coastal, shelf, and slope mud, sand, gravel/shell, seagrass, and shellfish habitats with scores 0.9 or less were judged to be affected to a minor extent. Included in this latter group are inshore pelagic habitats, presumably because of the threat to water column species, such as marine mammals and reptiles, from the trap lines and buoys.

Long-lining was judged to affect forty-five habitats to a moderate or minor extent (Table A3.37). Sixteen benthic habitats on the coast, shelf, and slope, and six inshore to deep offshore pelagic habitats, are moderately affected with mean weighted vulnerability scores of 1.0 to 1.7. An additional twenty-three coastal, shelf, slope, and deep habitats with scores 0.9 or less were judged to be affected to a minor extent.

Shellfish gathering was judged to affect thirty-six habitats (Table A3.38). Five shallow coastal sediment and reef habitats where shellfish typically occur are substantially affected with mean weighted vulnerability scores of 2.1 to 2.4. Moderately affected are an additional sixteen coastal mud, sand, and reef habitats. An additional fifteen coastal habitats with scores 0.9 or less were judged to be affected to a minor extent.

Set netting was judged to affect forty-nine habitats (Table A3.39). Four coastal subtidal reef habitats are substantially affected with mean weighted vulnerability scores of 2.1. Moderately affected are an additional eight exposed coastal, and shelf reef habitats and one coastal sand habitat with scores from 1.0 to 1.9. An additional thirty-seven coastal, shelf, and off-shore habitats with scores 0.9 or less were judged to be affected to a minor extent.

Seaweed gathering was judged to affect thirty-six habitats to a moderate or minor extent (Table A3.40). Ten coastal reef habitats are moderately affected with mean weighted vulnerability scores of 1.1 to 1.7. An additional twenty-six coastal reef, beach, mud, sand, gravel/shell, shellfish, and seagrass habitats with scores 0.9 or less were judged to be affected to a minor extent. Some of these reflect where shore- cast algae are removed from coastal ecosystems by human collection.

Abalone or paua gathering was judged to affect thirty-five habitats to a moderate or minor extent (Table A3.41). Thirteen coastal reef habitats are moderately affected with mean weighted vulnerability scores of 1.0 to 1.6 reflecting where most paua gathering takes place. An additional twenty-one coastal habitats with scores 0.9 or less were judged to be affected to a minor extent although how paua fishing was judged to affect some of these habitats, even to a small extent, is unclear given that benthic-phase paua don't naturally occur in these habitats. Indirect effects through displaced predation to adjacent habitats and reduced larval input to the pelagic zone may explain some of these minor scores.

High by-catch pelagic fishing was judged to affect thirty-four habitats (Table A3.42). Deep ocean pelagic habitats within and below the photic zone are substantially affected with mean weighted vulnerability scores of 2.0 to 2.1. Moderately affected are an additional four shelf and slope pelagic habitats, and one deep shelf reef habitat with scores from 1.1 to 1.8. An additional twenty-seven coastal, shelf, and off-shore benthic habitats with scores 0.7 or less were judged to be affected to a minor extent.

Spear fishing was judged to affect thirty-four habitats to a moderate or minor extent (Table A3.43). Ten coastal reef habitats are moderately affected with mean weighted vulnerability scores of 1.0 to 1.6, reflecting where most spear fishing takes place. An additional twenty-four shallow coastal habitats with scores 0.9 or less were judged to be affected to a minor extent.

Low bycatch pelagic fishing was judged to affect twenty-seven habitats to a moderate or minor extent (Table A3.44). Inner and outer shelf pelagic habitats are moderately affected with mean weighted vulnerability scores of 1.2 to 1.3. The remaining four pelagic habitats over the slope and in the deep ocean and an additional twenty-one shallow shelf benthic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Turbidity

Increases in turbidity may arise from a variety of causes including increased sediment input from rivers, increased storminess causing resuspension of sediments, and algal blooms and was judged to affect forty-nine habitats (Table A3.45). Five coastal reef habitats and shallow sand habitats on sheltered coasts are substantially affected with mean weighted vulnerability scores of 2.0 to 2.3. Moderately affected are an additional twenty-one coastal benthic and pelagic habitats. An additional twenty-one coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Invasive species

Invasive benthic space occupiers and competitors were judged to affect forty-five habitats (Table A3.46). Intertidal reefs in harbours are particularly vulnerable with a mean weighted vulnerability score of 3.0, reflecting the location of ports and that many invasive species foul ship hulls. Substantially affected are two further harbour and sheltered coast reef habitats. More moderately affected are twenty-four shallow coastal benthic habitats with scores from 1.0 to 1.9. An additional eighteen coastal habitats with scores 0.9 or less were judged to be affected to a minor extent.

Invasive disease species were judged to affect forty-two habitats to a moderate or minor extent (Table A3.47). Six coastal reef, sand and seagrass habitats are moderately affected with mean weighted vulnerability scores of 1.0 to 1.2. Another thirty-six coastal and shelf, benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Pollution

Oil pollution was judged to affect fifty habitats (Table A3.48). Saltmarsh and pipi beds are substantially affected with mean weighted vulnerability scores of 2.1 and 2.0 respectively. More moderately affected are an additional twenty coastal and shelf benthic and pelagic habitats. An additional twenty-eight coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Sewage pollution was judged to affect forty-four habitats (Table A3.49). Harbour and estuarine intertidal and subtidal mud and sand habitats are substantially affected with mean weighted vulnerability scores of 2.1 to 2.5. More moderately affected are an additional twenty-one coastal and shelf benthic and pelagic habitats with scores from 1.0 to 1.9. An additional twenty coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Elevated nitrogen and phosphorus levels can result from sewage, river flows and /or groundwater contamination and this threat was judged to affect forty-four habitats (Table A3.50). Harbour and estuarine habitats are especially affected comprising ten of the thirteen most vulnerable habitats. Harbour subtidal mud, reef and seagrass habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.1. More moderately affected are an additional sixteen coastal and shelf benthic and pelagic habitats with scores from 1.0 to 1.9. An additional twenty-five coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Heavy metal pollution was judged to affect forty-eight habitats (Table A3.51). Harbour and estuarine habitats are especially affected, comprising eight of the ten most vulnerable habitats. Harbour and estuarine intertidal mud and subtidal mud sand and reef habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.7. More moderately affected are an additional fourteen harbour, coastal, and shelf benthic and pelagic habitats with scores from 1.1 to 1.9. An additional thirty coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Pesticide pollution including PCB contamination was judged to affect forty-five habitats (Table A3.52). Harbour and estuarine habitats are especially affected comprising nine of the ten most vulnerable habitats. Harbour and estuarine subtidal mud habitats are substantially affected with a mean weighted vulnerability score of 2.7. More moderately affected are an additional eight harbour habitats and two coastal reef habitats with scores from 1.0 to 1.6. An additional thirty-four coastal, shelf, and slope benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Herbicide pollution was judged to affect forty-two habitats to a moderate or minor extent (Table A3.53). Harbour and estuarine habitats are especially affected, comprising nine of the eleven most vulnerable habitats. Harbour and estuarine subtidal mud and seagrass meadows were the most vulnerable with mean weighted vulnerability scores of 1.9 and 1.8 respectively. More moderately affected are an additional six harbour and estuarine habitats, and coastal intertidal and deep subtidal reefs with scores from 1.0 to 1.4. An additional thirty-one coastal and shelf benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Plastic pollution was judged to affect fifty habitats to a moderate or minor extent (Table A3.54). Inshore pelagic habitats are the most vulnerable with a mean weighted vulnerability score of 1.6. More moderately affected are four coastal reef habitats and subtidal harbour muds with scores of 1.1 to 1.2. An additional forty-four coastal, shelf, slope, and deep ocean benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Acoustic discharges and air-guns were judged to affect thirty-eight habitats to a moderate or minor extent (Table A3.55). Inshore pelagic habitats are the most vulnerable with a mean weighted vulnerability score of 1.1. Two additional pelagic habitats are affected in a minor way with scores of 0.7 and 0.4 respectively. An additional thirty five coastal, shelf, and slope and deep ocean benthic and pelagic habitats with scores 0.3 or less were judged to be affected to a very minor extent.

Electromagnetic discharges from underwater cables may interfere with foraging activities of those species that can detect weak electric fields and were judged to affect thirty-one coastal, shelf, and pelagic habitats to a very minor extent (Table A3.56).

River Inputs
Increased sediment loading due to land use in adjacent catchments was judged to affect fifty-two marine habitats (Table A3.57). Intertidal and subtidal reefs in harbours and sheltered coast beaches and intertidal reefs are particularly vulnerable with mean weighted vulnerability scores of 3.0 to 3.1. Substantially affected are seven further harbour habitats and fourteen coastal and shelf benthic habitats with scores of 2.0 to 2.9. More moderately affected are ten shallow coastal benthic habitats with scores from 1.0 to 1.9. An additional seventeen coastal, shelf, slope, and deep ocean benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Increased river flows were judged to affect thirty-six marine habitats (Table A3.58). Fiord rockwalls and harbour and estuarine mud habitats are substantially affected with mean weighted vulnerability scores of 2.0 to 2.7. More moderately affected are ten shallow coastal benthic habitats with scores from 1.0 to 1.5. An additional twenty-two coastal benthic habitats and shelf, and slope pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Decreased sediment loading due to dams and other sediment traps was judged to affect thirty-nine habitats to a moderate or minor extent (Table A3.59). Four harbour and estuarine habitats, saltmarsh, intertidal reef, subtidal reef and subtidal mud, are moderately affected with a mean weighted vulnerability score of 1.0 to 1.3. Another thirty-five coastal habitats with scores 0.9 or less were judged to be affected to a very minor extent.

Decreased river flows due to dams or diversions were judged to affect thirty-five habitats to a moderate or minor extent (Table A3.60). Three intertidal habitats in harbours and along sheltered coasts are moderately affected with a mean weighted vulnerability score of 1.0 to 1.3. Another thirty-three coastal habitats with scores 0.9 or less were judged to be affected to a very minor extent.

Dampening of river flows due to dams was judged to affect thirty-five habitats to a minor extent (Table A3.61). Seven harbour and estuarine habitats are the most vulnerable with mean weighted vulnerability scores of 0.4 to 0.7. Another twenty-eight coastal, shelf, and pelagic habitats with scores 0.3 or less were judged to be affected to a very minor extent.

Shipping
Grounding and sinking of ships was judged to affect forty-five habitats to a moderate or minor extent (Table A3.62). Four reef habitats in harbours, turfing algae on exposed coasts and seagrass meadows are moderately affected with a mean weighted vulnerability score of 1.0 to 1.4. Another forty coastal, shelf, slope, and deep ocean benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Underwater noise generated by ships was judged to affect thirty-nine habitats to a moderate or minor extent (Table A3.63). Deep subtidal reefs on exposed coasts are moderately affected with a mean weighted vulnerability score of 1.2. Another thirty-eight forty coastal and shelf, benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

Animal strikes by ships were judged to affect thirty-nine habitats to a minor extent (Table A3.64). The most vulnerable habitats are coastal and shelf pelagic waters and fiord rock walls with mean weighted vulnerability scores of 0.4 to 0.5. Another thirty-six coastal and shelf benthic and pelagic habitats with scores less than 0.4 were judged to be affected to a very minor extent.

Spatial closures to fishing due to marine reserves, cable-ways or shipping channels can displace fishing activity into other nearby habitats open to fishing and was judged to affect thirty-five habitats to a moderate or minor extent (Table A3.65). Fiord rockwalls and sediments, and coastal and shelf reefs are moderately affected with a mean weighted vulnerability score of 1.0 to 1.9. Another twenty-nine coastal and shelf, benthic and pelagic habitats with scores 0.9 or less were judged to be affected to a minor extent.

3.1.9 Cluster analysis

Threats across habitats

A CLUSTER analysis with SIMPROF test was carried out using PRIMER-E statistical software. There was only a weak tendency for threats stemming from the same underlying cause (e.g. pollution, fishing, engineering, climate change, etc) to group together on the basis of their mean weighted vulnerability score (Figure 13 and Table 11). There were 40 significantly different clusters ($p < 0.05$, SIMPROF test). Noise from people generated during ecotourism activity was dissimilar to all other threats, with approx 90% dissimilarity to all other threats. Similarly, mineral extraction by various methods clustered separately, from all other threats and other engineering types at approximately 75% dissimilarity.

Of the remaining threats, pollution from oil or oil products, plastic, pesticides and heavy metals could not be significantly differentiated. Interestingly there were many other two or three threat clusters ($p < 0.05$) which were heterogeneous with respect to threat origin. For example, shellfish gathering (fishing), reclamation (engineering), sea level rise and increased intertidal temperature (both climate change) could not be significantly differentiated.

Habitats across threats

A CLUSTER analysis with SIMPROF test carried out using PRIMER-E statistical software indicated there was a strong tendency for habitats to group on the basis of their depth and exposure and to a weaker extent by their substrate (Figures 14 – 16). There were 31 significantly different clusters ($p < 0.05$) based on mean habitat depth (Figure 14). The largest of these clusters split from the remaining groups at 20% similarity and comprised eleven slope and deep ocean benthic habitats including trenches, the abyssal plain, seamounts, vents, soft and hard canyons, and slope muds, sands, gravel/shell and reefs. The remaining clusters comprised all the coastal and shelf benthic habitats plus the pelagic habitats. Of these remaining habitats, the fiords and then pelagic habitats were the most dissimilar to other habitats, separating at approximately 40 and 45% similarity respectively.

The classification of habitats based on exposure was very similar to depth (Figure 15). The deep and slope habitats could not be significantly differentiated. Again, the fiord habitats clustered separately to the remaining habitats at 40% similarity and the pelagic at 45% similarity. Interestingly within the pelagic habitats, depth did not appear to be a significant factor in the clustering with mixed depth ranges within those habitats that could not be significantly differentiated.

The classification of habitats based on substrate showed less clear groupings than that for depth or exposure (Figure 16). Of all the substrates, the pelagic habitat was the only substrate that clustered at greater than 60% similarity.

Table 11: Classification of New Zealand marine habitats by exposure, depth and substrate used in the CLUSTER analyses. The labels used in Figures 13-16 are also provided.

Habitat	Exposure	Depth	Substrate	Label
Exposed Coasts : Sandy beaches	Exposed	Intertidal	Sand	E I SD
Sheltered Coast : Sandy beaches	Sheltered	Intertidal	Sand	S I SD
Harbour and Estuaries : Intertidal sand	Harbour	Intertidal	Sand	H I SD
Harbour and Estuaries : Saltmarsh	Harbour	Intertidal	Saltmarsh	H I SM
Harbour and Estuaries : Cockle bed	Harbour	Intertidal	Shellfish bed	H I SF
Harbour and Estuaries : Mangrove forest	Harbour	Intertidal	Mangrove	H I MG
Exposed Coasts : Sand 2–9 m	Exposed	Subtidal 2–9	Sand	E S 0-9 SD
Harbour and Estuaries : Pipi bed	Harbour	Intertidal	Shellfish bed	H I SF
Sheltered Coast : Sand 2–9 m	Sheltered	Subtidal 2–9	Sand	S S 0-9 SD
Exposed Coasts : Intertidal reefs	Exposed	Intertidal	Reef	E I R
Harbour and Estuaries : Intertidal reef	Harbour	Intertidal	Reef	H I R
Sheltered Coast : Intertidal reef	Sheltered	Intertidal	Reef	S I R
Harbour and Estuaries : Seagrass meadows	Harbour	Subtidal 2–9	Seagrass	H S 0-9 SG
Harbour and Estuaries : Intertidal mud	Harbour	Intertidal	Mud	H I MD
Harbour and Estuaries : Subtidal mud	Harbour	Subtidal 2–9	Mud	H S 0-9 MD
Harbour and Estuaries : Subtidal sand	Harbour	Subtidal 2–9	Sand	H S 0-0 SD
Fiord Habitats : Outer fiord rockwalls	Fiord	Fiord	Reef	F OF R
Sheltered Coast : Mud 2–9 m	Sheltered	Subtidal 2–9	Mud	S S 0-9 MD
Sheltered Coast : Sand 10–29 m	Sheltered	Subtidal 10–29	Sand	S S 10-29 SD
Sheltered Coast : Mud 10–29 m	Sheltered	Subtidal 10–29	Mud	S S 10-29 MD
Fiord Habitats : Inner fiord rockwalls	Fiord	Fiord	Reef	F IF R
Harbour and Estuaries : Subtidal reef	Harbour	Subtidal 2–9	Reef	H S 0-9 R
Exposed Coasts : Subtidal reefs 10–30 m	Exposed	Subtidal 10–29	Reef	E S 10-29 R
Exposed Coasts : Subtidal reefs 2–9 m	Exposed	Subtidal 2–9	Reef	E S 0-9 R
Exposed Coasts : Subtidal reefs 30–200 m	Exposed	Subtidal 30–200	Reef	E S 30-200 R
Sheltered Coast : Subtidal reefs 10–29 m	Sheltered	Subtidal 10–29	Reef	S S 10-29 R
Sheltered Coast : Subtidal reefs 2–9 m	Sheltered	Subtidal 2–9	Reef	S S 0-9 R

Habitat	Exposure	Depth	Substrate	Label
Sheltered Coast : Kelp Forest	Sheltered	Subtidal 2–9	Kelp	S S 0-9 K
Exposed Coasts : Kelp Forest	Exposed	Subtidal 10–29	Kelp	E S 10-29 K
Exposed Coasts : Turfing algal reefs	Exposed	Subtidal 2–9	Turfing algae	E S 0-9 TA
Fiord Habitats : Fiord sediments	Fiord	Fiord	Mud	F F MD
Pelagic Habitat : Slope - water column below photic zone	Pelagic	Subtidal 30–200	Pelagic	P S 30-200 P
Sheltered Coast : Gravel/pebble/shell 2–9 m	Sheltered	Subtidal 2–9	Gravel	S S 0-9 G
Sheltered Coast : Gravel/pebble/shell 10–29 m	Sheltered	Subtidal 10–29	Gravel	S S 10-29 G
Pelagic Habitat : Slope - water column in photic zone	Pelagic	Subtidal 0–50	Pelagic	P S 0-50 S
Exposed Coasts : Gravel/pebble/shell 2–9 m	Exposed	Subtidal 2–9	Gravel	E S 0-9 G
Exposed Coasts : Biogenic calcareous reefs	Exposed	Subtidal 10–29	Biogenic reef	E S 10-29 B
Exposed Coasts : Gravel/pebble/shell 10–29 m	Exposed	Subtidal 10–29	Gravel	E S 10-29 G
Pelagic Habitat : Coastal - whole water column inside 50 m contour	Pelagic	Subtidal 0–50	Pelagic	P S 0-50 C
Pelagic Habitat : Shelf - whole water column between 50–200 m contour	Pelagic	Subtidal 50–200	Pelagic	P S 50-200 C
Exposed Coasts : Mud 30–200 m	Exposed	Subtidal 30–200	Mud	E S 30-200 MD
Exposed Coasts : Gravel/pebble/shell 30–200 m	Exposed	Subtidal 30–200	Gravel	E S 30-200 G
Exposed Coasts : Sand 30–200 m	Exposed	Subtidal 30–200	Sand	E S 30-200 S
Exposed Coasts : Mud 10–29 m	Exposed	Subtidal 10–29	Mud	E S 10-29 MD
Pelagic Habitat : Deep ocean water column in photic zone	Pelagic	Subtidal 0–50	Pelagic	P S 0-50 P
Exposed Coasts : Sand 10–29 m	Exposed	Subtidal 10–29	Sand	E S 10-29 SD
Pelagic Habitat : Deep ocean water column below photic zone	Pelagic	Subtidal 2500	Pelagic	P S 2500 P
Deep Habitats : Soft abyssal 2000 m+	Deep	Abyssal 5000	Mud	D A 5000 MD
Slope Habitats : Reef 200–2000 m	Slope	Subtidal 1000	Reef	SP S 1000 R
Slope Habitats : Sand 200–2000 m	Slope	Subtidal 1000	Sand	SP S 1000 SD
Deep Habitats : Trench	Deep	Trench	Mud	D Trench MD
Slope Habitats : Mud 200–2000 m	Slope	Subtidal 1000	Mud	SP S 1000 MD
Slope Habitats : Gravel/pebbles/shells 200–2000 m	Slope	Subtidal 1000	Gravel	SP S 1000 G
Deep Habitats : Vent (hot and cold)	Deep	Subtidal 1000	Vent	D S 1000 V
Deep Habitats : Soft canyon	Deep	Subtidal 1000	Mud	D S 1000 MD
Deep Habitats : Hard canyon	Deep	Subtidal 1000	Reef	D S 1000 R
Deep Habitats : Seamount < 2000 m	Deep	Subtidal 2000 -	Seamount	D S<2000 SM
Deep Habitats : Seamount > 2000 m	Deep	Subtidal 2000 +	Seamount	D S>2000 SM

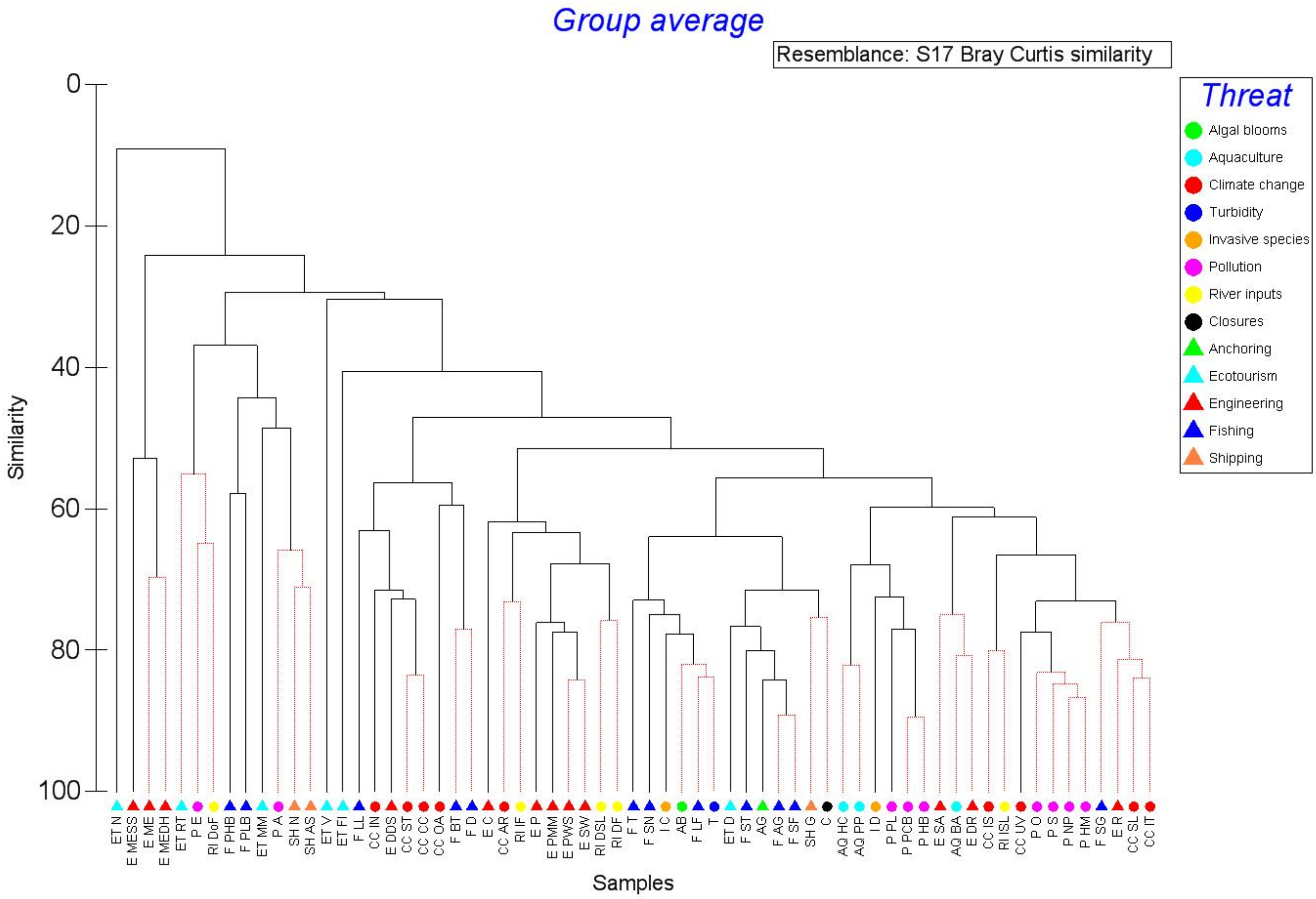


Figure 13: CLUSTER analysis of threats across habitats using the Bray Curtis similarity index to determine the tendency for threats stemming from the same underlying cause (e.g. fishing, engineering, climate change etc) to group together on the basis of their mean weighted vulnerability score. Habitats connected by red lines cannot be significantly differentiated (SIMPROF test, $p < 0.05$). See Table 11 for explanation of sample codes.

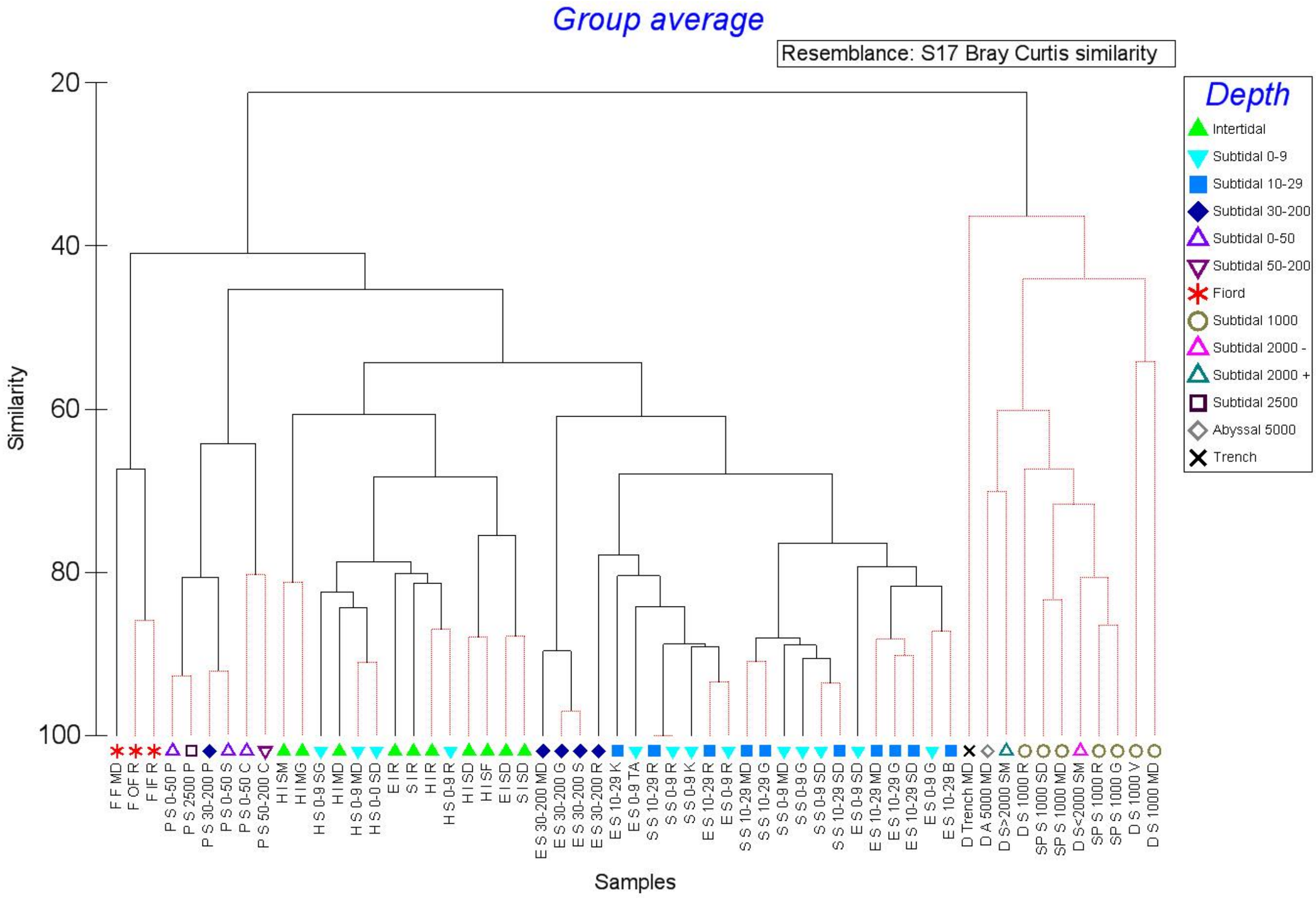


Figure 14: CLUSTER analysis of habitats across threats using the Bray Curtis similarity index to determine the tendency for habitats classified according to their mean depth (m) to group together on the basis of their mean weighted vulnerability score. Habitats connected by red lines cannot be significantly differentiated (SIMPROF test, $p < 0.05$). See Table 10 for explanation of sample codes.

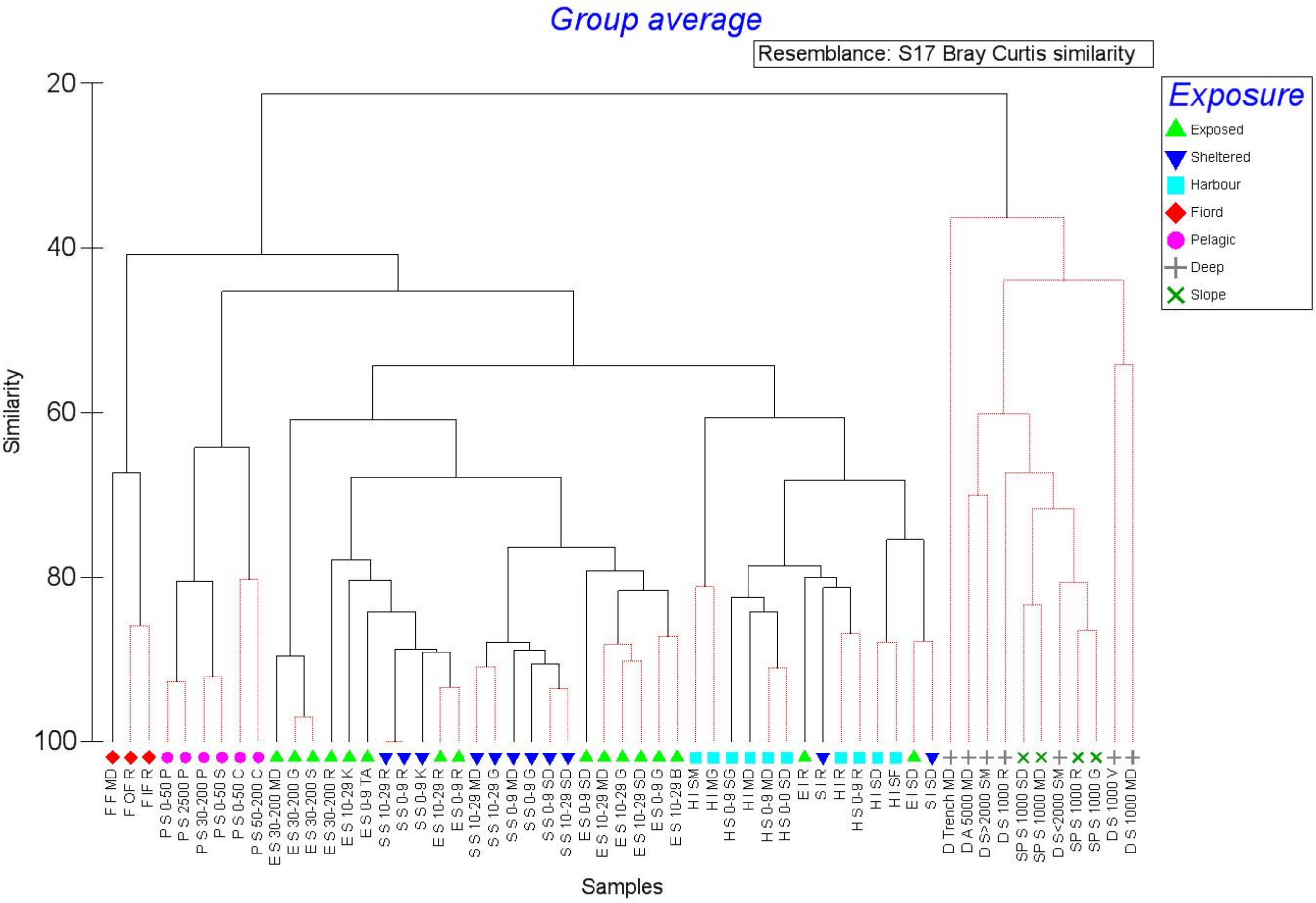


Figure 15: CLUSTER analysis of habitats across threats using the Bray Curtis similarity index to determine the tendency for habitats classified according to their exposure to group together on the basis of their mean weighted vulnerability score. Habitats connected by red lines cannot be significantly differentiated (SIMPROF test, $p < 0.05$). See Table 10 for explanation of sample codes.

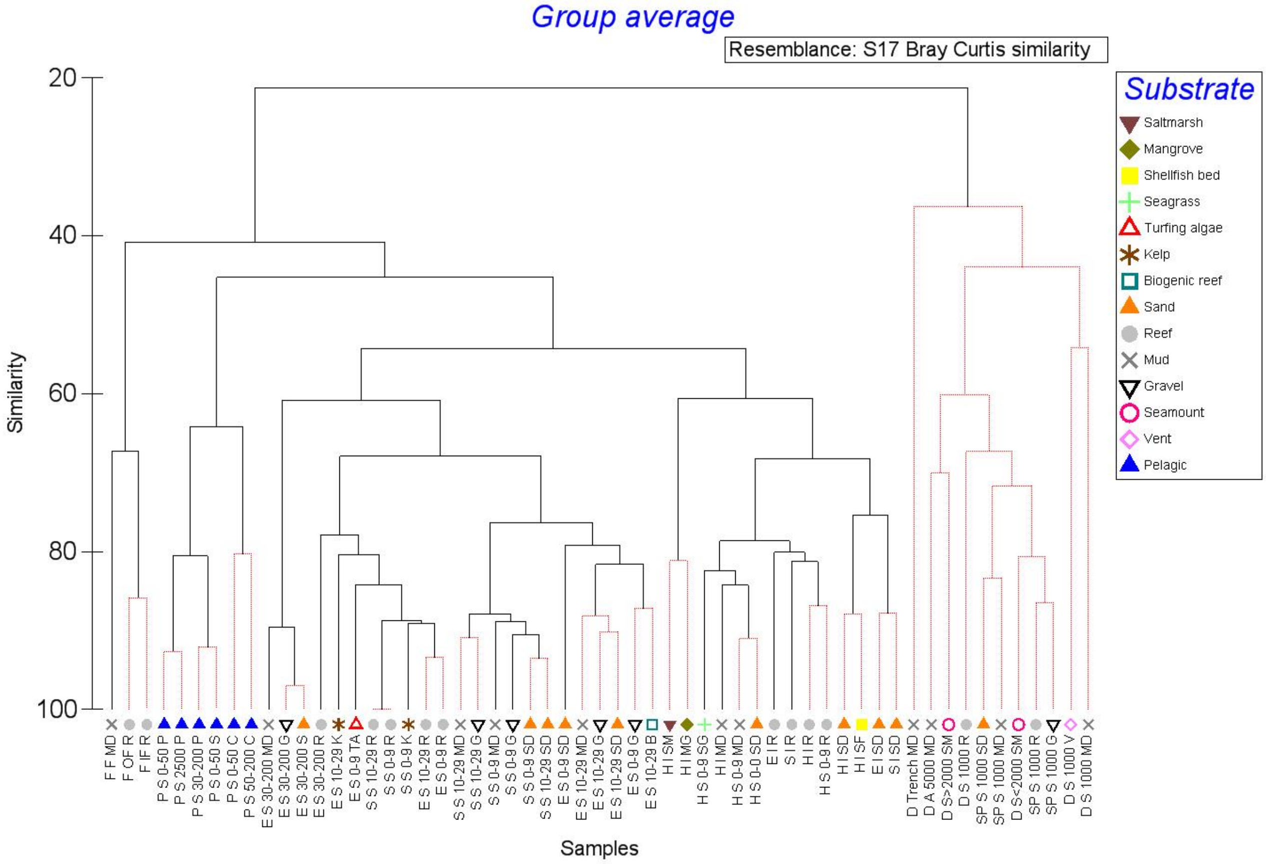


Figure 16: CLUSTER analysis of habitats across threats using the Bray Curtis similarity index to determine the tendency for habitats classified according to their substrate type to group together on the basis of their mean weighted vulnerability score. Habitats connected by red lines cannot be significantly differentiated (SIMPROF test, p < 0.05). See Table 10 for explanation of sample codes.

3.2 Spatial intensity of threats

In Appendix 4 we have compiled information regarding the spatial intensity of those few threats where information was readily available from a single source at a usefully small spatial scale so that at some later point maps of threat intensity could overlay maps of habitat vulnerability. Available effort was put into those threats that were the highest ranking in the vulnerability assessment (see section 3.1) and we present them in order of decreasing rank. However, for many threats the information remains dispersed among different institutions (e.g. regional councils) and/or is not available in an electronic format (Table 12). Collation and entering of these data into an electronic database would be a slow and expensive process and was beyond the capability of this project to support. For sixteen mainly low ranking threats relevant information about their spatial intensity is not yet available from any source.

Table 12: Anthropogenic threats to New Zealand marine habitats and the location of the spatial intensity information regarding those threats. DOC = Department of Conservation, MNZ = Maritime New Zealand, NIWA = National Institute of Water & Atmospheric Research.

Threat	Location of spatial intensity information
Algal blooms - both toxic and massive	This report
Anchoring	Not yet available
Aquaculture: Benthic accumulation of debris	Regional Councils
Aquaculture: Increase in habitat complexity	Regional Councils
Aquaculture: Decrease in primary production	Regional Councils
Ocean acidification	This report
Climate change: Increased sea temperature	This report
Climate change: Increased storminess	This report
Climate change: Change in currents	Not yet available
Climate change: Rise in sea-level	This report
Climate change: Increased stratification	Not yet available
Climate change: Increased intertidal temperature	NIWA
Climate change: UV increase	Not yet available
Climate change: Altered rainfall	NIWA
Ecotourism: Diving	Not yet available
Ecotourism: Changes in fish and invertebrate behaviour	Not yet available
Ecotourism: Marine mammal watching	DOC
Ecotourism: Noise	Not yet available
Ecotourism: Trampling	Not yet available
Ecotourism: Vehicles	Not yet available
Engineering: Dumping of dredge spoils	Regional Councils and MNZ
Engineering: Reclamation	Regional Councils
Engineering: Sand / gravel abstraction	Regional Councils
Engineering: Dredging	Regional Councils
Engineering: Causeways	Regional Councils
Engineering: Pile moorings/markers	Regional Councils
Engineering: Piled wharfs/sheds	Regional Councils
Engineering: Seawalls	Regional Councils
Engineering: Mineral extraction - surface suction	MNZ
Engineering: Pontoons	Regional Councils
Engineering: Minerals extraction - other methods	MNZ
Engineering: Mineral extraction - deep hole extraction	MNZ
Fishing: Bottom trawling	This report
Fishing: Dredging	This report
Fishing: Line fishing	Ministry of Fisheries
Fishing: Trapping	Ministry of Fisheries
Fishing: Long-lining	This report
Fishing: Shellfish gathering	Ministry of Fisheries
Fishing: Set netting	This report
Fishing: Seaweed gathering	Not yet available
Fishing: Abalone gathering	Ministry of Fisheries
Fishing: Pelagic high bycatch	Ministry of Fisheries
Fishing: Spear fishing	Not yet available
Fishing: Pelagic low bycatch	Ministry of Fisheries
Increased turbidity	This report
Invasive species: Space occupiers, competitors	This report
Invasive species: Disease	Not yet available

Pollution: Oil or oil products	This report and MNZ
Pollution: Sewage	Regional Councils
Pollution: Nitrogen and phosphorus	NIWA
Pollution: Heavy metals	Regional Councils
Pollution: Pesticides including PCBs	Regional Councils
Pollution: Herbicides	Regional Councils
Pollution: Plastic	Not yet available
Pollution: Acoustic discharges / guns	Not yet available
Pollution: Electromagnetic discharges	Regional Councils
River inputs: Increased sediment loading	This report
River inputs: Increased flow	This report
River inputs: Decreased sediment loading	NIWA
River inputs: Decreased flow	NIWA
River inputs: Dampening of flows	NIWA
Shipping: Grounding, sinking	MNZ
Shipping: Noise	MNZ
Shipping: Animal strikes	MNZ
Spatial closures to fishing	DOC

DISCUSSION AND CONCLUSIONS

We have undertaken the first comprehensive assessment of the threats from human activities to marine habitats within New Zealand's EEZ. Our expert assessment approach follows that of the global assessment of threats to marine ecosystems undertaken by Halpern et al. (2007) and is equivalent to a level 1 assessment within an environmental risk assessment for effects of fishing (ERAEF) framework (Hobday et al. 2006, Smith et al. 2007) but considered all threats to marine habitats, not just those from fishing activities. An assessment approach using experts was necessary because of the absence of extensive published information for all but a small subset of the potential approximately 4000 interactions between hazardous human activities and marine habitats.

In undertaking the assessment we attempted to minimise bias for or against particular habitats and threats by targeting experts with known expertise in particular habitats, obtaining at least five assessments for each habitat and by requesting that each expert evaluate each listed threat to the habitat assessed. Moreover, by requesting that for each threat assessed for a habitat the expert provide an indication of the quality of information used in the assessment we could ensure that poorly supported assessments were down-weighted. Overall, more than 50% of assessments for each habitat had the same modal score, indicating a satisfactory degree of consistency among experts. However, despite our best attempts, deep ocean pelagic habitats, slope canyon, reef and gravel habitats, outer shelf reef, sand, and mud habitats, as well as fiord habitats had fewer than the target of five expert responses. Thus, assessments for these habitats should be interpreted cautiously.

Our study provides evaluations of New Zealand's marine habitats most vulnerable to each threat as well as ranking the magnitude of the threats affecting each habitat. Additionally, by averaging over all habitats we provide a ranked list of threats to New Zealand marine ecosystems, and by averaging across all threats we provide a list of habitats ranked by vulnerability status.

We also characterised each threat as largely stemming from global human activities, catchment based activities, human activity directly in the sea or stemming from a mixture of two or more of these. The two top threats, 83% of the top six threats, 67% of the top twelve threats and over half of the twenty-six threats ranking 19= or higher fully, or in part, stem from human activities external to the marine environment itself and indicate the complexity and potential difficulty of mitigating the effects of these threats on New Zealand marine habitats.

By a considerable margin, the highest scoring threat over all marine habitats was ocean acidification, a consequence of higher CO_2 levels in the air and sea stemming from the burning of fossil fuels globally. However, the certainty score for this threat was the lowest indicating that the potential for widespread change is high but that full knowledge of the impacts from ocean acidification is yet to emerge. Ocean acidification is increasingly being recognised as a major threat to marine systems worldwide (Brierley & Kingsford 2009, Doney 2010). In the 2005 millennium ecosystem assessment this threat is not specifically addressed (Millennium Ecosystem Assessment 2005a and b). Halpern et al. (2007) ranked ocean acidification as the fourteenth highest threat in their global assessment. More recently Teck et al. (2010) ranked it as their top threat to temperate north-eastern Pacific Ocean marine ecosystems influenced by the Californian Current. Coincidently ocean acidification had the same mean vulnerability score in this project and in Teck et al. (2010). The magnitude of the threat of ocean acidification stems from its potential impact on almost every ecosystem and to most organisms, its persistency and the potential slow habitat recovery times. Less clear is the degree that marine organisms may adapt to slowly changing pH over the next century. This is reflected by our experts assigning habitat susceptibility the lowest score for all the vulnerability factors assessed for ocean acidification (Table 10). Around New Zealand the threat from ocean acidification is highest in the cooler waters to the south and least in the warm waters to the north-east (see Figure A4.1) because of the greater ability of cooler waters to absorb CO_2. Seamount summits because they lie in shallower waters with higher aragonite saturation states may provide a refuge from acidification for species that otherwise only occur on deeper more greatly affected habitats (Tittensor et al. 2010).

The second highest overall scoring threat was rising sea temperatures resulting from global climate change. Halpern et al. (2007) and Teck et al. (2010) also rank this threat highly; at first and third respectively. Like ocean acidification, increasing sea temperatures threaten New Zealand's marine habitats because of the potential impact on almost every ecosystem (see Figure A4.2) and to most organisms, its persistency and the potential slow habitat recovery times. Adaptation to higher sea temperatures over the next 50–100 years may be possible for some short generation, high fecundity species. Some species may move to deeper cooler waters, and the northern boundary of others may retreat southwards. Some northerly distributed species and habitats, such as mangrove forests and sub-tropical reef fish and invertebrates, could be advantaged by rising sea temperatures and their distributions may extend further southwards as has occurred in southeast Australia (Hobday et al. 2006). Increasing sea temperatures, reduces the saturation of CO_2 in seawater, and to some degree nullifies the effects of acidification (Brierley & Kingsford 2009). The other seven threats deriving from global climate change all ranked 19= or higher in our study and indicate the importance of international threats to New Zealand's marine ecosystems (Hoegh-Guldberg & Bruno 2010).

Human activities in catchments that discharge into the coastal marine environment were among some of the highest scoring threats to New Zealand's marine habitats. Foremost was increased sedimentation resulting from changes in land use. It was the third equal highest ranked threat over all habitats and was the highest ranked threat for five coastal habitats including harbour intertidal mud and sand, subtidal mud, seagrass meadows and kelp forest. Sedimentation rates in New Zealand's marine environment have generally increased seven to ten fold since humans settled 750 years ago and removed about 75% of the near continuous forest cover (Wilmshurst 1997, Goff 1997, Wilmshurst et al. 1999, Ewers et al. 2006, Gomez et al 2007). Sedimentation was also ranked highly by Halpern et al. (2007) in their global assessment but not by Teck et al. (2010) in the north-east Pacific Ocean. Its impact on coastal habitats is the focus of recent New Zealand research (Thrush et al. 2004, Lohrer et al. 2006, Morrison et al. 2009). Other human activities in catchments ranking 19= or higher include sewage discharge, increased nitrogen and phosphorus loading, and heavy metal pollution. Three other high ranking threats, algal blooms, increased turbidity and oil pollution, stem in part from human activities in catchments.

Seven of the threats to New Zealand marine habitats ranking 19= or higher were directly related to human activities in the marine environment including fishing, invasive species, coastal engineering and aquaculture. The most important of these is bottom trawling which overall was the third equal highest ranking threat. The second highest ranking marine activity was dredging for shellfish which although highly destructive usually operates over a smaller spatial scale than bottom trawling. Destructive demersal fishing methods such as bottom trawling and dredging ranked second in a global assessment of threats (Halpern et al. 2007) and fifth in the temperate north-east Pacific (Teck et al. 2010). The real and potential effects of bottom trawling and dredging on target and bycatch species as well as benthic habitats are well recognised in New Zealand and overseas (Dayton et al. 1995, Thrush et al. 1998, Hall 1999, Kaiser et al. 2002, Millennium Ecosystem Assessment, 2005a & b, Dulvy et al. 2006, Campbell & Gallagher 2007, Myers et al. 2007, Clark & Rowden 2009, Baird & Gilbert 2010, Donaldson et al. 2010, Clark & Tittensor 2010, Williams et al. 2010, Clark et al. in press) but remain pervasive forms of fishing. Their impact on by-catch species and benthic habitats can be greatly reduced, however, through a variety of gear modifications and fishing strategies (Hall & Mainprize 2005, Kennelly 2007).

The third highest ranking threat caused by direct activity in the marine environment is invasive species. This is a well recognised threat to New Zealand marine ecosystems and Biosecurity New Zealand, a unit within the Ministry of Agriculture and Forestry, has a mandate to prevent marine bioinvasions, monitor susceptible habitats and mitigate the effects of any successful threatening species. Our study indicated that invasive species impact forty-five New Zealand coastal and shelf marine habitats. Intertidal reefs in harbours are particularly vulnerable with a mean weighted vulnerability score of 3.0 and two further harbour and sheltered coastal reef habitats are significantly affected (Table A3.47). In our survey no benthic habitats on the slope or in the deep ocean were considered threatened by invasive species. This reflects the location of ports and that most invasive species that successfully foul ship hulls or may be carried in ballast water originate from shallow coastal habitats. Threats from marine invasive species rank lower than some other threats due to their predominately shallow coastal influence, lower functional impact and faster habitat recovery times (Table 10).

Coastal engineering works including dumping of dredge spoils and reclamation are important threats to some habitats. Shallow subtidal mud habitats on sheltered coasts and outer shelf mud habitats are significantly affected by dumping of dredge spoils while saltmarsh, mangrove forests and intertidal reefs fringing harbours and estuaries are particularly vulnerable to reclamation activities. In some harbours coastal engineering affects much of the shoreline but national data are unavailable from a single source and in many cases details exist in only in paper form making national assessment of this risk impossible within this project.

Our study indicates that generally, the number of threats to New Zealand's marine habitats declines with depth, particularly below mean depths of about 50 m (Figure 11a). Shallow coastal habitats are impacted by up to fifty-two non-trivial threats (those scoring at least 0.5) deriving from human activities, while deep water habitats are threatened by as few as two or three. Likewise, the estimated magnitude or severity of those effects declines steeply with mean depth of the habitat (Figure 11b). Shallow habitats have mean weighted vulnerability scores up to 1.2 while deepwater habitats have scores of about 0.1, over an order of magnitude difference in severity. Cluster analysis indicates that there was a strong tendency for habitats to group on the basis of their depth and exposure and to a weaker extent by their substrate. Eleven slope and deep ocean benthic habitats, including trenches, the abyssal plain, seamounts, vents, soft and hard canyons, and slope muds, sands, gravel/shell and reefs, formed the largest cluster. The remaining clusters comprised all the coastal and shelf benthic habitats plus the pelagic habitats.

Reef, sand and mud habitats in harbours and estuaries and along sheltered and exposed coasts were the most highly threatened habitats with threat scores of 1 or more (Table 9). The least threatened estuarine and harbour habitats were saltmarsh and mangrove forests with a mean threat score of 0.5 and a rank of thirty-first equal. Slope and deep water habitats were the least threatened and lowest ranked. The most threatened habitats were generally impacted by many threats and the least threatened habitats confronted by the fewest threats. Halpern et al. (2007) in their global assessment of threats to marine ecosystems and Teck et al. (2010) in their assessment of threats in the north-east Pacific also noted higher threat levels in coastal ecosystems than in deeper offshore habitats.

Over all threats, the functional impact of a threat, whether just one or a few species were affected, or the whole ecosystem was affected, was judged to have the greatest contribution to habitat vulnerability scores (Table 10). A few threats, such as highly targeted fishing methods such as trapping for lobsters, were judged to affect just a few species within a habitat. Other threats, such as bottom trawling and ocean acidification, potentially can affect the whole ecosystem. Threat frequency, whether the threat was pulsed and the timing of those pulses, or whether it was persistent, was the second greatest contribution to the vulnerability scores. Judged less important to the overall scores were habitat susceptibility and the area affected by a threat event. Recovery time was judged to have the smallest contribution to vulnerability as habitats were expected to recover from most threats relatively quickly once they ceased.

Interactions among threats

Whether the effects of different threats are additive, multiplicative (synergistic) or antagonistic is critical in assessing overall threat levels to particular habitats. Vinebrooke et al. (2004) suggest that the sign and strength of the correlation between species sensitivities to multiple stressors (threats) must be considered when predicting their impacts. Two recent reviews of experiments that have manipulated two or more environmental stressors have independently come up with similar results. Both Darling & Cote (2008) and Crain et al (2008) found that additive effects occur in about 25% of 2-way interactions, multiplicative effects in a little over a third and antagonistic effects in the remainder. However, the two studies differed in their overall assessment of interactions with Darling & Cote (2008) concluding that the observed combined actions of two stressors were on average similar to the predicted additive value. In contrast, Crain et al (2008) found that the overall interaction effect across all studies was synergistic but interaction type varied by specific stressor pair. In a review of the effects of multiple stressors on aquatic organisms, Heugens et al. (2001) found that generally organisms living close to their environmental tolerance limits were more vulnerable to additional stress. Moreover these authors found marked increases in the toxicity of chemical stressors between laboratory and relevant field situations when these interacted with environmental temperature and organism nutritional state. This indicates the need for carefully executed and paired laboratory and field experimentation to tease out the interactions among threats or stressors.

In compiling mean vulnerability scores across threats for particular habitats we have made the simplifying assumption that effects are additive. But we are aware that some threats interact in different ways. For instance, increasing sea temperatures, as it reduces the saturation of CO_2 in seawater, to some degree nullifies the effects of acidification (Brierley & Kingsford 2009). Similarly, river inputs of sediment and organic compounds can greatly influence the pH of shallow coastal waters and reverse or enhance the effects of ocean acidification depending on local circumstances (Brierley & Kingsford 2009 and references therein). In some areas climate change may increase rainfall and thus land erosion and sedimentation as well as nutrient and pollution inputs into coastal seas (Millennium Ecosystem Assessment

2005 a, b). In other places reduced rainfall may cause the opposite to occur. If sufficient information regarding threat interactions becomes available the mean vulnerability scores across threats for particular habitats estimated in this report could at some later date be recompiled using a different interaction term.

Survey refinement

Feedback from respondents suggests that the habitats and threats used in the assessment should be further refined if another similar survey takes place sometime in the future. For instance, fiord rock walls could be consolidated into one habitat, rather than two, leaving outer rockwalls to fall within the broader category of exposed rocky reefs. There was a request to include soft-sediment mussel beds as a separate habitat type in harbours, and in sheltered and exposed coasts. Similarly, it was suggested that hot vents and cold seeps should be split into separate habitats as they occur in very different localities.

Similarly with regard to threats it has been suggested that the threats from invasive species should be divided to reflect the differing impacts of invasive predators, herbivores, competitors, benthic space occupiers, toxic species and diseases. There were also comments that the threat of displaced fishing activity from spatial closures was not well understood and should be rephrased or withdrawn. Some respondents noted the lack of a threat category to evaluate the impact of scientific study in the sea. Others noted that sedimentation, sewage and pollution of various forms are both chronic and episodic in nature and so could be usefully split as they differ in spatial scale, frequency, and functional impact.

These are all worthy suggestions and should be seriously considered for any future work employing a similar sampling tool. However, we consider that they do not detract seriously from the major finding of this study that clearly indicates that some human activities pose little threat to New Zealand habitats while others have the potential to seriously impact all or a number of habitats. Individual habitat evaluations clearly indicate which human activities pose the greatest threats and the average score by habitat identifies which habitats are the most threatened. Inclusion of a greater range of threats, such as scientific study and splitting of some threats into chronic and episodic types, is unlikely to change the scores or ranking of the top threats.

Spatial intensity of threats

We compiled information regarding the spatial intensity of those few threats where information was readily available from a single source at a useful small spatial scale. Available effort was put into those threats that were the highest ranking in the vulnerability assessment. However, for many threats the information remains dispersed among different institutions (e.g. regional councils) and/or is not available in an electronic format. For instance, in some harbours coastal engineering affects much of the shoreline but national data are unavailable from a single source and in many cases details exist in only in paper form making national assessment of this risk impossible under this project. Priority should be given by regional councils to entering details and locations of coastal engineering into a GIS.

Application of knowledge about the spatial intensity of threats to assessing threats to particular habitats is only possible if maps exist showing the location of habitats. Unfortunately much of this information is lacking. Detailed habitat maps for shelf depth waters exist for the Bay of Islands, Wellington’s south coast, Foveaux Strait and a few other small areas. Moreover, the location of the 10 m depth contour – an important demarcation of habitats – is lacking for some parts of the New Zealand coastline. Ongoing support for the government funded Oceans Survey 20/20 programme might eventually lead to adequate benthic habitat maps being available for use in threat assessment.

Conclusions

1. The two top threats, 83% of the top six threats, 67% of the top twelve threats and over half of the twenty-six threats ranking 19= or higher fully, or in part, stem from human activities external to the marine environment itself and indicate the complexity and potential difficulty in reducing the threat status of New Zealand marine habitats.

2. By a considerable margin, the highest scoring threat over all marine habitats was ocean acidification, a consequence of higher CO_2 levels in the air and sea stemming from the burning of fossil fuels globally.

3. The second highest overall scoring threat was rising sea temperatures resulting from global climate change.

4. Human activities in catchments that discharge into the coastal marine environment were among some of the highest scoring threats to New Zealand's marine habitats. Foremost was increased sedimentation resulting from changes in land use. It was the third equal highest ranked threat over all habitats and was the highest ranked threat for five coastal habitats including harbour intertidal mud and sand, subtidal mud, seagrass meadows and kelp forest.

5. Seven of the threats to New Zealand marine habitats ranking 19= or higher were directly related to human activities in the marine environment including fishing, invasive species, coastal engineering and aquaculture. The most important of these is bottom trawling which overall was the third equal highest ranking threat. The second highest ranking marine activity was dredging for shellfish which although highly destructive usually operates over a smaller spatial scale than bottom trawling.

6. The third highest ranking threat caused by direct activity in the marine environment is invasive species. Intertidal reefs in harbours are particularly vulnerable and two further harbour and sheltered coastal reef habitats are significantly affected. In our survey no benthic habitats on the slope or in the deep ocean were considered threatened by invasive species. The threat from marine invasive species rank lower than some other threats due to its predominately shallow coastal influence, lower functional impact and faster habitat recovery times

7. Coastal engineering works including dumping of dredge spoils and reclamation are important threats to some habitats. Shallow subtidal mud habitats on sheltered coasts and outer shelf mud habitats are significantly affected by dumping of dredge spoils while saltmarsh, mangrove forests and intertidal reefs fringing harbours and estuaries are particularly vulnerable to reclamation activities.

8. Our study indicates that generally, the number of threats to New Zealand's marine habitats declines with depth, particularly below mean depths of about 50 m (Figure 25a). Shallow coastal habitats are impacted by up to fifty-two non-trivial threats deriving from human activities, while deep water habitats are threatened by as few as two or three. Likewise, the estimated magnitude or severity of those effects declines steeply with mean depth of the habitat.

9. Reef, sand and mud habitats in harbours and estuaries and along sheltered and exposed coasts were the most highly threatened habitats Slope and deep water habitats were among the least threatened and lowest ranked.

10. Over all threats, the functional impact of a threat, whether just one or a few species were affected, or the whole ecosystem was affected, was judged to have the greatest contribution to habitat vulnerability scores. Threat frequency, whether the threat was pulsed and the timing of those pulses, or whether it was persistent, was the second

greatest contribution to the vulnerability scores. Judged less important to the overall scores were habitat susceptibility and the area affected by a threat event. Recovery time was judged to have the smallest contribution to vulnerability as habitats were expected to recover from most threats relatively quickly once they ceased.

11. Detailed electronically available information on the spatial intensity of threats in New Zealand waters is readily available for only 20% of threats. For many threats the information remains dispersed among different institutions and/or is not available in an electronic format. Lack of detailed habitat maps for most of New Zealand's territorial seas and EEZ prevents the matching of threat intensity information to habitat locations.

MANAGEMENT IMPLICATIONS

The results of our study may be useful in identifying which threats to New Zealand's marine ecosystems require the first and greatest management response, which habitats should be the first focus for management action and what component (spatial scale, frequency etc) of the habitat-threat interaction is driving the response. This utility may be of value equally to agencies managing aspects of the marine environment at the local scale (say within a particular harbour or bay), regional scale (e.g. Hauraki Gulf) or at the national scale.

Because so many of the top threats to New Zealand marine habitats stem from human activities external to the marine environment reducing their impact is likely to be complex and difficult. There is likely to be little or nothing New Zealand marine managers can do to directly control ocean acidification or any of the threats stemming from global climate change. However, we can and should document their impacts on marine habitats and deliver these results to our politicians and bureaucrats negotiating the global control of greenhouse gases.

There is more hope for better management and control of catchment and marine based threats to marine habitats as these are under New Zealand's jurisdiction. Regional councils and unitary authorities have responsibility for management of catchments and coastal seas under the Resource Management Act (RMA), the Ministry of Fisheries has responsibility for mitigating the effects of fishing and DoC has responsibility for management of protected and threatened species and protected areas. These agencies need to work collaboratively if they wish to reduce the threat status of marine habitats. Success in this area may enable our marine ecosystems to better withstand the global threats of ocean acidification and climate change that are highly likely to intensify throughout this century.

The approach used in this study of breaking down the impact of threats on marine habitats into five categories and scoring these independently to assemble an overall assessment weighted by the level of knowledge available to undertake the evaluation could be used regionally or locally within a region to assess the vulnerability of a specific patch of habitat to the particular threats affecting it. This would provide decision makers with a transparent and repeatable tool to assess the current vulnerability of habitats in their region, determine the likely impact of a new threat and monitor the threat status of habitats over time. We are currently incorporating a version of this assessment approach into a tool for use by regional councils.

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Appendix 1: Instructions provided to each of the experts participating in the assessment of habitat vulnerability.

Project overview and matrix structure

This matrix is intended as a tool for systematically assessing the impact of the suite of human influences on New Zealand marine habitats. The framework is designed to solicit the opinions of leading experts from New Zealand and overseas who specialize in these habitats. Guidelines for contributing to the matrix are intended to make the process quantifiable, repeatable, and transparent.

This project, funded by the Ministry of Fisheries, builds upon efforts by Halpern et al (2007, 2008)[3, 4] who created a global map of human influence on particular ecosystems in part by soliciting expert opinion from around the world. While very useful from a global perspective, the focus of Halpern et al's research was too large to be useful at a New Zealand scale, did not include all marine habitats of New Zealand interest and only two New Zealand experts (one on rocky reefs and one on soft sediments) participated in their survey. Consequently we are largely reusing Halpern et al's (2007, 2008) criteria, applying them to the New Zealand situation and seeking input on threats to New Zealand marine habitats from >100 New Zealand experts and overseas experts with substantial New Zealand experience.

We have identified sixty-five potentially hazardous human activities in New Zealand's marine waters that may affect sixty-one identifiable marine habitats. In the absence of extensive published information for all but a small subset of the 3,956 potential interactions of hazardous activities and marine habitats we are adopting a methodology that uses expert knowledge in a quantifiable way to assess the relative impacts of threats for which the experts have direct experience, have knowledge of the specialist literature and/or have access to relevant data that does exist in the public domain.

We focus on the vulnerability of each habitat type to each particular threat. Each habitat-by-threat combination will be given a vulnerability score, devised according to the variables described below. Those scores ultimately will be used as multipliers to modify New Zealand maps of threat intensity/ frequency by habitat type, reflecting the relative impact of particular threats across different habitats around the country. This last step is contingent on additional funding becoming available through the Ministry of Fisheries.

We see vulnerability as the combination of multiple factors that ultimately affect the scale, severity and persistence of the impacts of a threat on a habitat. In the Habitat Vulnerability Matrix, you will rate the ***spatial scale***, ***frequency*** and ***functional impact*** of the threat in the given habitat as well as the ***susceptibility*** of the habitat to the threat and the ***recovery time*** of the habitat following disturbance. We have set a quantitative scale for each of these factors. We also include a measure of ***certainty*** that allows you to qualify your rankings with the level of confidence you have in your responses (see Table 1). The six factors and the scale for each are defined and discussed in more detail below.

[3] Halpern et al (2007). Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology Volume 21, No. 5, 1301–1315

[4] Halpern et al (2008). A global map of human impacts on marine ecosystems. Science 319: 948-952

Question Fields in the Survey

- **Identification information**
  - Name – Please list your name as you would like to be acknowledged. The person identified should be the primary assessor of all recorded vulnerability indicator scores.
  - Address– This questionnaire may have been passed on to you through our initial contact. Please provide your email address so that we may contact you if need be and so that we can send you a final report when it is available.

- **Habitat** – *the habitat to which an expert assessment applies*

Indicate the habitat for which you are making the vulnerability assessment. If you have expertise in multiple habitats, please fill out separate sheets for each habitat. Please select a habitat that best fits the one you have experience with from the list of habitats provided. If we have not listed a habitat, there is a space at the bottom right of the list of habitats for you to specify a habitat we have not listed. There is space provided for you to list specific locations you are considering if you do not feel qualified to discuss this habitat across the entire New Zealand region or if habitats are not uniformly vulnerable to potential threats across New Zealand. Note we are separately gathering data on the spatial distribution of different impacts so please rate a habitat on its average vulnerability to different impacts even if some places with this habitat are heavily impacted while other places are pristine.

Threat Effects

You have been asked to assess the vulnerability of a particular habitat(s) to each threat based on your experience and/or you knowledge of the literature and unpublished data. In all cases, please use your best judgment, drawing on published and unpublished empirical data, experiments, reviews, and personal experience in the field to assess vulnerability of your study habitat. Please indicate the habitat you are assessing and rate each of the following indicators using the guidelines given below, providing notes and/or documentation to support your assessment as you feel appropriate. If the threat does not apply to the habitat you are thinking of, you should still fill out the certainty category to indicate how confident you are of your answer.

- **Area of consequence** – *the average spatial scale at which a given threat event impacts the habitat*

First you will assign the average spatial scale at which the threat event acts within this ecosystem in the New Zealand region. This includes both direct and indirect impacts (see examples below). Scale will be measured as area (in km^2) and scored on the following scale:

Scale of impact: No threat
$< 1\ km^2$
$1\text{-}10\ km^2$
$10\text{-}100\ km^2$
$100\text{-}1000\ km^2$
$1000\text{-}10,000\ km^2$
$> 10,000\ km^2$

This is meant to measure the scale at which an event of a threat acts, not the cumulative or aggregate effect on the entire ecosystem. So, for example, a single pass of a demersal trawl covers about 1-10 km^2, while demersal trawling impacts thousands of km^2 of continental shelf habitat each year. It is the first scale that we are interested in. The second scale will get captured by our mapping efforts when we use data on the distribution of trawling (in this example) around New Zealand. Consider another example where dredging or construction of a causeway across a bay mouth directly impacts only a small area but dramatically affects tidal flow into the bay. In this case, the scale of the threat would be the entire bay.

◆ **Frequency** – *the average frequency of the threat within a given habitat*

As for spatial scale, you will report the average temporal scale over which the threat impacts your habitat. Frequency will be scored on the following scale:

Frequency of impact: Never occurs
Rare
Occasional
Annual or regular
Persistent

Rare impacts are those that are so infrequent that a species or system could not acclimate or adapt to them (e.g. catastrophic oil spills). Occasional impacts are frequent enough for adaptation, but irregular in nature (e.g. toxic). Annual or regular impacts are frequent and often seasonal or periodic in nature (e.g. changes in temperature associated with ENSO events, nutrient and sediment runoff events associated with seasonal rains). Persistent impacts are more or less constant year-round (e.g. shading effects of large pile wharfs, reclamations). As with spatial scale, the focus here is on the average length of the source of the threat, not the ecosystem response. For example, consider a case where overfishing of top predators is a periodic phenomenon in a given ecosystem (i.e., fishing fleets moved on to other areas or ecosystems), but its effects are persistent. This would get ranked as occasional; our recovery category below would be used to describe the time it would take for the habitat to recover from this threat. If different threat factors within a threat type have different frequencies, use an average value as your answer.

◆ **Functional impact** – *the primary level at which a threat acts within a given ecosystem*

For each threat, you will first assess what the primary impact of that threat is within your study ecosystem. In other words, what is affected? One or a few species, a single trophic level, more than one trophic level, or the entire community and its associated habitat structure? Extent of impact is scored on the following scale:

No impact
Species (single or multiple)
Single trophic level
> 1 trophic level
Entire community, including habitat structure

For example, if you were evaluating the vulnerability of biogenic reefs to climate change-induced acidification, the primary target of the threat would be corals, tube worms, calcareous algae or other carbonate skeleton-building organisms. Because these organisms provide biogenic habitat upon which many other species depend, this is considered an impact to the entire community, not just a species level impact. Similarly, overfishing that affects a key species or group of species may be considered an impact to the entire community if it is known to lead to broad-scale trophic cascades within the system of interest. “Species” can be used for single or multiple species, e.g. ship strikes impact several species of whales. Single and multiple trophic level ranks should be used when the threat broadly impacts multiple species within a trophic level(s), fundamentally changing the structure of that trophic level, but the impact does not have indirect effects on ecosystem function. For example, ecotourism and associated moorings and anchor damage may impact many species of sessile invertebrates within the same trophic level without cascading effects to the rest of the ecosystem (single trophic level), while hook-and-line fishing may remove huge numbers of species from several trophic levels but leave the habitat structure and associated plant and algal biomass intact (>1 trophic level).

◆ **Susceptibility –** *the average tendency of the habitat or ecosystem to change state in response to a threat*

Here we are asking you to rate the average change in the state of a habitat in response to a threat event. Because of the difficulty of developing a common metric that could be used across multiple levels of organization from species to ecosystem across threat by habitat combinations, we have adopted the approach of Halpern et al (2007) and used qualitative ranks for this vulnerability measure. The ranks refer to the susceptible components that respond to a threat (i.e. the functional level identified in the section above). Susceptibility is scored on the following scale:

Not susceptible
Low
Medium
High
Extreme

For instance, shallow subtidal sediment habitats on exposed coasts may be rather resistant to the disturbance of a bottom trawl because it is not unlike the regular disturbance imposed by storms. On the other hand this same habitat may be moderately susceptible to the effects of toxic algal blooms that kill the majority of sedentary benthic biota. A highly susceptible habitat may be biogenic calcareous reefs to the effects of acidification; this is rated a step down from extreme susceptibility however, as there may be some capacity for adaptation. An example of an extremely susceptible habitat to a threat is deep sea coral habitat to bottom trawling, as the slightest occurrence of the threat will cause a massive change in this habitat.

◆ **Recovery time** – *the average time required for the species, trophic level(s), or entire community to return to its 'natural' state following disturbance*

Next, rate the average time required for the affected species, trophic level(s), or entire community to return to its former state following disturbance by a particular threat. Recovery time will be scored on the following scale:

Recovery time: Unaffected
< 1 year
1-10 years
10-100 years
> 100 years

Again, focus on average recovery time for the affected component (i.e. species, trophic level, etc.) of the habitat. Note that functional impact would be expected to be low if recovery time was short

◆ **Certainty** – *the level of certainty you have in the answers you provided for the 5 modifiers above for each threat*

Finally, provide an estimate of your general level of confidence for the answers you provide for each threat. Your level of certainty will likely vary for each threat, and so we ask you to provide this estimate for each threat. Certainty will be scored on the following scale:

Certainty: None
Low
Medium
High
Absolutely certain

When evaluating your level of certainty, consider both your familiarity with the literature and your personal experience. Absolute certainty suggests that you know of extensive empirical work or have extensive personal experience about the impact of the threat on the marine habitat. High certainty suggests that you know of good empirical work or that you have regular personal experience. Medium certainty suggests that you know of some empirical work on the topic or have some personal experience. Low certainty suggests that you know of very little empirical work. Finally no certainty at all indicates you just have a hunch about its impact. Please provide a value for this category even if you choose N/A for any of the 5 categories above, as we want to know how certain you are of these answers as well.

- **Linkages among habitats** – *Threats occurring in one habitat may cause effects in other habitats*

We are cognisant of the fact that there may be indirect effects of the loss or impairment of certain ecosystems (e.g. nursery habitats like seagrass beds) that impact other ecosystems. Please indicate in the notes section provided which other habitats are most strongly linked in this way to the habitat you have focused on here.

Interactions among threats

We recognize that most places are threatened by multiple human activities and that often the effect of these threats is multiplicative rather than simply additive. Sometimes threats may be antagonistic. Taking the most conservative course, we will assume only additive effects of threats unless you state otherwise. Any information you have on the synergistic or antagonistic effects of threats will be useful; we hope that you will add notes or documentation to this effect where appropriate. In addition, there is space at the bottom of the form for you to identify the top three threats acting in your system and note whether any of these threats act synergistically (i.e., additive or multiplicative) or antagonistically.

Additional information

- **Notes**

You may use this area of the matrix to add any notes you deem relevant. They may relate to data sources, your decision-making process, any questions you had, uncertainty in your assessment or source data, interpretation of the scores, or other matters. You may also use this space to provide supporting documentation or citations.

- **Publications, supporting documentation**

Any citations for publications, supporting documents, datasets, or websites that you can provide to this project will be greatly appreciated. Eventually, the compiled references will be part of a database and made available to participating researchers. Please send these as a separate email attachment to a.macdiarmid@niwa.co.nz or by post mail to:

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Table A1.1. Ranking system for each vulnerability measure used to assess how threats affect NZ marine habitats (based on Table 2 in Halpern et al. (2007)).

Vulnerability Measure	Category	Rank	Descriptive Notes	Example
Area (km^2) of consequence of a threat event				
	No threat	0		
	<1	1		Damage from a single anchor; small oil/ diesel spill
	1-10	2	About the size of the Leigh Marine Reserve	Single bottom trawl tow
	10-100	3		Sediment run-off from deforestation event
	100-1,000	4		Major pollution event in river enters coastal waters
	1,000-10,000	5		Invasive species arrives; major oil spill
	>10,000	6	The size of the Hauraki Gulf or larger	Sea surface temperature change
Frequency				
	Never occurs	0		
	Rare	1	Very infrequent	Major oil spill
	Occasional	2	Frequent but irregular in nature	Toxic algal bloom
	Annual or regular	3	Frequent & often seasonal or periodic	Runoff events due to seasonal rains
	Persistent	4	More or less constant year round, lasting through multiple years or decades	Reclamation or shading effects of pile wharf
Functional Impact[5]				
	No impact	0		
	Species (single or multiple)	1	One or more species in a single or different trophic level	Ship strikes on whales
	Single trophic level	2	Multiple species affected; entire trophic level changes	Over harvest of multiple species within the same trophic guild
	>1 trophic level	3	Multiple species affected; multiple trophic levels change	Over harvest of key species from multiple trophic guilds
	Entire ecosystem	4	Cascading effect that affects entire ecosystem	Increase in ocean temperature or acidification
Susceptibility				
	Not susceptible	0		
	Low	1	No significant change in biomass, structure or diversity until extreme threat levels	Trawling on shallow sediment communities on an exposed coast
	Medium	2	Moderate intensities or frequencies causes change	Effects of industrial pollution discharges on coastal habitats
	High	3	Threat causes significant but not catastrophic effects; some capacity for adaptation	Effects of acidification on growth of calcareous biogenic reef organisms
	Extreme	4	Slightest occurrence causes a major change	Bottom trawling on deep-sea corals
Recovery time (yrs)				
	No impact	0		
	<1	1		Kelp forest recovery after disturbance
	1-10	2		Short lived species recover from episodic toxic pollution
	10-100	3		Long-lived species recover after over-harvesting eg. right whales
	>100 or permanent	4		Deep-sea coral recovery after trawl damage; reclamation
Certainty				
	None	0	Vague hunch or gut-feeling only	
	Low	1	No empirical work exists of this interaction specifically, perhaps some general knowledge	

[5] Note that functional impact would be expected to be low if recovery time was short

Medium	2	Some empirical work exists or expert has some personal knowledge
High	3	Body of empirical work exists or the expert has direct personal research experience
Absolutely certain	4	Extensive empirical work exists or the expert has extensive personal research knowledge

APPENDIX 2. ANTHROPOGENIC THREATS TO NEW ZEALAND MARINE ENVIRONMENTS BY HABITAT

Table A2.1: Anthropogenic threats to harbour and estuarine salt marshes and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Salt marsh

Threat	Threat Source	Mean weighted vulnerability score
Engineering: Reclamation	Marine	3.4
Climate change: Rise in sea-level	Global	3.3
Engineering: Causeways	Marine	2.6
River inputs: Increased sediment loading	Catchment	2.3
Pollution: Oil or oil products	Mixed	2.1
Climate change: Increased intertidal temperature	Global	1.5
Pollution: Nitrogen and phosphorus	Catchment	1.4
Pollution: Sewage	Catchment	1.4
Pollution: Herbicides	Catchment	1.4
Invasive species: Space occupiers, competitors	Marine	1.4
River inputs: Decreased sediment loading	Catchment	1.3
Climate change: Increased storminess	Global	1.1
Pollution: Heavy metals	Catchment	1.1
Vehicles on beaches	Marine	1.0
River inputs: Increased flow	Catchment	1.0
Engineering: Seawalls	Marine	0.9
River inputs: Decreased flow	Catchment	0.9
Climate change: Altered rainfall	Global	0.8
Pollution: Pesticides including PCBs	Catchment	0.7
Ocean acidification	Global	0.7
Climate change: Increased sea temperature	Global	0.6
Engineering: Piled wharfs/sheds	Marine	0.6
River inputs: Dampening of flows	Catchment	0.5
Climate change: Change in currents	Global	0.4
Climate change: UV increase	Global	0.4
Engineering: Pontoons	Marine	0.4
Tourism: Reef trampling	Marine	0.4
Ecotourism: Noise	Mixed	0.2
Pollution: Plastic	Mixed	0.1
Invasive species: Disease	Marine	0.1
Climate change: Increased stratification	Global	0.1

Table A2.2: Anthropogenic threats to harbour and estuarine mangrove forests and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Mangrove forest

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Rise in sea-level	Global	3.3
Engineering: Reclamation	Marine	3.0
Engineering: Causeways	Marine	2.0
River inputs: Increased sediment loading	Catchment	1.8
Climate change: Increased storminess	Global	1.7
Pollution: Nitrogen and phosphorus	Catchment	1.5
Pollution: Heavy metals	Catchment	1.4
Pollution: Pesticides including PCBs	Catchment	1.4
Pollution: Sewage	Catchment	1.3
Pollution: Oil or oil products	Mixed	1.3
Climate change: Increased intertidal temperature	Global	1.2
Engineering: Seawalls	Marine	1.2
Climate change: Increased sea temperature	Global	1.1
Ocean acidification	Global	1.1
Pollution: Herbicides	Catchment	1.1
Climate change: Altered rainfall	Global	1.1
Engineering: Piled wharfs/sheds	Marine	1.0
River inputs: Decreased sediment loading	Catchment	0.9
Climate change: Change in currents	Global	0.8
River inputs: Dampening of flows	Catchment	0.7
Vehicles on beaches	Marine	0.6
River inputs: Decreased flow	Catchment	0.5
Climate change: UV increase	Global	0.5
Pollution: Plastic	Mixed	0.5
Invasive species: Disease	Marine	0.5
River inputs: Increased flow	Catchment	0.4
Engineering: Pontoons	Marine	0.4
Invasive species: Space occupiers, competitors	Marine	0.3
Fishing: Set netting	Marine	0.3
Fishing: Shellfish gathering	Marine	0.2
Fishing: Line fishing	Marine	0.2
Tourism: Reef trampling	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
Engineering: Pile moorings/markers	Marine	0.1
Algal blooms - both toxic and massive	Marine	0.1
Aquaculture: Decrease in primary production	Marine	0.1
Climate change: Increased stratification	Global	0.1
Engineering: Dumping of dredge spoils	Marine	0.1
Anchoring	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.3: Anthropogenic threats to harbour and estuarine intertidal mud habitat and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Intertidal mud

Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased sediment loading	Catchment	2.8
Engineering: Causeways	Marine	2.8
Pollution: Heavy metals	Catchment	2.5
Pollution: Sewage	Catchment	2.5
Fishing: Shellfish gathering	Marine	2.4
Climate change: Rise in sea-level	Global	2.3
Climate change: Increased sea temperature	Global	2.3
Climate change: Increased intertidal temperature	Global	2.2
Engineering: Reclamation	Marine	2.2
Climate change: Increased storminess	Global	2.0
River inputs: Increased flow	Catchment	2.0
Aquaculture: Benthic accumulation of debris	Marine	2.0
Pollution: Nitrogen and phosphorus	Catchment	1.9
Ocean acidification	Global	1.7
Engineering: Pile moorings/markers	Marine	1.7
Engineering: Piled wharfs/sheds	Marine	1.7
Engineering: Pontoons	Marine	1.7
Pollution: Oil or oil products	Mixed	1.6
Engineering: Seawalls	Marine	1.5
Climate change: Change in currents	Global	1.5
Invasive species: Space occupiers, competitors	Marine	1.3
Pollution: Pesticides including PCBs	Catchment	1.3
Pollution: Herbicides	Catchment	1.3
River inputs: Decreased flow	Catchment	1.3
Climate change: Altered rainfall	Global	1.1
Climate change: UV increase	Global	1.1
Algal blooms - both toxic and massive	Marine	1.0
Increased turbidity	Mixed	1.0
Fishing: Dredging	Marine	0.9
River inputs: Decreased sediment loading	Catchment	0.9
Aquaculture: Increase in habitat complexity	Marine	0.8
Fishing: Bottom trawling	Marine	0.8
Engineering: Dredging	Marine	0.7
Aquaculture: Decrease in primary production	Marine	0.7
Climate change: Increased stratification	Global	0.6
Pollution: Plastic	Mixed	0.6
Invasive species: Disease	Marine	0.6
Fishing: Seaweed gathering	Marine	0.6
Shipping: Grounding, sinking	Marine	0.5
Spatial closures to fishing	Marine	0.5
Fishing: Line fishing	Marine	0.5
River inputs: Dampening of flows	Catchment	0.5
Fishing: Set netting	Marine	0.4
Engineering: Dumping of dredge spoils	Marine	0.4
Shipping: Noise pollution	Marine	0.4
Shipping: Animal strikes	Marine	0.4

Vehicles on beaches	Marine	0.3
Anchoring	Marine	0.3
Pollution: Electromagnetic discharges	Marine	0.3
Tourism: Reef trampling	Marine	0.3
Engineering: Sand / gravel abstraction	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Fishing: Abalone gathering	Marine	0.1
Fishing: Trapping	Marine	0.1
Engineering: Mineral extraction - surface suction	Marine	0.1
Fishing: Spear fishing	Marine	0.1
Ecotourism: Diving	Marine	0.1

Table A2.4: Anthropogenic threats to harbour and estuarine intertidal sand habitat and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Intertidal sand

Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased sediment loading	Catchment	2.9
Ocean acidification	Global	2.6
Climate change: Rise in sea-level	Global	2.6
Climate change: Increased intertidal temperature	Global	2.1
Engineering: Causeways	Marine	2.0
Fishing: Shellfish gathering	Marine	1.9
Pollution: Heavy metals	Catchment	1.9
Engineering: reclamation	Marine	1.8
Climate change: Increased sea temperature	Global	1.7
Climate change: Increased storminess	Global	1.6
Pollution: Sewage	Catchment	1.3
Pollution: Nitrogen and phosphorus	Catchment	1.3
Vehicles on beaches	Marine	1.2
Pollution: Oil or oil products	Mixed	1.1
River inputs: Increased flow	Catchment	1.1
Engineering: Pile moorings/markers	Marine	1.1
Engineering: Piled wharfs/sheds	Marine	1.1
Invasive species: Space occupiers, competitors	Marine	1.0
Engineering: Seawalls	Marine	1.0
Pollution: Pesticides including PCBs	Catchment	0.8
Climate change: Change in currents	Global	0.8
Engineering: Sand / gravel abstraction	Marine	0.8
Climate change: Altered rainfall	Global	0.7
Algal blooms - both toxic and massive	Marine	0.7
Aquaculture: Benthic accumulation of debris	Marine	0.6
Climate change: UV increase	Global	0.6
Pollution: Herbicides	Catchment	0.6
Engineering: Dredging	Marine	0.5
Engineering: Pontoons	Marine	0.5
Shipping: Grounding, sinking	Marine	0.5
River inputs: Decreased flow	Catchment	0.5
Spatial closures to fishing	Marine	0.5
Climate change: Increased stratification	Global	0.4

Pollution: Plastic	Mixed	0.4
Invasive species: Disease	Marine	0.4
Fishing: Seaweed gathering	Marine	0.4
Increased turbidity	Mixed	0.4
Fishing: Dredging	Marine	0.3
Fishing: Set netting	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Engineering: Dumping of dredge spoils	Marine	0.2
Fishing: Line fishing	Marine	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Aquaculture: Increase in habitat complexity	Marine	0.2
Fishing: Bottom trawling	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Fishing: Abalone gathering	Marine	0.1
Anchoring	Marine	0.1
Fishing: Trapping	Marine	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Shipping: Noise pollution	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Tourism: Reef trampling	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1

Table A2.5: Anthropogenic threats to harbour and estuarine cockle beds and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Cockle bed

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.2
River inputs: Increased sediment loading	Catchment	2.8
Climate change: Increased intertidal temperature	Global	2.8
Climate change: Rise in sea-level	Global	2.8
Fishing: Shellfish gathering	Marine	2.3
Engineering: Causeways	Marine	2.2
Climate change: Increased sea temperature	Global	1.9
Pollution: Heavy metals	Catchment	1.8
Climate change: Increased storminess	Global	1.6
Pollution: Oil or oil products	Mixed	1.6
Pollution: Sewage	Catchment	1.6
Engineering: reclamation	Marine	1.5
Engineering: Dredging	Marine	1.3
Pollution: Nitrogen and phosphorus	Catchment	1.2
River inputs: Increased flow	Catchment	1.2
Aquaculture: Benthic accumulation of debris	Marine	1.2
Pollution: Pesticides including PCBs	Catchment	1.2
Climate change: UV increase	Global	1.1
Engineering: Pile moorings/markers	Marine	1.1
Engineering: Piled wharfs/sheds	Marine	1.1
Climate change: Altered rainfall	Global	1.1

Invasive species: Space occupiers, competitors	Marine	0.9
Engineering: Dumping of dredge spoils	Marine	0.9
Climate change: Change in currents	Global	0.8
Pollution: Herbicides	Catchment	0.8
Algal blooms - both toxic and massive	Marine	0.8
Engineering: Seawalls	Marine	0.7
Engineering: Pontoons	Marine	0.7
Fishing: Dredging	Marine	0.7
Engineering: Sand / gravel abstraction	Marine	0.7
Vehicles on beaches	Marine	0.7
Fishing: Line fishing	Marine	0.5
Shipping: Grounding, sinking	Marine	0.5
Climate change: Increased stratification	Global	0.5
Pollution: Plastic	Mixed	0.5
River inputs: Decreased flow	Catchment	0.5
Fishing: Set netting	Marine	0.5
Invasive species: Disease	Marine	0.5
Fishing: Seaweed gathering	Marine	0.4
Increased turbidity	Mixed	0.4
River inputs: Decreased sediment loading	Catchment	0.4
Spatial closures to fishing	Marine	0.4
Engineering: Mineral extraction - surface suction	Marine	0.4
Aquaculture: Decrease in primary production	Marine	0.3
Aquaculture: Increase in habitat complexity	Marine	0.3
Fishing: Bottom trawling	Marine	0.3
Fishing: Abalone gathering	Marine	0.3
Anchoring	Marine	0.3
River inputs: Dampening of flows	Catchment	0.2
Fishing: Trapping	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Shipping: Noise pollution	Marine	0.2
Shipping: Animal strikes	Marine	0.1
Tourism: Reef trampling	Marine	0.1
Ecotourism: Diving	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1

Table A2.6: Anthropogenic threats to harbour and estuarine pipi beds and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Harbour and Estuaries: Pipi bed
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.4
River inputs: Increased sediment loading	Catchment	2.9
Climate change: Increased intertidal temperature	Global	2.9
Climate change: Rise in sea-level	Global	2.8
Climate change: Increased sea temperature	Global	2.4
Fishing: Shellfish gathering	Marine	2.3
Engineering: Causeways	Marine	2.1

Climate change: Increased storminess	Global	2.0
Pollution: Oil or oil products	Mixed	2.0
Pollution: Sewage	Catchment	1.9
Pollution: Heavy metals	Catchment	1.8
Engineering: reclamation	Marine	1.7
Pollution: Nitrogen and phosphorus	Catchment	1.6
River inputs: Increased flow	Catchment	1.5
Climate change: UV increase	Global	1.4
Aquaculture: Benthic accumulation of debris	Marine	1.4
Pollution: Pesticides including PCBs	Catchment	1.4
Engineering: Pile moorings/markers	Marine	1.3
Engineering: Piled wharfs/sheds	Marine	1.3
Engineering: Dredging	Marine	1.2
Invasive species: Space occupiers, competitors	Marine	1.1
Climate change: Altered rainfall	Global	1.1
Engineering: Dumping of dredge spoils	Marine	1.1
Climate change: Change in currents	Global	1.0
Pollution: Herbicides	Catchment	1.0
Engineering: Seawalls	Marine	0.9
Engineering: Pontoons	Marine	0.9
Algal blooms - both toxic and massive	Marine	0.9
Fishing: Dredging	Marine	0.9
Engineering: Sand / gravel abstraction	Marine	0.9
Fishing: Line fishing	Marine	0.6
Shipping: Grounding, sinking	Marine	0.6
Climate change: Increased stratification	Global	0.6
Pollution: Plastic	Mixed	0.6
River inputs: Decreased flow	Catchment	0.6
Fishing: Set netting	Marine	0.6
Invasive species: Disease	Marine	0.6
Fishing: Seaweed gathering	Marine	0.5
Increased turbidity	Mixed	0.5
River inputs: Decreased sediment loading	Catchment	0.5
Spatial closures to fishing	Marine	0.5
Vehicles on beaches	Marine	0.5
Engineering: Mineral extraction - surface suction	Marine	0.5
Aquaculture: Decrease in primary production	Marine	0.4
Aquaculture: Increase in habitat complexity	Marine	0.4
Fishing: Bottom trawling	Marine	0.4
Fishing: Abalone gathering	Marine	0.3
River inputs: Dampening of flows	Catchment	0.3
Anchoring	Marine	0.3
Fishing: Trapping	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Shipping: Noise pollution	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Tourism: Reef trampling	Marine	0.1
Ecotourism: Diving	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1

Table A2.7: Anthropogenic threats to harbour and estuarine intertidal reefs and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Intertidal reef

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
River inputs: Increased sediment loading	Catchment	3.3
Invasive species: Space occupiers, competitors	Marine	3.0
Engineering: reclamation	Marine	3.0
Climate change: Rise in sea-level	Global	2.4
Climate change: Increased sea temperature	Global	2.3
Fishing: Shellfish gathering	Marine	2.3
Climate change: Increased intertidal temperature	Global	2.3
Climate change: Increased storminess	Global	2.2
Climate change: Altered rainfall	Global	2.2
Climate change: UV increase	Global	2.2
Climate change: Change in currents	Global	2.1
Engineering: Causeways	Marine	2.0
Pollution: Oil or oil products	Mixed	1.9
Pollution: Heavy metals	Catchment	1.8
Pollution: Nitrogen and phosphorus	Catchment	1.8
Pollution: Sewage	Catchment	1.8
Engineering: Seawalls	Marine	1.5
Aquaculture: Benthic accumulation of debris	Marine	1.4
Fishing: Seaweed gathering	Marine	1.4
Fishing: Line fishing	Marine	1.3
Increased turbidity	Mixed	1.3
Pollution: Pesticides including PCBs	Catchment	1.3
Pollution: Herbicides	Catchment	1.3
Shipping: Grounding, sinking	Marine	1.3
Engineering: Pile moorings/markers	Marine	1.3
River inputs: Decreased sediment loading	Catchment	1.3
Spatial closures to fishing	Marine	1.3
Engineering: Dumping of dredge spoils	Marine	1.2
River inputs: Increased flow	Catchment	1.2
Climate change: Increased stratification	Global	1.2
Pollution: Plastic	Mixed	1.2
Tourism: Reef trampling	Marine	1.2
Aquaculture: Decrease in primary production	Marine	1.1
Aquaculture: Increase in habitat complexity	Marine	1.1
River inputs: Decreased flow	Catchment	1.1
Fishing: Set netting	Marine	1.0
Fishing: Abalone gathering	Marine	1.0
Fishing: Trapping	Marine	1.0
Engineering: Piled wharfs/sheds	Marine	1.0
Engineering: Pontoons	Marine	1.0
Algal blooms - both toxic and massive	Marine	0.9
Fishing: Dredging	Marine	0.9
Invasive species: Disease	Marine	0.9
Fishing: Bottom trawling	Marine	0.8
Engineering: Dredging	Marine	0.7

River inputs: Dampening of flows	Catchment	0.7
Engineering: Sand / gravel abstraction	Marine	0.6
Fishing: Spear fishing	Marine	0.5
Anchoring	Marine	0.5
Pollution: Electromagnetic discharges	Marine	0.5
Vehicles on beaches	Marine	0.4
Ecotourism: Diving	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
Fishing: Long-lining	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.2
Engineering: Mineral extraction - surface suction	Marine	0.1
Ecotourism: Noise	Mixed	0.1
Fishing: Pelagic low bycatch	Marine	0.1

Table A2.8: Anthropogenic threats to harbour and subtidal reefs and threat source, in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Subtidal reef

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.6
River inputs: Increased sediment loading	Catchment	3.2
Invasive species: Space occupiers, competitors	Marine	2.5
Climate change: Increased sea temperature	Global	2.2
Pollution: Heavy metals	Catchment	2.2
Fishing: Line fishing	Marine	2.2
Fishing: Set netting	Marine	2.1
Pollution: Nitrogen and phosphorus	Catchment	2.0
Engineering: reclamation	Marine	1.9
Pollution: Sewage	Catchment	1.9
Fishing: Shellfish gathering	Marine	1.9
Increased turbidity	Mixed	1.8
Climate change: Increased storminess	Global	1.7
Pollution: Pesticides including PCBs	Catchment	1.6
Climate change: Change in currents	Global	1.6
Engineering: Dumping of dredge spoils	Marine	1.5
Climate change: Rise in sea-level	Global	1.5
Aquaculture: Benthic accumulation of debris	Marine	1.4
Pollution: Oil or oil products	Mixed	1.4
Pollution: Herbicides	Catchment	1.4
Climate change: Altered rainfall	Global	1.4
Shipping: Grounding, sinking	Marine	1.4
Algal blooms - both toxic and massive	Marine	1.4
Fishing: Abalone gathering	Marine	1.4
Fishing: Spear fishing	Marine	1.4
River inputs: Increased flow	Catchment	1.3
Climate change: UV increase	Global	1.3
Engineering: Pile moorings/markers	Marine	1.3
Anchoring	Marine	1.3

Climate change: Increased intertidal temperature	Global	1.2
Fishing: Dredging	Marine	1.2
Climate change: Increased stratification	Global	1.2
Fishing: Trapping	Marine	1.2
Engineering: Piled wharfs/sheds	Marine	1.1
Invasive species: Disease	Marine	1.1
Aquaculture: Decrease in primary production	Marine	1.1
River inputs: Decreased sediment loading	Catchment	1.1
Fishing: Seaweed gathering	Marine	1.1
Pollution: Plastic	Mixed	1.1
Aquaculture: Increase in habitat complexity	Marine	1.1
Engineering: Dredging	Marine	1.0
Engineering: Seawalls	Marine	1.0
Spatial closures to fishing	Marine	1.0
Engineering: Pontoons	Marine	0.9
River inputs: Decreased flow	Catchment	0.9
Engineering: Causeways	Marine	0.8
Fishing: Bottom trawling	Marine	0.8
Engineering: Sand / gravel abstraction	Marine	0.7
Ecotourism: Diving	Marine	0.7
River inputs: Dampening of flows	Catchment	0.6
Pollution: Electromagnetic discharges	Marine	0.5
Tourism: Reef trampling	Marine	0.5
Shipping: Noise pollution	Marine	0.4
Fishing: Long-lining	Marine	0.4
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
Shipping: Animal strikes	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.2
Engineering: Mineral extraction - surface suction	Marine	0.1
Ecotourism: Noise	Mixed	0.1
Fishing: Pelagic low bycatch	Marine	0.1

Table A2.9: Anthropogenic threats to harbour and estuarine seagrass meadows and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Harbour and Estuaries: Seagrass meadows
Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased sediment loading	Catchment	2.9
Engineering: reclamation	Marine	2.4
Aquaculture: Benthic accumulation of debris	Marine	2.3
Engineering: Causeways	Marine	2.2
Pollution: Nitrogen and phosphorus	Catchment	2.0
Pollution: Oil or oil products	Mixed	1.9
Pollution: Herbicides	Catchment	1.8
Climate change: Increased sea temperature	Global	1.7
Ocean acidification	Global	1.7
Climate change: Increased intertidal temperature	Global	1.7
Engineering: Dredging	Marine	1.7
Climate change: Increased storminess	Global	1.6

Pollution: Sewage	Catchment	1.6
Engineering: Dumping of dredge spoils	Marine	1.6
Increased turbidity	Mixed	1.6
Climate change: Rise in sea-level	Global	1.5
Fishing: Shellfish gathering	Marine	1.5
Invasive species: Space occupiers, competitors	Marine	1.5
River inputs: Increased flow	Catchment	1.5
Climate change: UV increase	Global	1.4
Engineering: Piled wharfs/sheds	Marine	1.4
Pollution: Heavy metals	Catchment	1.3
Engineering: Seawalls	Marine	1.1
Pollution: Pesticides including PCBs	Catchment	1.1
Invasive species: Disease	Marine	1.1
Climate change: Altered rainfall	Global	1.0
Climate change: Change in currents	Global	1.0
Shipping: Grounding, sinking	Marine	1.0
Fishing: Dredging	Marine	0.9
Engineering: Pile moorings/markers	Marine	0.9
Engineering: Pontoons	Marine	0.8
Anchoring	Marine	0.8
Fishing: Bottom trawling	Marine	0.7
Fishing: Set netting	Marine	0.7
Aquaculture: Decrease in primary production	Marine	0.7
Fishing: Line fishing	Marine	0.6
Algal blooms - both toxic and massive	Marine	0.6
Engineering: Sand / gravel abstraction	Marine	0.5
Climate change: Increased stratification	Global	0.5
River inputs: Decreased sediment loading	Catchment	0.4
Fishing: Seaweed gathering	Marine	0.4
Engineering: Mineral extraction - surface suction	Marine	0.4
Spatial closures to fishing	Marine	0.4
Vehicles on beaches	Marine	0.4
Pollution: Plastic	Mixed	0.3
Aquaculture: Increase in habitat complexity	Marine	0.3
River inputs: Decreased flow	Catchment	0.3
Fishing: Abalone gathering	Marine	0.3
Fishing: Spear fishing	Marine	0.3
Fishing: Trapping	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Tourism: Reef trampling	Marine	0.2
Shipping: Noise pollution	Marine	0.2
Shipping: Animal strikes	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1
Ecotourism: Diving	Marine	0.1

Table A2.10: Anthropogenic threats to harbour and estuarine subtidal sand and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Subtidal sand

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Increased sea temperature	Global	2.7
Ocean acidification	Global	2.7
Climate change: Increased storminess	Global	2.5
River inputs: Increased sediment loading	Catchment	2.3
Pollution: Sewage	Catchment	2.1
Climate change: Increased intertidal temperature	Global	2.1
Pollution: Heavy metals	Catchment	2.0
Pollution: Nitrogen and phosphorus	Catchment	1.9
Engineering: Seawalls	Marine	1.9
Climate change: UV increase	Global	1.8
Aquaculture: Benthic accumulation of debris	Marine	1.7
Engineering: reclamation	Marine	1.6
Climate change: Rise in sea-level	Global	1.6
Fishing: Dredging	Marine	1.6
Fishing: Shellfish gathering	Marine	1.6
Engineering: Dumping of dredge spoils	Marine	1.6
Pollution: Pesticides including PCBs	Catchment	1.5
Engineering: Piled wharfs/sheds	Marine	1.5
Climate change: Altered rainfall	Global	1.5
Pollution: Oil or oil products	Mixed	1.4
Engineering: Pile moorings/markers	Marine	1.4
Fishing: Line fishing	Marine	1.4
Pollution: Herbicides	Catchment	1.3
Invasive species: Space occupiers, competitors	Marine	1.3
Engineering: Dredging	Marine	1.3
Fishing: Bottom trawling	Marine	1.2
Engineering: Causeways	Marine	1.2
Algal blooms - both toxic and massive	Marine	1.2
River inputs: Increased flow	Catchment	1.1
Climate change: Change in currents	Global	1.1
Increased turbidity	Mixed	1.1
Engineering: Pontoons	Marine	1.1
Engineering: Sand / gravel abstraction	Marine	1.1
Climate change: Increased stratification	Global	1.0
Invasive species: Disease	Marine	1.0
Pollution: Plastic	Mixed	0.9
Shipping: Grounding, sinking	Marine	0.9
Fishing: Set netting	Marine	0.8
River inputs: Decreased sediment loading	Catchment	0.7
Aquaculture: Decrease in primary production	Marine	0.7
Aquaculture: Increase in habitat complexity	Marine	0.7
River inputs: Decreased flow	Catchment	0.7
Fishing: Trapping	Marine	0.7
Fishing: Seaweed gathering	Marine	0.6
Pollution: Electromagnetic discharges	Marine	0.5
Engineering: Mineral extraction - surface suction	Marine	0.5

Spatial closures to fishing	Marine	0.5
River inputs: Dampening of flows	Catchment	0.4
Anchoring	Marine	0.4
Fishing: Abalone gathering	Marine	0.4
Fishing: Spear fishing	Marine	0.4
Tourism: Reef trampling	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Shipping: Animal strikes	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Vehicles on beaches	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Ecotourism: Diving	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.11: Anthropogenic threats to harbour and estuarine subtidal sand and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Harbour and Estuaries: Subtidal mud

Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased sediment loading	Catchment	2.7
Pollution: Heavy metals	Catchment	2.7
Climate change: Increased storminess	Global	2.5
Pollution: Sewage	Catchment	2.5
Climate change: Increased intertidal temperature	Global	2.2
Climate change: Increased sea temperature	Global	2.2
Pollution: Nitrogen and phosphorus	Catchment	2.1
Pollution: Pesticides including PCBs	Catchment	2.1
Aquaculture: Benthic accumulation of debris	Marine	2.1
River inputs: Increased flow	Catchment	2.0
Engineering: Seawalls	Marine	1.9
Pollution: Herbicides	Catchment	1.9
Engineering: reclamation	Marine	1.8
Invasive species: Space occupiers, competitors	Marine	1.8
Pollution: Oil or oil products	Mixed	1.8
Climate change: UV increase	Global	1.8
Climate change: Rise in sea-level	Global	1.7
Ocean acidification	Global	1.7
Engineering: Dredging	Marine	1.7
Fishing: Dredging	Marine	1.7
Engineering: Piled wharfs/sheds	Marine	1.6
Climate change: Change in currents	Global	1.6
Fishing: Shellfish gathering	Marine	1.6
Engineering: Dumping of dredge spoils	Marine	1.6
Climate change: Altered rainfall	Global	1.5
Engineering: Pile moorings/markers	Marine	1.4
Fishing: Bottom trawling	Marine	1.4
Engineering: Causeways	Marine	1.3
Increased turbidity	Mixed	1.2
Fishing: Line fishing	Marine	1.2
Engineering: Pontoons	Marine	1.1

Pollution: Plastic	Mixed	1.1
Algal blooms - both toxic and massive	Marine	1.1
Climate change: Increased stratification	Global	1.1
River inputs: Decreased sediment loading	Catchment	1.0
Aquaculture: Decrease in primary production	Marine	1.0
Aquaculture: Increase in habitat complexity	Marine	1.0
Engineering: Sand / gravel abstraction	Marine	0.9
River inputs: Decreased flow	Catchment	0.9
Shipping: Grounding, sinking	Marine	0.8
Invasive species: Disease	Marine	0.7
River inputs: Dampening of flows	Catchment	0.6
Fishing: Set netting	Marine	0.6
Pollution: Electromagnetic discharges	Marine	0.6
Engineering: Mineral extraction - surface suction	Marine	0.6
Fishing: Seaweed gathering	Marine	0.5
Spatial closures to fishing	Marine	0.5
Fishing: Trapping	Marine	0.5
Anchoring	Marine	0.5
Tourism: Reef trampling	Marine	0.4
Shipping: Noise pollution	Marine	0.4
Fishing: Abalone gathering	Marine	0.3
Fishing: Spear fishing	Marine	0.3
Shipping: Animal strikes	Marine	0.3
Pollution: Acoustic discharges / guns	Marine	0.3
Vehicles on beaches	Marine	0.2
Ecotourism: Diving	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.12: Anthropogenic threats to sheltered coastal sandy beaches and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Sandy beaches

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Rise in sea-level	Global	3.4
Ocean acidification	Global	3.2
River inputs: Increased sediment loading	Catchment	3.1
Engineering: reclamation	Marine	2.3
Climate change: Increased storminess	Global	2.1
Climate change: Increased intertidal temperature	Global	1.9
Climate change: Increased sea temperature	Global	1.9
Vehicles on beaches	Marine	1.7
Pollution: Heavy metals	Catchment	1.2
Engineering: Piled wharfs/sheds	Marine	1.2
Engineering: Seawalls	Marine	1.2
Engineering: Causeways	Marine	1.1
Engineering: Sand / gravel abstraction	Marine	1.1
Invasive species: Space occupiers, competitors	Marine	0.9
Pollution: Nitrogen and phosphorus	Catchment	0.9
Pollution: Sewage	Catchment	0.8

River inputs: Increased flow	Catchment	0.8
Climate change: Change in currents	Global	0.8
Fishing: Shellfish gathering	Marine	0.7
Pollution: Oil or oil products	Mixed	0.7
Engineering: Pile moorings/markers	Marine	0.6
Engineering: Pontoons	Marine	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Pollution: Plastic	Mixed	0.6
Increased turbidity	Mixed	0.5
Climate change: Altered rainfall	Global	0.5
River inputs: Decreased sediment loading	Catchment	0.5
Algal blooms - both toxic and massive	Marine	0.4
Pollution: Herbicides	Catchment	0.4
River inputs: Decreased flow	Catchment	0.3
Fishing: Seaweed gathering	Marine	0.3
Spatial closures to fishing	Marine	0.3
River inputs: Dampening of flows	Catchment	0.3
Climate change: UV increase	Global	0.2
Shipping: Grounding, sinking	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2

Table A2.13: Anthropogenic threats to sheltered coastal intertidal reefs and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Intertidal reef

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.4
River inputs: Increased sediment loading	Catchment	3.2
Engineering: reclamation	Marine	2.7
Climate change: Rise in sea-level	Global	2.2
Fishing: Shellfish gathering	Marine	2.1
Invasive species: Space occupiers, competitors	Marine	2.0
Climate change: Increased intertidal temperature	Global	2.0
Engineering: Causeways	Marine	2.0
Climate change: Increased sea temperature	Global	1.9
Increased turbidity	Mixed	1.7
Pollution: Sewage	Catchment	1.6
Pollution: Nitrogen and phosphorus	Catchment	1.6
Engineering: Pile moorings/markers	Marine	1.6
Climate change: Increased storminess	Global	1.5
Pollution: Heavy metals	Catchment	1.5
Algal blooms - both toxic and massive	Marine	1.2
Aquaculture: Benthic accumulation of debris	Marine	1.2
Climate change: UV increase	Global	1.2
Tourism: Reef trampling	Marine	1.2
Climate change: Altered rainfall	Global	1.1
River inputs: Increased flow	Catchment	1.1
Pollution: Oil or oil products	Mixed	1.0
Invasive species: Disease	Marine	1.0
River inputs: Decreased flow	Catchment	1.0
Climate change: Change in currents	Global	0.9

Engineering: Piled wharfs/sheds	Marine	0.9
Engineering: Pontoons	Marine	0.9
Fishing: Seaweed gathering	Marine	0.8
Fishing: Set netting	Marine	0.7
Fishing: Trapping	Marine	0.7
Fishing: Line fishing	Marine	0.7
Anchoring	Marine	0.7
Fishing: Abalone gathering	Marine	0.7
Pollution: Pesticides including PCBs	Catchment	0.7
Pollution: Herbicides	Catchment	0.7
Engineering: Seawalls	Marine	0.7
Engineering: Dumping of dredge spoils	Marine	0.6
Spatial closures to fishing	Marine	0.6
Shipping: Grounding, sinking	Marine	0.6
Aquaculture: Decrease in primary production	Marine	0.6
Climate change: Increased stratification	Global	0.5
Aquaculture: Increase in habitat complexity	Marine	0.5
River inputs: Decreased sediment loading	Catchment	0.5
Fishing: Spear fishing	Marine	0.4
Fishing: Bottom trawling	Marine	0.4
Engineering: Dredging	Marine	0.4
Fishing: Dredging	Marine	0.4
Pollution: Plastic	Mixed	0.4
Engineering: Sand / gravel abstraction	Marine	0.4
Vehicles on beaches	Marine	0.4
Ecotourism: Diving	Marine	0.3
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
Fishing: Long-lining	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Pollution: Electromagnetic discharges	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.14: Anthropogenic threats to sheltered coastal kelp forest and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Sheltered Coast: Kelp Forest
Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased sediment loading	Catchment	2.5
Increased turbidity	Mixed	2.3
Ocean acidification	Global	2.2
Fishing: Set netting	Marine	2.1
Climate change: Increased storminess	Global	2.0
Invasive species: Space occupiers, competitors	Marine	1.9
Fishing: Trapping	Marine	1.9
Fishing: Line fishing	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.6
Fishing: Long-lining	Marine	1.6
Anchoring	Marine	1.5
Fishing: Spear fishing	Marine	1.5

Fishing: Shellfish gathering	Marine	1.5
Fishing: Seaweed gathering	Marine	1.5
Engineering: Dumping of dredge spoils	Marine	1.3
Climate change: Increased sea temperature	Global	1.2
Climate change: Change in currents	Global	1.2
Ecotourism: Diving	Marine	1.2
Fishing: Abalone gathering	Marine	1.1
Aquaculture: Benthic accumulation of debris	Marine	0.9
Fishing: Bottom trawling	Marine	0.9
Climate change: Rise in sea-level	Global	0.9
Spatial closures to fishing	Marine	0.9
Pollution: Sewage	Catchment	0.8
Climate change: Increased stratification	Global	0.8
Engineering: Dredging	Marine	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.7
Fishing: Dredging	Marine	0.7
Aquaculture: Increase in habitat complexity	Marine	0.7
Pollution: Oil or oil products	Mixed	0.7
Shipping: Grounding, sinking	Marine	0.7
Climate change: Altered rainfall	Global	0.7
Climate change: Increased intertidal temperature	Global	0.7
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.7
Engineering: reclamation	Marine	0.6
Fishing: Pelagic high bycatch	Marine	0.6
Pollution: Plastic	Mixed	0.6
River inputs: Decreased sediment loading	Catchment	0.5
Engineering: Pile moorings/markers	Marine	0.5
Aquaculture: Decrease in primary production	Marine	0.4
Invasive species: Disease	Marine	0.4
Engineering: Sand / gravel abstraction	Marine	0.4
Pollution: Heavy metals	Catchment	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
River inputs: Increased flow	Catchment	0.3
Pollution: Electromagnetic discharges	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Climate change: UV increase	Global	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Tourism: Reef trampling	Marine	0.2
Engineering: Causeways	Marine	0.1
Engineering: Piled wharfs/sheds	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Engineering: Mineral extraction - surface suction	Marine	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.15: Anthropogenic threats to sheltered coastal subtidal reefs 2-9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Sheltered Coast: Subtidal reefs 2–9 m
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.9
River inputs: Increased sediment loading	Catchment	2.7
Fishing: Set netting	Marine	2.1
Increased turbidity	Mixed	2.0
Fishing: Line fishing	Marine	2.0
Invasive species: Space occupiers, competitors	Marine	1.9
Fishing: Trapping	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.6
Anchoring	Marine	1.6
Fishing: Spear fishing	Marine	1.6
Climate change: Increased sea temperature	Global	1.5
Climate change: Increased storminess	Global	1.5
Fishing: Shellfish gathering	Marine	1.5
Fishing: Long-lining	Marine	1.4
Climate change: Change in currents	Global	1.4
Fishing: Abalone gathering	Marine	1.4
Pollution: Sewage	Catchment	1.3
Pollution: Nitrogen and phosphorus	Catchment	1.3
Fishing: Seaweed gathering	Marine	1.3
Aquaculture: Benthic accumulation of debris	Marine	1.2
Engineering: Dumping of dredge spoils	Marine	1.2
Engineering: reclamation	Marine	1.2
Pollution: Heavy metals	Catchment	1.2
Ecotourism: Diving	Marine	1.2
Climate change: Increased stratification	Global	1.1
Fishing: Bottom trawling	Marine	1.0
Fishing: Dredging	Marine	0.9
Aquaculture: Increase in habitat complexity	Marine	0.9
Climate change: Rise in sea-level	Global	0.9
Pollution: Oil or oil products	Mixed	0.9
Shipping: Grounding, sinking	Marine	0.9
Climate change: Altered rainfall	Global	0.9
Engineering: Dredging	Marine	0.8
Aquaculture: Decrease in primary production	Marine	0.8
Climate change: Increased intertidal temperature	Global	0.8
Spatial closures to fishing	Marine	0.8
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.8
Fishing: Pelagic high bycatch	Marine	0.7
Invasive species: Disease	Marine	0.7
Engineering: Sand / gravel abstraction	Marine	0.6
Climate change: UV increase	Global	0.6
Pollution: Plastic	Mixed	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Pollution: Herbicides	Catchment	0.6
River inputs: Decreased sediment loading	Catchment	0.6
Engineering: Pile moorings/markers	Marine	0.5

River inputs: Increased flow	Catchment	0.5
Engineering: Causeways	Marine	0.4
River inputs: Decreased flow	Catchment	0.4
Engineering: Piled wharfs/sheds	Marine	0.3
Pollution: Electromagnetic discharges	Marine	0.3
Ecotourism: Marine mammal watching	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Fishing: Pelagic low bycatch	Marine	0.3
Tourism: Reef trampling	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.2
Engineering: Minerals extraction - other methods	Marine	0.2
Engineering: Pontoons	Marine	0.2
Shipping: Animal strikes	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Engineering: Seawalls	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.16: Anthropogenic threats to sheltered coastal gravel/pebble/sand habitat and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Gravel/pebble/shell 2–9 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Fishing: Bottom trawling	Marine	2.8
Fishing: Dredging	Marine	2.8
River inputs: Increased sediment loading	Catchment	2.2
Climate change: Increased sea temperature	Global	2.0
Engineering: Dredging	Marine	2.0
Increased turbidity	Mixed	1.9
Aquaculture: Benthic accumulation of debris	Marine	1.9
Climate change: Increased storminess	Global	1.9
Engineering: Dumping of dredge spoils	Marine	1.9
Engineering: Sand / gravel abstraction	Marine	1.8
Algal blooms - both toxic and massive	Marine	1.7
Invasive species: Space occupiers, competitors	Marine	1.7
Fishing: Long-lining	Marine	1.6
Climate change: Change in currents	Global	1.5
Pollution: Sewage	Catchment	1.4
Engineering: reclamation	Marine	1.3
Climate change: Increased stratification	Global	1.3
Fishing: Line fishing	Marine	1.2
Aquaculture: Increase in habitat complexity	Marine	1.2
Climate change: Rise in sea-level	Global	1.1
Fishing: Trapping	Marine	1.1
Fishing: Shellfish gathering	Marine	1.0
Pollution: Oil or oil products	Mixed	1.0
Engineering: Mineral extraction - surface suction	Marine	0.8
Fishing: Set netting	Marine	0.8
Anchoring	Marine	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.8

Climate change: UV increase	Global	0.7
Aquaculture: Decrease in primary production	Marine	0.7
Pollution: Heavy metals	Catchment	0.7
Shipping: Grounding, sinking	Marine	0.7
Pollution: Plastic	Mixed	0.6
Fishing: Pelagic high bycatch	Marine	0.6
Engineering: Mineral extraction - deep hole extraction	Marine	0.6
Climate change: Altered rainfall	Global	0.5
Climate change: Increased intertidal temperature	Global	0.4
Ecotourism: Diving	Marine	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Fishing: Abalone gathering	Marine	0.4
Fishing: Seaweed gathering	Marine	0.4
Engineering: Minerals extraction - other methods	Marine	0.4
Spatial closures to fishing	Marine	0.4
Pollution: Herbicides	Catchment	0.4
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.4
River inputs: Decreased sediment loading	Catchment	0.3
Engineering: Seawalls	Marine	0.2
Engineering: Pile moorings/markers	Marine	0.2
Engineering: Piled wharfs/sheds	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Engineering: Pontoons	Marine	0.2
Engineering: Causeways	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Invasive species: Disease	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Shipping: Noise pollution	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1

Table A2.17: Anthropogenic threats to sheltered coastal sand 2-9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Sand 2–9 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
River inputs: Increased sediment loading	Catchment	2.4
Fishing: Bottom trawling	Marine	2.3
Fishing: Dredging	Marine	2.3
Climate change: Increased sea temperature	Global	2.1
Engineering: Sand / gravel abstraction	Marine	2.1
Increased turbidity	Mixed	2.0
Aquaculture: Benthic accumulation of debris	Marine	1.9
Climate change: Increased storminess	Global	1.9
Algal blooms - both toxic and massive	Marine	1.8
Engineering: Dumping of dredge spoils	Marine	1.7
Engineering: Dredging	Marine	1.7
Climate change: Change in currents	Global	1.5
Invasive species: Space occupiers, competitors	Marine	1.5

Pollution: Sewage	Catchment	1.1
Engineering: reclamation	Marine	1.1
Climate change: Increased stratification	Global	1.1
Fishing: Line fishing	Marine	1.0
Aquaculture: Increase in habitat complexity	Marine	1.0
Fishing: Shellfish gathering	Marine	1.0
Fishing: Long-lining	Marine	1.0
Climate change: UV increase	Global	1.0
Climate change: Rise in sea-level	Global	1.0
Pollution: Oil or oil products	Mixed	0.9
Fishing: Trapping	Marine	0.9
Aquaculture: Decrease in primary production	Marine	0.8
Engineering: Mineral extraction - surface suction	Marine	0.8
Climate change: Increased intertidal temperature	Global	0.8
Fishing: Set netting	Marine	0.7
Anchoring	Marine	0.7
Climate change: Altered rainfall	Global	0.7
Pollution: Nitrogen and phosphorus	Catchment	0.6
Engineering: Seawalls	Marine	0.5
Pollution: Heavy metals	Catchment	0.5
Shipping: Grounding, sinking	Marine	0.5
Vehicles on beaches	Marine	0.5
Ecotourism: Diving	Marine	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Pollution: Plastic	Mixed	0.4
Fishing: Abalone gathering	Marine	0.4
Fishing: Seaweed gathering	Marine	0.4
Engineering: Pile moorings/markers	Marine	0.4
Engineering: Piled wharfs/sheds	Marine	0.4
Fishing: Pelagic high bycatch	Marine	0.4
Engineering: Minerals extraction - other methods	Marine	0.3
Spatial closures to fishing	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Engineering: Mineral extraction - deep hole extraction	Marine	0.3
Fishing: Spear fishing	Marine	0.3
River inputs: Increased flow	Catchment	0.3
Pollution: Herbicides	Catchment	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Engineering: Pontoons	Marine	0.2
Engineering: Causeways	Marine	0.2
River inputs: Decreased flow	Catchment	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Invasive species: Disease	Marine	0.1
Shipping: Noise pollution	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.18: Anthropogenic threats to sheltered coastal mud 2–9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Sheltered Coast: Mud 2–9 m
Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.0
Fishing: Dredging	Marine	2.9
Ocean acidification	Global	2.7
Aquaculture: Benthic accumulation of debris	Marine	2.6
River inputs: Increased sediment loading	Catchment	2.2
Climate change: Increased sea temperature	Global	2.1
Climate change: Change in currents	Global	2.0
Engineering: Dumping of dredge spoils	Marine	2.0
Engineering: Dredging	Marine	2.0
Climate change: Increased storminess	Global	1.9
Engineering: Sand / gravel abstraction	Marine	1.6
Increased turbidity	Mixed	1.5
Aquaculture: Decrease in primary production	Marine	1.4
Pollution: Sewage	Catchment	1.3
Aquaculture: Increase in habitat complexity	Marine	1.3
Engineering: Mineral extraction - surface suction	Marine	1.3
Fishing: Line fishing	Marine	1.2
Invasive species: Space occupiers, competitors	Marine	1.2
Fishing: Shellfish gathering	Marine	1.2
Algal blooms - both toxic and massive	Marine	1.1
Pollution: Oil or oil products	Mixed	1.1
Fishing: Long-lining	Marine	1.0
Fishing: Trapping	Marine	0.9
Engineering: reclamation	Marine	0.9
Climate change: Increased stratification	Global	0.9
Climate change: Altered rainfall	Global	0.9
Climate change: Increased intertidal temperature	Global	0.8
Pollution: Pesticides including PCBs	Catchment	0.7
Fishing: Set netting	Marine	0.6
Anchoring	Marine	0.6
Pollution: Nitrogen and phosphorus	Catchment	0.6
Pollution: Heavy metals	Catchment	0.6
Climate change: Rise in sea-level	Global	0.6
Pollution: Plastic	Mixed	0.6
Climate change: UV increase	Global	0.6
Engineering: Minerals extraction - other methods	Marine	0.6
Engineering: Seawalls	Marine	0.6
Fishing: Abalone gathering	Marine	0.5
Fishing: Seaweed gathering	Marine	0.5
Spatial closures to fishing	Marine	0.5
River inputs: Decreased sediment loading	Catchment	0.5
Engineering: Pile moorings/markers	Marine	0.5
Engineering: Piled wharfs/sheds	Marine	0.5
Ecotourism: Diving	Marine	0.4
Shipping: Grounding, sinking	Marine	0.4
Fishing: Pelagic high bycatch	Marine	0.4

Pollution: Herbicides	Catchment	0.4
Engineering: Mineral extraction - deep hole extraction	Marine	0.4
Fishing: Spear fishing	Marine	0.3
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
River inputs: Increased flow	Catchment	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Engineering: Pontoons	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Vehicles on beaches	Marine	0.2
Invasive species: Disease	Marine	0.1
River inputs: Decreased flow	Catchment	0.1
Shipping: Noise pollution	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.19: Anthropogenic threats to sheltered coastal subtidal reefs 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Subtidal reefs 10–29 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.9
River inputs: Increased sediment loading	Catchment	2.7
Fishing: Set netting	Marine	2.1
Increased turbidity	Mixed	2.0
Fishing: Line fishing	Marine	2.0
Invasive species: Space occupiers, competitors	Marine	1.9
Fishing: Trapping	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.6
Anchoring	Marine	1.6
Fishing: Spear fishing	Marine	1.6
Climate change: Increased sea temperature	Global	1.5
Climate change: Increased storminess	Global	1.5
Fishing: Shellfish gathering	Marine	1.5
Climate change: Change in currents	Global	1.4
Fishing: Long-lining	Marine	1.4
Fishing: Abalone gathering	Marine	1.4
Pollution: Sewage	Catchment	1.3
Pollution: Nitrogen and phosphorus	Catchment	1.3
Fishing: Seaweed gathering	Marine	1.3
Engineering: Dumping of dredge spoils	Marine	1.2
Aquaculture: Benthic accumulation of debris	Marine	1.2
Engineering: reclamation	Marine	1.2
Ecotourism: Diving	Marine	1.2
Pollution: Heavy metals	Catchment	1.2
Climate change: Increased stratification	Global	1.1
Fishing: Bottom trawling	Marine	1.0
Fishing: Dredging	Marine	0.9
Aquaculture: Increase in habitat complexity	Marine	0.9
Pollution: Oil or oil products	Mixed	0.9

Climate change: Rise in sea-level	Global	0.9
Climate change: Altered rainfall	Global	0.9
Shipping: Grounding, sinking	Marine	0.9
Engineering: Dredging	Marine	0.8
Aquaculture: Decrease in primary production	Marine	0.8
Spatial closures to fishing	Marine	0.8
Climate change: Increased intertidal temperature	Global	0.8
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.8
Fishing: Pelagic high bycatch	Marine	0.7
Invasive species: Disease	Marine	0.7
Engineering: Sand / gravel abstraction	Marine	0.6
Pollution: Plastic	Mixed	0.6
Climate change: UV increase	Global	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Pollution: Herbicides	Catchment	0.6
River inputs: Decreased sediment loading	Catchment	0.6
Engineering: Pile moorings/markers	Marine	0.5
River inputs: Increased flow	Catchment	0.5
River inputs: Decreased flow	Catchment	0.4
Engineering: Causeways	Marine	0.4
Engineering: Piled wharfs/sheds	Marine	0.3
Ecotourism: Marine mammal watching	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Pollution: Electromagnetic discharges	Marine	0.3
Fishing: Pelagic low bycatch	Marine	0.3
Tourism: Reef trampling	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.2
Engineering: Minerals extraction - other methods	Marine	0.2
Engineering: Pontoons	Marine	0.2
Shipping: Animal strikes	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Engineering: Seawalls	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.20: Anthropogenic threats to sheltered coastal gravel/pebble/shell 10-29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Sheltered Coast: Gravel/pebble/shell 10–29 m
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Fishing: Bottom trawling	Marine	2.9
Fishing: Dredging	Marine	2.8
River inputs: Increased sediment loading	Catchment	2.3
Climate change: Increased sea temperature	Global	2.1
Engineering: Dumping of dredge spoils	Marine	1.6
Climate change: Change in currents	Global	1.6
Aquaculture: Benthic accumulation of debris	Marine	1.5
Climate change: Increased storminess	Global	1.5
Engineering: Sand / gravel abstraction	Marine	1.5
Algal blooms - both toxic and massive	Marine	1.2

Increased turbidity	Mixed	1.2
Engineering: Dredging	Marine	1.2
Fishing: Line fishing	Marine	1.2
Fishing: Long-lining	Marine	1.2
Invasive species: Space occupiers, competitors	Marine	1.0
Pollution: Sewage	Catchment	0.9
Aquaculture: Increase in habitat complexity	Marine	0.9
Fishing: Trapping	Marine	0.9
Fishing: Shellfish gathering	Marine	0.8
Pollution: Oil or oil products	Mixed	0.8
Engineering: reclamation	Marine	0.8
Climate change: Increased stratification	Global	0.7
Engineering: Mineral extraction - surface suction	Marine	0.6
Fishing: Set netting	Marine	0.6
Aquaculture: Decrease in primary production	Marine	0.5
Anchoring	Marine	0.5
Ecotourism: Diving	Marine	0.5
Climate change: Rise in sea-level	Global	0.5
Engineering: Mineral extraction - deep hole extraction	Marine	0.5
Climate change: Altered rainfall	Global	0.4
Pollution: Plastic	Mixed	0.4
Fishing: Abalone gathering	Marine	0.4
Fishing: Pelagic high bycatch	Marine	0.4
Pollution: Heavy metals	Catchment	0.4
Spatial closures to fishing	Marine	0.4
Climate change: Increased intertidal temperature	Global	0.3
Pollution: Nitrogen and phosphorus	Catchment	0.3
Climate change: UV increase	Global	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Fishing: Seaweed gathering	Marine	0.3
Shipping: Grounding, sinking	Marine	0.3
Engineering: Minerals extraction - other methods	Marine	0.3
Pollution: Herbicides	Catchment	0.3
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
Engineering: Seawalls	Marine	0.2
River inputs: Decreased sediment loading	Catchment	0.2
Fishing: Spear fishing	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Engineering: Piled wharfs/sheds	Marine	0.1
Engineering: Pile moorings/markers	Marine	0.1
River inputs: Decreased flow	Catchment	0.1
Engineering: Pontoons	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1
Shipping: Noise pollution	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.21: Anthropogenic threats to sheltered coastal sand 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Sheltered Coast : Sand 10–29 m
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Fishing: Bottom trawling	Marine	2.9
Fishing: Dredging	Marine	2.8
River inputs: Increased sediment loading	Catchment	2.3
Climate change: Increased sea temperature	Global	2.1
Aquaculture: Benthic accumulation of debris	Marine	2.0
Climate change: Increased storminess	Global	1.9
Engineering: Dumping of dredge spoils	Marine	1.7
Engineering: Sand / gravel abstraction	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.7
Climate change: Change in currents	Global	1.6
Increased turbidity	Mixed	1.5
Engineering: Dredging	Marine	1.4
Fishing: Line fishing	Marine	1.2
Pollution: Sewage	Catchment	1.1
Aquaculture: Increase in habitat complexity	Marine	1.0
Fishing: Shellfish gathering	Marine	1.0
Fishing: Long-lining	Marine	1.0
Invasive species: Space occupiers, competitors	Marine	1.0
Pollution: Oil or oil products	Mixed	0.9
Fishing: Trapping	Marine	0.9
Engineering: Mineral extraction - surface suction	Marine	0.8
Aquaculture: Decrease in primary production	Marine	0.8
Engineering: reclamation	Marine	0.8
Climate change: Increased stratification	Global	0.8
Climate change: Increased intertidal temperature	Global	0.7
Fishing: Set netting	Marine	0.7
Anchoring	Marine	0.7
Pollution: Nitrogen and phosphorus	Catchment	0.6
Climate change: Altered rainfall	Global	0.5
Engineering: Seawalls	Marine	0.5
Climate change: UV increase	Global	0.5
Ecotourism: Diving	Marine	0.5
Climate change: Rise in sea-level	Global	0.4
Engineering: Piled wharfs/sheds	Marine	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Engineering: Pile moorings/markers	Marine	0.4
Fishing: Seaweed gathering	Marine	0.4
Pollution: Plastic	Mixed	0.4
Fishing: Abalone gathering	Marine	0.4
Fishing: Pelagic high bycatch	Marine	0.4
Pollution: Heavy metals	Catchment	0.3
Shipping: Grounding, sinking	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Spatial closures to fishing	Marine	0.3
Engineering: Mineral extraction - deep hole extraction	Marine	0.3

Engineering: Minerals extraction - other methods	Marine	0.3
Fishing: Spear fishing	Marine	0.3
Vehicles on beaches	Marine	0.2
River inputs: Decreased flow	Catchment	0.2
Engineering: Pontoons	Marine	0.2
Pollution: Herbicides	Catchment	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
River inputs: Increased flow	Catchment	0.1
Shipping: Noise pollution	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.22: Anthropogenic threats to sheltered coastal mud 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Sheltered Coast: Mud 10–29 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	2.9
Fishing: Dredging	Marine	2.8
Ocean acidification	Global	2.7
River inputs: Increased sediment loading	Catchment	2.3
Aquaculture: Benthic accumulation of debris	Marine	1.9
Climate change: Increased sea temperature	Global	1.8
Engineering: Dumping of dredge spoils	Marine	1.7
Climate change: Change in currents	Global	1.6
Climate change: Increased storminess	Global	1.5
Engineering: Sand / gravel abstraction	Marine	1.4
Engineering: Dredging	Marine	1.4
Increased turbidity	Mixed	1.1
Fishing: Line fishing	Marine	1.0
Aquaculture: Increase in habitat complexity	Marine	1.0
Pollution: Sewage	Catchment	0.9
Pollution: Oil or oil products	Mixed	0.9
Algal blooms - both toxic and massive	Marine	0.9
Fishing: Shellfish gathering	Marine	0.9
Engineering: Mineral extraction - surface suction	Marine	0.9
Aquaculture: Decrease in primary production	Marine	0.8
Fishing: Long-lining	Marine	0.8
Engineering: reclamation	Marine	0.7
Invasive species: Space occupiers, competitors	Marine	0.7
Fishing: Trapping	Marine	0.7
Climate change: Increased intertidal temperature	Global	0.6
Climate change: Increased stratification	Global	0.6
Climate change: Altered rainfall	Global	0.5
Fishing: Set netting	Marine	0.5
Climate change: Rise in sea-level	Global	0.4
Engineering: Piled wharfs/sheds	Marine	0.4

Engineering: Seawalls	Marine	0.4
Pollution: Heavy metals	Catchment	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Engineering: Pile moorings/markers	Marine	0.4
Fishing: Seaweed gathering	Marine	0.4
Climate change: UV increase	Global	0.4
Ecotourism: Diving	Marine	0.4
Anchoring	Marine	0.4
Pollution: Nitrogen and phosphorus	Catchment	0.3
Pollution: Plastic	Mixed	0.3
Shipping: Grounding, sinking	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Spatial closures to fishing	Marine	0.3
Fishing: Abalone gathering	Marine	0.3
Fishing: Pelagic high bycatch	Marine	0.3
Engineering: Mineral extraction - deep hole extraction	Marine	0.3
Engineering: Minerals extraction - other methods	Marine	0.3
Vehicles on beaches	Marine	0.2
River inputs: Decreased flow	Catchment	0.2
Engineering: Pontoons	Marine	0.2
Pollution: Herbicides	Catchment	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
River inputs: Increased flow	Catchment	0.1
Shipping: Noise pollution	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.23: Anthropogenic threats to exposed coastal sandy beaches and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Sandy beaches

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Increased storminess	Global	3.1
Ocean acidification	Global	3.1
Climate change: Increased sea temperature	Global	3.1
Climate change: Rise in sea-level	Global	2.8
River inputs: Increased sediment loading	Catchment	2.5
Climate change: Increased intertidal temperature	Global	1.9
Vehicles on beaches	Marine	1.8
Climate change: Change in currents	Global	1.5
Engineering: reclamation	Marine	1.5
River inputs: Increased flow	Catchment	1.3
Engineering: Piled wharfs/sheds	Marine	1.2
Engineering: Causeways	Marine	1.1
Engineering: Sand / gravel abstraction	Marine	1.1
Climate change: Altered rainfall	Global	1.0
Invasive species: Space occupiers, competitors	Marine	0.9

Increased turbidity	Mixed	0.9
Pollution: Sewage	Catchment	0.8
Engineering: Seawalls	Marine	0.8
Pollution: Oil or oil products	Mixed	0.7
Algal blooms - both toxic and massive	Marine	0.7
River inputs: Decreased flow	Catchment	0.7
Pollution: Nitrogen and phosphorus	Catchment	0.6
Pollution: Heavy metals	Catchment	0.6
Pollution: Plastic	Mixed	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Engineering: Pile moorings/markers	Marine	0.6
Engineering: Pontoons	Marine	0.6
Shipping: Grounding, sinking	Marine	0.5
River inputs: Decreased sediment loading	Catchment	0.5
Fishing: Shellfish gathering	Marine	0.4
Pollution: Herbicides	Catchment	0.4
Fishing: Seaweed gathering	Marine	0.3
Spatial closures to fishing	Marine	0.3
River inputs: Dampening of flows	Catchment	0.3
Climate change: UV increase	Global	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Fishing: Trapping	Marine	0.1
Fishing: Line fishing	Marine	0.1
Fishing: Set netting	Marine	0.1

Table A2.24: Anthropogenic threats to exposed coastal intertidal reefs and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Intertidal reefs
Threat	Threat Source	Mean weighted vulnerability score
Climate change: Increased storminess	Global	3.5
Climate change: Increased intertidal temperature	Global	2.8
Ocean acidification	Global	2.3
Climate change: Increased sea temperature	Global	2.3
Climate change: Rise in sea-level	Global	2.1
River inputs: Increased sediment loading	Catchment	2.0
Climate change: Change in currents	Global	2.0
Climate change: UV increase	Global	2.0
Invasive species: Space occupiers, competitors	Marine	1.9
Increased turbidity	Mixed	1.8
Tourism: Reef trampling	Marine	1.8
Fishing: Seaweed gathering	Marine	1.7
Pollution: Sewage	Catchment	1.6
Pollution: Nitrogen and phosphorus	Catchment	1.6
Fishing: Shellfish gathering	Marine	1.6
Pollution: Oil or oil products	Mixed	1.6
Climate change: Altered rainfall	Global	1.6
Pollution: Heavy metals	Catchment	1.5
Climate change: Increased stratification	Global	1.3
Engineering: reclamation	Marine	1.3
Engineering: Causeways	Marine	1.3

Algal blooms - both toxic and massive	Marine	1.2
Invasive species: Disease	Marine	1.2
Fishing: Trapping	Marine	1.1
Fishing: Abalone gathering	Marine	1.1
Pollution: Plastic	Mixed	1.1
Pollution: Pesticides including PCBs	Catchment	1.0
Pollution: Herbicides	Catchment	1.0
Fishing: Line fishing	Marine	0.9
Fishing: Bottom trawling	Marine	0.9
Fishing: Dredging	Marine	0.9
Engineering: Pile moorings/markers	Marine	0.9
Fishing: Set netting	Marine	0.7
Fishing: Spear fishing	Marine	0.7
Shipping: Grounding, sinking	Marine	0.7
Engineering: Sand / gravel abstraction	Marine	0.7
Aquaculture: Decrease in primary production	Marine	0.7
Aquaculture: Increase in habitat complexity	Marine	0.7
Engineering: Seawalls	Marine	0.7
Ecotourism: Diving	Marine	0.6
Fishing: Long-lining	Marine	0.6
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.6
Aquaculture: Benthic accumulation of debris	Marine	0.6
Engineering: Dredging	Marine	0.6
River inputs: Decreased sediment loading	Catchment	0.6
Anchoring	Marine	0.5
River inputs: Increased flow	Catchment	0.5
Spatial closures to fishing	Marine	0.4
Engineering: Dumping of dredge spoils	Marine	0.4
River inputs: Decreased flow	Catchment	0.4
Vehicles on beaches	Marine	0.4
Shipping: Noise pollution	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
Engineering: Piled wharfs/sheds	Marine	0.3
Engineering: Pontoons	Marine	0.3
Shipping: Animal strikes	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Ecotourism: Noise	Mixed	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.25: Anthropogenic threats to exposed coastal turfing algal reefs and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Turfing algal reefs

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.5
Climate change: Increased storminess	Global	2.0
Fishing: Trapping	Marine	1.7
Increased turbidity	Mixed	1.7

Fishing: Line fishing	Marine	1.7
Fishing: Abalone gathering	Marine	1.6
Anchoring	Marine	1.6
Algal blooms - both toxic and massive	Marine	1.6
Invasive species: Space occupiers, competitors	Marine	1.6
Fishing: Seaweed gathering	Marine	1.5
Fishing: Set netting	Marine	1.5
Climate change: Increased sea temperature	Global	1.5
Fishing: Spear fishing	Marine	1.4
River inputs: Increased sediment loading	Catchment	1.3
Ecotourism: Diving	Marine	1.3
Fishing: Long-lining	Marine	1.3
Shipping: Grounding, sinking	Marine	1.2
Climate change: Change in currents	Global	1.1
Pollution: Sewage	Catchment	1.1
Climate change: Rise in sea-level	Global	1.0
Climate change: Increased stratification	Global	1.0
Pollution: Nitrogen and phosphorus	Catchment	0.9
Spatial closures to fishing	Marine	0.8
Fishing: Shellfish gathering	Marine	0.8
Pollution: Oil or oil products	Mixed	0.8
Fishing: Bottom trawling	Marine	0.7
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.7
Fishing: Dredging	Marine	0.7
Pollution: Plastic	Mixed	0.7
Invasive species: Disease	Marine	0.7
Aquaculture: Benthic accumulation of debris	Marine	0.6
Engineering: Pile moorings/markers	Marine	0.6
Climate change: UV increase	Global	0.6
Pollution: Heavy metals	Catchment	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Pollution: Herbicides	Catchment	0.6
Engineering: Dumping of dredge spoils	Marine	0.5
Shipping: Noise pollution	Marine	0.5
Climate change: Increased intertidal temperature	Global	0.4
Engineering: Sand / gravel abstraction	Marine	0.4
Engineering: Dredging	Marine	0.3
Climate change: Altered rainfall	Global	0.3
Aquaculture: Decrease in primary production	Marine	0.3
River inputs: Increased flow	Catchment	0.3
Aquaculture: Increase in habitat complexity	Marine	0.2
River inputs: Decreased sediment loading	Catchment	0.2
Engineering: Mineral extraction - surface suction	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Tourism: Reef trampling	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.26: Anthropogenic threats to exposed coastal kelp forest and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts : Kelp Forest

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Increased storminess	Global	1.7
Fishing: Seaweed gathering	Marine	1.7
Ocean acidification	Global	1.6
Fishing: Trapping	Marine	1.6
Increased turbidity	Mixed	1.6
River inputs: Increased sediment loading	Catchment	1.5
Fishing: Line fishing	Marine	1.4
Fishing: Set netting	Marine	1.3
Fishing: Abalone gathering	Marine	1.3
Anchoring	Marine	1.3
Fishing: Spear fishing	Marine	1.2
Algal blooms - both toxic and massive	Marine	1.0
Fishing: Bottom trawling	Marine	1.0
Invasive species: Space occupiers, competitors	Marine	1.0
Ecotourism: Diving	Marine	1.0
Climate change: Increased sea temperature	Global	1.0
Climate change: Change in currents	Global	0.9
Fishing: Long-lining	Marine	0.9
Spatial closures to fishing	Marine	0.9
Engineering: Dumping of dredge spoils	Marine	0.8
Fishing: Shellfish gathering	Marine	0.7
Shipping: Grounding, sinking	Marine	0.7
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.7
Climate change: Rise in sea-level	Global	0.7
Climate change: Increased stratification	Global	0.6
Fishing: Dredging	Marine	0.6
Pollution: Sewage	Catchment	0.6
Pollution: Oil or oil products	Mixed	0.6
Aquaculture: Benthic accumulation of debris	Marine	0.6
Pollution: Nitrogen and phosphorus	Catchment	0.5
Pollution: Plastic	Mixed	0.5
Engineering: Dredging	Marine	0.4
Engineering: reclamation	Marine	0.4
Aquaculture: Increase in habitat complexity	Marine	0.4
Climate change: Altered rainfall	Global	0.4
Climate change: Increased intertidal temperature	Global	0.4
Engineering: Pile moorings/markers	Marine	0.4
Climate change: UV increase	Global	0.3
Pollution: Heavy metals	Catchment	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
Engineering: Sand / gravel abstraction	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Invasive species: Disease	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.2
Tourism: Reef trampling	Marine	0.2

Aquaculture: Decrease in primary production	Marine	0.1
River inputs: Increased flow	Catchment	0.1
Engineering: Causeways	Marine	0.1
Fishing: Pelagic high bycatch	Marine	0.1
Engineering: Mineral extraction - surface suction	Marine	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1
Engineering: Piled wharfs/sheds	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.27: Anthropogenic threats to exposed coastal subtidal reefs 2-9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Subtidal reefs 2–9 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.1
Fishing: Trapping	Marine	2.0
Climate change: Increased storminess	Global	1.9
River inputs: Increased sediment loading	Catchment	1.8
Increased turbidity	Mixed	1.7
Fishing: Line fishing	Marine	1.6
Fishing: Set netting	Marine	1.6
Algal blooms - both toxic and massive	Marine	1.4
Fishing: Seaweed gathering	Marine	1.4
Fishing: Spear fishing	Marine	1.4
Fishing: Bottom trawling	Marine	1.3
Climate change: Change in currents	Global	1.3
Fishing: Long-lining	Marine	1.3
Fishing: Abalone gathering	Marine	1.3
Engineering: Dumping of dredge spoils	Marine	1.2
Invasive species: Space occupiers, competitors	Marine	1.2
Anchoring	Marine	1.2
Ecotourism: Diving	Marine	1.2
Climate change: Increased sea temperature	Global	1.1
Climate change: Increased stratification	Global	1.1
Fishing: Dredging	Marine	1.0
Fishing: Shellfish gathering	Marine	1.0
Pollution: Sewage	Catchment	0.9
Pollution: Oil or oil products	Mixed	0.9
Engineering: Dredging	Marine	0.8
Aquaculture: Benthic accumulation of debris	Marine	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.8
Shipping: Grounding, sinking	Marine	0.8
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.8
Spatial closures to fishing	Marine	0.8
Climate change: Rise in sea-level	Global	0.7
Engineering: reclamation	Marine	0.7
Aquaculture: Increase in habitat complexity	Marine	0.7
Climate change: UV increase	Global	0.6
Pollution: Heavy metals	Catchment	0.6

Climate change: Altered rainfall	Global	0.6
Climate change: Increased intertidal temperature	Global	0.6
Pollution: Plastic	Mixed	0.5
Pollution: Pesticides including PCBs	Catchment	0.5
Pollution: Herbicides	Catchment	0.5
Aquaculture: Decrease in primary production	Marine	0.5
Engineering: Sand / gravel abstraction	Marine	0.4
Shipping: Noise pollution	Marine	0.4
Invasive species: Disease	Marine	0.4
River inputs: Decreased sediment loading	Catchment	0.4
River inputs: Increased flow	Catchment	0.4
Engineering: Pile moorings/markers	Marine	0.4
Tourism: Reef trampling	Marine	0.4
Engineering: Causeways	Marine	0.3
River inputs: Decreased flow	Catchment	0.3
Fishing: Pelagic high bycatch	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Engineering: Piled wharfs/sheds	Marine	0.2
Shipping: Animal strikes	Marine	0.1
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Engineering: Seawalls	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
River inputs: Dampening of flows	Catchment	0.1
Engineering: Pontoons	Marine	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.28: Anthropogenic threats to exposed coastal gravel/pebble/shell 2-9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Gravel/pebble/shell 2–9 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.4
Fishing: Bottom trawling	Marine	2.8
Fishing: Dredging	Marine	2.8
Climate change: Increased storminess	Global	1.9
Engineering: Dredging	Marine	1.8
Algal blooms - both toxic and massive	Marine	1.6
Engineering: Sand / gravel abstraction	Marine	1.6
Climate change: Increased sea temperature	Global	1.6
Climate change: Change in currents	Global	1.4
Aquaculture: Benthic accumulation of debris	Marine	1.4
Fishing: Long-lining	Marine	1.3
River inputs: Increased sediment loading	Catchment	1.2
Climate change: Increased stratification	Global	1.2
Engineering: Dumping of dredge spoils	Marine	1.2
Fishing: Trapping	Marine	1.1
Pollution: Sewage	Catchment	1.1
Climate change: Rise in sea-level	Global	1.1

Increased turbidity	Mixed	1.0
Climate change: UV increase	Global	1.0
Engineering: reclamation	Marine	1.0
Invasive species: Space occupiers, competitors	Marine	0.8
Pollution: Oil or oil products	Mixed	0.8
Fishing: Line fishing	Marine	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.8
Anchoring	Marine	0.7
Shipping: Grounding, sinking	Marine	0.7
Pollution: Heavy metals	Catchment	0.7
Fishing: Set netting	Marine	0.6
Fishing: Seaweed gathering	Marine	0.6
Pollution: Plastic	Mixed	0.5
Fishing: Abalone gathering	Marine	0.5
Engineering: Mineral extraction - surface suction	Marine	0.5
Aquaculture: Increase in habitat complexity	Marine	0.5
Pollution: Pesticides including PCBs	Catchment	0.4
Pollution: Herbicides	Catchment	0.4
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.4
Fishing: Shellfish gathering	Marine	0.4
Climate change: Altered rainfall	Global	0.3
Climate change: Increased intertidal temperature	Global	0.3
Shipping: Noise pollution	Marine	0.3
Ecotourism: Diving	Marine	0.3
Aquaculture: Decrease in primary production	Marine	0.3
Invasive species: Disease	Marine	0.2
Fishing: Spear fishing	Marine	0.2
River inputs: Decreased sediment loading	Catchment	0.2
Shipping: Animal strikes	Marine	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.2
Engineering: Causeways	Marine	0.2
Spatial closures to fishing	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.29: Anthropogenic threats to exposed coastal biogenic calcareous reefs and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Biogenic calcareous reefs
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Fishing: Bottom trawling	Marine	2.8
Fishing: Dredging	Marine	2.6
Algal blooms - both toxic and massive	Marine	2.4
River inputs: Increased sediment loading	Catchment	1.9
Fishing: Trapping	Marine	1.9
Engineering: Sand / gravel abstraction	Marine	1.8
Engineering: Dredging	Marine	1.7
Fishing: Set netting	Marine	1.7
Climate change: Increased storminess	Global	1.4
Climate change: Increased sea temperature	Global	1.4
Climate change: Increased stratification	Global	1.3

Increased turbidity	Mixed	1.2
Climate change: Change in currents	Global	1.1
Anchoring	Marine	1.0
Aquaculture: Benthic accumulation of debris	Marine	0.9
Pollution: Sewage	Catchment	0.8
Engineering: Dumping of dredge spoils	Marine	0.8
Invasive species: Space occupiers, competitors	Marine	0.8
Pollution: Oil or oil products	Mixed	0.8
Climate change: Rise in sea-level	Global	0.7
Climate change: UV increase	Global	0.7
Fishing: Line fishing	Marine	0.6
Fishing: Long-lining	Marine	0.6
Fishing: Seaweed gathering	Marine	0.6
Invasive species: Disease	Marine	0.6
Shipping: Grounding, sinking	Marine	0.5
Engineering: reclamation	Marine	0.5
Pollution: Heavy metals	Catchment	0.5
Pollution: Plastic	Mixed	0.5
Fishing: Abalone gathering	Marine	0.5
Engineering: Mineral extraction - surface suction	Marine	0.5
Pollution: Nitrogen and phosphorus	Catchment	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Pollution: Herbicides	Catchment	0.4
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.4
Fishing: Spear fishing	Marine	0.4
Climate change: Altered rainfall	Global	0.3
Climate change: Increased intertidal temperature	Global	0.3
Aquaculture: Increase in habitat complexity	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Ecotourism: Diving	Marine	0.3
Aquaculture: Decrease in primary production	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.2
Shipping: Animal strikes	Marine	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.2
Spatial closures to fishing	Marine	0.1

Table A2.30: Anthropogenic threats to exposed coastal sand 2–9 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Sand 2–9 m
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.6
Climate change: Increased storminess	Global	2.2
Algal blooms - both toxic and massive	Marine	1.7
River inputs: Increased sediment loading	Catchment	1.6
Fishing: Dredging	Marine	1.6
Engineering: Sand / gravel abstraction	Marine	1.5
Fishing: Bottom trawling	Marine	1.4
Increased turbidity	Mixed	1.3
Climate change: Increased sea temperature	Global	1.2
Engineering: Dredging	Marine	1.2

Climate change: Change in currents	Global	1.0
Climate change: Rise in sea-level	Global	1.0
Climate change: Increased stratification	Global	0.8
Pollution: Sewage	Catchment	0.8
Climate change: Altered rainfall	Global	0.8
Climate change: UV increase	Global	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.7
Fishing: Line fishing	Marine	0.7
Aquaculture: Benthic accumulation of debris	Marine	0.7
Fishing: Set netting	Marine	0.7
River inputs: Increased flow	Catchment	0.7
Engineering: Dumping of dredge spoils	Marine	0.6
Fishing: Long-lining	Marine	0.6
Vehicles on beaches	Marine	0.6
Fishing: Trapping	Marine	0.5
Invasive species: Space occupiers, competitors	Marine	0.5
Shipping: Grounding, sinking	Marine	0.5
Engineering: reclamation	Marine	0.5
Pollution: Oil or oil products	Mixed	0.4
Pollution: Heavy metals	Catchment	0.4
Pollution: Plastic	Mixed	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Climate change: Increased intertidal temperature	Global	0.4
River inputs: Decreased sediment loading	Catchment	0.4
Anchoring	Marine	0.3
Aquaculture: Increase in habitat complexity	Marine	0.3
Fishing: Shellfish gathering	Marine	0.3
Pollution: Herbicides	Catchment	0.3
Fishing: Seaweed gathering	Marine	0.3
River inputs: Decreased flow	Catchment	0.3
Engineering: Seawalls	Marine	0.3
Fishing: Abalone gathering	Marine	0.2
Shipping: Noise pollution	Marine	0.2
Ecotourism: Diving	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Engineering: Mineral extraction - surface suction	Marine	0.2
Engineering: Causeways	Marine	0.2
Fishing: Spear fishing	Marine	0.1
Invasive species: Disease	Marine	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.31: Anthropogenic threats to exposed coastal subtidal reefs 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Subtidal reefs 10–29 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.4
Fishing: Trapping	Marine	2.3
Climate change: Increased storminess	Global	2.2
River inputs: Increased sediment loading	Catchment	2.1
Increased turbidity	Mixed	2.0
Fishing: Set netting	Marine	1.9
Fishing: Line fishing	Marine	1.7
Fishing: Seaweed gathering	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.6
Fishing: Spear fishing	Marine	1.6
Fishing: Bottom trawling	Marine	1.5
Climate change: Change in currents	Global	1.5
Fishing: Long-lining	Marine	1.5
Fishing: Abalone gathering	Marine	1.5
Anchoring	Marine	1.4
Engineering: Dumping of dredge spoils	Marine	1.3
Invasive species: Space occupiers, competitors	Marine	1.3
Ecotourism: Diving	Marine	1.3
Climate change: Increased sea temperature	Global	1.2
Climate change: Increased stratification	Global	1.2
Fishing: Dredging	Marine	1.1
Fishing: Shellfish gathering	Marine	1.1
Pollution: Sewage	Catchment	1.0
Pollution: Oil or oil products	Mixed	1.0
Aquaculture: Benthic accumulation of debris	Marine	0.9
Engineering: Dredging	Marine	0.9
Pollution: Nitrogen and phosphorus	Catchment	0.9
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.9
Spatial closures to fishing	Marine	0.9
Climate change: Rise in sea-level	Global	0.8
Engineering: reclamation	Marine	0.8
Aquaculture: Increase in habitat complexity	Marine	0.8
Shipping: Grounding, sinking	Marine	0.8
Climate change: UV increase	Global	0.7
Pollution: Heavy metals	Catchment	0.7
Climate change: Altered rainfall	Global	0.7
Pollution: Plastic	Mixed	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Pollution: Herbicides	Catchment	0.6
Climate change: Increased intertidal temperature	Global	0.6
Aquaculture: Decrease in primary production	Marine	0.6
Engineering: Sand / gravel abstraction	Marine	0.5
Invasive species: Disease	Marine	0.5
River inputs: Decreased sediment loading	Catchment	0.5
River inputs: Increased flow	Catchment	0.5

Tourism: Reef trampling	Marine	0.5
Shipping: Noise pollution	Marine	0.4
Engineering: Pile moorings/markers	Marine	0.4
Engineering: Causeways	Marine	0.4
River inputs: Decreased flow	Catchment	0.3
Fishing: Pelagic high bycatch	Marine	0.3
Engineering: Piled wharfs/sheds	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2
River inputs: Dampening of flows	Catchment	0.2
Engineering: Pontoons	Marine	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Engineering: Seawalls	Marine	0.1
Fishing: Pelagic low bycatch	Marine	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.32: Anthropogenic threats to exposed coastal gravel/pebble/shell 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Gravel/pebble/shell 10–29 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.3
Fishing: Bottom trawling	Marine	2.6
Fishing: Dredging	Marine	2.6
Climate change: Increased storminess	Global	1.6
Climate change: Increased sea temperature	Global	1.4
Algal blooms - both toxic and massive	Marine	1.3
Engineering: Sand / gravel abstraction	Marine	1.1
River inputs: Increased sediment loading	Catchment	1.1
Fishing: Trapping	Marine	0.9
Climate change: Change in currents	Global	0.9
Engineering: Dumping of dredge spoils	Marine	0.9
Aquaculture: Benthic accumulation of debris	Marine	0.9
Climate change: Increased stratification	Global	0.8
Engineering: Dredging	Marine	0.7
Fishing: Long-lining	Marine	0.7
Pollution: Sewage	Catchment	0.7
Fishing: Line fishing	Marine	0.7
Increased turbidity	Mixed	0.7
Fishing: Set netting	Marine	0.5
Pollution: Nitrogen and phosphorus	Catchment	0.5
Pollution: Oil or oil products	Mixed	0.5
Climate change: Rise in sea-level	Global	0.5
Invasive species: Space occupiers, competitors	Marine	0.5
Climate change: UV increase	Global	0.4
Fishing: Seaweed gathering	Marine	0.4
Anchoring	Marine	0.4
Fishing: Abalone gathering	Marine	0.4

Engineering: reclamation	Marine	0.4
Pollution: Plastic	Mixed	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Aquaculture: Increase in habitat complexity	Marine	0.3
Pollution: Heavy metals	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
Shipping: Grounding, sinking	Marine	0.3
Invasive species: Disease	Marine	0.3
Climate change: Altered rainfall	Global	0.2
Fishing: Shellfish gathering	Marine	0.2
Climate change: Increased intertidal temperature	Global	0.2
Shipping: Noise pollution	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Ecotourism: Diving	Marine	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.2
River inputs: Decreased sediment loading	Catchment	0.1
River inputs: Decreased flow	Catchment	0.1
Shipping: Animal strikes	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Spatial closures to fishing	Marine	0.1

Table A2.33: Anthropogenic threats to exposed coastal sand 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Sand 10–29 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	2.7
Fishing: Dredging	Marine	2.6
Ocean acidification	Global	2.6
Climate change: Increased storminess	Global	1.8
Algal blooms - both toxic and massive	Marine	1.4
Climate change: Increased sea temperature	Global	1.4
Engineering: Sand / gravel abstraction	Marine	1.2
Fishing: Trapping	Marine	1.1
Climate change: Change in currents	Global	1.0
Engineering: Dumping of dredge spoils	Marine	1.0
Fishing: Set netting	Marine	1.0
River inputs: Increased sediment loading	Catchment	0.9
Engineering: Dredging	Marine	0.8
Fishing: Long-lining	Marine	0.8
Pollution: Sewage	Catchment	0.8
Fishing: Line fishing	Marine	0.8
Aquaculture: Benthic accumulation of debris	Marine	0.7
Climate change: Increased stratification	Global	0.7
Pollution: Nitrogen and phosphorus	Catchment	0.7
Increased turbidity	Mixed	0.6
Climate change: UV increase	Global	0.5

Pollution: Oil or oil products	Mixed	0.4
Pollution: Plastic	Mixed	0.4
Fishing: Seaweed gathering	Marine	0.4
Climate change: Altered rainfall	Global	0.4
Pollution: Pesticides including PCBs	Catchment	0.4
Aquaculture: Increase in habitat complexity	Marine	0.3
Anchoring	Marine	0.3
Pollution: Heavy metals	Catchment	0.3
Climate change: Rise in sea-level	Global	0.3
Pollution: Herbicides	Catchment	0.3
Fishing: Shellfish gathering	Marine	0.3
Climate change: Increased intertidal temperature	Global	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Fishing: Abalone gathering	Marine	0.3
Engineering: Seawalls	Marine	0.3
Shipping: Noise pollution	Marine	0.2
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Engineering: Mineral extraction - surface suction	Marine	0.2
Invasive species: Space occupiers, competitors	Marine	0.2
Shipping: Grounding, sinking	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Ecotourism: Diving	Marine	0.2
Invasive species: Disease	Marine	0.2
Engineering: reclamation	Marine	0.2
River inputs: Increased flow	Catchment	0.2
River inputs: Decreased flow	Catchment	0.2

Table A2.34: Anthropogenic threats to exposed coastal mud 10–29 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Mud 10–29 m
Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	2.9
Fishing: Dredging	Marine	2.8
Ocean acidification	Global	2.3
Climate change: Increased storminess	Global	1.9
Climate change: Change in currents	Global	1.4
Algal blooms - both toxic and massive	Marine	1.2
Aquaculture: Benthic accumulation of debris	Marine	1.2
Engineering: Sand / gravel abstraction	Marine	1.2
Climate change: Increased stratification	Global	1.1
Climate change: Increased sea temperature	Global	1.0
River inputs: Increased sediment loading	Catchment	1.0
Engineering: Dumping of dredge spoils	Marine	1.0
Engineering: Dredging	Marine	1.0
Fishing: Long-lining	Marine	0.9
Pollution: Sewage	Catchment	0.9
Fishing: Trapping	Marine	0.8
Pollution: Nitrogen and phosphorus	Catchment	0.8

Pollution: Oil or oil products	Mixed	0.7
Fishing: Line fishing	Marine	0.7
Increased turbidity	Mixed	0.6
Aquaculture: Increase in habitat complexity	Marine	0.6
Anchoring	Marine	0.5
Pollution: Heavy metals	Catchment	0.4
Fishing: Set netting	Marine	0.4
Pollution: Plastic	Mixed	0.4
Climate change: UV increase	Global	0.4
Fishing: Seaweed gathering	Marine	0.4
Climate change: Rise in sea-level	Global	0.3
Shipping: Noise pollution	Marine	0.3
Climate change: Altered rainfall	Global	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
Fishing: Shellfish gathering	Marine	0.3
Climate change: Increased intertidal temperature	Global	0.3
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.3
Aquaculture: Decrease in primary production	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Invasive species: Space occupiers, competitors	Marine	0.2
Fishing: Abalone gathering	Marine	0.2
Shipping: Grounding, sinking	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Ecotourism: Diving	Marine	0.2
Shipping: Animal strikes	Marine	0.2
Invasive species: Disease	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.35: Anthropogenic threats to exposed coastal subtidal reefs 30–200 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Subtidal reefs 30–200 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.3
Climate change: Change in currents	Global	2.3
Fishing: Bottom trawling	Marine	2.2
Climate change: Increased sea temperature	Global	2.2
Fishing: Trapping	Marine	2.2
River inputs: Increased sediment loading	Catchment	2.1
Algal blooms - both toxic and massive	Marine	2.1
Climate change: Increased storminess	Global	2.0
Engineering: Dumping of dredge spoils	Marine	1.9
Climate change: Increased stratification	Global	1.9
Pollution: Oil or oil products	Mixed	1.9
Invasive species: Space occupiers, competitors	Marine	1.9
Increased turbidity	Mixed	1.8
Fishing: Long-lining	Marine	1.7
Pollution: Nitrogen and phosphorus	Catchment	1.6
Pollution: Sewage	Catchment	1.6

Aquaculture: Benthic accumulation of debris	Marine	1.5
Spatial closures to fishing	Marine	1.5
Fishing: Line fishing	Marine	1.5
Anchoring	Marine	1.4
Climate change: Rise in sea-level	Global	1.3
Pollution: Heavy metals	Catchment	1.3
Aquaculture: Increase in habitat complexity	Marine	1.2
Shipping: Noise pollution	Marine	1.2
Fishing: Set netting	Marine	1.2
Fishing: Abalone gathering	Marine	1.2
Fishing: Pelagic high bycatch	Marine	1.1
Pollution: Plastic	Mixed	1.1
Climate change: Altered rainfall	Global	1.1
Pollution: Pesticides including PCBs	Catchment	1.1
Pollution: Herbicides	Catchment	1.1
Shipping: Grounding, sinking	Marine	1.1
Invasive species: Disease	Marine	1.1
Fishing: Spear fishing	Marine	1.1
Fishing: Shellfish gathering	Marine	1.1
Climate change: UV increase	Global	1.0
Climate change: Increased intertidal temperature	Global	1.0
Ecotourism: Diving	Marine	1.0
Ecotourism: Changes in fish and invertebrate behaviour	Marine	1.0
Engineering: reclamation	Marine	1.0
Fishing: Dredging	Marine	0.9
Aquaculture: Decrease in primary production	Marine	0.9
Fishing: Seaweed gathering	Marine	0.8
Engineering: Pile moorings/markers	Marine	0.7
Engineering: Sand / gravel abstraction	Marine	0.6
Fishing: Pelagic low bycatch	Marine	0.6
River inputs: Increased flow	Catchment	0.6
Pollution: Electromagnetic discharges	Marine	0.5
Engineering: Dredging	Marine	0.5
Engineering: Mineral extraction - surface suction	Marine	0.4
Ecotourism: Marine mammal watching	Marine	0.4
River inputs: Decreased flow	Catchment	0.4
Shipping: Animal strikes	Marine	0.3
Pollution: Acoustic discharges / guns	Marine	0.3
Engineering: Piled wharfs/sheds	Marine	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Tourism: Reef trampling	Marine	0.3
River inputs: Dampening of flows	Catchment	0.2
Engineering: Causeways	Marine	0.2
Engineering: Pontoons	Marine	0.1
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Engineering: Seawalls	Marine	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.36: Anthropogenic threats to exposed coastal gravel/pebble/shell 30–200 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Gravel/pebble/shell 30–200 m
Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.0
Fishing: Bottom trawling	Marine	2.9
Fishing: Dredging	Marine	2.6
Engineering: Dumping of dredge spoils	Marine	1.6
Climate change: Change in currents	Global	1.3
Climate change: Increased sea temperature	Global	1.3
Fishing: Trapping	Marine	1.0
Engineering: Sand / gravel abstraction	Marine	0.9
Climate change: Increased stratification	Global	0.7
Climate change: Increased storminess	Global	0.7
Fishing: Pelagic high bycatch	Marine	0.7
River inputs: Increased sediment loading	Catchment	0.7
Pollution: Oil or oil products	Mixed	0.6
Aquaculture: Benthic accumulation of debris	Marine	0.6
Aquaculture: Increase in habitat complexity	Marine	0.6
Climate change: UV increase	Global	0.6
Fishing: Long-lining	Marine	0.5
Pollution: Plastic	Mixed	0.4
Fishing: Pelagic low bycatch	Marine	0.4
Climate change: Increased intertidal temperature	Global	0.4
Climate change: Rise in sea-level	Global	0.4
Climate change: Altered rainfall	Global	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Pollution: Heavy metals	Catchment	0.3
Aquaculture: Decrease in primary production	Marine	0.3
Pollution: Nitrogen and phosphorus	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
Pollution: Sewage	Catchment	0.3
Shipping: Noise pollution	Marine	0.3
Increased turbidity	Mixed	0.3
Algal blooms - both toxic and massive	Marine	0.3
Shipping: Grounding, sinking	Marine	0.3
Shipping: Animal strikes	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Anchoring	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.1
Invasive species: Space occupiers, competitors	Marine	0.1
Fishing: Set netting	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.37: Anthropogenic threats to exposed coastal sand 30–200 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Exposed Coasts: Sand 30–200 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.0
Fishing: Dredging	Marine	2.8
Ocean acidification	Global	1.9
Engineering: Dumping of dredge spoils	Marine	1.6
Climate change: Change in currents	Global	1.3
Climate change: Increased sea temperature	Global	1.3
Fishing: Trapping	Marine	1.0
Engineering: Sand / gravel abstraction	Marine	0.9
Climate change: Increased stratification	Global	0.7
Climate change: Increased storminess	Global	0.7
Fishing: Pelagic high bycatch	Marine	0.7
Pollution: Oil or oil products	Mixed	0.6
Aquaculture: Benthic accumulation of debris	Marine	0.6
Aquaculture: Increase in habitat complexity	Marine	0.6
Climate change: UV increase	Global	0.6
River inputs: Increased sediment loading	Catchment	0.5
Fishing: Long-lining	Marine	0.5
Pollution: Plastic	Mixed	0.4
Fishing: Pelagic low bycatch	Marine	0.4
Climate change: Increased intertidal temperature	Global	0.4
Climate change: Rise in sea-level	Global	0.4
Climate change: Altered rainfall	Global	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
Pollution: Heavy metals	Catchment	0.3
Aquaculture: Decrease in primary production	Marine	0.3
Pollution: Nitrogen and phosphorus	Catchment	0.3
Pollution: Herbicides	Catchment	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
Pollution: Sewage	Catchment	0.3
Shipping: Noise pollution	Marine	0.3
Increased turbidity	Mixed	0.3
Algal blooms - both toxic and massive	Marine	0.3
Shipping: Grounding, sinking	Marine	0.3
Shipping: Animal strikes	Marine	0.2
Pollution: Acoustic discharges / guns	Marine	0.2
Anchoring	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.1
Invasive species: Space occupiers, competitors	Marine	0.1
Fishing: Set netting	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.38: Anthropogenic threats to exposed coastal mud 30–200 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Exposed Coasts: Mud 30–200 m
Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.2
Fishing: Dredging	Marine	2.9
Engineering: Dumping of dredge spoils	Marine	2.3
Ocean acidification	Global	1.9
Climate change: Change in currents	Global	1.8
Climate change: Increased sea temperature	Global	1.3
Fishing: Trapping	Marine	1.0
Climate change: Increased stratification	Global	1.0
Pollution: Oil or oil products	Mixed	1.0
Climate change: Increased storminess	Global	1.0
Aquaculture: Benthic accumulation of debris	Marine	0.9
Engineering: Sand / gravel abstraction	Marine	0.9
Aquaculture: Increase in habitat complexity	Marine	0.9
Fishing: Pelagic high bycatch	Marine	0.7
Climate change: UV increase	Global	0.6
Climate change: Altered rainfall	Global	0.5
River inputs: Increased sediment loading	Catchment	0.5
Fishing: Long-lining	Marine	0.5
Pollution: Plastic	Mixed	0.5
Pollution: Pesticides including PCBs	Catchment	0.5
Pollution: Heavy metals	Catchment	0.5
Aquaculture: Decrease in primary production	Marine	0.5
Pollution: Nitrogen and phosphorus	Catchment	0.5
Pollution: Herbicides	Catchment	0.5
Engineering: Mineral extraction - surface suction	Marine	0.5
Pollution: Sewage	Catchment	0.4
Fishing: Pelagic low bycatch	Marine	0.4
Shipping: Noise pollution	Marine	0.4
Climate change: Increased intertidal temperature	Global	0.4
Climate change: Rise in sea-level	Global	0.4
Increased turbidity	Mixed	0.3
Algal blooms - both toxic and massive	Marine	0.3
Shipping: Grounding, sinking	Marine	0.3
Shipping: Animal strikes	Marine	0.3
Pollution: Acoustic discharges / guns	Marine	0.3
Anchoring	Marine	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Invasive species: Space occupiers, competitors	Marine	0.1
Fishing: Set netting	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.39: Anthropogenic threats to fiord inner rock walls and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Fiord Habitats: Inner fiord rock walls

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Altered rainfall	Global	2.5
Fishing: Trapping	Marine	2.2
River inputs: Increased flow	Catchment	2.0
Increased turbidity	Mixed	2.0
Ecotourism: Diving	Marine	2.0
Spatial closures to fishing	Marine	1.9
Fishing: Line fishing	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.7
Invasive species: Space occupiers, competitors	Marine	1.5
Anchoring	Marine	1.4
Ocean acidification	Global	1.4
Climate change: Increased sea temperature	Global	1.4
Ecotourism: Marine mammal watching	Marine	1.2
Fishing: Bottom trawling	Marine	1.2
Fishing: Dredging	Marine	1.1
Fishing: Abalone gathering	Marine	1.0
Fishing: Spear fishing	Marine	1.0
River inputs: Increased sediment loading	Catchment	0.8
Shipping: Grounding, sinking	Marine	0.7
Fishing: Set netting	Marine	0.6
Shipping: Animal strikes	Marine	0.5
Fishing: Long-lining	Marine	0.5
Fishing: Seaweed gathering	Marine	0.4
Climate change: Increased stratification	Global	0.4
Climate change: Change in currents	Global	0.4
Pollution: Sewage	Catchment	0.3
River inputs: Decreased flow	Catchment	0.3
Pollution: Plastic	Mixed	0.2
Fishing: Pelagic low bycatch	Marine	0.2
Pollution: Oil or oil products	Mixed	0.2
Fishing: Shellfish gathering	Marine	0.2
Engineering: Pontoons	Marine	0.2
Engineering: Piled wharfs/sheds	Marine	0.1
Engineering: Pile moorings/markers	Marine	0.1
Vehicles on beaches	Marine	0.1
Invasive species: Disease	Marine	0.1

Table A2.40: Anthropogenic threats to fiord outer rock walls and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Fiord Habitats: Outer fiord rock walls

Threat	Threat Source	Mean weighted vulnerability score
River inputs: Increased flow	Catchment	2.7
Fishing: Trapping	Marine	2.3
Climate change: Altered rainfall	Global	2.2
Increased turbidity	Mixed	1.8
Fishing: Line fishing	Marine	1.7
Ecotourism: Diving	Marine	1.5
Spatial closures to fishing	Marine	1.4
Anchoring	Marine	1.3
Ocean acidification	Global	1.2
Invasive species: Space occupiers, competitors	Marine	1.1
River inputs: Increased sediment loading	Catchment	1.1
Algal blooms - both toxic and massive	Marine	1.0
Fishing: Abalone gathering	Marine	1.0
Ecotourism: Marine mammal watching	Marine	0.9
Fishing: Dredging	Marine	0.9
Fishing: Spear fishing	Marine	0.9
Climate change: Increased sea temperature	Global	0.8
Fishing: Bottom trawling	Marine	0.8
Shipping: Grounding, sinking	Marine	0.5
Fishing: Set netting	Marine	0.4
Pollution: Sewage	Catchment	0.4
River inputs: Decreased flow	Catchment	0.4
Shipping: Animal strikes	Marine	0.3
Fishing: Long-lining	Marine	0.3
Pollution: Plastic	Mixed	0.3
Fishing: Pelagic low bycatch	Marine	0.3
Pollution: Oil or oil products	Mixed	0.3
Fishing: Seaweed gathering	Marine	0.2
Engineering: Piled wharfs/sheds	Marine	0.2
Engineering: Pile moorings/markers	Marine	0.2
Vehicles on beaches	Marine	0.2
Pollution: Pesticides including PCBs	Catchment	0.1

Table A2.41: Anthropogenic threats to fiord sediments and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Fiord Habitats: sediments

Threat	Threat Source	Mean weighted vulnerability score
Climate change: Altered rainfall	Global	3.0
Ocean acidification	Global	2.5
Climate change: Increased sea temperature	Global	1.6
Ecotourism: Diving	Marine	1.6
Climate change: Increased stratification	Global	1.2
Invasive species: Space occupiers, competitors	Marine	1.2
Spatial closures to fishing	Marine	1.2
Fishing: Trapping	Marine	1.0
Algal blooms - both toxic and massive	Marine	0.9
Increased turbidity	Mixed	0.8
Fishing: Bottom trawling	Marine	0.8
Ecotourism: Marine mammal watching	Marine	0.6
Climate change: Change in currents	Global	0.6
River inputs: Increased flow	Catchment	0.6
Fishing: Dredging	Marine	0.6
Fishing: Line fishing	Marine	0.5
River inputs: Increased sediment loading	Catchment	0.5
Fishing: Set netting	Marine	0.4
Fishing: Spear fishing	Marine	0.4
Shipping: Grounding, sinking	Marine	0.4
Shipping: Animal strikes	Marine	0.3
Anchoring	Marine	0.3
Fishing: Shellfish gathering	Marine	0.3
Engineering: Pontoons	Marine	0.3
Fishing: Seaweed gathering	Marine	0.3
Fishing: Long-lining	Marine	0.2
Fishing: Abalone gathering	Marine	0.2
Invasive species: Disease	Marine	0.1
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.1

Table A2.42: Anthropogenic threats to the coastal whole water column inside the 50 m contour and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Coastal - whole water column inside 50 m contour

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.7
Algal blooms - both toxic and massive	Marine	2.3
Climate change: Increased sea temperature	Global	2.1
Fishing: Pelagic high bycatch	Marine	1.8
Engineering: Dumping of dredge spoils	Marine	1.8
Pollution: Plastic	Mixed	1.6

Pollution: Heavy metals	Catchment	1.6
Fishing: Long-lining	Marine	1.3
Climate change: Increased stratification	Global	1.3
Fishing: Line fishing	Marine	1.3
Increased turbidity	Mixed	1.3
Climate change: UV increase	Global	1.2
Fishing: Pelagic low bycatch	Marine	1.2
Pollution: Oil or oil products	Mixed	1.2
Aquaculture: Decrease in primary production	Marine	1.2
Pollution: Acoustic discharges / guns	Marine	1.1
Pollution: Sewage	Catchment	1.1
Pollution: Nitrogen and phosphorus	Catchment	1.0
River inputs: Increased sediment loading	Catchment	0.9
Pollution: Pesticides including PCBs	Catchment	0.9
Fishing: Set netting	Marine	0.9
Invasive species: Space occupiers, competitors	Marine	0.7
Shipping: Noise pollution	Marine	0.7
Climate change: Increased storminess	Global	0.7
Engineering: Dredging	Marine	0.7
Pollution: Herbicides	Catchment	0.6
Ecotourism: Marine mammal watching	Marine	0.5
Shipping: Animal strikes	Marine	0.5
Invasive species: Disease	Marine	0.5
Fishing: Bottom trawling	Marine	0.5
Aquaculture: Benthic accumulation of debris	Marine	0.5
Engineering: Sand / gravel abstraction	Marine	0.4
Climate change: Increased intertidal temperature	Global	0.3
Pollution: Electromagnetic discharges	Marine	0.3
Engineering: Mineral extraction - surface suction	Marine	0.3
Engineering: Mineral extraction - deep hole extraction	Marine	0.3
Ecotourism: Diving	Marine	0.3
Climate change: Change in currents	Global	0.2
River inputs: Decreased sediment loading	Catchment	0.2
River inputs: Decreased flow	Catchment	0.2
River inputs: Increased flow	Catchment	0.2
Climate change: Altered rainfall	Global	0.2
River inputs: Dampening of flows	Catchment	0.2
Anchoring	Marine	0.2
Fishing: Trapping	Marine	0.2
Fishing: Dredging	Marine	0.2
Fishing: Abalone gathering	Marine	0.2
Fishing: Spear fishing	Marine	0.2
Fishing: Shellfish gathering	Marine	0.2
Climate change: Rise in sea-level	Global	0.1
Engineering: reclamation	Marine	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Engineering: Causeways	Marine	0.1
Engineering: Pontoons	Marine	0.1
Engineering: Piled wharfs/sheds	Marine	0.1
Engineering: Pile moorings/markers	Marine	0.1
Engineering: Seawalls	Marine	0.1
Ecotourism: Changes in fish and invertebrate behaviour	Marine	0.1

Table A2.43: Anthropogenic threats to the shelf whole water column between the 50–200 m contour and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Shelf - whole water column between 50–200 m contour

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.1
Climate change: Increased sea temperature	Global	2.8
Fishing: Pelagic high bycatch	Marine	1.7
Algal blooms - both toxic and massive	Marine	1.7
Fishing: Long-lining	Marine	1.6
Climate change: Increased stratification	Global	1.4
Climate change: UV increase	Global	1.3
Fishing: Pelagic low bycatch	Marine	1.3
Fishing: Line fishing	Marine	1.1
Pollution: Oil or oil products	Mixed	0.9
Increased turbidity	Mixed	0.9
Pollution: Plastic	Mixed	0.9
Aquaculture: Decrease in primary production	Marine	0.9
Engineering: Dumping of dredge spoils	Marine	0.8
Pollution: Heavy metals	Catchment	0.8
Pollution: Acoustic discharges / guns	Marine	0.7
Pollution: Sewage	Catchment	0.7
Climate change: Change in currents	Global	0.6
Pollution: Nitrogen and phosphorus	Catchment	0.6
River inputs: Increased sediment loading	Catchment	0.6
Pollution: Pesticides including PCBs	Catchment	0.6
Invasive species: Space occupiers, competitors	Marine	0.5
Shipping: Noise pollution	Marine	0.5
Climate change: Increased storminess	Global	0.5
Ecotourism: Marine mammal watching	Marine	0.5
Shipping: Animal strikes	Marine	0.4
Pollution: Herbicides	Catchment	0.4
Engineering: Dredging	Marine	0.4
Fishing: Set netting	Marine	0.3
Invasive species: Disease	Marine	0.3
Fishing: Bottom trawling	Marine	0.2
River inputs: Decreased sediment loading	Catchment	0.2
River inputs: Decreased flow	Catchment	0.2
River inputs: Increased flow	Catchment	0.2
Climate change: Rise in sea-level	Global	0.2
Climate change: Increased intertidal temperature	Global	0.2
Pollution: Electromagnetic discharges	Marine	0.2
Engineering: Mineral extraction - surface suction	Marine	0.2
Engineering: Mineral extraction - deep hole extraction	Marine	0.2
Engineering: Sand / gravel abstraction	Marine	0.2
Climate change: Altered rainfall	Global	0.1
River inputs: Dampening of flows	Catchment	0.1
Engineering: reclamation	Marine	0.1

Table A2.44: Anthropogenic threats to the slope water column in the photic zone and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Slope - water column in photic zone

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Climate change: Increased sea temperature	Global	3.4
Climate change: Increased stratification	Global	3.4
Climate change: Change in currents	Global	3.2
Climate change: UV increase	Global	2.1
Fishing: Pelagic high bycatch	Marine	1.8
Pollution: Oil or oil products	Mixed	1.5
Pollution: Nitrogen and phosphorus	Catchment	1.0
Fishing: Long-lining	Marine	1.0
Algal blooms - both toxic and massive	Marine	0.9
Fishing: Line fishing	Marine	0.9
Fishing: Pelagic low bycatch	Marine	0.8
Engineering: Dumping of dredge spoils	Marine	0.6
Increased turbidity	Mixed	0.6
Fishing: Bottom trawling	Marine	0.6
Pollution: Plastic	Mixed	0.6
River inputs: Increased sediment loading	Catchment	0.4
Fishing: Set netting	Marine	0.4
Pollution: Heavy metals	Catchment	0.3
River inputs: Decreased sediment loading	Catchment	0.3
Spatial closures to fishing	Marine	0.3
Invasive species: Space occupiers, competitors	Marine	0.3
Pollution: Acoustic discharges / guns	Marine	0.3
Shipping: Noise pollution	Marine	0.3
Climate change: Increased storminess	Global	0.3
Invasive species: Disease	Marine	0.3
Shipping: Animal strikes	Marine	0.3
Pollution: Pesticides including PCBs	Catchment	0.2
River inputs: Decreased flow	Catchment	0.2
River inputs: Increased flow	Catchment	0.2
Climate change: Altered rainfall	Global	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.2
Climate change: Rise in sea-level	Global	0.1
Pollution: Sewage	Catchment	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Shipping: Grounding, sinking	Marine	0.1
River inputs: Dampening of flows	Catchment	0.1
Engineering: reclamation	Marine	0.1
Climate change: Increased intertidal temperature	Global	0.1
Pollution: Herbicides	Catchment	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Anchoring	Marine	0.1

Table A2.45: Anthropogenic threats to the slope water column below the photic zone and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Slope - water column below photic zone

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.4
Climate change: Increased sea temperature	Global	3.4
Climate change: Increased stratification	Global	3.4
Climate change: Change in currents	Global	3.2
Fishing: Pelagic high bycatch	Marine	1.7
Climate change: UV increase	Global	1.4
Pollution: Nitrogen and phosphorus	Catchment	1.3
Pollution: Oil or oil products	Mixed	1.2
Fishing: Long-lining	Marine	1.0
Engineering: Dumping of dredge spoils	Marine	0.7
Algal blooms - both toxic and massive	Marine	0.7
Increased turbidity	Mixed	0.7
River inputs: Increased sediment loading	Catchment	0.6
Fishing: Line fishing	Marine	0.5
Fishing: Pelagic low bycatch	Marine	0.5
Fishing: Bottom trawling	Marine	0.5
Pollution: Heavy metals	Catchment	0.4
Fishing: Set netting	Marine	0.4
River inputs: Decreased sediment loading	Catchment	0.4
Spatial closures to fishing	Marine	0.4
Invasive species: Space occupiers, competitors	Marine	0.4
Pollution: Acoustic discharges / guns	Marine	0.3
Pollution: Pesticides including PCBs	Catchment	0.3
River inputs: Decreased flow	Catchment	0.3
River inputs: Increased flow	Catchment	0.3
Pollution: Plastic	Mixed	0.2
Shipping: Noise pollution	Marine	0.2
Climate change: Increased storminess	Global	0.2
Invasive species: Disease	Marine	0.2
Climate change: Rise in sea-level	Global	0.2
Climate change: Altered rainfall	Global	0.2
Pollution: Sewage	Catchment	0.2
Aquaculture: Decrease in primary production	Marine	0.2
Shipping: Animal strikes	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1
Ecotourism: Noise	Mixed	0.1
Engineering: Minerals extraction - other methods	Marine	0.1
Shipping: Grounding, sinking	Marine	0.1
River inputs: Dampening of flows	Catchment	0.1
Engineering: reclamation	Marine	0.1
Climate change: Increased intertidal temperature	Global	0.1
Pollution: Herbicides	Catchment	0.1
Pollution: Electromagnetic discharges	Marine	0.1
Anchoring	Marine	0.1

Table A2.46: Anthropogenic threats to the deep water column in the photic zone and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Deep ocean water column in photic zone

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Climate change: Increased sea temperature	Global	3.5
Climate change: Change in currents	Global	3.5
Climate change: Increased stratification	Global	2.2
Fishing: Pelagic high bycatch	Marine	2.1
Climate change: UV increase	Global	1.3
Pollution: Oil or oil products	Mixed	1.3
Engineering: Dumping of dredge spoils	Marine	1.2
Fishing: Long-lining	Marine	1.2
Fishing: Line fishing	Marine	1.0
Pollution: Nitrogen and phosphorus	Catchment	0.9
Algal blooms - both toxic and massive	Marine	0.9
Fishing: Pelagic low bycatch	Marine	0.9
Pollution: Heavy metals	Catchment	0.7
Pollution: Plastic	Mixed	0.6
Pollution: Acoustic discharges / guns	Marine	0.4
Fishing: Set netting	Marine	0.3
Shipping: Noise pollution	Marine	0.3
River inputs: Increased sediment loading	Catchment	0.2
Pollution: Pesticides including PCBs	Catchment	0.2
Shipping: Animal strikes	Marine	0.2
Increased turbidity	Mixed	0.1
Engineering: Mineral extraction - surface suction	Marine	0.1
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Ecotourism: Marine mammal watching	Marine	0.1
Climate change: Increased storminess	Global	0.1
Invasive species: Disease	Marine	0.1

Table A2.47: Anthropogenic threats to the deep water column below the photic zone and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Pelagic Habitat : Deep ocean water column below photic zone

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	3.5
Climate change: Increased sea temperature	Global	3.5
Climate change: Change in currents	Global	3.5
Climate change: Increased stratification	Global	2.2
Fishing: Pelagic high bycatch	Marine	2.0
Engineering: Dumping of dredge spoils	Marine	1.2
Fishing: Long-lining	Marine	1.1
Climate change: UV increase	Global	0.9

Pollution: Nitrogen and phosphorus	Catchment	0.9
Pollution: Oil or oil products	Mixed	0.8
Pollution: Heavy metals	Catchment	0.7
Fishing: Line fishing	Marine	0.6
Algal blooms - both toxic and massive	Marine	0.5
Fishing: Pelagic low bycatch	Marine	0.5
Pollution: Acoustic discharges / guns	Marine	0.3
River inputs: Increased sediment loading	Catchment	0.2
Fishing: Set netting	Marine	0.2
Pollution: Pesticides including PCBs	Catchment	0.2
Increased turbidity	Mixed	0.1
Engineering: Mineral extraction - surface suction	Marine	0.1
Engineering: Mineral extraction - deep hole extraction	Marine	0.1
Pollution: Plastic	Mixed	0.1
Shipping: Noise pollution	Marine	0.1

Table A2.48: Anthropogenic threats to hard canyon habitat and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Slope Habitats: Hard canyon
Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	2.9
Ocean acidification	Global	2.8
Climate change: Increased sea temperature	Global	0.6
Climate change: Change in currents	Global	0.5
Fishing: Long-lining	Marine	0.4
Fishing: Pelagic high bycatch	Marine	0.2
Ecotourism: Marine mammal watching	Marine	0.1
Increased turbidity	Mixed	0.1
Ecotourism: Noise	Mixed	0.1

Table A2.49: Anthropogenic threats to soft canyon habitat and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

		Slope Habitats: Soft canyon
Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.1
Fishing: Pelagic high bycatch	Marine	0.3
Ecotourism: Marine mammal watching	Marine	0.3
Increased turbidity	Mixed	0.2
Ecotourism: Noise	Mixed	0.2

Table A2.50: Anthropogenic threats to reefs 200-2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Slope Habitats: Reef 200–2000 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.1
Ocean acidification	Global	2.5
Fishing: Long-lining	Marine	1.0
Engineering: Mineral extraction - surface suction	Marine	0.5
Engineering: Minerals extraction - other methods	Marine	0.5
Engineering: Mineral extraction - deep hole extraction	Marine	0.5
River inputs: Increased sediment loading	Catchment	0.4
Engineering: Dredging	Marine	0.4
Climate change: Change in currents	Global	0.3
Engineering: Dumping of dredge spoils	Marine	0.3
Engineering: Sand / gravel abstraction	Marine	0.3
River inputs: Decreased flow	Catchment	0.3
Climate change: Increased sea temperature	Global	0.2
Fishing: Trapping	Marine	0.2
Algal blooms - both toxic and massive	Marine	0.1
Fishing: Set netting	Marine	0.1
Pollution: Oil or oil products	Mixed	0.1
Fishing: Pelagic high bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Pollution: Heavy metals	Catchment	0.1
Pollution: Plastic	Mixed	0.1
Shipping: Grounding, sinking	Marine	0.1

Table A2.51: Anthropogenic threats to gravel/pebbles/shell habitat 200–2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Slope Habitats: Gravel/ pebbles/shells 200–2000 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.3
Ocean acidification	Global	2.7
Fishing: Long-lining	Marine	1.0
Climate change: Change in currents	Global	0.9
Climate change: Increased sea temperature	Global	0.9
Engineering: Dumping of dredge spoils	Marine	0.7
Engineering: Mineral extraction - surface suction	Marine	0.5
Engineering: Minerals extraction - other methods	Marine	0.5
Engineering: Mineral extraction - deep hole extraction	Marine	0.5
River inputs: Increased sediment loading	Catchment	0.3
Engineering: Sand / gravel abstraction	Marine	0.3
Fishing: Trapping	Marine	0.2

Algal blooms - both toxic and massive	Marine	0.1
Fishing: Set netting	Marine	0.1
Pollution: Oil or oil products	Mixed	0.1
Fishing: Pelagic high bycatch	Marine	0.1
Pollution: Acoustic discharges / guns	Marine	0.1

Table A2.52: Anthropogenic threats to mud habitat 200–2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Slope Habitats: Mud 200–2000 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.0
Ocean acidification	Global	1.1
Engineering: Dumping of dredge spoils	Marine	1.0
Climate change: Change in currents	Global	0.7
Climate change: Increased sea temperature	Global	0.7
Engineering: Mineral extraction - surface suction	Marine	0.5
Fishing: Long-lining	Marine	0.4
River inputs: Increased sediment loading	Catchment	0.4
Engineering: Minerals extraction - other methods	Marine	0.3
Engineering: Mineral extraction - deep hole extraction	Marine	0.3
Climate change: Increased stratification	Global	0.2
Fishing: Dredging	Marine	0.2
Engineering: Sand / gravel abstraction	Marine	0.1
Algal blooms - both toxic and massive	Marine	0.1
Pollution: Heavy metals	Catchment	0.1
Pollution: Plastic	Mixed	0.1
Fishing: Set netting	Marine	0.1
Pollution: Oil or oil products	Mixed	0.1
Increased turbidity	Mixed	0.1

Table A2.53: Anthropogenic threats to sand 200–2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Slope Habitats: Sand 200–2000 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.1
Ocean acidification	Global	1.8
Engineering: Dumping of dredge spoils	Marine	1.5
Climate change: Change in currents	Global	1.3
Climate change: Increased sea temperature	Global	1.0
Engineering: Mineral extraction - surface suction	Marine	0.8
Fishing: Long-lining	Marine	0.6
Engineering: Minerals extraction - other methods	Marine	0.4
River inputs: Increased sediment loading	Catchment	0.4
Engineering: Mineral extraction - deep hole extraction	Marine	0.4

Climate change: Increased stratification	Global	0.4
Fishing: Dredging	Marine	0.3
Engineering: Sand / gravel abstraction	Marine	0.2
Algal blooms - both toxic and massive	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.1
Pollution: Heavy metals	Catchment	0.1
Shipping: Grounding, sinking	Marine	0.1
Pollution: Plastic	Mixed	0.1
Fishing: Set netting	Marine	0.1
Climate change: Increased storminess	Global	0.1
Pollution: Oil or oil products	Mixed	0.1
Pollution: Acoustic discharges / guns	Marine	0.1
Increased turbidity	Mixed	0.1

Table A2.54: Anthropogenic threats to vents and seeps and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Deep Habitats: Vents and seeps

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	2.6
Engineering: Minerals extraction - other methods	Marine	1.5
Ocean acidification	Global	0.6
Fishing: Long-lining	Marine	0.4
Engineering: Mineral extraction - surface suction	Marine	0.1
Engineering: Dumping of dredge spoils	Marine	0.1
Climate change: Increased sea temperature	Global	0.1
River inputs: Increased sediment loading	Catchment	0.1

Table A2.55: Anthropogenic threats to seamount habitat <2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Deep Habitats: Seamounts <2000 m

Threat	Threat Source	Mean weighted vulnerability score
Fishing: Bottom trawling	Marine	3.2
Ocean acidification	Global	3.0
Fishing: Long-lining	Marine	1.7
Engineering: Minerals extraction - other methods	Marine	1.0
Engineering: Mineral extraction - surface suction	Marine	0.6
Engineering: Mineral extraction - deep hole extraction	Marine	0.4
Engineering: Dumping of dredge spoils	Marine	0.3
Climate change: Change in currents	Global	0.2
Climate change: Increased sea temperature	Global	0.2
Engineering: Sand / gravel abstraction	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.1

Table A2.56: Anthropogenic threats to seamount habitat >2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Deep Habitats: Seamount >2000 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	1.4
Fishing: Long-lining	Marine	0.8
Fishing: Bottom trawling	Marine	0.7
Engineering: Minerals extraction - other methods	Marine	0.6
Engineering: Mineral extraction - surface suction	Marine	0.4
Engineering: Mineral extraction - deep hole extraction	Marine	0.4
Climate change: Change in currents	Global	0.2
Engineering: Dumping of dredge spoils	Marine	0.2
Climate change: Increased sea temperature	Global	0.2
Engineering: Sand / gravel abstraction	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.1

Table A2.57: Anthropogenic threats to soft abyssal habitat >2000 m and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Deep Habitats: Soft abyssal >2000 m

Threat	Threat Source	Mean weighted vulnerability score
Ocean acidification	Global	2.9
Engineering: Mineral extraction - surface suction	Marine	0.9
Fishing: Bottom trawling	Marine	0.7
Engineering: Minerals extraction - other methods	Marine	0.6
Climate change: Change in currents	Global	0.6
Fishing: Long-lining	Marine	0.5
Engineering: Dumping of dredge spoils	Marine	0.5
Climate change: Increased sea temperature	Global	0.5
Engineering: Mineral extraction - deep hole extraction	Marine	0.4
Climate change: Increased stratification	Global	0.3
Engineering: Sand / gravel abstraction	Marine	0.2
Pollution: Heavy metals	Catchment	0.2
Shipping: Grounding, sinking	Marine	0.2
Fishing: Pelagic high bycatch	Marine	0.1
Engineering: Dredging	Marine	0.1
Pollution: Plastic	Mixed	0.1

Table A2.58: Anthropogenic threats to trench habitats and threat source in order of decreasing mean weighted vulnerability score. Threats with a score of zero are not shown. The maximum possible score = 4.

Deep Habitats: Trench

Threat	Threat Source	Mean weighted vulnerability score
Acidification due to climate change	Global	2.8
Change in currents due to climate change	Global	0.5
Increased sea temperature due to climate change	Global	0.2
Recreational line fishing	Marine	0.1
Dredging	Marine	0.1
Ship grounding, sinking	Marine	0.1
Algal blooms - both toxic and massive	Marine	0.1

APPENDIX 3: NEW ZEALAND MARINE HABITATS THREATENED BY SPECIFIC HUMAN RELATED THREATS

Table A3.1: Marine habitats in order of decreasing mean weighted vulnerability to algal blooms, both massive and toxic. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Algal blooms - both toxic and massive
Habitat	Mean weighted vulnerability score
Exposed Coasts : Biogenic calcareous reefs	2.4
Pelagic Habitat : Coastal - whole water column inside 50 m contour	2.3
Exposed Coasts : Subtidal reefs 30-200 m	2.1
Sheltered Coast : Sand 2-9 m	1.8
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.7
Fiord Habitats : Inner fiord rockwalls	1.7
Exposed Coasts : Sand 2-9 m	1.7
Sheltered Coast : Sand 10-29 m	1.7
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.7
Exposed Coasts : Subtidal reefs 10-30 m	1.6
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.6
Exposed Coasts : Turfing algal reefs	1.6
Sheltered Coast : Subtidal reefs 10-29 m	1.6
Sheltered Coast : Subtidal reefs 2-9 m	1.6
Sheltered Coast : Kelp Forest	1.6
Exposed Coasts : Sand 10-29 m	1.4
Exposed Coasts : Subtidal reefs 2-9 m	1.4
Harbour and Estuaries : Subtidal reef	1.4
Exposed Coasts : Gravel/pebble/shell 10-29 m	1.3
Exposed Coasts : Mud 10-29 m	1.2
Exposed Coasts : Intertidal reefs	1.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.2
Sheltered Coast : Intertidal reef	1.2
Harbour and Estuaries : Subtidal sand	1.2
Sheltered Coast : Mud 2-9 m	1.1
Harbour and Estuaries : Subtidal mud	1.1
Fiord Habitats : Outer fiord rockwalls	1.0
Exposed Coasts : Kelp Forest	1.0
Harbour and Estuaries : Intertidal mud	1.0
Pelagic Habitat : Deep ocean water column in photic zone	0.9
Pelagic Habitat : Slope - water column in photic zone	0.9
Fiord Habitats : Fiord sediments	0.9
Sheltered Coast : Mud 10-29 m	0.9
Harbour and Estuaries : Intertidal reef	0.9
Harbour and Estuaries : Pipi bed	0.9
Harbour and Estuaries : Cockle bed	0.8
Pelagic Habitat : Slope - water column below photic zone	0.7
Exposed Coasts : Sandy beaches	0.7

Harbour and Estuaries : Intertidal sand	0.7
Harbour and Estuaries : Seagrass	0.6
Pelagic Habitat : Deep ocean water column below photic zone	0.5
Sheltered Coast : Sandy beaches	0.4
Exposed Coasts : Mud 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Slope Habitats : Sand 200-2000 m	0.2
Deep Habitats : Trench	0.1
Slope Habitats : Mud 200-2000 m	0.1
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1
Harbour and Estuaries : Mangrove	0.1

Table A3.2: Marine habitats in order of decreasing mean weighted vulnerability to anchoring. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Anchoring
Habitat	Mean weighted vulnerability score
Exposed Coasts : Turfing algal reefs	1.6
Sheltered Coast : Subtidal reefs 10-29 m	1.6
Sheltered Coast : Subtidal reefs 2-9 m	1.6
Sheltered Coast : Kelp Forest	1.5
Exposed Coasts : Subtidal reefs 30-200 m	1.4
Fiord Habitats : Inner fiord rockwalls	1.4
Exposed Coasts : Subtidal reefs 10-30 m	1.4
Harbour and Estuaries : Subtidal reef	1.3
Fiord Habitats : Outer fiord rockwalls	1.3
Exposed Coasts : Kelp Forest	1.3
Exposed Coasts : Subtidal reefs 2-9 m	1.2
Exposed Coasts : Biogenic calcareous reefs	1.0
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.8
Harbour and Estuaries : Seagrass	0.8
Sheltered Coast : Sand 2-9 m	0.7
Sheltered Coast : Sand 10-29 m	0.7
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.7
Sheltered Coast : Intertidal reef	0.7
Sheltered Coast : Mud 2-9 m	0.6
Exposed Coasts : Mud 10-29 m	0.5
Exposed Coasts : Intertidal reefs	0.5
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.5
Harbour and Estuaries : Subtidal mud	0.5
Harbour and Estuaries : Intertidal reef	0.5
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.4
Harbour and Estuaries : Subtidal sand	0.4
Sheltered Coast : Mud 10-29 m	0.4

Exposed Coasts : Sand 2-9 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Harbour and Estuaries : Intertidal mud	0.3
Fiord Habitats : Fiord sediments	0.3
Harbour and Estuaries : Pipi bed	0.3
Harbour and Estuaries : Cockle bed	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Exposed Coasts : Mud 30-200 m	0.2
Exposed Coasts : Sand 30-200 m	0.2
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.2
Pelagic Habitat : Slope - water column in photic zone	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Harbour and Estuaries : Intertidal sand	0.1
Harbour and Estuaries : Mangrove	0.1

Table A3.3: Marine habitats in order of decreasing mean weighted vulnerability to benthic accumulation of debris under marine farms. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Aquaculture: Benthic accumulation of debris
Habitat	Mean weighted vulnerability score
Sheltered Coast : Mud 2-9 m	2.6
Harbour and Estuaries : Seagrass	2.3
Harbour and Estuaries : Subtidal mud	2.1
Sheltered Coast : Sand 10-29 m	2.0
Harbour and Estuaries : Intertidal mud	2.0
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.9
Sheltered Coast : Sand 2-9 m	1.9
Sheltered Coast : Mud 10-29 m	1.9
Harbour and Estuaries : Subtidal sand	1.7
Exposed Coasts : Subtidal reefs 30-200 m	1.5
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.5
Harbour and Estuaries : Subtidal reef	1.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.4
Harbour and Estuaries : Intertidal reef	1.4
Harbour and Estuaries : Pipi bed	1.4
Sheltered Coast : Subtidal reefs 10-29 m	1.2
Sheltered Coast : Subtidal reefs 2-9 m	1.2
Sheltered Coast : Intertidal reef	1.2
Exposed Coasts : Mud 10-29 m	1.2
Harbour and Estuaries : Cockle bed	1.2
Sheltered Coast : Kelp Forest	0.9
Exposed Coasts : Subtidal reefs 10-30 m	0.9
Exposed Coasts : Biogenic calcareous reefs	0.9
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.9
Exposed Coasts : Mud 30-200 m	0.9

Exposed Coasts : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Sand 2-9 m	0.7
Exposed Coasts : Sand 10-29 m	0.7
Exposed Coasts : Turfing algal reefs	0.6
Exposed Coasts : Kelp Forest	0.6
Exposed Coasts : Intertidal reefs	0.6
Exposed Coasts : Sand 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.6
Harbour and Estuaries : Intertidal sand	0.6
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.5

Table A3.4: Marine habitats in order of decreasing mean weighted vulnerability to increase in habitat complexity in and around marine farms. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Aquaculture: Increase in habitat complexity
Habitat	Mean weighted vulnerability score
Sheltered Coast : Mud 2-9 m	1.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.2
Harbour and Estuaries : Subtidal reef	1.1
Harbour and Estuaries : Intertidal reef	1.1
Harbour and Estuaries : Subtidal mud	1.0
Sheltered Coast : Sand 10-29 m	1.0
Sheltered Coast : Sand 2-9 m	1.0
Sheltered Coast : Mud 10-29 m	1.0
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.9
Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Exposed Coasts : Mud 30-200 m	0.9
Harbour and Estuaries : Intertidal mud	0.8
Exposed Coasts : Subtidal reefs 10-30 m	0.8
Harbour and Estuaries : Subtidal sand	0.7
Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Subtidal reefs 2-9 m	0.7
Exposed Coasts : Intertidal reefs	0.7
Exposed Coasts : Mud 10-29 m	0.6
Exposed Coasts : Sand 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.5
Sheltered Coast : Intertidal reef	0.5
Harbour and Estuaries : Pipi bed	0.4
Exposed Coasts : Kelp Forest	0.4
Harbour and Estuaries : Seagrass	0.3
Harbour and Estuaries : Cockle bed	0.3
Exposed Coasts : Biogenic calcareous reefs	0.3

Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Sand 2-9 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Exposed Coasts : Turfing algal reefs	0.2
Harbour and Estuaries : Intertidal sand	0.2

Table A3.5: Marine habitats in order of decreasing mean weighted vulnerability to decreases in local primary production around marine farms. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Aquaculture: Decrease in primary production
Habitat	Mean weighted vulnerability score
Sheltered Coast : Mud 2-9 m	1.4
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.2
Harbour and Estuaries : Subtidal reef	1.1
Harbour and Estuaries : Intertidal reef	1.1
Harbour and Estuaries : Subtidal mud	1.0
Exposed Coasts : Subtidal reefs 30-200 m	0.9
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.9
Sheltered Coast : Sand 10-29 m	0.8
Sheltered Coast : Sand 2-9 m	0.8
Sheltered Coast : Mud 10-29 m	0.8
Sheltered Coast : Subtidal reefs 10-29 m	0.8
Sheltered Coast : Subtidal reefs 2-9 m	0.8
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.7
Harbour and Estuaries : Intertidal mud	0.7
Harbour and Estuaries : Subtidal sand	0.7
Exposed Coasts : Intertidal reefs	0.7
Harbour and Estuaries : Seagrass	0.7
Exposed Coasts : Subtidal reefs 10-30 m	0.6
Sheltered Coast : Intertidal reef	0.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Subtidal reefs 2-9 m	0.5
Sheltered Coast : Kelp Forest	0.4
Harbour and Estuaries : Pipi bed	0.4
Exposed Coasts : Mud 10-29 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.3
Harbour and Estuaries : Cockle bed	0.3
Exposed Coasts : Biogenic calcareous reefs	0.3
Exposed Coasts : Turfing algal reefs	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Sand 10-29 m	0.2

Harbour and Estuaries : Intertidal sand	0.2
Pelagic Habitat : Slope - water column in photic zone	0.2
Pelagic Habitat : Slope - water column below photic zone	0.2
Exposed Coasts : Kelp Forest	0.1
Harbour and Estuaries : Mangrove	0.1

Table A3.6: Marine habitats in order of decreasing mean weighted vulnerability to ocean acidification. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ocean acidification
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal reef	3.6
Harbour and Estuaries : Intertidal reef	3.5
Sheltered Coast : Sand 10-29 m	3.5
Sheltered Coast : Sand 2-9 m	3.5
Sheltered Coast : Gravel/pebble/shell 2-9 m	3.5
Sheltered Coast : Gravel/pebble/shell 10-29 m	3.5
Exposed Coasts : Biogenic calcareous reefs	3.5
Pelagic Habitat : Slope - water column in photic zone	3.5
Pelagic Habitat : Deep ocean water column in photic zone	3.5
Pelagic Habitat : Deep ocean water column below photic zone	3.5
Sheltered Coast : Intertidal reef	3.4
Harbour and Estuaries : Pipi bed	3.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	3.4
Pelagic Habitat : Slope - water column below photic zone	3.4
Exposed Coasts : Subtidal reefs 30-200 m	3.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	3.3
Harbour and Estuaries : Cockle bed	3.2
Sheltered Coast : Sandy beaches	3.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	3.1
Exposed Coasts : Sandy beaches	3.1
Exposed Coasts : Gravel/pebble/shell 30-200 m	3.0
Deep Habitats : Seamount < 2000 m	3.0
Sheltered Coast : Subtidal reefs 10-29 m	2.9
Sheltered Coast : Subtidal reefs 2-9 m	2.9
Deep Habitats : Soft abyssal 2000 m+	2.9
Deep Habitats : Trench	2.8
Deep Habitats : Hard canyon	2.8
Sheltered Coast : Mud 2-9 m	2.7
Pelagic Habitat : Coastal - whole water column inside 50 m contour	2.7
Sheltered Coast : Mud 10-29 m	2.7
Harbour and Estuaries : Subtidal sand	2.7
Slope Habitats : Gravel/pebbles/shells 200-2000 m	2.7
Exposed Coasts : Sand 2-9 m	2.6
Exposed Coasts : Sand 10-29 m	2.6

Harbour and Estuaries : Intertidal sand	2.6
Exposed Coasts : Turfing algal reefs	2.5
Fiord Habitats : Fiord sediments	2.5
Slope Habitats : Reef 200-2000 m	2.5
Exposed Coasts : Subtidal reefs 10-30 m	2.4
Exposed Coasts : Intertidal reefs	2.3
Exposed Coasts : Mud 10-29 m	2.3
Sheltered Coast : Kelp Forest	2.2
Exposed Coasts : Subtidal reefs 2-9 m	2.1
Exposed Coasts : Mud 30-200 m	1.9
Exposed Coasts : Sand 30-200 m	1.9
Slope Habitats : Sand 200-2000 m	1.8
Harbour and Estuaries : Subtidal mud	1.7
Harbour and Estuaries : Intertidal mud	1.7
Harbour and Estuaries : Seagrass	1.7
Exposed Coasts : Kelp Forest	1.6
Fiord Habitats : Inner fiord rockwalls	1.4
Deep Habitats : Seamount > 2000 m	1.4
Fiord Habitats : Outer fiord rockwalls	1.2
Harbour and Estuaries : Mangrove	1.1
Slope Habitats : Mud 200-2000 m	1.1
Harbour and Estuaries : Saltmarsh	0.7
Deep Habitats : Vent (hot and cold)	0.6
Deep Habitats : Soft canyon	NA

Table A3.7: Marine habitats in order of decreasing mean weighted vulnerability to increased sea temperature. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Increased sea temperature
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Deep ocean water column in photic zone	3.5
Pelagic Habitat : Deep ocean water column below photic zone	3.5
Pelagic Habitat : Slope - water column in photic zone	3.4
Pelagic Habitat : Slope - water column below photic zone	3.4
Exposed Coasts : Sandy beaches	3.1
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	2.8
Harbour and Estuaries : Subtidal sand	2.7
Harbour and Estuaries : Pipi bed	2.4
Harbour and Estuaries : Intertidal reef	2.3
Exposed Coasts : Intertidal reefs	2.3
Harbour and Estuaries : Intertidal mud	2.3
Harbour and Estuaries : Subtidal reef	2.2
Exposed Coasts : Subtidal reefs 30-200 m	2.2
Harbour and Estuaries : Subtidal mud	2.2
Sheltered Coast : Sand 10-29 m	2.1

Sheltered Coast : Sand 2-9 m	2.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	2.1
Sheltered Coast : Mud 2-9 m	2.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	2.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	2.0
Sheltered Coast : Intertidal reef	1.9
Harbour and Estuaries : Cockle bed	1.9
Sheltered Coast : Sandy beaches	1.9
Sheltered Coast : Mud 10-29 m	1.8
Harbour and Estuaries : Intertidal sand	1.7
Harbour and Estuaries : Seagrass	1.7
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.6
Fiord Habitats : Fiord sediments	1.6
Sheltered Coast : Subtidal reefs 10-29 m	1.5
Sheltered Coast : Subtidal reefs 2-9 m	1.5
Exposed Coasts : Turfing algal reefs	1.5
Exposed Coasts : Biogenic calcareous reefs	1.4
Exposed Coasts : Gravel/pebble/shell 10-29 m	1.4
Exposed Coasts : Sand 10-29 m	1.4
Fiord Habitats : Inner fiord rockwalls	1.4
Exposed Coasts : Gravel/pebble/shell 30-200 m	1.3
Exposed Coasts : Mud 30-200 m	1.3
Exposed Coasts : Sand 30-200 m	1.3
Exposed Coasts : Sand 2-9 m	1.2
Exposed Coasts : Subtidal reefs 10-30 m	1.2
Sheltered Coast : Kelp Forest	1.2
Exposed Coasts : Subtidal reefs 2-9 m	1.1
Harbour and Estuaries : Mangrove	1.1
Exposed Coasts : Mud 10-29 m	1.0
Slope Habitats : Sand 200-2000 m	1.0
Exposed Coasts : Kelp Forest	1.0
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.9
Fiord Habitats : Outer fiord rockwalls	0.8
Slope Habitats : Mud 200-2000 m	0.7
Deep Habitats : Hard canyon	0.6
Harbour and Estuaries : Saltmarsh	0.6
Deep Habitats : Soft abyssal 2000 m+	0.5
Deep Habitats : Seamount < 2000 m	0.2
Deep Habitats : Trench	0.2
Slope Habitats : Reef 200-2000 m	0.2
Deep Habitats : Seamount > 2000 m	0.2
Deep Habitats : Vent (hot and cold)	0.1
Deep Habitats : Soft canyon	NA

Table A3.8: Marine habitats in order of decreasing mean weighted vulnerability to increased storminess due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Increased storminess
Habitat	Mean weighted vulnerability score
Exposed Coasts : Intertidal reefs	3.5
Exposed Coasts : Sandy beaches	3.1
Harbour and Estuaries : Subtidal sand	2.5
Harbour and Estuaries : Subtidal mud	2.5
Harbour and Estuaries : Intertidal reef	2.2
Exposed Coasts : Sand 2-9 m	2.2
Exposed Coasts : Subtidal reefs 10-30 m	2.2
Sheltered Coast : Sandy beaches	2.1
Harbour and Estuaries : Pipi bed	2.0
Harbour and Estuaries : Intertidal mud	2.0
Exposed Coasts : Subtidal reefs 30-200 m	2.0
Exposed Coasts : Turfing algal reefs	2.0
Sheltered Coast : Kelp Forest	2.0
Sheltered Coast : Sand 10-29 m	1.9
Sheltered Coast : Sand 2-9 m	1.9
Sheltered Coast : Mud 2-9 m	1.9
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.9
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.9
Exposed Coasts : Subtidal reefs 2-9 m	1.9
Exposed Coasts : Mud 10-29 m	1.9
Exposed Coasts : Sand 10-29 m	1.8
Harbour and Estuaries : Subtidal reef	1.7
Harbour and Estuaries : Mangrove	1.7
Exposed Coasts : Kelp Forest	1.7
Harbour and Estuaries : Cockle bed	1.6
Harbour and Estuaries : Intertidal sand	1.6
Harbour and Estuaries : Seagrass	1.6
Exposed Coasts : Gravel/pebble/shell 10-29 m	1.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.5
Sheltered Coast : Intertidal reef	1.5
Sheltered Coast : Mud 10-29 m	1.5
Sheltered Coast : Subtidal reefs 10-29 m	1.5
Sheltered Coast : Subtidal reefs 2-9 m	1.5
Exposed Coasts : Biogenic calcareous reefs	1.4
Harbour and Estuaries : Saltmarsh	1.1
Exposed Coasts : Mud 30-200 m	1.0
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.7
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.7
Exposed Coasts : Sand 30-200 m	0.7

Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.5
Pelagic Habitat : Slope - water column in photic zone	0.3
Pelagic Habitat : Slope - water column below photic zone	0.2
Pelagic Habitat : Deep ocean water column in photic zone	0.1
Slope Habitats : Sand 200-2000 m	0.1

Table A3.9: Marine habitats in order of decreasing mean weighted vulnerability to change in currents due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Change in currents
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Deep ocean water column in photic zone	3.5
Pelagic Habitat : Deep ocean water column below photic zone	3.5
Pelagic Habitat : Slope - water column in photic zone	3.2
Pelagic Habitat : Slope - water column below photic zone	3.2
Exposed Coasts : Subtidal reefs 30-200 m	2.3
Harbour and Estuaries : Intertidal reef	2.1
Exposed Coasts : Intertidal reefs	2.0
Sheltered Coast : Mud 2-9 m	2.0
Exposed Coasts : Mud 30-200 m	1.8
Harbour and Estuaries : Subtidal mud	1.6
Sheltered Coast : Sand 10-29 m	1.6
Harbour and Estuaries : Subtidal reef	1.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.6
Sheltered Coast : Mud 10-29 m	1.6
Exposed Coasts : Sandy beaches	1.5
Exposed Coasts : Subtidal reefs 10-30 m	1.5
Harbour and Estuaries : Intertidal mud	1.5
Sheltered Coast : Sand 2-9 m	1.5
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.5
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.4
Exposed Coasts : Mud 10-29 m	1.4
Sheltered Coast : Subtidal reefs 10-29 m	1.4
Sheltered Coast : Subtidal reefs 2-9 m	1.4
Exposed Coasts : Subtidal reefs 2-9 m	1.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	1.3
Exposed Coasts : Sand 30-200 m	1.3
Slope Habitats : Sand 200-2000 m	1.3
Sheltered Coast : Kelp Forest	1.2
Harbour and Estuaries : Subtidal sand	1.1
Exposed Coasts : Turfing algal reefs	1.1
Exposed Coasts : Biogenic calcareous reefs	1.1
Exposed Coasts : Sand 2-9 m	1.0
Harbour and Estuaries : Pipi bed	1.0
Exposed Coasts : Sand 10-29 m	1.0
Harbour and Estuaries : Seagrass	1.0

Exposed Coasts : Kelp Forest	0.9
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.9
Sheltered Coast : Intertidal reef	0.9
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.9
Sheltered Coast : Sandy beaches	0.8
Harbour and Estuaries : Mangrove	0.8
Harbour and Estuaries : Cockle bed	0.8
Harbour and Estuaries : Intertidal sand	0.8
Slope Habitats : Mud 200-2000 m	0.7
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.6
Fiord Habitats : Fiord sediments	0.6
Deep Habitats : Soft abyssal 2000 m+	0.6
Deep Habitats : Hard canyon	0.5
Deep Habitats : Trench	0.5
Harbour and Estuaries : Saltmarsh	0.4
Fiord Habitats : Inner fiord rockwalls	0.4
Slope Habitats : Reef 200-2000 m	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Deep Habitats : Seamount < 2000 m	0.2
Deep Habitats : Seamount > 2000 m	0.2
Deep Habitats : Soft canyon	NA

Table A3.10: Marine habitats in order of decreasing mean weighted vulnerability to rise in sea level due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

Climate change: Rise in sea-level

Habitat	Mean weighted vulnerability score
Sheltered Coast : Sandy beaches	3.4
Harbour and Estuaries : Mangrove	3.3
Harbour and Estuaries : Saltmarsh	3.3
Exposed Coasts : Sandy beaches	2.8
Harbour and Estuaries : Pipi bed	2.8
Harbour and Estuaries : Cockle bed	2.8
Harbour and Estuaries : Intertidal sand	2.6
Harbour and Estuaries : Intertidal reef	2.4
Harbour and Estuaries : Intertidal mud	2.3
Sheltered Coast : Intertidal reef	2.2
Exposed Coasts : Intertidal reefs	2.1
Harbour and Estuaries : Subtidal mud	1.7
Harbour and Estuaries : Subtidal sand	1.6
Harbour and Estuaries : Subtidal reef	1.5
Harbour and Estuaries : Seagrass	1.5
Exposed Coasts : Subtidal reefs 30-200 m	1.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.1
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.1
Sheltered Coast : Sand 2-9 m	1.0

Exposed Coasts : Turfing algal reefs	1.0
Exposed Coasts : Sand 2-9 m	1.0
Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Sheltered Coast : Kelp Forest	0.9
Exposed Coasts : Subtidal reefs 10-30 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.7
Exposed Coasts : Biogenic calcareous reefs	0.7
Exposed Coasts : Kelp Forest	0.7
Sheltered Coast : Mud 2-9 m	0.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.5
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.5
Exposed Coasts : Mud 30-200 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.4
Exposed Coasts : Sand 30-200 m	0.4
Exposed Coasts : Mud 10-29 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Pelagic Habitat : Slope - water column below photic zone	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Pelagic Habitat : Slope - water column in photic zone	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1

Table A3.11: Marine habitats in order of decreasing mean weighted vulnerability to increased stratification due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Increased stratification
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Slope - water column below photic zone	3.4
Pelagic Habitat : Slope - water column in photic zone	3.4
Pelagic Habitat : Deep ocean water column in photic zone	2.2
Pelagic Habitat : Deep ocean water column below photic zone	2.2
Exposed Coasts : Subtidal reefs 30-200 m	1.9
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.4
Exposed Coasts : Intertidal reefs	1.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.3
Exposed Coasts : Biogenic calcareous reefs	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.3
Harbour and Estuaries : Intertidal reef	1.2
Harbour and Estuaries : Subtidal reef	1.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.2
Exposed Coasts : Subtidal reefs 10-30 m	1.2
Fiord Habitats : Fiord sediments	1.2
Harbour and Estuaries : Subtidal mud	1.1
Sheltered Coast : Sand 2-9 m	1.1

Sheltered Coast : Subtidal reefs 10-29 m	1.1
Sheltered Coast : Subtidal reefs 2-9 m	1.1
Exposed Coasts : Subtidal reefs 2-9 m	1.1
Exposed Coasts : Mud 10-29 m	1.1
Harbour and Estuaries : Subtidal sand	1.0
Exposed Coasts : Turfing algal reefs	1.0
Exposed Coasts : Mud 30-200 m	1.0
Sheltered Coast : Mud 2-9 m	0.9
Exposed Coasts : Sand 2-9 m	0.8
Sheltered Coast : Kelp Forest	0.8
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.8
Sheltered Coast : Sand 10-29 m	0.8
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.7
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.7
Exposed Coasts : Sand 30-200 m	0.7
Exposed Coasts : Sand 10-29 m	0.7
Harbour and Estuaries : Pipi bed	0.6
Harbour and Estuaries : Intertidal mud	0.6
Exposed Coasts : Kelp Forest	0.6
Sheltered Coast : Mud 10-29 m	0.6
Harbour and Estuaries : Cockle bed	0.5
Sheltered Coast : Intertidal reef	0.5
Harbour and Estuaries : Seagrass	0.5
Harbour and Estuaries : Intertidal sand	0.4
Slope Habitats : Sand 200-2000 m	0.4
Fiord Habitats : Inner fiord rockwalls	0.4
Deep Habitats : Soft abyssal 2000 m+	0.3
Slope Habitats : Mud 200-2000 m	0.2
Harbour and Estuaries : Mangrove	0.1
Harbour and Estuaries : Saltmarsh	0.1

Table A3.12: Marine habitats in order of decreasing mean weighted vulnerability to increased intertidal temperature due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Increased intertidal temperature
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Pipi bed	2.9
Exposed Coasts : Intertidal reefs	2.8
Harbour and Estuaries : Cockle bed	2.8
Harbour and Estuaries : Intertidal reef	2.3
Harbour and Estuaries : Subtidal mud	2.2
Harbour and Estuaries : Intertidal mud	2.2
Harbour and Estuaries : Subtidal sand	2.1
Harbour and Estuaries : Intertidal sand	2.1
Sheltered Coast : Intertidal reef	2.0

Sheltered Coast : Sandy beaches	1.9
Exposed Coasts : Sandy beaches	1.9
Harbour and Estuaries : Seagrass meadows	1.7
Harbour and Estuaries : Saltmarsh	1.5
Harbour and Estuaries : Subtidal reef	1.2
Harbour and Estuaries : Mangrove forest	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.0
Sheltered Coast : Sand 2-9 m	0.8
Sheltered Coast : Subtidal reefs 10-29 m	0.8
Sheltered Coast : Subtidal reefs 2-9 m	0.8
Sheltered Coast : Mud 2-9 m	0.8
Sheltered Coast : Kelp Forest	0.7
Sheltered Coast : Sand 10-29 m	0.7
Exposed Coasts : Subtidal reefs 10-30 m	0.6
Exposed Coasts : Subtidal reefs 2-9 m	0.6
Sheltered Coast : Mud 10-29 m	0.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Turfing algal reefs	0.4
Exposed Coasts : Mud 30-200 m	0.4
Exposed Coasts : Sand 2-9 m	0.4
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.4
Exposed Coasts : Sand 30-200 m	0.4
Exposed Coasts : Kelp Forest	0.4
Exposed Coasts : Biogenic calcareous reefs	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.3
Exposed Coasts : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1

Table A3.13: Marine habitats in order of decreasing mean weighted vulnerability to UV increase due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: UV increase
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal reef	2.2
Pelagic Habitat : Slope - water column in photic zone	2.1
Exposed Coasts : Intertidal reefs	2.0
Harbour and Estuaries : Subtidal mud	1.8
Harbour and Estuaries : Subtidal sand	1.8
Harbour and Estuaries : Pipi bed	1.4
Harbour and Estuaries : Seagrass meadows	1.4

Pelagic Habitat : Slope - water column below photic zone	1.4
Harbour and Estuaries : Subtidal reef	1.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.3
Pelagic Habitat : Deep ocean water column in photic zone	1.3
Sheltered Coast : Intertidal reef	1.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.2
Harbour and Estuaries : Cockle bed	1.1
Harbour and Estuaries : Intertidal mud	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.0
Sheltered Coast : Sand 2-9 m	1.0
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.0
Pelagic Habitat : Deep ocean water column below photic zone	0.9
Exposed Coasts : Sand 2-9 m	0.8
Exposed Coasts : Subtidal reefs 10-30 m	0.7
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.7
Exposed Coasts : Biogenic calcareous reefs	0.7
Harbour and Estuaries : Intertidal sand	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Sheltered Coast : Mud 2-9 m	0.6
Exposed Coasts : Subtidal reefs 2-9 m	0.6
Exposed Coasts : Turfing algal reefs	0.6
Exposed Coasts : Mud 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.6
Exposed Coasts : Sand 30-200 m	0.6
Harbour and Estuaries : Mangrove forest	0.5
Sheltered Coast : Sand 10-29 m	0.5
Exposed Coasts : Sand 10-29 m	0.5
Harbour and Estuaries : Saltmarsh	0.4
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Mud 10-29 m	0.4
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Kelp Forest	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Sheltered Coast : Sandy beaches	0.2
Exposed Coasts : Sandy beaches	0.2
Sheltered Coast : Kelp Forest	0.2

Table A3.14: Marine habitats in order of decreasing mean weighted vulnerability to altered rainfall due to climate change. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Climate change: Altered rainfall
Habitat	Mean weighted vulnerability score
Fiord Habitats : Fiord sediments	3.0
Fiord Habitats : Inner fiord rockwalls	2.5

Harbour and Estuaries : Intertidal reef	2.2
Fiord Habitats : Outer fiord rockwalls	2.2
Exposed Coasts : Intertidal reefs	1.6
Harbour and Estuaries : Subtidal mud	1.5
Harbour and Estuaries : Subtidal sand	1.5
Harbour and Estuaries : Subtidal reef	1.4
Harbour and Estuaries : Pipi bed	1.1
Sheltered Coast : Intertidal reef	1.1
Harbour and Estuaries : Cockle bed	1.1
Harbour and Estuaries : Intertidal mud	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Harbour and Estuaries : Mangrove forest	1.1
Harbour and Estuaries : Seagrass meadows	1.0
Exposed Coasts : Sandy beaches	1.0
Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Sheltered Coast : Mud 2-9 m	0.9
Exposed Coasts : Sand 2-9 m	0.8
Harbour and Estuaries : Saltmarsh	0.8
Sheltered Coast : Sand 2-9 m	0.7
Exposed Coasts : Subtidal reefs 10-30 m	0.7
Harbour and Estuaries : Intertidal sand	0.7
Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Subtidal reefs 2-9 m	0.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Sheltered Coast : Sand 10-29 m	0.5
Sheltered Coast : Mud 10-29 m	0.5
Sheltered Coast : Sandy beaches	0.5
Exposed Coasts : Sand 10-29 m	0.4
Exposed Coasts : Kelp Forest	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.3
Exposed Coasts : Biogenic calcareous reefs	0.3
Exposed Coasts : Turfing algal reefs	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Mud 10-29 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.2
Pelagic Habitat : Slope - water column below photic zone	0.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.1

Table A3.15: Marine habitats in order of decreasing mean weighted vulnerability to diving activity. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Diving
Habitat	Mean weighted vulnerability score
Fiord Habitats : Inner fiord rockwalls	2.0
Fiord Habitats : Fiord sediments	1.6
Fiord Habitats : Outer fiord rockwalls	1.5
Exposed Coasts : Subtidal reefs 10-30 m	1.3
Exposed Coasts : Turfing algal reefs	1.3
Sheltered Coast : Subtidal reefs 10-29 m	1.2
Sheltered Coast : Subtidal reefs 2-9 m	1.2
Sheltered Coast : Kelp Forest	1.2
Exposed Coasts : Subtidal reefs 2-9 m	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.0
Exposed Coasts : Kelp Forest	1.0
Harbour and Estuaries : Subtidal reef	0.7
Exposed Coasts : Intertidal reefs	0.6
Sheltered Coast : Sand 10-29 m	0.5
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.5
Sheltered Coast : Mud 2-9 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Harbour and Estuaries : Intertidal reef	0.3
Sheltered Coast : Intertidal reef	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.3
Exposed Coasts : Biogenic calcareous reefs	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.3
Harbour and Estuaries : Subtidal mud	0.2
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Sand 10-29 m	0.2
Exposed Coasts : Mud 10-29 m	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Harbour and Estuaries : Subtidal sand	0.1
Harbour and Estuaries : Pipi bed	0.1
Harbour and Estuaries : Cockle bed	0.1
Harbour and Estuaries : Intertidal mud	0.1
Harbour and Estuaries : Seagrass meadows	0.1

Table A3.16: Marine habitats in order of decreasing mean weighted vulnerability to vehicles on beaches. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Vehicles on beaches
Habitat	Mean weighted vulnerability score
Exposed Coasts : Sandy beaches	1.8
Sheltered Coast : Sandy beaches	1.7
Harbour and Estuaries : Intertidal sand	1.2
Harbour and Estuaries : Saltmarsh	1.0
Harbour and Estuaries : Cockle bed	0.7
Harbour and Estuaries : Mangrove forest	0.6
Exposed Coasts : Sand 2-9 m	0.6
Harbour and Estuaries : Pipi bed	0.5
Sheltered Coast : Sand 2-9 m	0.5
Exposed Coasts : Intertidal reefs	0.4
Harbour and Estuaries : Intertidal reef	0.4
Sheltered Coast : Intertidal reef	0.4
Harbour and Estuaries : Seagrass meadows	0.4
Harbour and Estuaries : Intertidal mud	0.3
Harbour and Estuaries : Subtidal mud	0.2
Harbour and Estuaries : Subtidal sand	0.2
Fiord Habitats : Outer fiord rockwalls	0.2
Sheltered Coast : Mud 2-9 m	0.2
Sheltered Coast : Sand 10-29 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Fiord Habitats : Inner fiord rockwalls	0.1

Table A3.17: Marine habitats in order of decreasing mean weighted vulnerability to changes in behavious of fish and invertebrate behaviour due to ecotourism. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Changes in fish and invertebrate behaviour
Habitat	Mean weighted vulnerability score
Exposed Coasts : Subtidal reefs 30-200 m	1
Exposed Coasts : Subtidal reefs 10-30 m	0.9
Sheltered Coast : Subtidal reefs 10-29 m	0.8
Sheltered Coast : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Turfing algal reefs	0.7
Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Kelp Forest	0.7
Exposed Coasts : Intertidal reefs	0.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.4

Exposed Coasts : Biogenic calcareous reefs	0.4
Harbour and Estuaries : Subtidal reef	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Sheltered Coast : Mud 2-9 m	0.3
Harbour and Estuaries : Intertidal reef	0.3
Sheltered Coast : Intertidal reef	0.3
Exposed Coasts : Mud 10-29 m	0.3
Sheltered Coast : Sand 10-29 m	0.2
Sheltered Coast : Sand 2-9 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Sand 10-29 m	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Harbour and Estuaries : Mangrove forest	0.2
Fiord Habitats : Fiord sediments	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1

Table A3.18: Marine habitats in order of decreasing mean weighted vulnerability to reef trampling by humans. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Reef trampling
Habitat	Mean weighted vulnerability score
Exposed Coasts : Intertidal reefs	1.8
Harbour and Estuaries : Intertidal reef	1.2
Sheltered Coast : Intertidal reef	1.2
Harbour and Estuaries : Subtidal reef	0.5
Exposed Coasts : Subtidal reefs 10-30 m	0.5
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Harbour and Estuaries : Subtidal mud	0.4
Harbour and Estuaries : Saltmarsh	0.4
Exposed Coasts : Subtidal reefs 30-200 m	0.3
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Harbour and Estuaries : Intertidal mud	0.3
Harbour and Estuaries : Subtidal sand	0.3
Sheltered Coast : Kelp Forest	0.2
Exposed Coasts : Kelp Forest	0.2
Harbour and Estuaries : Seagrass meadows	0.2
Harbour and Estuaries : Mangrove forest	0.2
Exposed Coasts : Turfing algal reefs	0.1
Harbour and Estuaries : Pipi bed	0.1
Harbour and Estuaries : Intertidal sand	0.1
Harbour and Estuaries : Cockle bed	0.1

Table A3.19: Marine habitats in order of decreasing mean weighted vulnerability to marine mammal watching. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Marine mammal watching
Habitat	Mean weighted vulnerability score
Fiord Habitats : Inner fiord rockwalls	1.2
Fiord Habitats : Outer fiord rockwalls	0.9
Fiord Habitats : Fiord sediments	0.6
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.5
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.5
Exposed Coasts : Subtidal reefs 30-200 m	0.4
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Deep Habitats : Soft canyon	0.3
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Exposed Coasts : Subtidal reefs 2-9 m	0.2
Sheltered Coast : Kelp Forest	0.2
Sheltered Coast : Mud 2-9 m	0.2
Sheltered Coast : Sand 10-29 m	0.2
Sheltered Coast : Sand 2-9 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Harbour and Estuaries : Subtidal sand	0.2
Exposed Coasts : Sandy beaches	0.2
Sheltered Coast : Sandy beaches	0.2
Pelagic Habitat : Slope - water column in photic zone	0.2
Exposed Coasts : Kelp Forest	0.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Harbour and Estuaries : Subtidal mud	0.1
Harbour and Estuaries : Pipi bed	0.1
Harbour and Estuaries : Cockle bed	0.1
Harbour and Estuaries : Seagrass meadows	0.1
Harbour and Estuaries : Intertidal sand	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Deep ocean water column in photic zone	0.1
Deep Habitats : Hard canyon	0.1

Table A3.20: Marine habitats in order of decreasing mean weighted vulnerability to noise from ecotourism. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Ecotourism: Noise
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Saltmarsh	0.2
Deep Habitats : Soft canyon	0.2
Exposed Coasts : Subtidal reefs 30-200 m	0.1
Exposed Coasts : Subtidal reefs 10-30 m	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Harbour and Estuaries : Subtidal sand	0.1
Exposed Coasts : Kelp Forest	0.1
Harbour and Estuaries : Subtidal mud	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Deep Habitats : Hard canyon	0.1
Exposed Coasts : Turfing algal reefs	0.1
Exposed Coasts : Intertidal reefs	0.1
Harbour and Estuaries : Subtidal reef	0.1
Harbour and Estuaries : Intertidal reef	0.1
Sheltered Coast : Intertidal reef	0.1

Table A3.21: Marine habitats in order of decreasing mean weighted vulnerability to dumping of dredge spoils. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Dumping of dredge spoils
Habitat	Mean weighted vulnerability score
Exposed Coasts : Mud 30-200 m	2.3
Sheltered Coast : Mud 2-9 m	2.0
Exposed Coasts : Subtidal reefs 30-200 m	1.9
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.9
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.8
Sheltered Coast : Sand 10-29 m	1.7
Sheltered Coast : Sand 2-9 m	1.7
Sheltered Coast : Mud 10-29 m	1.7
Harbour and Estuaries : Subtidal sand	1.6
Harbour and Estuaries : Subtidal mud	1.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.6
Harbour and Estuaries : Seagrass meadows	1.6
Exposed Coasts : Gravel/pebble/shell 30-200 m	1.6
Exposed Coasts : Sand 30-200 m	1.6
Harbour and Estuaries : Subtidal reef	1.5
Slope Habitats : Sand 200-2000 m	1.5
Exposed Coasts : Subtidal reefs 10-30 m	1.3

Sheltered Coast : Kelp Forest	1.3
Exposed Coasts : Subtidal reefs 2-9 m	1.2
Harbour and Estuaries : Intertidal reef	1.2
Sheltered Coast : Subtidal reefs 10-29 m	1.2
Sheltered Coast : Subtidal reefs 2-9 m	1.2
Pelagic Habitat : Deep ocean water column in photic zone	1.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.2
Pelagic Habitat : Deep ocean water column below photic zone	1.2
Harbour and Estuaries : Pipi bed	1.1
Exposed Coasts : Mud 10-29 m	1.0
Exposed Coasts : Sand 10-29 m	1.0
Slope Habitats : Mud 200-2000 m	1.0
Harbour and Estuaries : Cockle bed	0.9
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.9
Exposed Coasts : Kelp Forest	0.8
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.8
Exposed Coasts : Biogenic calcareous reefs	0.8
Pelagic Habitat : Slope - water column below photic zone	0.7
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.7
Sheltered Coast : Intertidal reef	0.6
Pelagic Habitat : Slope - water column in photic zone	0.6
Exposed Coasts : Sand 2-9 m	0.6
Exposed Coasts : Turfing algal reefs	0.5
Deep Habitats : Soft abyssal 2000 m+	0.5
Exposed Coasts : Intertidal reefs	0.4
Harbour and Estuaries : Intertidal mud	0.4
Slope Habitats : Reef 200-2000 m	0.3
Deep Habitats : Seamount < 2000 m	0.3
Harbour and Estuaries : Intertidal sand	0.2
Deep Habitats : Seamount > 2000 m	0.2
Harbour and Estuaries : Mangrove forest	0.1
Deep Habitats : Vent (hot and cold)	0.1

Table A3.22: Marine habitats in order of decreasing mean weighted vulnerability to reclamation. Habitats with a score of zero are not shown. The maximum possible score = 4.

Engineering: Reclamation

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Saltmarsh	3.4
Harbour and Estuaries : Intertidal reefs	3.0
Harbour and Estuaries : Mangrove forest	3.0
Sheltered Coast : Intertidal reef	2.7
Harbour and Estuaries : Seagrass meadow	2.4
Sheltered Coast : Sandy beaches	2.3
Harbour and Estuaries : Intertidal mud	2.2
Harbour and Estuaries : Subtidal reef	1.9
Harbour and Estuaries : Subtidal mud	1.8
Harbour and Estuaries : Intertidal sand	1.8

Harbour and Estuaries : Pipi bed	1.7
Harbour and Estuaries : Subtidal sand	1.6
Exposed Coasts : Sandy beaches	1.5
Harbour and Estuaries : Cockle bed	1.5
Exposed Coasts : Intertidal reefs	1.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.3
Sheltered Coast : Subtidal reefs 10-29 m	1.2
Sheltered Coast : Subtidal reefs 2-9 m	1.2
Sheltered Coast : Sand 2-9 m	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.0
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.0
Sheltered Coast : Mud 2-9 m	0.9
Exposed Coasts : Subtidal reefs 10-30 m	0.8
Sheltered Coast : Sand 10-29 m	0.8
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.7
Sheltered Coast : Mud 10-29 m	0.7
Sheltered Coast : Kelp Forest	0.6
Exposed Coasts : Sand 2-9 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.5
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Kelp Forest	0.4
Exposed Coasts : Sand 10-29 m	0.2
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1

Table A3.23: Marine habitats in order of decreasing mean weighted vulnerability to sand or gravel abstraction. Habitats with a score of zero are not shown. The maximum possible score = 4.

Engineering: Sand / gravel abstraction

Habitat	Mean weighted vulnerability score
Sheltered Coast : Sand 2-9 m	2.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.8
Exposed Coasts : Biogenic calcareous reefs	1.8
Sheltered Coast : Sand 10-29 m	1.7
Sheltered Coast : Mud 2-9 m	1.6
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.5
Exposed Coasts : Sand 2-9 m	1.5
Sheltered Coast : Mud 10-29 m	1.4
Exposed Coasts : Mud 10-29 m	1.2
Exposed Coasts : Sand 10-29 m	1.2
Harbour and Estuaries : Subtidal sand	1.1
Exposed Coasts : Gravel/pebble/shell 10-29 m	1.1
Exposed Coasts : Sandy beaches	1.1
Sheltered Coast : Sandy beaches	1.1
Exposed Coasts : Mud 30-200 m	0.9

Harbour and Estuaries : Subtidal mud	0.9
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.9
Exposed Coasts : Sand 30-200 m	0.9
Harbour and Estuaries : Pipi bed	0.9
Harbour and Estuaries : Intertidal sand	0.8
Harbour and Estuaries : Subtidal reef	0.7
Harbour and Estuaries : Cockle bed	0.7
Exposed Coasts : Intertidal reefs	0.7
Exposed Coasts : Subtidal reefs 30-200 m	0.6
Harbour and Estuaries : Intertidal reef	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Harbour and Estuaries : Seagrass meadows	0.5
Exposed Coasts : Subtidal reefs 10-30 m	0.5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.4
Sheltered Coast : Kelp Forest	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Sheltered Coast : Intertidal reef	0.4
Exposed Coasts : Turfing algal reefs	0.4
Exposed Coasts : Kelp Forest	0.3
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.3
Slope Habitats : Reef 200-2000 m	0.3
Slope Habitats : Sand 200-2000 m	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Deep Habitats : Soft abyssal 2000 m+	0.2
Harbour and Estuaries : Intertidal mud	0.2
Deep Habitats : Seamount < 2000 m	0.2
Deep Habitats : Seamount > 2000 m	0.2
Slope Habitats : Mud 200-2000 m	0.1

Table A3.24: Marine habitats in order of decreasing mean weighted vulnerability to dredging. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Dredging
Habitat	Mean weighted vulnerability score
Sheltered Coast : Gravel/pebble/shell 2-9 m	2.0
Sheltered Coast : Mud 2-9 m	2.0
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.8
Sheltered Coast : Sand 2-9 m	1.7
Exposed Coasts : Biogenic calcareous reefs	1.7
Harbour and Estuaries : Subtidal mud	1.7
Harbour and Estuaries : Seagrass meadows	1.7
Sheltered Coast : Sand 10-29 m	1.4
Sheltered Coast : Mud 10-29 m	1.4
Harbour and Estuaries : Subtidal sand	1.3
Harbour and Estuaries : Cockle bed	1.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.2

Exposed Coasts : Sand 2-9 m	1.2
Harbour and Estuaries : Pipi bed	1.2
Exposed Coasts : Mud 10-29 m	1.0
Harbour and Estuaries : Subtidal reef	1.0
Exposed Coasts : Subtidal reefs 10-30 m	0.9
Exposed Coasts : Sand 10-29 m	0.8
Sheltered Coast : Subtidal reefs 10-29 m	0.8
Sheltered Coast : Subtidal reefs 2-9 m	0.8
Sheltered Coast : Kelp Forest	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.7
Harbour and Estuaries : Intertidal reef	0.7
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.7
Harbour and Estuaries : Intertidal mud	0.7
Exposed Coasts : Intertidal reefs	0.6
Harbour and Estuaries : Intertidal sand	0.5
Exposed Coasts : Subtidal reefs 30-200 m	0.5
Sheltered Coast : Intertidal reef	0.4
Exposed Coasts : Kelp Forest	0.4
Slope Habitats : Reef 200-2000 m	0.4
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.4
Exposed Coasts : Turfing algal reefs	0.3
Deep Habitats : Soft abyssal 2000 m+	0.1
Deep Habitats : Trench	0.1

Table A3.25: Marine habitats in order of decreasing mean weighted vulnerability to causeway construction. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Causeways
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	2.8
Harbour and Estuaries : Saltmarsh	2.6
Harbour and Estuaries : Seagrass meadows	2.2
Harbour and Estuaries : Cockle bed	2.2
Harbour and Estuaries : Pipi bed	2.1
Harbour and Estuaries : Intertidal reef	2.0
Harbour and Estuaries : Intertidal sand	2.0
Harbour and Estuaries : Mangrove forest	2.0
Sheltered Coast : Intertidal reef	2.0
Harbour and Estuaries : Subtidal mud	1.3
Exposed Coasts : Intertidal reefs	1.3
Harbour and Estuaries : Subtidal sand	1.2
Exposed Coasts : Sandy beaches	1.1
Sheltered Coast : Sandy beaches	1.1
Harbour and Estuaries : Subtidal reef	0.8
Exposed Coasts : Subtidal reefs 10-30 m	0.4

Sheltered Coast : Subtidal reefs 10-29 m	0.4
Sheltered Coast : Subtidal reefs 2-9 m	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Sheltered Coast : Sand 2-9 m	0.2
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Subtidal reefs 30-200 m	0.2
Sheltered Coast : Kelp Forest	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1
Exposed Coasts : Kelp Forest	0.1

Table A3.26: Marine habitats in order of decreasing mean weighted vulnerability to pile morrings or markers. Habitats with a score of zero are not shown. The maximum possible score = 4.

Engineering: Pile moorings/markers

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	1.7
Sheltered Coast : Intertidal reef	1.6
Harbour and Estuaries : Subtidal mud	1.4
Harbour and Estuaries : Subtidal sand	1.4
Harbour and Estuaries : Pipi bed	1.3
Harbour and Estuaries : Intertidal reef	1.3
Harbour and Estuaries : Subtidal reef	1.3
Harbour and Estuaries : Cockle bed	1.1
Harbour and Estuaries : Intertidal sand	1.1
Harbour and Estuaries : Seagrass meadows	0.9
Exposed Coasts : Intertidal reefs	0.9
Exposed Coasts : Subtidal reefs 30-200 m	0.7
Exposed Coasts : Sandy beaches	0.6
Sheltered Coast : Sandy beaches	0.6
Exposed Coasts : Turfing algal reefs	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.5
Sheltered Coast : Subtidal reefs 2-9 m	0.5
Sheltered Coast : Kelp Forest	0.5
Sheltered Coast : Mud 2-9 m	0.5
Exposed Coasts : Subtidal reefs 10-30 m	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Exposed Coasts : Kelp Forest	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Fiord Habitats : Outer fiord rockwalls	0.2
Harbour and Estuaries : Mangrove forest	0.1

Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Fiord Habitats : Inner fiord rockwalls	0.1

Table A3.27: Marine habitats in order of decreasing mean weighted vulnerability to piled wharfs and sheds. Habitats with a score of zero are not shown. The maximum possible score = 4.

Engineering: Piled wharfs/sheds

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	1.7
Harbour and Estuaries : Subtidal mud	1.6
Harbour and Estuaries : Subtidal sand	1.5
Harbour and Estuaries : Seagrass meadows	1.4
Harbour and Estuaries : Pipi bed	1.3
Exposed Coasts : Sandy beaches	1.2
Sheltered Coast : Sandy beaches	1.2
Harbour and Estuaries : Subtidal reef	1.1
Harbour and Estuaries : Cockle bed	1.1
Harbour and Estuaries : Intertidal sand	1.1
Harbour and Estuaries : Intertidal reef	1.0
Harbour and Estuaries : Mangrove forest	1.0
Sheltered Coast : Intertidal reef	0.9
Harbour and Estuaries : Saltmarsh	0.6
Sheltered Coast : Mud 2-9 m	0.5
Sheltered Coast : Sand 2-9 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Intertidal reefs	0.3
Exposed Coasts : Subtidal reefs 30-200 m	0.3
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Exposed Coasts : Subtidal reefs 10-30 m	0.3
Exposed Coasts : Subtidal reefs 2-9 m	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Fiord Habitats : Outer fiord rockwalls	0.2
Sheltered Coast : Kelp Forest	0.1
Exposed Coasts : Kelp Forest	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Fiord Habitats : Inner fiord rockwalls	0.1

Table A3.28: Marine habitats in order of decreasing mean weighted vulnerability to seawalll construction. Habitats with a score of zero are not shown. The maximum possible score = 4.

Habitat	Engineering: Seawalls Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	1.9
Harbour and Estuaries : Subtidal sand	1.9
Harbour and Estuaries : Intertidal mud	1.5
Harbour and Estuaries : Intertidal reef	1.5
Sheltered Coast : Sandy beaches	1.2
Harbour and Estuaries : Mangrove forest	1.2
Harbour and Estuaries : Seagrass meadows	1.1
Harbour and Estuaries : Subtidal reef	1.0
Harbour and Estuaries : Intertidal sand	1.0
Harbour and Estuaries : Pipi bed	0.9
Harbour and Estuaries : Saltmarsh	0.9
Exposed Coasts : Sandy beaches	0.8
Harbour and Estuaries : Cockle bed	0.7
Sheltered Coast : Intertidal reef	0.7
Exposed Coasts : Intertidal reefs	0.7
Sheltered Coast : Mud 2-9 m	0.6
Sheltered Coast : Sand 2-9 m	0.5
Sheltered Coast : Sand 10-29 m	0.5
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Sand 2-9 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.2
Exposed Coasts : Subtidal reefs 30-200 m	0.1
Sheltered Coast : Subtidal reefs 10-29 m	0.1
Sheltered Coast : Subtidal reefs 2-9 m	0.1
Exposed Coasts : Subtidal reefs 10-30 m	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1

Table A3.29: Marine habitats in order of decreasing mean weighted vulnerability to surface suction extraction of minerals. Habitats with a score of zero are not shown. The maximum possible score = 4.

Habitat	Engineering: Mineral extraction - surface suction Mean weighted vulnerability score
Sheltered Coast : Mud 2-9 m	1.3
Sheltered Coast : Mud 10-29 m	0.9

Deep Habitats : Soft abyssal 2000 m+	0.9
Sheltered Coast : Sand 2-9 m	0.8
Sheltered Coast : Sand 10-29 m	0.8
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.8
Slope Habitats : Sand 200-2000 m	0.8
Harbour and Estuaries : Subtidal mud	0.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.6
Deep Habitats : Seamount < 2000 m	0.6
Harbour and Estuaries : Subtidal sand	0.5
Harbour and Estuaries : Pipi bed	0.5
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.5
Slope Habitats : Reef 200-2000 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.5
Slope Habitats : Mud 200-2000 m	0.5
Harbour and Estuaries : Seagrass meadows	0.4
Harbour and Estuaries : Cockle bed	0.4
Exposed Coasts : Subtidal reefs 30-200 m	0.4
Deep Habitats : Seamount > 2000 m	0.4
Exposed Coasts : Intertidal reefs	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.3
Exposed Coasts : Mud 10-29 m	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Sand 10-29 m	0.2
Sheltered Coast : Subtidal reefs 10-29 m	0.2
Sheltered Coast : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Exposed Coasts : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Turfing algal reefs	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Harbour and Estuaries : Intertidal mud	0.1
Harbour and Estuaries : Intertidal reef	0.1
Harbour and Estuaries : Subtidal reef	0.1
Sheltered Coast : Kelp Forest	0.1
Exposed Coasts : Kelp Forest	0.1
Pelagic Habitat : Deep ocean water column in photic zone	0.1
Pelagic Habitat : Deep ocean water column below photic zone	0.1
Deep Habitats : Vent (hot and cold)	0.1

Table A3.30: Marine habitats in order of decreasing mean weighted vulnerability to pontoons. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Pontoons
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	1.7
Harbour and Estuaries : Subtidal mud	1.1
Harbour and Estuaries : Subtidal sand	1.1
Harbour and Estuaries : Intertidal reef	1.0
Harbour and Estuaries : Pipi bed	0.9
Harbour and Estuaries : Subtidal reef	0.9
Sheltered Coast : Intertidal reef	0.9
Harbour and Estuaries : Seagrass meadows	0.8
Harbour and Estuaries : Cockle bed	0.7
Sheltered Coast : Sandy beaches	0.6
Exposed Coasts : Sandy beaches	0.6
Harbour and Estuaries : Intertidal sand	0.5
Harbour and Estuaries : Mangrove forest	0.4
Harbour and Estuaries : Saltmarsh	0.4
Exposed Coasts : Intertidal reefs	0.3
Fiord Habitats : Fiord sediments	0.3
Sheltered Coast : Mud 2-9 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Sheltered Coast : Sand 2-9 m	0.2
Sheltered Coast : Sand 10-29 m	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Sheltered Coast : Subtidal reefs 10-29 m	0.2
Sheltered Coast : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Fiord Habitats : Inner fiord rockwalls	0.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Exposed Coasts : Subtidal reefs 30-200 m	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1

Table A3.31: Marine habitats in order of decreasing mean weighted vulnerability to other methods of mineral extraction. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Minerals extraction - other methods
Habitat	Mean weighted vulnerability score
Deep Habitats : Vent (hot and cold)	1.5
Deep Habitats : Seamount < 2000 m	1.0

Sheltered Coast : Mud 2-9 m	0.6
Deep Habitats : Soft abyssal 2000 m+	0.6
Deep Habitats : Seamount > 2000 m	0.6
Slope Habitats : Reef 200-2000 m	0.5
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.5
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Slope Habitats : Sand 200-2000 m	0.4
Sheltered Coast : Mud 10-29 m	0.3
Sheltered Coast : Sand 2-9 m	0.3
Sheltered Coast : Sand 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Slope Habitats : Mud 200-2000 m	0.3
Sheltered Coast : Subtidal reefs 10-29 m	0.2
Sheltered Coast : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.1
Exposed Coasts : Subtidal reefs 30-200 m	0.1
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Sheltered Coast : Kelp Forest	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1

Table A3.32: Marine habitats in order of decreasing mean weighted vulnerability to deep hole extraction of minerals. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Engineering: Mineral extraction - deep hole extraction
Habitat	Mean weighted vulnerability score
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.6
Slope Habitats : Reef 200-2000 m	0.5
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.5
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.5
Deep Habitats : Seamount < 2000 m	0.4
Sheltered Coast : Mud 2-9 m	0.4
Deep Habitats : Soft abyssal 2000 m+	0.4
Deep Habitats : Seamount > 2000 m	0.4
Slope Habitats : Sand 200-2000 m	0.4
Sheltered Coast : Mud 10-29 m	0.3
Sheltered Coast : Sand 2-9 m	0.3
Sheltered Coast : Sand 10-29 m	0.3
Slope Habitats : Mud 200-2000 m	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Biogenic calcareous reefs	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2

Sheltered Coast : Subtidal reefs 10-29 m	0.1
Sheltered Coast : Subtidal reefs 2-9 m	0.1
Exposed Coasts : Subtidal reefs 10-30 m	0.1
Exposed Coasts : Subtidal reefs 30-200 m	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Pelagic Habitat : Deep ocean water column in photic zone	0.1
Pelagic Habitat : Deep ocean water column below photic zone	0.1

Table A3.33: Marine habitats in order of decreasing mean weighted vulnerability to bottom trawling. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Bottom trawling
Habitat	Mean weighted vulnerability score
Slope Habitats : Gravel/pebbles/shells 200-2000 m	3.3
Deep Habitats : Seamount < 2000 m	3.2
Exposed Coasts : Mud 30-200 m	3.2
Slope Habitats : Reef 200-2000 m	3.1
Slope Habitats : Sand 200-2000 m	3.1
Deep Habitats : Soft canyon	3.1
Sheltered Coast : Mud 2-9 m	3.0
Slope Habitats : Mud 200-2000 m	3.0
Exposed Coasts : Sand 30-200 m	3.0
Sheltered Coast : Gravel/pebble/shell 10-29 m	2.9
Sheltered Coast : Mud 10-29 m	2.9
Sheltered Coast : Sand 10-29 m	2.9
Exposed Coasts : Mud 10-29 m	2.9
Exposed Coasts : Gravel/pebble/shell 30-200 m	2.9
Deep Habitats : Hard canyon	2.9
Sheltered Coast : Gravel/pebble/shell 2-9 m	2.8
Exposed Coasts : Gravel/pebble/shell 2-9 m	2.8
Exposed Coasts : Biogenic calcareous reefs	2.8
Exposed Coasts : Sand 10-29 m	2.7
Exposed Coasts : Gravel/pebble/shell 10-29 m	2.6
Deep Habitats : Vent (hot and cold)	2.6
Sheltered Coast : Sand 2-9 m	2.3
Exposed Coasts : Subtidal reefs 30-200 m	2.2
Exposed Coasts : Subtidal reefs 10-30 m	1.5
Harbour and Estuaries : Subtidal mud	1.4
Exposed Coasts : Sand 2-9 m	1.4
Exposed Coasts : Subtidal reefs 2-9 m	1.3
Harbour and Estuaries : Subtidal sand	1.2
Fiord Habitats : Inner fiord rockwalls	1.2
Sheltered Coast : Subtidal reefs 10-29 m	1.0
Sheltered Coast : Subtidal reefs 2-9 m	1.0
Exposed Coasts : Kelp Forest	1.0
Sheltered Coast : Kelp Forest	0.9

Exposed Coasts : Intertidal reefs	0.9
Harbour and Estuaries : Intertidal mud	0.8
Harbour and Estuaries : Intertidal reef	0.8
Harbour and Estuaries : Subtidal reef	0.8
Fiord Habitats : Fiord sediments	0.8
Fiord Habitats : Outer fiord rockwalls	0.8
Deep Habitats : Soft abyssal 2000 m+	0.7
Deep Habitats : Seamount > 2000 m	0.7
Harbour and Estuaries : Seagrass meadows	0.7
Exposed Coasts : Turfing algal reefs	0.7
Pelagic Habitat : Slope - water column in photic zone	0.6
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.5
Pelagic Habitat : Slope - water column below photic zone	0.5
Harbour and Estuaries : Pipi bed	0.4
Sheltered Coast : Intertidal reef	0.4
Harbour and Estuaries : Cockle bed	0.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Harbour and Estuaries : Intertidal sand	0.2

Table A3.34: Marine habitats in order of decreasing mean weighted vulnerability to scallop and oyster dredging. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Dredging
Habitat	Mean weighted vulnerability score
Exposed Coasts : Mud 30-200 m	2.9
Sheltered Coast : Mud 2-9 m	2.9
Exposed Coasts : Sand 30-200 m	2.8
Sheltered Coast : Gravel/pebble/shell 10-29 m	2.8
Sheltered Coast : Mud 10-29 m	2.8
Sheltered Coast : Sand 10-29 m	2.8
Exposed Coasts : Mud 10-29 m	2.8
Sheltered Coast : Gravel/pebble/shell 2-9 m	2.8
Exposed Coasts : Gravel/pebble/shell 2-9 m	2.8
Exposed Coasts : Gravel/pebble/shell 30-200 m	2.6
Exposed Coasts : Biogenic calcareous reefs	2.6
Exposed Coasts : Sand 10-29 m	2.6
Exposed Coasts : Gravel/pebble/shell 10-29 m	2.6
Sheltered Coast : Sand 2-9 m	2.3
Harbour and Estuaries : Subtidal mud	1.7
Exposed Coasts : Sand 2-9 m	1.6
Harbour and Estuaries : Subtidal sand	1.6
Harbour and Estuaries : Subtidal reef	1.2
Exposed Coasts : Subtidal reefs 10-30 m	1.1
Fiord Habitats : Inner fiord rockwalls	1.1
Exposed Coasts : Subtidal reefs 2-9 m	1.0
Exposed Coasts : Subtidal reefs 30-200 m	0.9

Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Exposed Coasts : Intertidal reefs	0.9
Harbour and Estuaries : Intertidal mud	0.9
Harbour and Estuaries : Intertidal reef	0.9
Fiord Habitats : Outer fiord rockwalls	0.9
Harbour and Estuaries : Seagrass meadows	0.9
Harbour and Estuaries : Pipi bed	0.9
Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Turfing algal reefs	0.7
Harbour and Estuaries : Cockle bed	0.7
Exposed Coasts : Kelp Forest	0.6
Fiord Habitats : Fiord sediments	0.6
Sheltered Coast : Intertidal reef	0.4
Slope Habitats : Sand 200-2000 m	0.3
Harbour and Estuaries : Intertidal sand	0.3
Slope Habitats : Mud 200-2000 m	0.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2

Table A3.35: Marine habitats in order of decreasing mean weighted vulnerability to line fishing. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Line fishing
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal reef	2.2
Sheltered Coast : Subtidal reefs 10-29 m	2.0
Sheltered Coast : Subtidal reefs 2-9 m	2.0
Exposed Coasts : Subtidal reefs 10-30 m	1.7
Fiord Habitats : Inner fiord rockwalls	1.7
Fiord Habitats : Outer fiord rockwalls	1.7
Sheltered Coast : Kelp Forest	1.7
Exposed Coasts : Turfing algal reefs	1.7
Exposed Coasts : Subtidal reefs 2-9 m	1.6
Exposed Coasts : Subtidal reefs 30-200 m	1.5
Harbour and Estuaries : Subtidal sand	1.4
Exposed Coasts : Kelp Forest	1.4
Harbour and Estuaries : Intertidal reef	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.3
Sheltered Coast : Mud 2-9 m	1.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.2
Sheltered Coast : Sand 10-29 m	1.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.2
Harbour and Estuaries : Subtidal mud	1.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.1
Sheltered Coast : Mud 10-29 m	1.0
Sheltered Coast : Sand 2-9 m	1.0
Pelagic Habitat : Deep ocean water column in photic zone	1.0

Exposed Coasts : Intertidal reefs	0.9
Pelagic Habitat : Slope - water column in photic zone	0.9
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.8
Exposed Coasts : Sand 10-29 m	0.8
Exposed Coasts : Mud 10-29 m	0.7
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.7
Exposed Coasts : Sand 2-9 m	0.7
Sheltered Coast : Intertidal reef	0.7
Exposed Coasts : Biogenic calcareous reefs	0.6
Harbour and Estuaries : Seagrass meadows	0.6
Harbour and Estuaries : Pipi bed	0.6
Pelagic Habitat : Deep ocean water column below photic zone	0.6
Harbour and Estuaries : Intertidal mud	0.5
Harbour and Estuaries : Cockle bed	0.5
Fiord Habitats : Fiord sediments	0.5
Pelagic Habitat : Slope - water column below photic zone	0.5
Harbour and Estuaries : Intertidal sand	0.2
Harbour and Estuaries : Mangrove forest	0.2
Exposed Coasts : Sandy beaches	0.1
Deep Habitats : Trench	0.1

Table A3.36: Marine habitats in order of decreasing mean weighted vulnerability to trapping. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Trapping
Habitat	Mean weighted vulnerability score
Exposed Coasts : Subtidal reefs 10-30 m	2.3
Fiord Habitats : Outer fiord rockwalls	2.3
Fiord Habitats : Inner fiord rockwalls	2.2
Exposed Coasts : Subtidal reefs 30-200 m	2.2
Exposed Coasts : Subtidal reefs 2-9 m	2.0
Sheltered Coast : Kelp Forest	1.9
Exposed Coasts : Biogenic calcareous reefs	1.9
Sheltered Coast : Subtidal reefs 10-29 m	1.7
Sheltered Coast : Subtidal reefs 2-9 m	1.7
Exposed Coasts : Turfing algal reefs	1.7
Exposed Coasts : Kelp Forest	1.6
Harbour and Estuaries : Subtidal reef	1.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.1
Exposed Coasts : Intertidal reefs	1.1
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.1
Exposed Coasts : Sand 10-29 m	1.1
Harbour and Estuaries : Intertidal reef	1.0
Fiord Habitats : Fiord sediments	1.0
Exposed Coasts : Mud 30-200 m	1.0
Exposed Coasts : Sand 30-200 m	1.0

Exposed Coasts : Gravel/pebble/shell 30-200 m	1.0
Sheltered Coast : Mud 2-9 m	0.9
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.9
Sheltered Coast : Sand 10-29 m	0.9
Sheltered Coast : Sand 2-9 m	0.9
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.9
Exposed Coasts : Mud 10-29 m	0.8
Harbour and Estuaries : Subtidal sand	0.7
Sheltered Coast : Mud 10-29 m	0.7
Sheltered Coast : Intertidal reef	0.7
Harbour and Estuaries : Subtidal mud	0.5
Exposed Coasts : Sand 2-9 m	0.5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Harbour and Estuaries : Seagrass meadows	0.2
Harbour and Estuaries : Pipi bed	0.2
Harbour and Estuaries : Cockle bed	0.2
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.2
Slope Habitats : Reef 200-2000 m	0.2
Harbour and Estuaries : Intertidal mud	0.1
Harbour and Estuaries : Intertidal sand	0.1
Exposed Coasts : Sandy beaches	0.1

Table A3.37: Marine habitats in order of decreasing mean weighted vulnerability to long-lining. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Long-lining
Habitat	Mean weighted vulnerability score
Exposed Coasts : Subtidal reefs 30-200 m	1.7
Deep Habitats : Seamount < 2000 m	1.7
Sheltered Coast : Kelp Forest	1.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.6
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.6
Exposed Coasts : Subtidal reefs 10-30 m	1.5
Sheltered Coast : Subtidal reefs 10-29 m	1.4
Sheltered Coast : Subtidal reefs 2-9 m	1.4
Exposed Coasts : Subtidal reefs 2-9 m	1.3
Exposed Coasts : Turfing algal reefs	1.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.2
Pelagic Habitat : Deep ocean water column in photic zone	1.2
Pelagic Habitat : Deep ocean water column below photic zone	1.1
Sheltered Coast : Mud 2-9 m	1.0
Sheltered Coast : Sand 10-29 m	1.0
Sheltered Coast : Sand 2-9 m	1.0
Slope Habitats : Gravel/pebbles/shells 200-2000 m	1.0

Slope Habitats : Reef 200-2000 m	1.0
Pelagic Habitat : Slope - water column in photic zone	1.0
Pelagic Habitat : Slope - water column below photic zone	1.0
Exposed Coasts : Kelp Forest	0.9
Exposed Coasts : Mud 10-29 m	0.9
Exposed Coasts : Sand 10-29 m	0.8
Sheltered Coast : Mud 10-29 m	0.8
Deep Habitats : Seamount > 2000 m	0.8
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.7
Exposed Coasts : Biogenic calcareous reefs	0.6
Exposed Coasts : Intertidal reefs	0.6
Exposed Coasts : Sand 2-9 m	0.6
Slope Habitats : Sand 200-2000 m	0.6
Fiord Habitats : Inner fiord rockwalls	0.5
Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Sand 30-200 m	0.5
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.5
Deep Habitats : Soft abyssal 2000 m+	0.5
Harbour and Estuaries : Subtidal reef	0.4
Slope Habitats : Mud 200-2000 m	0.4
Deep Habitats : Hard canyon	0.4
Deep Habitats : Vent (hot and cold)	0.4
Fiord Habitats : Outer fiord rockwalls	0.3
Harbour and Estuaries : Intertidal reef	0.2
Fiord Habitats : Fiord sediments	0.2
Sheltered Coast : Intertidal reef	0.2

Table A3.38: Marine habitats in order of decreasing mean weighted vulnerability to shellfish gathering. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Shellfish gathering
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	2.4
Harbour and Estuaries : Intertidal reef	2.3
Harbour and Estuaries : Pipi bed	2.3
Harbour and Estuaries : Cockle bed	2.3
Sheltered Coast : Intertidal reef	2.1
Harbour and Estuaries : Subtidal reef	1.9
Harbour and Estuaries : Intertidal sand	1.9
Exposed Coasts : Intertidal reefs	1.6
Harbour and Estuaries : Subtidal sand	1.6
Harbour and Estuaries : Subtidal mud	1.6
Sheltered Coast : Kelp Forest	1.5
Sheltered Coast : Subtidal reefs 10-29 m	1.5
Sheltered Coast : Subtidal reefs 2-9 m	1.5
Harbour and Estuaries : Seagrass meadows	1.5

Sheltered Coast : Mud 2-9 m	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Exposed Coasts : Subtidal reefs 10-30 m	1.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.0
Exposed Coasts : Subtidal reefs 2-9 m	1.0
Sheltered Coast : Sand 10-29 m	1.0
Sheltered Coast : Sand 2-9 m	1.0
Sheltered Coast : Mud 10-29 m	0.9
Exposed Coasts : Turfing algal reefs	0.8
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.8
Exposed Coasts : Kelp Forest	0.7
Sheltered Coast : Sandy beaches	0.7
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Sandy beaches	0.4
Exposed Coasts : Mud 10-29 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Exposed Coasts : Sand 2-9 m	0.3
Fiord Habitats : Fiord sediments	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Fiord Habitats : Inner fiord rockwalls	0.2
Harbour and Estuaries : Mangrove forest	0.2

Table A3.39: Marine habitats in order of decreasing mean weighted vulnerability to set netting. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Set netting
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal reef	2.1
Sheltered Coast : Kelp Forest	2.1
Sheltered Coast : Subtidal reefs 10-29 m	2.1
Sheltered Coast : Subtidal reefs 2-9 m	2.1
Exposed Coasts : Subtidal reefs 10-30 m	1.9
Exposed Coasts : Biogenic calcareous reefs	1.7
Exposed Coasts : Subtidal reefs 2-9 m	1.6
Exposed Coasts : Turfing algal reefs	1.5
Exposed Coasts : Kelp Forest	1.3
Exposed Coasts : Subtidal reefs 30-200 m	1.2
Harbour and Estuaries : Intertidal reef	1.0
Exposed Coasts : Sand 10-29 m	1.0
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.9
Harbour and Estuaries : Subtidal sand	0.8
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.8
Sheltered Coast : Intertidal reef	0.7
Exposed Coasts : Intertidal reefs	0.7
Harbour and Estuaries : Seagrass meadows	0.7

Sheltered Coast : Sand 10-29 m	0.7
Sheltered Coast : Sand 2-9 m	0.7
Exposed Coasts : Sand 2-9 m	0.7
Harbour and Estuaries : Pipi bed	0.6
Harbour and Estuaries : Subtidal mud	0.6
Sheltered Coast : Mud 2-9 m	0.6
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.6
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.6
Fiord Habitats : Inner fiord rockwalls	0.6
Harbour and Estuaries : Cockle bed	0.5
Sheltered Coast : Mud 10-29 m	0.5
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.5
Harbour and Estuaries : Intertidal mud	0.4
Exposed Coasts : Mud 10-29 m	0.4
Fiord Habitats : Fiord sediments	0.4
Pelagic Habitat : Slope - water column in photic zone	0.4
Pelagic Habitat : Slope - water column below photic zone	0.4
Fiord Habitats : Outer fiord rockwalls	0.4
Harbour and Estuaries : Intertidal sand	0.3
Harbour and Estuaries : Mangrove forest	0.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.3
Pelagic Habitat : Deep ocean water column in photic zone	0.3
Pelagic Habitat : Deep ocean water column below photic zone	0.2
Exposed Coasts : Sandy beaches	0.1
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1
Slope Habitats : Sand 200-2000 m	0.1
Exposed Coasts : Mud 30-200 m	0.1
Exposed Coasts : Sand 30-200 m	0.1
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.1
Slope Habitats : Mud 200-2000 m	0.1

Table A3.40: Marine habitats in order of decreasing mean weighted vulnerability to seaweed gathering. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Seaweed gathering
Habitat	Mean weighted vulnerability score
Exposed Coasts : Subtidal reefs 10-30 m	1.7
Exposed Coasts : Kelp Forest	1.7
Exposed Coasts : Intertidal reefs	1.7
Sheltered Coast : Kelp Forest	1.5
Exposed Coasts : Turfing algal reefs	1.5
Exposed Coasts : Subtidal reefs 2-9 m	1.4
Harbour and Estuaries : Intertidal reef	1.4
Sheltered Coast : Subtidal reefs 10-29 m	1.3
Sheltered Coast : Subtidal reefs 2-9 m	1.3
Harbour and Estuaries : Subtidal reef	1.1
Exposed Coasts : Subtidal reefs 30-200 m	0.8
Sheltered Coast : Intertidal reef	0.8
Exposed Coasts : Biogenic calcareous reefs	0.6
Harbour and Estuaries : Subtidal sand	0.6
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.6
Harbour and Estuaries : Intertidal mud	0.6
Harbour and Estuaries : Pipi bed	0.5
Harbour and Estuaries : Subtidal mud	0.5
Sheltered Coast : Mud 2-9 m	0.5
Exposed Coasts : Sand 10-29 m	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Harbour and Estuaries : Seagrass meadows	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Fiord Habitats : Inner fiord rockwalls	0.4
Harbour and Estuaries : Cockle bed	0.4
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Mud 10-29 m	0.4
Harbour and Estuaries : Intertidal sand	0.4
Exposed Coasts : Sand 2-9 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Fiord Habitats : Fiord sediments	0.3
Exposed Coasts : Sandy beaches	0.3
Sheltered Coast : Sandy beaches	0.3
Fiord Habitats : Outer fiord rockwalls	0.2

Table A3.41: Marine habitats in order of decreasing mean weighted vulnerability to abalone gathering. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Abalone gathering
Habitat	Mean weighted vulnerability score
Exposed Coasts : Turfing algal reefs	1.6
Exposed Coasts : Subtidal reefs 10-30 m	1.5
Sheltered Coast : Subtidal reefs 10-29 m	1.4
Sheltered Coast : Subtidal reefs 2-9 m	1.4
Harbour and Estuaries : Subtidal reef	1.4
Exposed Coasts : Kelp Forest	1.3
Exposed Coasts : Subtidal reefs 2-9 m	1.3
Exposed Coasts : Subtidal reefs 30-200 m	1.2
Exposed Coasts : Intertidal reefs	1.1
Sheltered Coast : Kelp Forest	1.1
Harbour and Estuaries : Intertidal reef	1.0
Fiord Habitats : Inner fiord rockwalls	1.0
Fiord Habitats : Outer fiord rockwalls	1.0
Sheltered Coast : Intertidal reef	0.7
Exposed Coasts : Biogenic calcareous reefs	0.5
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.5
Sheltered Coast : Mud 2-9 m	0.5
Harbour and Estuaries : Subtidal sand	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Harbour and Estuaries : Pipi bed	0.3
Harbour and Estuaries : Subtidal mud	0.3
Exposed Coasts : Sand 10-29 m	0.3
Harbour and Estuaries : Seagrass meadows	0.3
Harbour and Estuaries : Cockle bed	0.3
Sheltered Coast : Mud 10-29 m	0.3
Exposed Coasts : Mud 10-29 m	0.2
Exposed Coasts : Sand 2-9 m	0.2
Fiord Habitats : Fiord sediments	0.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Harbour and Estuaries : Intertidal mud	0.1
Harbour and Estuaries : Intertidal sand	0.1

Table A3.42: Marine habitats in order of decreasing mean weighted vulnerability to high bycatch pelagic fishing. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Pelagic high bycatch
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Deep ocean water column in photic zone	2.1
Pelagic Habitat : Deep ocean water column below photic zone	2.0
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.8
Pelagic Habitat : Slope - water column in photic zone	1.8
Pelagic Habitat : Slope - water column below photic zone	1.7
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.7
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Sheltered Coast : Subtidal reefs 10-29 m	0.7
Sheltered Coast : Subtidal reefs 2-9 m	0.7
Exposed Coasts : Mud 30-200 m	0.7
Exposed Coasts : Sand 30-200 m	0.7
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.7
Sheltered Coast : Kelp Forest	0.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.6
Sheltered Coast : Mud 2-9 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Subtidal reefs 10-30 m	0.3
Exposed Coasts : Subtidal reefs 2-9 m	0.3
Sheltered Coast : Mud 10-29 m	0.3
Deep Habitats : Soft canyon	0.3
Harbour and Estuaries : Subtidal reef	0.2
Exposed Coasts : Intertidal reefs	0.2
Harbour and Estuaries : Intertidal reef	0.2
Sheltered Coast : Intertidal reef	0.2
Deep Habitats : Hard canyon	0.2
Exposed Coasts : Kelp Forest	0.1
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1
Slope Habitats : Sand 200-2000 m	0.1
Deep Habitats : Seamount < 2000 m	0.1
Deep Habitats : Seamount > 2000 m	0.1
Deep Habitats : Soft abyssal 2000 m+	0.1

Table A3.43: Marine habitats in order of decreasing mean weighted vulnerability to spear fishing. Habitats with a score of zero are not shown. The maximum possible score = 4.

Fishing: Spear fishing

Habitat	Mean weighted vulnerability score
Sheltered Coast : Subtidal reefs 10-29 m	1.6
Sheltered Coast : Subtidal reefs 2-9 m	1.6
Exposed Coasts : Subtidal reefs 10-30 m	1.6
Sheltered Coast : Kelp Forest	1.5
Exposed Coasts : Subtidal reefs 2-9 m	1.4
Harbour and Estuaries : Subtidal reef	1.4
Exposed Coasts : Turfing algal reefs	1.4
Exposed Coasts : Kelp Forest	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Fiord Habitats : Inner fiord rockwalls	1.0
Fiord Habitats : Outer fiord rockwalls	0.9
Exposed Coasts : Intertidal reefs	0.7
Harbour and Estuaries : Intertidal reef	0.5
Sheltered Coast : Intertidal reef	0.4
Exposed Coasts : Biogenic calcareous reefs	0.4
Harbour and Estuaries : Subtidal sand	0.4
Fiord Habitats : Fiord sediments	0.4
Sheltered Coast : Mud 2-9 m	0.3
Sheltered Coast : Sand 10-29 m	0.3
Sheltered Coast : Sand 2-9 m	0.3
Harbour and Estuaries : Subtidal mud	0.3
Harbour and Estuaries : Seagrass meadows	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Harbour and Estuaries : Pipi bed	0.2
Exposed Coasts : Sand 10-29 m	0.2
Harbour and Estuaries : Cockle bed	0.2
Exposed Coasts : Mud 10-29 m	0.2
Exposed Coasts : Sand 2-9 m	0.1
Harbour and Estuaries : Intertidal mud	0.1

Table A3.44: Marine habitats in order of decreasing mean weighted vulnerability to low bycatch pelagic fishing. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Fishing: Pelagic low bycatch
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.2
Pelagic Habitat : Deep ocean water column in photic zone	0.9
Pelagic Habitat : Slope - water column in photic zone	0.8
Exposed Coasts : Subtidal reefs 30-200 m	0.6
Pelagic Habitat : Deep ocean water column below photic zone	0.5
Pelagic Habitat : Slope - water column below photic zone	0.5
Exposed Coasts : Mud 30-200 m	0.4
Exposed Coasts : Sand 30-200 m	0.4
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.4
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Fiord Habitats : Outer fiord rockwalls	0.3
Fiord Habitats : Inner fiord rockwalls	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.1
Sheltered Coast : Kelp Forest	0.1
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Harbour and Estuaries : Subtidal reef	0.1
Exposed Coasts : Intertidal reefs	0.1
Harbour and Estuaries : Intertidal reef	0.1
Sheltered Coast : Intertidal reef	0.1
Sheltered Coast : Mud 2-9 m	0.1
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Sand 2-9 m	0.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1

Table A3.45: Marine habitats in order of decreasing mean weighted vulnerability to increased turbidity. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Increased turbidity
Habitat	Mean weighted vulnerability score
Sheltered Coast : Kelp Forest	2.3
Sheltered Coast : Subtidal reefs 10-29 m	2.0
Sheltered Coast : Subtidal reefs 2-9 m	2.0
Fiord Habitats : Inner fiord rockwalls	2.0
Exposed Coasts : Subtidal reefs 10-30 m	2.0

Sheltered Coast : Sand 2-9 m	2.0
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.9
Exposed Coasts : Subtidal reefs 30-200 m	1.8
Fiord Habitats : Outer fiord rockwalls	1.8
Harbour and Estuaries : Subtidal reef	1.8
Exposed Coasts : Intertidal reefs	1.8
Exposed Coasts : Subtidal reefs 2-9 m	1.7
Sheltered Coast : Intertidal reef	1.7
Exposed Coasts : Turfing algal reefs	1.7
Exposed Coasts : Kelp Forest	1.6
Harbour and Estuaries : Seagrass meadows	1.6
Sheltered Coast : Mud 2-9 m	1.5
Sheltered Coast : Sand 10-29 m	1.5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.3
Harbour and Estuaries : Intertidal reef	1.3
Exposed Coasts : Sand 2-9 m	1.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.2
Exposed Coasts : Biogenic calcareous reefs	1.2
Harbour and Estuaries : Subtidal mud	1.2
Sheltered Coast : Mud 10-29 m	1.1
Harbour and Estuaries : Subtidal sand	1.1
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.0
Harbour and Estuaries : Intertidal mud	1.0
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.9
Exposed Coasts : Sandy beaches	0.9
Fiord Habitats : Fiord sediments	0.8
Pelagic Habitat : Slope - water column below photic zone	0.7
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.7
Pelagic Habitat : Slope - water column in photic zone	0.6
Exposed Coasts : Sand 10-29 m	0.6
Exposed Coasts : Mud 10-29 m	0.6
Harbour and Estuaries : Pipi bed	0.5
Sheltered Coast : Sandy beaches	0.5
Harbour and Estuaries : Cockle bed	0.4
Harbour and Estuaries : Intertidal sand	0.4
Exposed Coasts : Mud 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Deep Habitats : Soft canyon	0.2
Pelagic Habitat : Deep ocean water column in photic zone	0.1
Pelagic Habitat : Deep ocean water column below photic zone	0.1
Deep Habitats : Hard canyon	0.1
Slope Habitats : Sand 200-2000 m	0.1
Slope Habitats : Mud 200-2000 m	0.1

Table A3.46: Marine habitats in order of decreasing mean weighted vulnerability to invasive species that compete with other species to occupy space. Habitats with a score of zero are not shown. The maximum possible score = 4.

Invasive species: Space occupiers, competitors

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal reef	3.0
Harbour and Estuaries : Subtidal reef	2.5
Sheltered Coast : Intertidal reef	2.0
Sheltered Coast : Kelp Forest	1.9
Sheltered Coast : Subtidal reefs 10-29 m	1.9
Sheltered Coast : Subtidal reefs 2-9 m	1.9
Exposed Coasts : Subtidal reefs 30-200 m	1.9
Exposed Coasts : Intertidal reefs	1.9
Harbour and Estuaries : Subtidal mud	1.8
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.7
Exposed Coasts : Turfing algal reefs	1.6
Fiord Habitats : Inner fiord rockwalls	1.5
Sheltered Coast : Sand 2-9 m	1.5
Harbour and Estuaries : Seagrass meadows	1.5
Harbour and Estuaries : Saltmarsh	1.4
Exposed Coasts : Subtidal reefs 10-30 m	1.3
Harbour and Estuaries : Subtidal sand	1.3
Harbour and Estuaries : Intertidal mud	1.3
Exposed Coasts : Subtidal reefs 2-9 m	1.2
Sheltered Coast : Mud 2-9 m	1.2
Fiord Habitats : Fiord sediments	1.2
Fiord Habitats : Outer fiord rockwalls	1.1
Harbour and Estuaries : Pipi bed	1.1
Exposed Coasts : Kelp Forest	1.0
Sheltered Coast : Sand 10-29 m	1.0
Sheltered Coast : Gravel/pebble/shell 10-29 m	1.0
Harbour and Estuaries : Intertidal sand	1.0
Exposed Coasts : Sandy beaches	0.9
Sheltered Coast : Sandy beaches	0.9
Harbour and Estuaries : Cockle bed	0.9
Exposed Coasts : Biogenic calcareous reefs	0.8
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.8
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.7
Sheltered Coast : Mud 10-29 m	0.7
Exposed Coasts : Sand 2-9 m	0.5
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.5
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.5
Pelagic Habitat : Slope - water column below photic zone	0.4
Pelagic Habitat : Slope - water column in photic zone	0.3
Harbour and Estuaries : Mangrove forest	0.3

Exposed Coasts : Sand 10-29 m	0.2
Exposed Coasts : Mud 10-29 m	0.2
Exposed Coasts : Mud 30-200 m	0.1
Exposed Coasts : Sand 30-200 m	0.1
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.1

Table A3.47: Marine habitats in order of decreasing mean weighted vulnerability to invasive disease organisms. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Invasive species: Disease
Habitat	Mean weighted vulnerability score
Exposed Coasts : Intertidal reefs	1.2
Harbour and Estuaries : Subtidal reef	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Harbour and Estuaries : Seagrass meadows	1.1
Sheltered Coast : Intertidal reef	1.0
Harbour and Estuaries : Subtidal sand	1.0
Harbour and Estuaries : Intertidal reef	0.9
Sheltered Coast : Subtidal reefs 10-29 m	0.7
Sheltered Coast : Subtidal reefs 2-9 m	0.7
Harbour and Estuaries : Subtidal mud	0.7
Exposed Coasts : Turfing algal reefs	0.7
Harbour and Estuaries : Intertidal mud	0.6
Harbour and Estuaries : Pipi bed	0.6
Exposed Coasts : Biogenic calcareous reefs	0.6
Exposed Coasts : Subtidal reefs 10-30 m	0.5
Harbour and Estuaries : Cockle bed	0.5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.5
Harbour and Estuaries : Mangrove forest	0.5
Sheltered Coast : Kelp Forest	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Harbour and Estuaries : Intertidal sand	0.4
Exposed Coasts : Kelp Forest	0.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Pelagic Habitat : Slope - water column below photic zone	0.2
Exposed Coasts : Sand 10-29 m	0.2
Fiord Habitats : Inner fiord rockwalls	0.1
Sheltered Coast : Sand 2-9 m	0.1
Harbour and Estuaries : Saltmarsh	0.1
Sheltered Coast : Mud 2-9 m	0.1
Fiord Habitats : Fiord sediments	0.1
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1

Exposed Coasts : Sand 2-9 m	0.1
Exposed Coasts : Mud 10-29 m	0.1
Exposed Coasts : Mud 30-200 m	0.1
Exposed Coasts : Sand 30-200 m	0.1
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.1
Pelagic Habitat : Deep ocean water column in photic zone	0.1

Table A3.48: Marine habitats in order of decreasing mean weighted vulnerability to oil or oil product pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

Pollution: Oil or oil products

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Saltmarsh	2.1
Harbour and Estuaries : Pipi bed	2.0
Exposed Coasts : Subtidal reefs 30-200 m	1.9
Harbour and Estuaries : Seagrass meadows	1.9
Harbour and Estuaries : Intertidal reef	1.9
Harbour and Estuaries : Subtidal mud	1.8
Exposed Coasts : Intertidal reefs	1.6
Harbour and Estuaries : Intertidal mud	1.6
Harbour and Estuaries : Cockle bed	1.6
Pelagic Habitat : Slope - water column in photic zone	1.5
Harbour and Estuaries : Subtidal reef	1.4
Harbour and Estuaries : Subtidal sand	1.4
Harbour and Estuaries : Mangrove forest	1.3
Pelagic Habitat : Deep ocean water column in photic zone	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.2
Pelagic Habitat : Slope - water column below photic zone	1.2
Harbour and Estuaries : Intertidal sand	1.1
Sheltered Coast : Mud 2-9 m	1.1
Sheltered Coast : Intertidal reef	1.0
Exposed Coasts : Subtidal reefs 10-30 m	1.0
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.0
Exposed Coasts : Mud 30-200 m	1.0
Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Exposed Coasts : Subtidal reefs 2-9 m	0.9
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.9
Sheltered Coast : Sand 2-9 m	0.9
Sheltered Coast : Sand 10-29 m	0.9
Sheltered Coast : Mud 10-29 m	0.9
Exposed Coasts : Turfing algal reefs	0.8
Exposed Coasts : Biogenic calcareous reefs	0.8
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.8
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.8
Pelagic Habitat : Deep ocean water column below photic zone	0.8

Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Mud 10-29 m	0.7
Exposed Coasts : Sandy beaches	0.7
Sheltered Coast : Sandy beaches	0.7
Exposed Coasts : Kelp Forest	0.6
Exposed Coasts : Sand 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.6
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.5
Exposed Coasts : Sand 10-29 m	0.4
Exposed Coasts : Sand 2-9 m	0.4
Fiord Habitats : Outer fiord rockwalls	0.3
Fiord Habitats : Inner fiord rockwalls	0.2
Slope Habitats : Sand 200-2000 m	0.1
Slope Habitats : Mud 200-2000 m	0.1
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1

Table A3.49: Marine habitats in order of decreasing mean weighted vulnerability to sewage pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Sewage
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	2.5
Harbour and Estuaries : Intertidal mud	2.5
Harbour and Estuaries : Subtidal sand	2.1
Harbour and Estuaries : Pipi bed	1.9
Harbour and Estuaries : Subtidal reef	1.9
Harbour and Estuaries : Intertidal reef	1.8
Exposed Coasts : Subtidal reefs 30-200 m	1.6
Harbour and Estuaries : Seagrass meadows	1.6
Exposed Coasts : Intertidal reefs	1.6
Harbour and Estuaries : Cockle bed	1.6
Sheltered Coast : Intertidal reef	1.6
Harbour and Estuaries : Saltmarsh	1.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	1.4
Harbour and Estuaries : Mangrove forest	1.3
Harbour and Estuaries : Intertidal sand	1.3
Sheltered Coast : Mud 2-9 m	1.3
Sheltered Coast : Subtidal reefs 10-29 m	1.3
Sheltered Coast : Subtidal reefs 2-9 m	1.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.1
Sheltered Coast : Sand 2-9 m	1.1
Sheltered Coast : Sand 10-29 m	1.1
Exposed Coasts : Turfing algal reefs	1.1
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.1
Exposed Coasts : Subtidal reefs 10-30 m	1.0

Exposed Coasts : Subtidal reefs 2-9 m	0.9
Sheltered Coast : Mud 10-29 m	0.9
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.9
Exposed Coasts : Mud 10-29 m	0.9
Exposed Coasts : Biogenic calcareous reefs	0.8
Sheltered Coast : Kelp Forest	0.8
Exposed Coasts : Sandy beaches	0.8
Sheltered Coast : Sandy beaches	0.8
Exposed Coasts : Sand 10-29 m	0.8
Exposed Coasts : Sand 2-9 m	0.8
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.7
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.7
Exposed Coasts : Kelp Forest	0.6
Exposed Coasts : Mud 30-200 m	0.4
Fiord Habitats : Outer fiord rockwalls	0.4
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Fiord Habitats : Inner fiord rockwalls	0.3
Pelagic Habitat : Slope - water column below photic zone	0.2
Pelagic Habitat : Slope - water column in photic zone	0.1

Table A3.50: Marine habitats in order of decreasing mean weighted vulnerability to nitrogen and phosphorus pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Nitrogen and phosphorus
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	2.1
Harbour and Estuaries : Subtidal reef	2.0
Harbour and Estuaries : Seagrass meadows	2.0
Harbour and Estuaries : Intertidal mud	1.9
Harbour and Estuaries : Subtidal sand	1.9
Harbour and Estuaries : Intertidal reef	1.8
Harbour and Estuaries : Pipi bed	1.6
Exposed Coasts : Subtidal reefs 30-200 m	1.6
Exposed Coasts : Intertidal reefs	1.6
Sheltered Coast : Intertidal reef	1.6
Harbour and Estuaries : Mangrove forest	1.5
Harbour and Estuaries : Saltmarsh	1.4
Harbour and Estuaries : Intertidal sand	1.3
Sheltered Coast : Subtidal reefs 10-29 m	1.3
Sheltered Coast : Subtidal reefs 2-9 m	1.3
Pelagic Habitat : Slope - water column below photic zone	1.3
Harbour and Estuaries : Cockle bed	1.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.0
Pelagic Habitat : Slope - water column in photic zone	1.0

Exposed Coasts : Turfing algal reefs	0.9
Exposed Coasts : Subtidal reefs 10-30 m	0.9
Sheltered Coast : Sandy beaches	0.9
Pelagic Habitat : Deep ocean water column in photic zone	0.9
Pelagic Habitat : Deep ocean water column below photic zone	0.9
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.8
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Mud 10-29 m	0.8
Sheltered Coast : Kelp Forest	0.7
Exposed Coasts : Sand 10-29 m	0.7
Exposed Coasts : Sand 2-9 m	0.7
Sheltered Coast : Mud 2-9 m	0.6
Sheltered Coast : Sand 2-9 m	0.6
Sheltered Coast : Sand 10-29 m	0.6
Exposed Coasts : Sandy beaches	0.6
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.6
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.5
Exposed Coasts : Kelp Forest	0.5
Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.4
Sheltered Coast : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3

Table A3.51: Marine habitats in order of decreasing mean weighted vulnerability to heavy metal pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

Pollution: Heavy metals

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	2.7
Harbour and Estuaries : Intertidal mud	2.5
Harbour and Estuaries : Subtidal reef	2.2
Harbour and Estuaries : Subtidal sand	2.0
Harbour and Estuaries : Intertidal sand	1.9
Harbour and Estuaries : Intertidal reef	1.8
Harbour and Estuaries : Pipi bed	1.8
Harbour and Estuaries : Cockle bed	1.8
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.6
Exposed Coasts : Intertidal reefs	1.5
Sheltered Coast : Intertidal reef	1.5
Harbour and Estuaries : Mangrove forest	1.4
Harbour and Estuaries : Seagrass meadows	1.3
Exposed Coasts : Subtidal reefs 30-200 m	1.3
Sheltered Coast : Subtidal reefs 10-29 m	1.2
Sheltered Coast : Subtidal reefs 2-9 m	1.2

Sheltered Coast : Sandy beaches	1.2
Harbour and Estuaries : Saltmarsh	1.1
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.8
Exposed Coasts : Subtidal reefs 10-30 m	0.7
Pelagic Habitat : Deep ocean water column in photic zone	0.7
Pelagic Habitat : Deep ocean water column below photic zone	0.7
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.7
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.7
Exposed Coasts : Turfing algal reefs	0.6
Exposed Coasts : Subtidal reefs 2-9 m	0.6
Sheltered Coast : Mud 2-9 m	0.6
Exposed Coasts : Sandy beaches	0.6
Sheltered Coast : Sand 2-9 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.5
Pelagic Habitat : Slope - water column below photic zone	0.4
Exposed Coasts : Mud 10-29 m	0.4
Exposed Coasts : Sand 2-9 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Pelagic Habitat : Slope - water column in photic zone	0.3
Sheltered Coast : Kelp Forest	0.3
Exposed Coasts : Sand 10-29 m	0.3
Sheltered Coast : Sand 10-29 m	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Kelp Forest	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Deep Habitats : Soft abyssal 2000 m+	0.2
Slope Habitats : Sand 200-2000 m	0.1
Slope Habitats : Mud 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1

Table A3.52: Marine habitats in order of decreasing mean weighted vulnerability to pesticide including PCB pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

Pollution: Pesticides including PCBs

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	2.1
Harbour and Estuaries : Subtidal reef	1.6
Harbour and Estuaries : Subtidal sand	1.5
Harbour and Estuaries : Pipi bed	1.4
Harbour and Estuaries : Mangrove forest	1.4
Harbour and Estuaries : Intertidal mud	1.3
Harbour and Estuaries : Intertidal reef	1.3

Harbour and Estuaries : Cockle bed	1.2
Harbour and Estuaries : Seagrass meadows	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Exposed Coasts : Intertidal reefs	1.0
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.9
Harbour and Estuaries : Intertidal sand	0.8
Sheltered Coast : Intertidal reef	0.7
Harbour and Estuaries : Saltmarsh	0.7
Sheltered Coast : Mud 2-9 m	0.7
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Sheltered Coast : Sandy beaches	0.6
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.6
Exposed Coasts : Subtidal reefs 10-30 m	0.6
Exposed Coasts : Turfing algal reefs	0.6
Exposed Coasts : Sandy beaches	0.6
Exposed Coasts : Subtidal reefs 2-9 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Exposed Coasts : Biogenic calcareous reefs	0.4
Exposed Coasts : Sand 2-9 m	0.4
Sheltered Coast : Mud 10-29 m	0.4
Exposed Coasts : Sand 10-29 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Pelagic Habitat : Slope - water column below photic zone	0.3
Exposed Coasts : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Sheltered Coast : Kelp Forest	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Kelp Forest	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Pelagic Habitat : Deep ocean water column in photic zone	0.2
Pelagic Habitat : Deep ocean water column below photic zone	0.2
Pelagic Habitat : Slope - water column in photic zone	0.2
Fiord Habitats : Outer fiord rockwalls	0.1

Table A3.53: Marine habitats in order of decreasing mean weighted vulnerability to herbicide pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Herbicides
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	1.9
Harbour and Estuaries : Seagrass meadows	1.8
Harbour and Estuaries : Subtidal reef	1.4

Harbour and Estuaries : Saltmarsh	1.4
Harbour and Estuaries : Subtidal sand	1.3
Harbour and Estuaries : Intertidal mud	1.3
Harbour and Estuaries : Intertidal reef	1.3
Harbour and Estuaries : Mangrove forest	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Harbour and Estuaries : Pipi bed	1.0
Exposed Coasts : Intertidal reefs	1.0
Harbour and Estuaries : Cockle bed	0.8
Sheltered Coast : Intertidal reef	0.7
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.6
Harbour and Estuaries : Intertidal sand	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Exposed Coasts : Subtidal reefs 10-30 m	0.6
Exposed Coasts : Turfing algal reefs	0.6
Exposed Coasts : Subtidal reefs 2-9 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Sheltered Coast : Mud 2-9 m	0.4
Sheltered Coast : Sandy beaches	0.4
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.4
Exposed Coasts : Sandy beaches	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.4
Exposed Coasts : Biogenic calcareous reefs	0.4
Exposed Coasts : Sand 2-9 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Exposed Coasts : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Sheltered Coast : Kelp Forest	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Kelp Forest	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Sheltered Coast : Sand 2-9 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Sheltered Coast : Sand 10-29 m	0.2
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1

Table A3.54: Marine habitats in order of decreasing mean weighted vulnerability to plastic pollution. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Plastic
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.6
Harbour and Estuaries : Intertidal reef	1.2
Harbour and Estuaries : Subtidal mud	1.1
Harbour and Estuaries : Subtidal reef	1.1
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Exposed Coasts : Intertidal reefs	1.1
Harbour and Estuaries : Subtidal sand	0.9
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.9
Exposed Coasts : Turfing algal reefs	0.7
Harbour and Estuaries : Intertidal mud	0.6
Harbour and Estuaries : Pipi bed	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Exposed Coasts : Subtidal reefs 10-30 m	0.6
Sheltered Coast : Mud 2-9 m	0.6
Sheltered Coast : Sandy beaches	0.6
Exposed Coasts : Sandy beaches	0.6
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.6
Sheltered Coast : Kelp Forest	0.6
Pelagic Habitat : Slope - water column in photic zone	0.6
Pelagic Habitat : Deep ocean water column in photic zone	0.6
Harbour and Estuaries : Mangrove forest	0.5
Harbour and Estuaries : Cockle bed	0.5
Exposed Coasts : Subtidal reefs 2-9 m	0.5
Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.5
Exposed Coasts : Kelp Forest	0.5
Sheltered Coast : Intertidal reef	0.4
Harbour and Estuaries : Intertidal sand	0.4
Exposed Coasts : Sand 2-9 m	0.4
Exposed Coasts : Sand 10-29 m	0.4
Exposed Coasts : Mud 10-29 m	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Exposed Coasts : Sand 30-200 m	0.4
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.4
Sheltered Coast : Sand 2-9 m	0.4
Sheltered Coast : Sand 10-29 m	0.4
Harbour and Estuaries : Seagrass meadows	0.3

Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Sheltered Coast : Mud 10-29 m	0.3
Fiord Habitats : Outer fiord rockwalls	0.3
Pelagic Habitat : Slope - water column below photic zone	0.2
Fiord Habitats : Inner fiord rockwalls	0.2
Harbour and Estuaries : Saltmarsh	0.1
Pelagic Habitat : Deep ocean water column below photic zone	0.1
Deep Habitats : Soft abyssal 2000 m+	0.1
Slope Habitats : Sand 200-2000 m	0.1
Slope Habitats : Mud 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1

Table A3.55: Marine habitats in order of decreasing mean weighted vulnerability to noise pollution from acoustic devices/guns. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Acoustic discharges / guns
Habitat	Mean weighted vulnerability score
Pelagic Habitat : Coastal - whole water column inside 50 m contour	1.1
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.7
Pelagic Habitat : Deep ocean water column in photic zone	0.4
Harbour and Estuaries : Subtidal mud	0.3
Exposed Coasts : Subtidal reefs 30-200 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.3
Exposed Coasts : Mud 30-200 m	0.3
Pelagic Habitat : Slope - water column below photic zone	0.3
Pelagic Habitat : Deep ocean water column below photic zone	0.3
Harbour and Estuaries : Intertidal reef	0.2
Harbour and Estuaries : Subtidal reef	0.2
Harbour and Estuaries : Subtidal sand	0.2
Harbour and Estuaries : Intertidal mud	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.2
Exposed Coasts : Sand 30-200 m	0.2
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.2
Exposed Coasts : Intertidal reefs	0.1
Harbour and Estuaries : Pipi bed	0.1
Sheltered Coast : Subtidal reefs 10-29 m	0.1
Sheltered Coast : Subtidal reefs 2-9 m	0.1
Sheltered Coast : Mud 2-9 m	0.1
Sheltered Coast : Kelp Forest	0.1
Harbour and Estuaries : Mangrove forest	0.1
Harbour and Estuaries : Cockle bed	0.1
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.1
Harbour and Estuaries : Intertidal sand	0.1
Exposed Coasts : Sand 2-9 m	0.1
Exposed Coasts : Sand 10-29 m	0.1

Exposed Coasts : Mud 10-29 m	0.1
Sheltered Coast : Sand 2-9 m	0.1
Sheltered Coast : Sand 10-29 m	0.1
Harbour and Estuaries : Seagrass meadows	0.1
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1
Slope Habitats : Sand 200-2000 m	0.1
Slope Habitats : Reef 200-2000 m	0.1
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.1

Table A3.56: Marine habitats in order of decreasing mean weighted vulnerability to electromagnetic discharges from submarine cables. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Pollution: Electromagnetic discharges
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal mud	0.6
Exposed Coasts : Subtidal reefs 30-200 m	0.5
Harbour and Estuaries : Intertidal reef	0.5
Harbour and Estuaries : Subtidal reef	0.5
Harbour and Estuaries : Subtidal sand	0.5
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.3
Harbour and Estuaries : Intertidal mud	0.3
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Sheltered Coast : Kelp Forest	0.3
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Exposed Coasts : Mud 30-200 m	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Intertidal reefs	0.2
Harbour and Estuaries : Pipi bed	0.2
Sheltered Coast : Mud 2-9 m	0.2
Harbour and Estuaries : Cockle bed	0.2
Harbour and Estuaries : Seagrass meadows	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Exposed Coasts : Subtidal reefs 2-9 m	0.2
Pelagic Habitat : Slope - water column in photic zone	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Exposed Coasts : Sand 30-200 m	0.1
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.1
Harbour and Estuaries : Intertidal sand	0.1
Sheltered Coast : Sand 2-9 m	0.1
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1
Exposed Coasts : Kelp Forest	0.1
Sheltered Coast : Intertidal reef	0.1

Table A3.57: Marine habitats in order of decreasing mean weighted vulnerability to increased sediment loading on rivers. Habitats with a score of zero are not shown. The maximum possible score = 4.

River inputs: Increased sediment loading

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal reef	3.3
Harbour and Estuaries : Subtidal reef	3.2
Sheltered Coast : Intertidal reef	3.2
Sheltered Coast : Sandy beaches	3.1
Harbour and Estuaries : Pipi bed	2.9
Harbour and Estuaries : Seagrass meadows	2.9
Harbour and Estuaries : Intertidal sand	2.9
Harbour and Estuaries : Intertidal mud	2.8
Harbour and Estuaries : Cockle bed	2.8
Harbour and Estuaries : Subtidal mud	2.7
Sheltered Coast : Subtidal reefs 10-29 m	2.7
Sheltered Coast : Subtidal reefs 2-9 m	2.7
Sheltered Coast : Kelp Forest	2.5
Exposed Coasts : Sandy beaches	2.5
Sheltered Coast : Sand 2-9 m	2.4
Harbour and Estuaries : Subtidal sand	2.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	2.3
Sheltered Coast : Sand 10-29 m	2.3
Sheltered Coast : Mud 10-29 m	2.3
Harbour and Estuaries : Saltmarsh	2.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	2.2
Sheltered Coast : Mud 2-9 m	2.2
Exposed Coasts : Subtidal reefs 30-200 m	2.1
Exposed Coasts : Subtidal reefs 10-30 m	2.1
Exposed Coasts : Intertidal reefs	2.0
Exposed Coasts : Biogenic calcareous reefs	1.9
Exposed Coasts : Subtidal reefs 2-9 m	1.8
Harbour and Estuaries : Mangrove forest	1.8
Exposed Coasts : Sand 2-9 m	1.6
Exposed Coasts : Kelp Forest	1.5
Exposed Coasts : Turfing algal reefs	1.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	1.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	1.1
Fiord Habitats : Outer fiord rockwalls	1.1
Exposed Coasts : Mud 10-29 m	1.0
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.9
Exposed Coasts : Sand 10-29 m	0.9
Fiord Habitats : Inner fiord rockwalls	0.8
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.7
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.6
Pelagic Habitat : Slope - water column below photic zone	0.6

Exposed Coasts : Mud 30-200 m	0.5
Exposed Coasts : Sand 30-200 m	0.5
Fiord Habitats : Fiord sediments	0.5
Pelagic Habitat : Slope - water column in photic zone	0.4
Slope Habitats : Sand 200-2000 m	0.4
Slope Habitats : Reef 200-2000 m	0.4
Slope Habitats : Mud 200-2000 m	0.4
Slope Habitats : Gravel/pebbles/shells 200-2000 m	0.3
Pelagic Habitat : Deep ocean water column in photic zone	0.2
Pelagic Habitat : Deep ocean water column below photic zone	0.2
Deep Habitats : Vent (hot and cold)	0.1

Table A3.58: Marine habitats in order of decreasing mean weighted vulnerability to increased river flows. Habitats with a score of zero are not shown. The maximum possible score = 4.

	River inputs: Increased flow
Habitat	Mean weighted vulnerability score
Fiord Habitats : Outer fiord rockwalls	2.7
Harbour and Estuaries : Intertidal mud	2.0
Harbour and Estuaries : Subtidal mud	2.0
Fiord Habitats : Inner fiord rockwalls	2.0
Harbour and Estuaries : Pipi bed	1.5
Harbour and Estuaries : Seagrass meadows	1.5
Harbour and Estuaries : Subtidal reef	1.3
Exposed Coasts : Sandy beaches	1.3
Harbour and Estuaries : Intertidal reef	1.2
Harbour and Estuaries : Cockle bed	1.2
Sheltered Coast : Intertidal reef	1.1
Harbour and Estuaries : Intertidal sand	1.1
Harbour and Estuaries : Subtidal sand	1.1
Harbour and Estuaries : Saltmarsh	1.0
Sheltered Coast : Sandy beaches	0.8
Exposed Coasts : Sand 2-9 m	0.7
Exposed Coasts : Subtidal reefs 30-200 m	0.6
Fiord Habitats : Fiord sediments	0.6
Sheltered Coast : Subtidal reefs 10-29 m	0.5
Sheltered Coast : Subtidal reefs 2-9 m	0.5
Exposed Coasts : Subtidal reefs 10-30 m	0.5
Exposed Coasts : Intertidal reefs	0.5
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Harbour and Estuaries : Mangrove forest	0.4
Sheltered Coast : Kelp Forest	0.3
Sheltered Coast : Sand 2-9 m	0.3
Exposed Coasts : Turfing algal reefs	0.3
Pelagic Habitat : Slope - water column below photic zone	0.3
Sheltered Coast : Mud 2-9 m	0.2

Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Exposed Coasts : Sand 10-29 m	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Pelagic Habitat : Slope - water column in photic zone	0.2
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1
Exposed Coasts : Kelp Forest	0.1

Table A3.59: Marine habitats in order of decreasing mean weighted vulnerability to decreased sediment loading on rivers. Habitats with a score of zero are not shown. The maximum possible score = 4.

River inputs: Decreased sediment loading

Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal reef	1.3
Harbour and Estuaries : Saltmarsh	1.3
Harbour and Estuaries : Subtidal reef	1.1
Harbour and Estuaries : Subtidal mud	1.0
Harbour and Estuaries : Intertidal mud	0.9
Harbour and Estuaries : Mangrove forest	0.9
Harbour and Estuaries : Subtidal sand	0.7
Sheltered Coast : Subtidal reefs 10-29 m	0.6
Sheltered Coast : Subtidal reefs 2-9 m	0.6
Exposed Coasts : Intertidal reefs	0.6
Harbour and Estuaries : Pipi bed	0.5
Exposed Coasts : Sandy beaches	0.5
Sheltered Coast : Intertidal reef	0.5
Sheltered Coast : Sandy beaches	0.5
Exposed Coasts : Subtidal reefs 10-30 m	0.5
Sheltered Coast : Kelp Forest	0.5
Sheltered Coast : Mud 2-9 m	0.5
Harbour and Estuaries : Seagrass meadows	0.4
Harbour and Estuaries : Cockle bed	0.4
Exposed Coasts : Sand 2-9 m	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Pelagic Habitat : Slope - water column below photic zone	0.4
Harbour and Estuaries : Intertidal sand	0.3
Exposed Coasts : Subtidal reefs 30-200 m	0.3
Sheltered Coast : Sand 2-9 m	0.3
Exposed Coasts : Sand 10-29 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.3
Sheltered Coast : Sand 10-29 m	0.3
Sheltered Coast : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.3
Exposed Coasts : Mud 10-29 m	0.3
Exposed Coasts : Turfing algal reefs	0.2

Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Exposed Coasts : Kelp Forest	0.2
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.2
Exposed Coasts : Biogenic calcareous reefs	0.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.1

Table A3.60: Marine habitats in order of decreasing mean weighted vulnerability to decreased river flows. Habitats with a score of zero are not shown. The maximum possible score = 4.

	River inputs: Decreased flow
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal mud	1.3
Harbour and Estuaries : Intertidal reef	1.1
Sheltered Coast : Intertidal reef	1.0
Harbour and Estuaries : Subtidal reef	0.9
Harbour and Estuaries : Subtidal mud	0.9
Harbour and Estuaries : Saltmarsh	0.9
Harbour and Estuaries : Subtidal sand	0.7
Exposed Coasts : Sandy beaches	0.7
Harbour and Estuaries : Pipi bed	0.6
Harbour and Estuaries : Mangrove forest	0.5
Harbour and Estuaries : Cockle bed	0.5
Harbour and Estuaries : Intertidal sand	0.5
Sheltered Coast : Subtidal reefs 10-29 m	0.4
Sheltered Coast : Subtidal reefs 2-9 m	0.4
Exposed Coasts : Intertidal reefs	0.4
Exposed Coasts : Subtidal reefs 30-200 m	0.4
Fiord Habitats : Outer fiord rockwalls	0.4
Sheltered Coast : Sandy beaches	0.3
Exposed Coasts : Subtidal reefs 10-30 m	0.3
Harbour and Estuaries : Seagrass meadows	0.3
Exposed Coasts : Subtidal reefs 2-9 m	0.3
Pelagic Habitat : Slope - water column below photic zone	0.3
Exposed Coasts : Sand 2-9 m	0.3
Fiord Habitats : Inner fiord rockwalls	0.3
Slope Habitats : Reef 200-2000 m	0.3
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Pelagic Habitat : Slope - water column in photic zone	0.2
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.2
Exposed Coasts : Sand 10-29 m	0.2
Sheltered Coast : Sand 10-29 m	0.2
Sheltered Coast : Mud 10-29 m	0.2
Sheltered Coast : Mud 2-9 m	0.1
Sheltered Coast : Sand 2-9 m	0.1

Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.1

Table A3.61: Marine habitats in order of decreasing mean weighted vulnerability to dampening of river flows. Habitats with a score of zero are not shown. The maximum possible score = 4.

	River inputs: Dampening of flows
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Intertidal reef	0.7
Harbour and Estuaries : Mangrove forest	0.7
Harbour and Estuaries : Subtidal reef	0.6
Harbour and Estuaries : Subtidal mud	0.6
Harbour and Estuaries : Intertidal mud	0.5
Harbour and Estuaries : Saltmarsh	0.5
Harbour and Estuaries : Subtidal sand	0.4
Exposed Coasts : Sandy beaches	0.3
Harbour and Estuaries : Pipi bed	0.3
Sheltered Coast : Sandy beaches	0.3
Sheltered Coast : Intertidal reef	0.2
Harbour and Estuaries : Cockle bed	0.2
Harbour and Estuaries : Intertidal sand	0.2
Sheltered Coast : Subtidal reefs 10-29 m	0.2
Sheltered Coast : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Intertidal reefs	0.2
Exposed Coasts : Subtidal reefs 30-200 m	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Harbour and Estuaries : Seagrass meadows	0.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.2
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.1

Table A3.62: Marine habitats in order of decreasing mean weighted vulnerability to ship grounding or sinking. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Shipping: Grounding, sinking
Habitat	Mean weighted vulnerability score
Harbour and Estuaries : Subtidal reef	1.4
Harbour and Estuaries : Intertidal reef	1.3
Exposed Coasts : Turfing algal reefs	1.2
Exposed Coasts : Subtidal reefs 30-200 m	1.1
Harbour and Estuaries : Seagrass meadows	1.0

Harbour and Estuaries : Subtidal sand	0.9
Sheltered Coast : Subtidal reefs 10-29 m	0.9
Sheltered Coast : Subtidal reefs 2-9 m	0.9
Harbour and Estuaries : Subtidal mud	0.8
Exposed Coasts : Subtidal reefs 10-30 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Intertidal reefs	0.7
Fiord Habitats : Inner fiord rockwalls	0.7
Sheltered Coast : Kelp Forest	0.7
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.7
Exposed Coasts : Kelp Forest	0.7
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.7
Harbour and Estuaries : Pipi bed	0.6
Sheltered Coast : Intertidal reef	0.6
Harbour and Estuaries : Intertidal mud	0.5
Exposed Coasts : Sandy beaches	0.5
Harbour and Estuaries : Cockle bed	0.5
Harbour and Estuaries : Intertidal sand	0.5
Fiord Habitats : Outer fiord rockwalls	0.5
Exposed Coasts : Sand 2-9 m	0.5
Sheltered Coast : Sand 2-9 m	0.5
Exposed Coasts : Biogenic calcareous reefs	0.5
Sheltered Coast : Mud 2-9 m	0.4
Fiord Habitats : Fiord sediments	0.4
Sheltered Coast : Sand 10-29 m	0.3
Sheltered Coast : Mud 10-29 m	0.3
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Exposed Coasts : Mud 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Sheltered Coast : Sandy beaches	0.2
Exposed Coasts : Sand 10-29 m	0.2
Exposed Coasts : Mud 10-29 m	0.2
Deep Habitats : Soft abyssal 2000 m+	0.2
Pelagic Habitat : Slope - water column below photic zone	0.1
Pelagic Habitat : Slope - water column in photic zone	0.1
Slope Habitats : Reef 200-2000 m	0.1
Slope Habitats : Sand 200-2000 m	0.1
Deep Habitats : Trench	0.1

Table A3.63: Marine habitats in order of decreasing mean weighted vulnerability to ship noise. Habitats with a score of zero are not shown. The maximum possible score = 4.

Shipping: Noise pollution

Habitat	Mean weighted vulnerability score
Exposed Coasts : Subtidal reefs 30-200 m	1.2
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.7
Exposed Coasts : Turfing algal reefs	0.5
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.5
Harbour and Estuaries : Subtidal reef	0.4
Harbour and Estuaries : Subtidal mud	0.4
Exposed Coasts : Subtidal reefs 10-30 m	0.4
Exposed Coasts : Subtidal reefs 2-9 m	0.4
Harbour and Estuaries : Intertidal mud	0.4
Exposed Coasts : Mud 30-200 m	0.4
Harbour and Estuaries : Intertidal reef	0.3
Harbour and Estuaries : Subtidal sand	0.3
Sheltered Coast : Subtidal reefs 10-29 m	0.3
Sheltered Coast : Subtidal reefs 2-9 m	0.3
Exposed Coasts : Intertidal reefs	0.3
Sheltered Coast : Kelp Forest	0.3
Exposed Coasts : Kelp Forest	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.3
Exposed Coasts : Biogenic calcareous reefs	0.3
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.3
Exposed Coasts : Sand 30-200 m	0.3
Exposed Coasts : Mud 10-29 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.3
Pelagic Habitat : Deep ocean water column in photic zone	0.3
Harbour and Estuaries : Seagrass meadows	0.2
Harbour and Estuaries : Pipi bed	0.2
Harbour and Estuaries : Cockle bed	0.2
Exposed Coasts : Sand 2-9 m	0.2
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.2
Exposed Coasts : Sand 10-29 m	0.2
Pelagic Habitat : Slope - water column below photic zone	0.2
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.1
Harbour and Estuaries : Intertidal sand	0.1
Sheltered Coast : Sand 2-9 m	0.1
Sheltered Coast : Mud 2-9 m	0.1
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1
Pelagic Habitat : Deep ocean water column below photic zone	0.1

Table A3.64: Marine habitats in order of decreasing mean weighted vulnerability to animal strikes by ships. Habitats with a score of zero are not shown. The maximum possible score = 4.

Habitat	Shipping: Animal strikes Mean weighted vulnerability score
Pelagic Habitat : Coastal - whole water column inside 50 m contour	0.5
Fiord Habitats : Inner fiord rockwalls	0.5
Pelagic Habitat : Shelf - whole water column between 50-200 m contour	0.4
Harbour and Estuaries : Intertidal mud	0.4
Exposed Coasts : Subtidal reefs 30-200 m	0.3
Harbour and Estuaries : Subtidal mud	0.3
Exposed Coasts : Mud 30-200 m	0.3
Pelagic Habitat : Slope - water column in photic zone	0.3
Fiord Habitats : Outer fiord rockwalls	0.3
Fiord Habitats : Fiord sediments	0.3
Exposed Coasts : Turfing algal reefs	0.2
Harbour and Estuaries : Subtidal reef	0.2
Exposed Coasts : Subtidal reefs 10-30 m	0.2
Harbour and Estuaries : Intertidal reef	0.2
Harbour and Estuaries : Subtidal sand	0.2
Sheltered Coast : Subtidal reefs 10-29 m	0.2
Sheltered Coast : Subtidal reefs 2-9 m	0.2
Exposed Coasts : Intertidal reefs	0.2
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.2
Exposed Coasts : Biogenic calcareous reefs	0.2
Exposed Coasts : Gravel/pebble/shell 30-200 m	0.2
Exposed Coasts : Sand 30-200 m	0.2
Exposed Coasts : Mud 10-29 m	0.2
Pelagic Habitat : Deep ocean water column in photic zone	0.2
Harbour and Estuaries : Pipi bed	0.2
Sheltered Coast : Mud 2-9 m	0.2
Exposed Coasts : Subtidal reefs 2-9 m	0.1
Sheltered Coast : Kelp Forest	0.1
Exposed Coasts : Kelp Forest	0.1
Harbour and Estuaries : Seagrass meadows	0.1
Harbour and Estuaries : Cockle bed	0.1
Exposed Coasts : Sand 2-9 m	0.1
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.1
Exposed Coasts : Sand 10-29 m	0.1
Pelagic Habitat : Slope - water column below photic zone	0.1
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.1
Harbour and Estuaries : Intertidal sand	0.1
Sheltered Coast : Sand 2-9 m	0.1
Sheltered Coast : Sand 10-29 m	0.1
Sheltered Coast : Mud 10-29 m	0.1
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.1

Table A3.65: Marine habitats in order of decreasing mean weighted vulnerability to spatial closures to fishing. Habitats with a score of zero are not shown. The maximum possible score = 4.

	Spatial closures to fishing
Habitat	Mean weighted vulnerability score
Fiord Habitats : Inner fiord rockwalls	1.9
Exposed Coasts : Subtidal reefs 30-200 m	1.5
Fiord Habitats : Outer fiord rockwalls	1.4
Harbour and Estuaries : Intertidal reef	1.3
Fiord Habitats : Fiord sediments	1.2
Harbour and Estuaries : Subtidal reef	1.0
Exposed Coasts : Subtidal reefs 10-30 m	0.9
Sheltered Coast : Kelp Forest	0.9
Exposed Coasts : Kelp Forest	0.9
Exposed Coasts : Turfing algal reefs	0.8
Sheltered Coast : Subtidal reefs 10-29 m	0.8
Sheltered Coast : Subtidal reefs 2-9 m	0.8
Exposed Coasts : Subtidal reefs 2-9 m	0.8
Sheltered Coast : Intertidal reef	0.6
Harbour and Estuaries : Intertidal mud	0.5
Harbour and Estuaries : Subtidal mud	0.5
Harbour and Estuaries : Subtidal sand	0.5
Harbour and Estuaries : Pipi bed	0.5
Sheltered Coast : Mud 2-9 m	0.5
Harbour and Estuaries : Intertidal sand	0.5
Exposed Coasts : Intertidal reefs	0.4
Harbour and Estuaries : Seagrass meadows	0.4
Harbour and Estuaries : Cockle bed	0.4
Pelagic Habitat : Slope - water column below photic zone	0.4
Sheltered Coast : Gravel/pebble/shell 2-9 m	0.4
Sheltered Coast : Gravel/pebble/shell 10-29 m	0.4
Pelagic Habitat : Slope - water column in photic zone	0.3
Sheltered Coast : Sand 2-9 m	0.3
Sheltered Coast : Sand 10-29 m	0.3
Sheltered Coast : Mud 10-29 m	0.3
Exposed Coasts : Sandy beaches	0.3
Sheltered Coast : Sandy beaches	0.3
Exposed Coasts : Gravel/pebble/shell 2-9 m	0.1
Exposed Coasts : Biogenic calcareous reefs	0.1
Exposed Coasts : Gravel/pebble/shell 10-29 m	0.1

APPENDIX 4: SPATIAL INTENSITY OF THREATS

Introduction

In the sections below for each threat we summarise the key experts to contact in relation to the threat, describe the data available, describe the method used to collect or generate the data, outline any key models or datasets and/or features of note, provide a figure as an example of the graphical presentation of the data and lastly indicate where further information regarding the threat can be found.

A4.1 Ocean acidification

Key contacts

Sara Mikaloff-Fletcher (NIWA)
John Dunne (NOAA-GFDL) - John.Dunne@noaa.gov
Brett Mullan, Sam Dean (NIWA)

Description of the data

A 1^o x 1^o (latitude, longitude) grid of ocean pH over New Zealand's EEZ is available for the 1990s, 2040s, and 2090s. For each of these periods, the data include the mean value and the 'worst' value (minimum) that each grid box is projected to experience over the given decade. The work on the ocean biogeochemistry component of the model is not yet publicly available and has been provided to us as a courtesy. Therefore, John Dunne of NOAA-GFDL John.Dunne@noaa.gov) MUST be invited to be a co-author on any reports and papers that use this work.

Methodology for generating the data

The data are derived from the NOAA-GFDL ES2.1 coupled climate model forced with IPCC SRES-A2 emissions scenario. Values for the EEZ were extracted by Sara Mikaloff-Fletcher (s.mikalofffletcher@niwa.co.nz) in April 2010. The data were plotted as contour plots and as shaded boxes where each box represents a model grid cell. Data were extrapolated to fill in parts of the coast not adequately represented in the original 1^o x 1^o model (Figure A4.1).

Description of key models and datasets

The Tracers of Ocean Phytoplankton with Allometric Zooplankton (TOPAZ) model of ocean ecosystems and biogeochemical cycles developed at NOAA's Geophysical Fluid Dynamics Laboratory considers 22 tracers including three phytoplankton groups, two forms of dissolved organic matter, heterotrophic biomass, and dissolved inorganic species for C, N, P, Si, Fe, $CaCO_3$ and O_2 cycling. The model includes such processes as gas exchange, atmospheric deposition, scavenging, N_2 fixation and denitrification. Loss of phytoplankton is parameterized through the size-based relationship of Dunne et al. (2005). Ocean circulation and stratification are simulated with the Modular Ocean Model, version 4 (MOM4) at nominal 1 resolution in the horizontal (1/3 near the equator) and 50 layers in the vertical (Griffies et al. 2005). Physical parameterizations include an explicit free surface with real fresh water input, neutral diffusion and sub-grid-scale diffusion through Gent-McWilliams skew-diffusion, K-profile parameterisation (KPP) of the surface mixed layer, bottom topography represented with partial cells, isotropic and anisotropic friction, and multiple tracer advection schemes.

In historical biogeochemical reanalysis configuration, the model is forced using version II of the Common Ocean Reference Experiment (CORE; Large and Yeager, 2004; http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE/doc.html) ice/ocean model configuration. Atmospheric forcing is derived from a 1948-2007 atmospheric reanalysis of surface atmospheric temperature pressure and humidity conditions. Also taken into account are downward radiative, momentum, and freshwater fluxes and upward radiative and evaporative fluxes. Turbulent fluxes are calculated from the NCAR bulk formulae (Bryan et al., 1996).

For the coupled runs, the GFDL Earth System Model (ESM2.1) includes atmospheric (AM2.1) and terrestrial biosphere (LM3v) components (Anderson et al., 2004; Shevliakova et al., 2009), in addition to the TOPAZ biogeochemistry model. The physical variables in GFDL's ESM2.1 were initialized from GFDL's CM2.1 (Delworth et al., 2006). The control run based on 1860 conditions was run for 2000 virtual years. Biogeochemical parameters were initialized from observations from the World Ocean Atlas 2001 (Conkright et al., 2002) and GLODAP (Key et al., 2004). This model was spun up for an additional 1000 years, with a fixed CO2 atmospheric boundary condition of 286 ppm. For an additional 100 years, the atmospheric boundary condition was switched to a fully interactive atmospheric CO2 tracer. Simulations were then made based on the IPCC AR4 protocols (A1B scenario).

Data currently available

Minimum pH values for 1990s, 2040s and 2090s as gridded 1^o x 1^o datasets.
Mean pH values for 1990s, 2040s and 2090s as gridded 1^o x 1^o datasets.
More tracers and time periods may be available on request.

Limitations of the model

The sea surface temperature and pH projections in ESM2.1 are subject to uncertainties in the prescribed fossil fuel emissions scenario, the modelled sensitivity of earth's climate to greenhouse gas emissions, and the representation of carbon-climate feedbacks as described in the references below. In particular, since the model is constructed for global scales at coarse resolution (1^o x 1^o) to represent features occurring at the many hundreds of kilometres scale, its ability to represent critical factors driving local habitats in the New Zealand EEZ is limited (see Figure A4.1).

Future development

The models upon which these estimates were based are currently under active development by John Dunne and his colleagues at NOAA-GFDL. We recommend that before an attempt is made to complete the assessment of risk to NZ marine habitats from this threat that the latest model estimates are sourced from the modelling team.

Further Information

Detailed documentation and references for the CM2.1 coupled climate model are available at: http://nomads.gfdl.noaa.gov/CM2.X/references/

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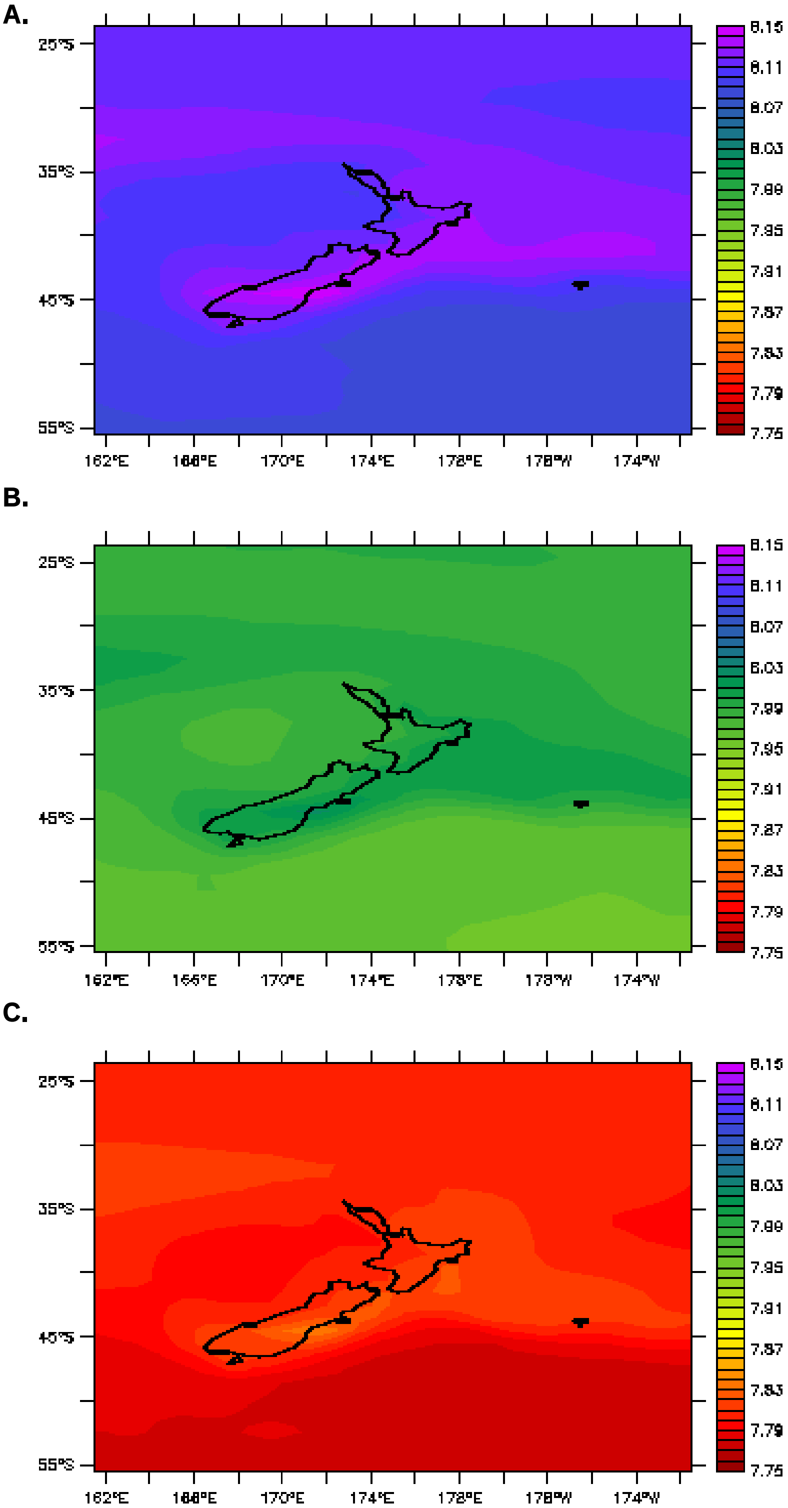

Figure A4.1: Modelled mean pH values for 1990s (A), 2040s (B) and 2090s (C).

A4.2 Climate change: sea surface temperature (SST)

Key contacts

Sara Mikaloff-Fletcher (NIWA)
John Dunne (NOAA-GFDL) - John.Dunne@noaa.gov
Brett Mullan, Sam Dean (NIWA)
Marine Environment Classification (MEC) – Arne Pallentin (NIWA)

Description of the data

NOAA-GFDL
A 1^{o} x 1^{o} grid of ocean SST over New Zealand's EEZ for the 1990s, 2040s, and 2090s. For each of these periods, the data include the mean value and the 'worst' value (maximum) that each grid box is projected to experience over the given decade. The work on the ocean biogeochemistry component of the model is not yet publicly available and has been provided to us as a courtesy. Therefore, John Dunne of NOAA-GFDL John.Dunne@noaa.gov) MUST be invited to be a co-author on any reports and papers that use this work.

MEC (from Snelder et al. 2005)
Sea surface temperature (SST) was expressed by four variables formulated to capture specific oceanographic processes, both physical and chemical that affect biological pattern (Snelder et al. 2005).

Methodology for generating the data

NOAA-GFDL
The data are derived from the NOAA-GFDL CM2.1 coupled climate model forced with IPCC SRES-A2 emissions scenario. Values for the EEZ were extracted by Sara Mikaloff-Fletcher (s.mikalofffletcher@niwa.co.nz) in April 2010. The data were plotted as contour plots and as shaded boxes where each box represents a model grid cell. Data were extrapolated to fill in parts of the coast not adequately represented in the original 1^{o} x 1^{o} model (Figure A4.2).

MEC
The variable layers based on SST are all calculated from a SST climatology dataset derived from the NIWA SST archive. The procedures for collecting satellite radiometer data, detecting cloud and retrieving SST are described by Uddstrom & Oien (1999). The climatology was prepared by compositing data for each of the 96 months in the years 1993 to 2000 on a grid with approximately 9 km resolution. The climatologies were later interpolated onto the 1 km^2 classification grid. This interpolation was considered reasonable because of the relatively smooth and slowly changing character of most of the SST variables. Wintertime SST was chosen as a proxy for water mass, which is related to differences in both temperature and chemical characteristics of the water including nutrient availability. Wintertime SST was evaluated by spatial smoothing of temperature at the time of typically lowest SST (day 250, early September). The annual amplitude of SST was chosen to reflect differences in stratification and wind mixing that together produce a mixed layer across the classified area. Annual amplitude of SST was evaluated from the annual harmonic which is spatially smoothed. The spatial gradient of annual mean SST is used to recognise fronts in oceanic water masses that are expected to correlate with variation in primary productivity. The spatial gradient of annual mean SST was produced by smoothing annual mean SST then evaluating the magnitude of the spatial gradient (in ºC km^{-1}) for each grid cell by centred differencing. The summertime SST anomaly is expected to define anomalies in temperature that are due to hydrodynamic forcing, such as upwelling and vigorous mixing due to eddies. Areas with high

summer SST anomaly are expected to correlate with high primary productivity. Summer SST anomaly was derived from SST measured in late February data (day 50), the time of year when SST is typically highest by band-pass filtering at scales between 20 and 450 km.

Description of key models and datasets

NOAA-GFDL

The Tracers of Ocean Phytoplankton with Allometric Zooplankton (TOPAZ) model of ocean ecosystems and biogeochemical cycles developed at NOAA's Geophysical Fluid Dynamics Laboratory considers 22 tracers including three phytoplankton groups, two forms of dissolved organic matter, heterotrophic biomass, and dissolved inorganic species for C, N, P, Si, Fe, $CaCO_3$ and O_2 cycling. The model includes such processes as gas exchange, atmospheric deposition, scavenging, N_2 fixation and denitrification. Loss of phytoplankton is parameterized through the size-based relationship of Dunne et al. (2005). Ocean circulation and stratification are simulated with the Modular Ocean Model, version 4 (MOM4) at nominal 1 resolution in the horizontal (1/3 near the equator) and 50 layers in the vertical (Griffies et al. 2005). Physical parameterizations include an explicit free surface with real fresh water input, neutral diffusion and sub-grid-scale diffusion through Gent-McWilliams skew-diffusion, K-profile parameterization (KPP) of the surface mixed layer, bottom topography represented with partial cells, isotropic and anisotropic friction, and multiple tracer advection schemes.

In historical biogeochemical reanalysis configuration, the model is forced using version II of the Common Ocean Reference Experiment (CORE; Large and Yeager, 2004; http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE/doc.html) ice/ocean model configuration. Atmospheric forcing is derived from a 1948-2007 atmospheric reanalysis of surface atmospheric temperature pressure and humidity conditions. Also taken into account are downward radiative, momentum, and freshwater fluxes and upward radiative and evaporative fluxes. Turbulent fluxes are calculated from the NCAR bulk formulae (Bryan et al., 1996).

For the coupled runs, the GFDL Earth System Model (ESM2.1) includes atmospheric (AM2.1) and terrestrial biosphere (LM3v) components (Anderson et al., 2004; Shevliakova et al., 2009), in addition to the TOPAZ biogeochemistry model. The physical variables in GFDL's ESM2.1 were initialized from GFDL's CM2.1 (Delworth et al., 2006). The control run based on 1860 conditions was spun-up for 2000 years. Biogeochemical parameters were initialized from observations from the World Ocean Atlas 2001 (Conkright et al., 2002) and GLODAP (Key et al., 2004). This model was spun up for an additional 1000 years, with a fixed CO_2 atmospheric boundary condition of 286 ppm. For an additional 100 years, the atmospheric boundary condition was switched to a fully interactive atmospheric CO_2 tracer. Simulations were then made based on the IPCC AR4 protocols (A1B scenario).

Data currently available

Maximum SST values for 1990s, 2040s and 2090s as gridded 1^o x 1^o datasets.
Mean SST values for 1990s, 2040s and 2090s as gridded 1^o x 1^o datasets.
Wintertime sea surface temperature anomaly from MEC
Annual amplitude of sea surface temperature from MEC
Spatial gradient annual mean sea surface temperature from MEC
Summertime sea surface temperature anomaly from MEC

Limitations of the data

The sea surface temperature and pH projections in ESM2.1 are subject to uncertainties in the prescribed fossil fuel emissions scenario, the modelled sensitivity of earth's climate to greenhouse gas emissions, and the representation of carbon-climate feedbacks as described in the references below. In particular, since the model is constructed for global scales at coarse resolution (1^o x 1^o) to represent features occurring at the many hundreds of kilometres scale, its ability to represent critical factors driving local habitats in the New Zealand EEZ is limited.

Future development

The models upon which these estimates were based is currently under active development by John Dunne and his colleagues at NOAA-GFDL. We recommend that before an attempt is made to complete the assessment of risk to NZ marine habitats from this threat that the latest model estimates are sourced from the modelling team.

Further Information

Detailed documentation and references for the CM2.1 coupled climate model are available at: http://nomads.gfdl.noaa.gov/CM2.X/references/

Anderson, J.L.; Balaji, V.; Broccoli, A.J.; Cooke, W.; Delworth, T.; Dixon, K.; Donner, L. J.; Dunne, K.A.; Freidenreich, S.M.; Garner, S.T.; Gudgel, R.G.; Gordon, C.T.; Held, I.M.; Hemler, R.S.; Horowitz, L.W.; Klein, S.A.; Knutson, T.R.; Kushner, P.J.; Langenhorst, A.R.; Lau, N.C.; Liang, Z.; Malyshev, S.L.; Milly, P.C.D.; Nath, M.J.; Ploshay, J.J.; Ramaswamy, V.; Schwarzkopf, M.D.; Shevlikova, E.; Sirutis, J.J.; Soden, B.J.; Stern, W.F.; Thompson, L.A.; Wilson, R.J.; Wittenberg, A.T.; Wyman, B.L. (2004). The new GFDL global atmosphere and land model AM2-LM2: Evaluation with prescribed SST simulations. *J. Climate 17:* 4641–4673.

Bryan, F.O.; Kauffman, B.G; Large, W.G.; Gent, P.R. (1996). The NCAR CSM flux coupler. Technical note TN-425+STR, NCAR.

Conkright, M.E.; Locarnini, R.A.; Garcia, H.E.; O'Brien, T.D.; Boyer, T.P.; Stephens, C.; Antonov, J.I. (2002). World Ocean Atlas 2001: Objective analyses, data statistics and figures, CDROM documentation, National Oceanographic Data Centre, Silver Spring, MD.

Delworth, T.; Broccoli, A.J.; Rosati, A.; Stouffer, R.; Balaji, V.; Beesley, J.A.; Cooke, W.; Dixon, K.; Dunne, J.P.; Dunne, K.A.; Durachta, J.W.; Findell, K.L.; Ginoux, P.; Gnanadesikan, A.; Gordon, C.T.; Griffies, S.M.; Gudgel, R.G.; Harrison, M.J.; Held, I.M.; Hemler, R.S.; Horowitz, L.W.; Klein, S.A.; Knutson, T.R.; Kushner, P.J.; Langenhorst, A.R.; Lee, H.C.; Lin, S.J.; Lu, J.; Malyshev, S.L.; Milly, P.C.D.; Ramaswamy, V.; Russell, J.; Schwarzkopf, M.D.; Shevlikova, E.; Sirutis, J.J.; Spelman, M.; Stern, W.F.; Winton, M.; Wittenberg, A.T.; Wyman, B.L.; Zeng, F.; Zhang, R. (2006). GFDL's CM2 global coupled climate models. Part I: Formulation and simulation characteristics. *J. Climate 19:* 643–674.

Dunne, J.P.; Armstrong, R.A.; Gnanadesikan, A.; Sarmiento, J.L.; Slater, R.D. (2005). Empirical and mechanistic models for particle export ratio. Global Biogeochem. Cycles, 18, doi:10.1029/2004GB002390.

Dunne, J.P.; Sarmiento, J.L.; Gnanadesikan, A. (2007). A synthesis of global particle export from the surface ocean and cycling through the ocean interior and on the seafloor, Global Biogeochem. Cy., 21, doi:10.1029/2006GB002907

Gnanadesikan, A.; Dixon, K.; Griffies, S.M.; Balaji, V.; Barreiro, M.; Beesley, J.A.; Cooke, W.; Delworth, T.; Gerdes, R.; Harrison, M.J.; Held, I.M.; Hurlin, W.; Lee, H. C.; Liang, Z.; Nong, G.; Pacanowski, R.C.; Rosati, A.; Russell, J.; Samuels, B.L.; Song, Q.; Spelman, M.; Stouffer, R.; Sweeney, C.O.; Vecchi, G.; Winton, M.; Wittenberg, A.T.; Zeng, F.; Zhang, R.; Dunne, J.P. (2006). GFDL's CM2 global coupled climate models. Part II: The baseline ocean simulation. *J. Climate 19:* 675–697.

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Large, W.; Yeager, S. (2004). Diurnal to decadal global forcing for ocean and sea-ice models: the data sets and fux climatologies. NCAR Technical Note: NCAR/TN-460+STR. CGD Division of the National Center for Atmospheric Research.

Shevliakova, E.; Pacala, S.W.; Malyshev, S.; Milly, P.C.D.; Sentman, L.T. et al. (2009). Carbon cycling under 300 years of land use change: Importance of the secondary vegetation sink. Global Biogeochemical Cycles, 23, GB2022, doi:10.1029/2007GB003176.

Snelder, T.; Leathwick, J.; Dey, K.; Weatherhad, M.; Fenwick, G.; Francis, M.; Gorman, R.; Grieve, J.; Hadfield, M.; Hewitt, J.; Hume, T.; Richardson, K.; Rowden, A.; Uddstrom, M.; Wild, M.; Zeldis, J. (2005). The New Zealand Marine Environment Classification. Ministry for the Environment report 594. 70 p.

Uddstrom, M.; Oien, N. (1999). On the use of high-resolution satellite data to describe the spatial and temporal variability of sea surface temperatures in the New Zealand region. *Journal of Geophysical Research 104(C9)*: doi: 10.1029/1999JC900167. issn: 0148-0227.

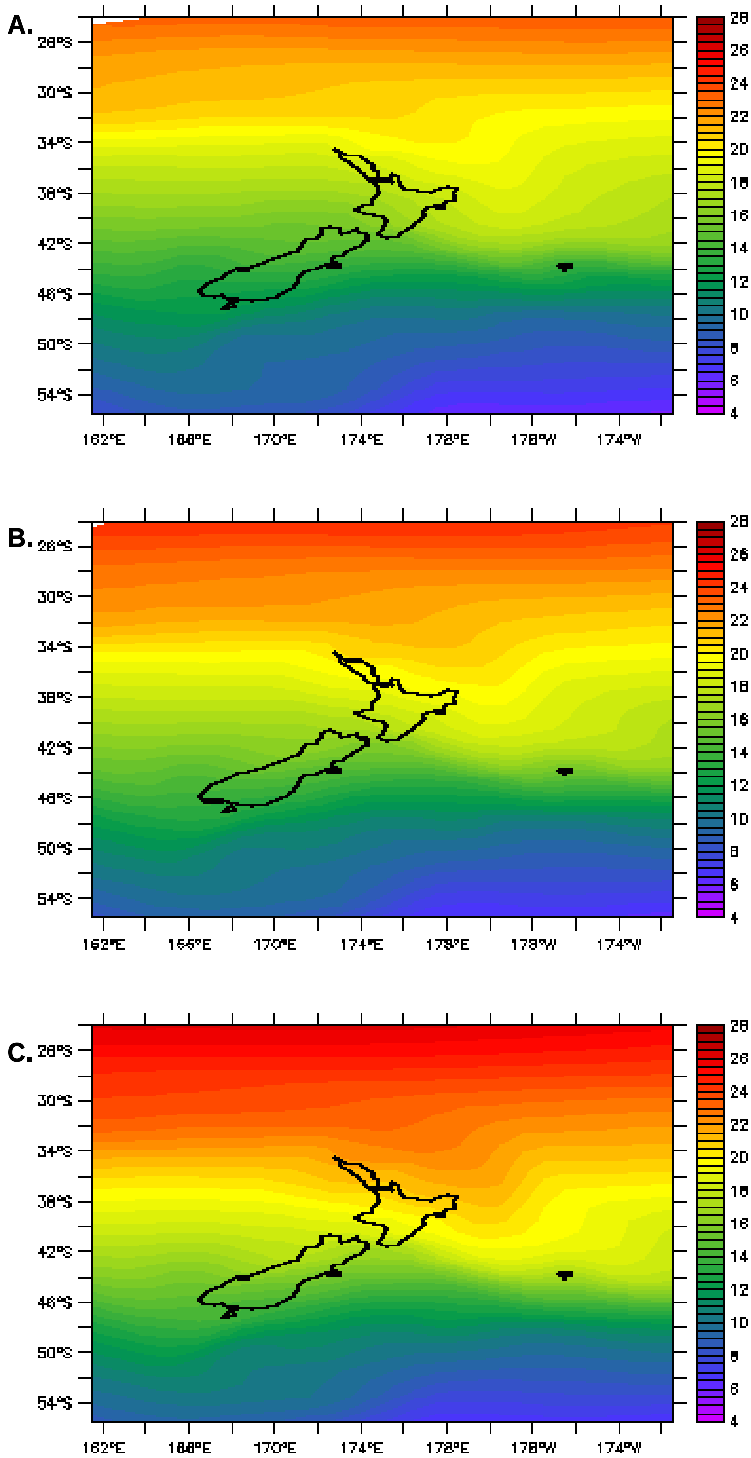

Figure A4.2: Mean SST values for 1990s (A), 2040s (B) and 2090s (C) modeled from the NOAA-GFDL CM2.1 coupled climate model forced with IPCC SRES-A2 emissions scenario.

A4.3 Fishing: bottom trawling

Key contacts

Suze Baird and Brent Wood (NIWA)
s.baird@niwa.co.nz
b.wood@niwa.co.nz
Mfish database – rdm@fish.govt.nz

Description of the data

A database built by NIWA under MFish project BEN200601 (Baird et al. 2009) contains two sets of bottom trawl effort data in New Zealand waters shallower than 1600 m for the fishing years (1 October–30 September) 1989–90 to 2004–05:

1. One dataset has daily bottom trawl effort that allows description of broad scale effort described by the number of trawls in MFish statistical areas, and
2. The second dataset has tow by tow records, each with a derived swept area assigned to the track line created between the start and finish positions (latitude and longitude to the nearest arc-minute of a degree). This spatially-enabled database includes trawls that used bottom trawl gear and midwater trawl gear within a metre of the seafloor overlaid on a 25 km^2 cell grid in an equal area projection.

Datasets include target species, fishing method (gear type), vessel identifier and characteristics, fishery area (statistical area, Fishery Management Area), and start date. The tow by tow records have start and finish date, time, and position data.

As an example, data can be extracted and mapped to show 1990–2005 total area swept by bottom trawling in 25 km^2 cells for the New Zealand EEZ.

Methodology for generating the data

Data for 1989–90 to 2004–05 fishing years were requested from MFish database warehou (contact: rdm@fish.govt.nz); these data represented records reported on Catch Effort Landing Returns (CELR) and Trawl Catch Effort Processing Returns (TCEPR). Broad grooming rules were applied to the data (accepted by the Aquatic Environment Working Group). Approximately 1 million tows were contained in each of the two datasets.

Polygons were built for trawls where position data were available (TCEPR), based on a doorspread-derived swept area and the reported fishing locations. To aid in the categorisation and analysis of the data, a grid of approximately 5x5 km cells was created in another database table; this was considered as a reasonably fine unit for an area the size of the EEZ. This grid was generated in the Albers Conic Equal Area Projection for the New Zealand EEZ and reprojected to latitude and longitude degrees to overlay with TCEPR effort data as a basis for spatial analysis. The resolution of tow position data was, at best, about 1.852 km. Each cell was assigned a depth derived from the NIWA regional bathymetry dataset that represented the depth at the cell midpoint.

Data currently available

Data can be extracted directly from the database as text files or shapefiles: either at the scale of a fishery area or trawl polygon described above. For the finer scale data, shapefiles can represent both the cumulative swept area (where the trawls are overlaid and summed) and the footprint (seafloor area covered by trawling). Use of the database reuires MFish permission.

Limitations of the data

The dataset based on CELR data is limited in its use for spatial analysis because data are reported by statistical area and there are no data that allow derivation of any measures of swept area. Thus, these data can be summarised only as the number of tows (by target species, vessel size, year, month) by statistical area. These data represent about 50% of the total number of tows over the 16-year study and represent fishing in inshore shallow waters.

The second dataset was built with several assumptions about the data. These assumptions and their implications (including the underestimation of the swept area) are discussed by Baird et al. (2009). In particular it was assumed that tows followed straight lines; the position data represented where trawling took place (in reality it is the vessel position at the start and finish of trawling, not the gear position); the gear was in contact with the seafloor throughout the tow; all bottom tows used single trawl gear; the seafloor was homogeneous in each cell; and all seafloor in less than 1600 m was trawlable.

During the mid-late 1990s, fishers on many smaller vessels (less than 28 m) changed from reporting their fishing effort on CELRs to TCEPRs, thus after the late 1990s there is better spatial representation of bottom trawling, particularly in shallower inshore waters around the North Island. Inshore fishers in South Island waters were less likely to change forms and the swept area estimation in these areas is grossly underestimated.

Figures A4.3 and A4.4 show the differences in scale of the two datasets.

Future development

Since 2007, a new form has been introduced to replace the CELR; this provides some (limited) position data (start of tow).

Further Information

A similar dataset of the TCEPR data up to 2007–08 was built for MfE under project MfE09103: however, the grooming of this dataset was less rigorous than that for the BEN200601 project.

Baird, S.J.; Wood, B.A.; Bagley, N.W. (2009). Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989–90 to 2004–05. Draft New Zealand Aquatic Environment and Biodiversity Report prepared for Ministry of Fisheries under project BEN200601, Objectives 1-4.Mfish Research Database Documentation - http://www.fish.govt.nz/en-nz/Research+Services/Research+Database+Documentation/default.htm?wbc_purpose=Basic%2525252525252526WBCMODE

Individual researchers working on various target species may have long-term groomed datasets that could be used in this work.

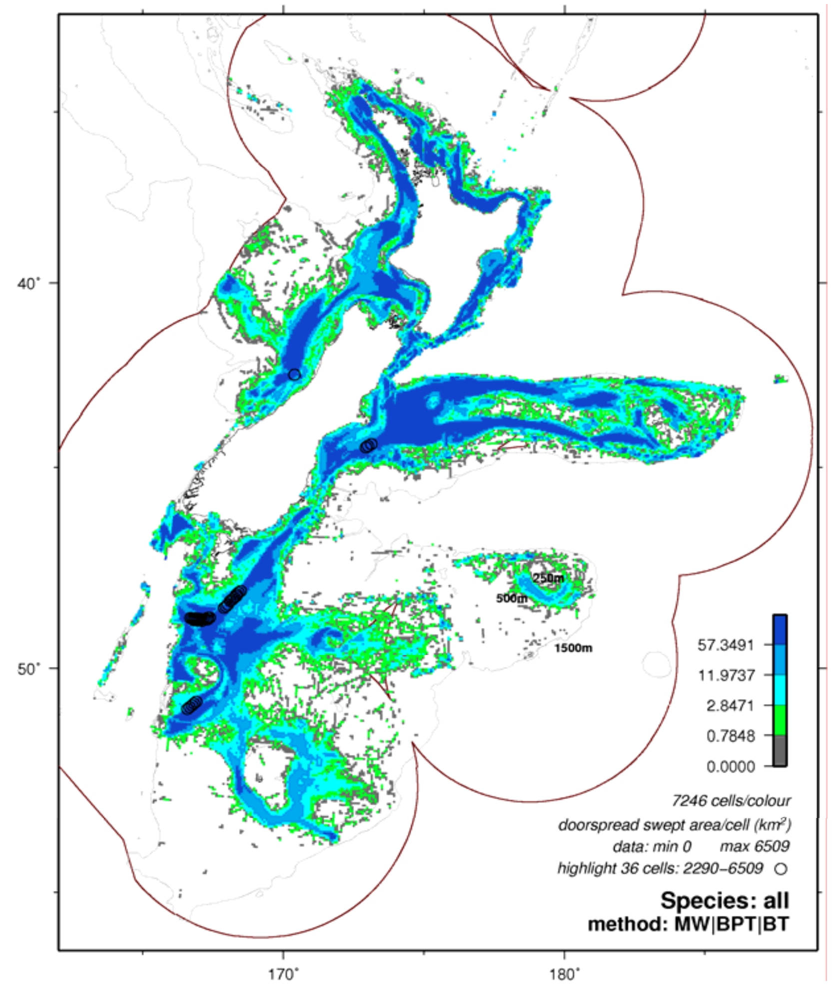

Figure A4.3: Distribution of cumulative swept area totals per cell, for trawl effort on or near the seafloor, based on TCEPR records, for all years combined (1989–90 to 2004–05). From Baird et al. (2009).

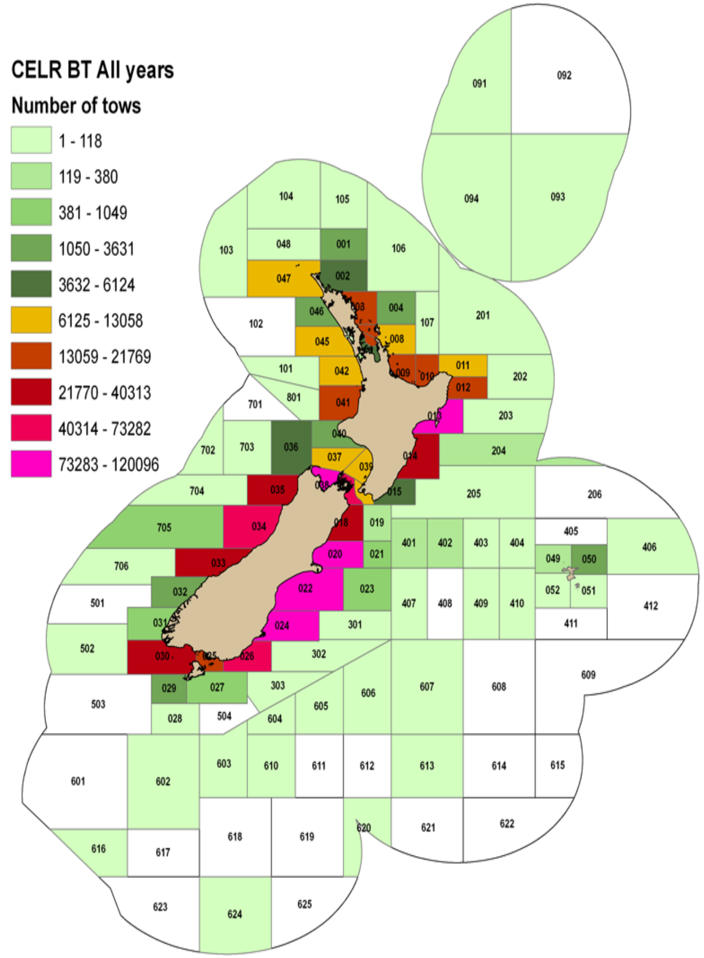

Figure A4.4: Distribution of bottom trawl effort reported on CELRs, for all fishing years 1989–90 to 2004–05. From Baird et al. (2009).

A4.4 River inputs: increased sediment loading

Key contacts

Murray Hicks and Ude Shankar (NIWA)

Description of the data

Hicks & Shankar (2003) estimated yields of river suspended sediment as tonnes per square kilometre per year ($t.km^{-2}.y^{-1}$). Hicks et al. (2004) examined the relationship between sediment loading and organic matter in New Zealand rivers.

Methodology for generating the data

These data have been generated by an empirical model that relates river sediment yield to mean annual rainfall and an erosion-terrain classification created by Landcare Research on the basis of slope, rock-type, soils, main erosion processes, and expert knowledge. The model is calibrated from river suspended sediment data measured at over 200 river gauging stations in catchments covering about half of the New Zealand land area, and by investigations of sedimentation rates in Fiordland. The model is adjusted uniformly over the gauged catchments so that the sediment yields predicted by the model match the gauged yields.

Key models and datasets

1. Sediment and coastal yield models prepared by Sediment Processes Group at the National Institute of Water and Atmospheric Research Ltd (NIWA), Christchurch.
2. Mean-annual rainfall model for sediment yield model by Ude Shankar, NIWA, Christchurch.
3. Erosion terrain classification for yield model by Landcare Research.
4. Ocean floor relief compiled from data held at NIWA, Wellington.
5. River suspended load data from NIWA Water Resources Archive, Christchurch.
6. Fiord sedimentation rates from Pickrill (1993).

Data currently available

Direct model output data upon request.
Large rivers and regional sediment yields as Excel spreadsheet
"Sediment From New Zealand Rivers" NIWA Chart, miscilaneous series 79.

Further Information

Hicks, D.M.; Shankar, U. (2003). Sediment from New Zealand rivers. NIWA Chart, Miscellaneous Series No.79.

Hicks, M.; Quinn, J.; Trustrum, N. (2004). Sediment load and organic matter. Chapter 12 *In:* Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (Eds.). Freshwaters of New Zealand. New Zealand Hydrological Society and New Zealand Limnological Society, Wellington, 764p.

Pickrill, R.A. (1993). Sediment yields in Fiordland. *Journal of Hydrology (New Zealand), 31:* 39–55.

Morrison, M.A.; Lowe, M.L.; Parsons, D.M.; Usmar, M.R.; McLeod, I.M. (2009). A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. *New Zealand Aquatic Environment and Biodiversity Report No. 37*, 100 p.

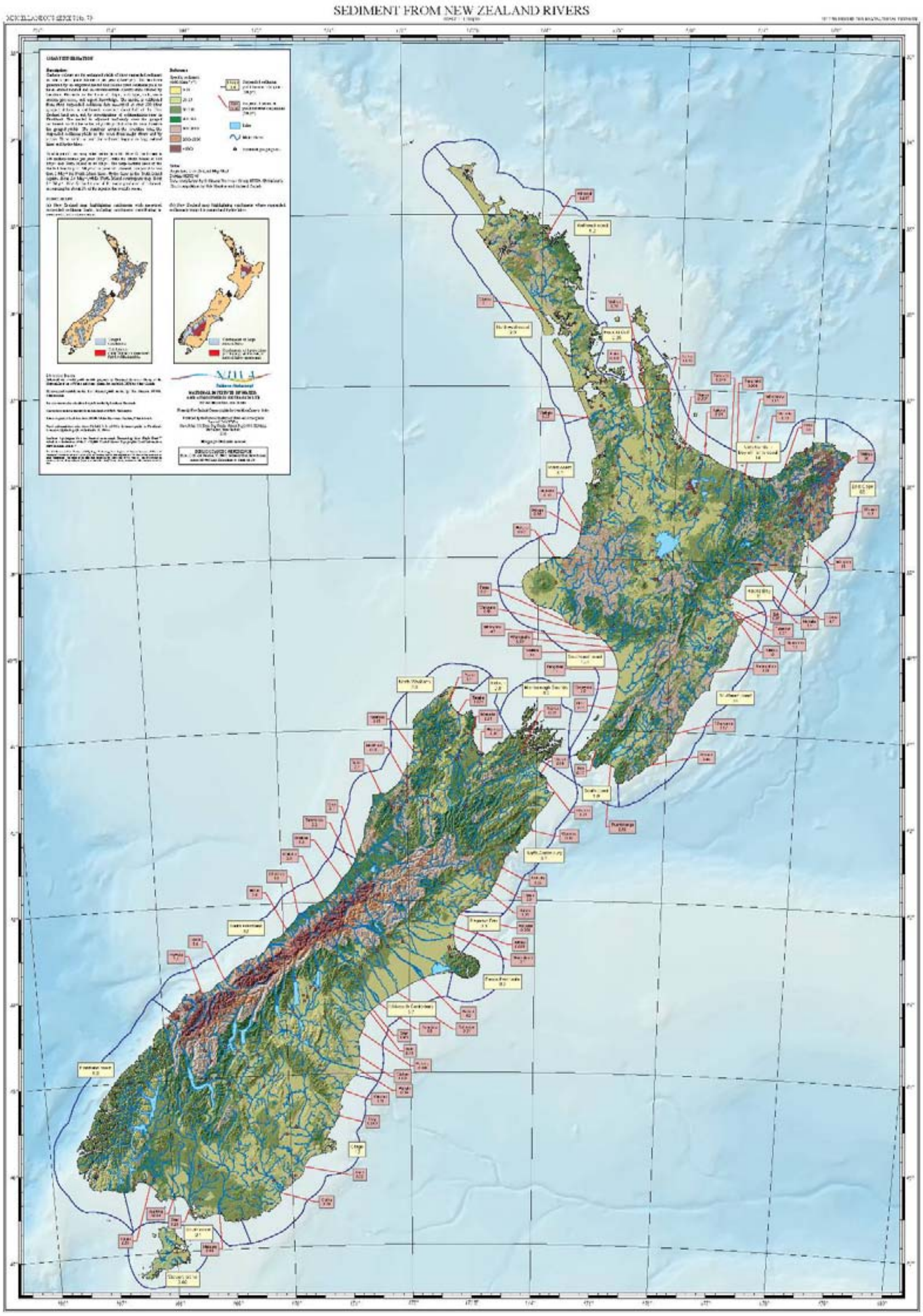

Figure A4.6: Sediment from New Zealand rivers, NIWA Chart, Miscellaneous Series 79. Note that in this low resolution reproduction the individual river outputs cannot be read. Contact Murray Hicks at m.hicks@niwa.co.nz for a high resolution version of the chart and for detailed model outputs.

A4.5 Climate change: Increased storminess

Key contacts

Sam Dean, Brett Mullan and Trevor Carey-Smith (NIWA)
Marine Environment Classification (MEC)

Description of the data

Nothing specific is yet available about how climate change and associated change in wind strength and direction may affect the wave climate around New Zealand. Information summarised in the Marine Environmental Classification (MEC) describes the historical mean orbital velocities and extreme orbital velocities at the sea bed induced by swell waves. This velocity plays an important role in structuring benthic communities by inducing bed stress and re-suspension of bed material. Both average and extreme (represented by the 95th percentile) orbital velocities were considered to be potentially important. The mean orbital velocity represents the variation in mean wave energy whereas extreme orbital velocity discriminates locations on the basis of rare high magnitude wave events.

Methodology for generating the data

The EEZ scale orbital velocity variables were based on a wave climatology derived from a 20-year hindcast (1979–1998) of swell wave conditions in the New Zealand region (Gorman & Laing 2000). The wave climatology was used to interpolate the mean and 95th percentile values of significant wave height and mean values of wave peak period onto the 1 km bathymetry grid. The wave height, period and depth were used to estimate mean and 95^{th} percentile bed orbital velocities. Bed orbital velocities were assumed to be zero where depth was greater than 200 m. No accounting was made for refraction or sheltering by land inside the 50 m isobath, resulting in some unreasonably high values in sheltered coastal environments.

Key models and datasets

20-year hindcast (1979–1998) of swell wave conditions in the New Zealand region (Gorman and Laing 2000)

Data currently available

Dataset name: MEC mean orbital velocity raster dataset
Cell size: 1000 x 1000 meters
Spatial reference: Clarke_1866_mercator

Further Information

Gorman, R.M.; Laing, A.K. (2000). A long-term wave hindcast for the New Zealand coast. Sixth International Workshop on Wave Hindcasting and Forecasting, Monterey, California.

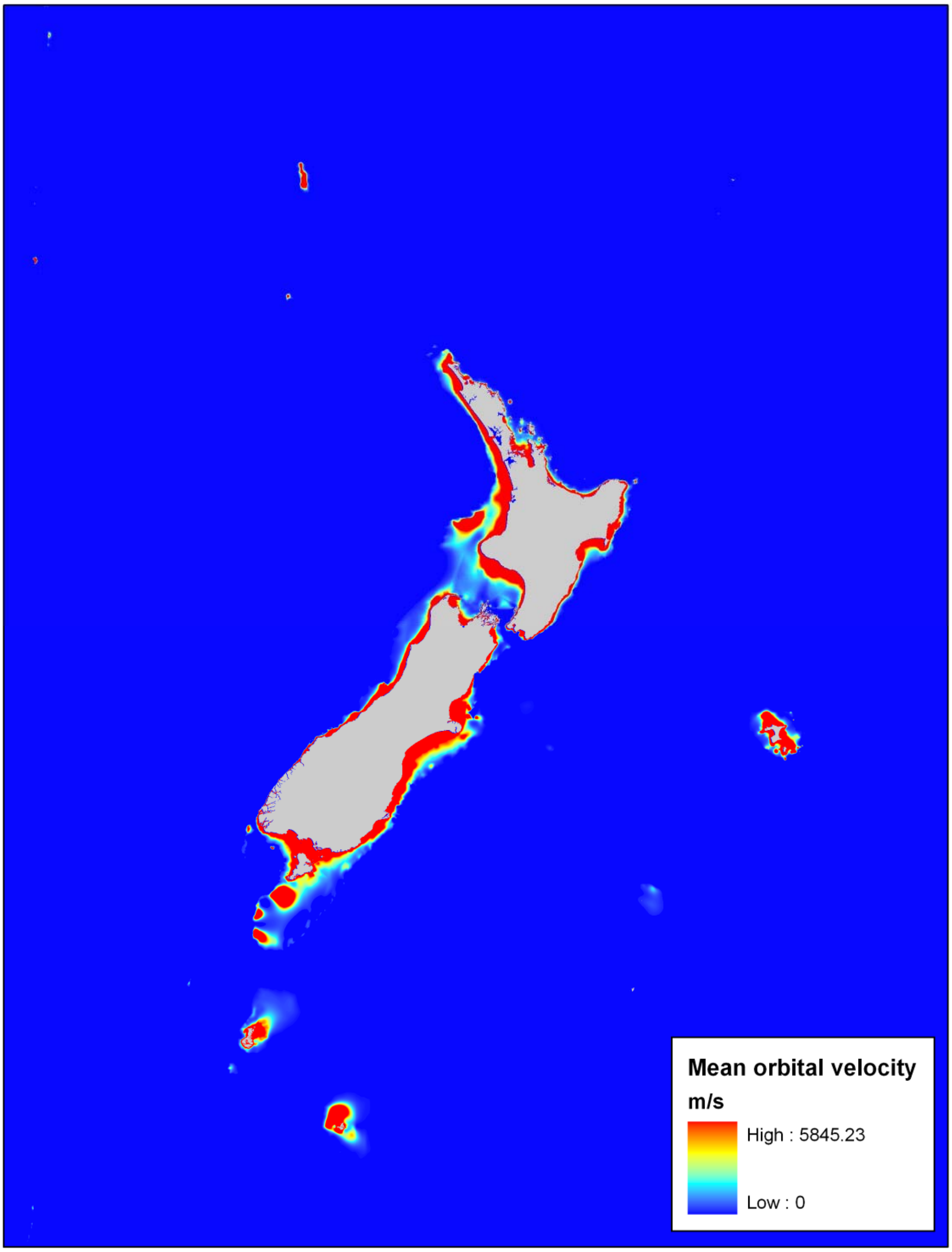

Figure A4.7: Mean orbital velocity (m/s) for New Zealand.

A4.6 Fishing: scallop or oyster dredging

Key contacts

Keith Michael and Suze Baird (NIWA)
MFish database manager

Description of the data

Oyster

- MFish CELR data (catch and effort, number of dredge tows, by reporting area)
- MFish CELR form data covers all commercial fishers dredging for scallops or oysters
- Swath maps of shipping channels
- Sidescan sonar
- Benthic video survey (2006)
- Benthic still images (1960s, 1999, and 2007 onwards)
- Sediment and habitat maps
- Quantitative data on the composition of benthic communities from limited sampling in 1998 and one investigation in 1999.
- Bycatch data from stock assessment surveys (images and direct recording)
- Fishers logbook data (not publicly available) on catch and effort, and bycatch

Scallop

- The National Institute of Water and Atmospheric Research (NIWA) currently carries out the role of Data Manager and Custodian for the fisheries research data owned by the Ministry of Fisheries (MFish).
- The Ministry of Fisheries data set incorporates historic research data, data collected more recently by MAF Fisheries prior to the split in 1995 of Policy to the Ministry of Fisheries and research to NIWA, and currently data collected by NIWA and other agencies for the Ministry of Fisheries.
- Dredge surveys are seen as the most efficient means of estimating population abundance and length frequency distributions, as well as to determine scallop condition and to check for signs of large scale mortality or recruitment.
- The scallop database is implemented as a relational database.
- This database has eleven tables containing information pertaining to research scallop surveys. The following is a listing of the tables contained in the scallop database:
    1. t_trip : contains profile information on all scallop trips.
    2. t_trip_comm : contains comments for a particular trip.
    3. t_stratum : contains details of strata surveyed for a trip.
    4. t_station : contains data on location, gear used and environment at each station within a trip.
    5. t_stat_comm : contains comments for a station in a trip.
    6. t_catch : contains catch weight and abundance of species caught at a station
    7. t_subcatch : contains weight and sample details of samples taken from the catch for further measurements.
    8. t_lgth : contains shell length frequency data.
    9. t_height : contains shell height frequency data.
    10. t_vessels: contains vessel name and other general comments about vessels used during scallop trips.
    11. 11. t_dredge **:** contains details and comments about individual dredges used during a scallop survey

Methodology for generating the data

Oyster

- Recorded from the fishery
- Dredge surveys
- Camera surveys
- Side scan surveys and swath mapping
- CELR - Catch Effort Landing Return form (called CEL within the database). Records estimated catch, effort and actual landings for a gear type used on the day. One form may represent multiple dredge tows.

Scallops

- Scallop dredge surveys have been carried out using two main methods: Fixed stations on a 1.0 nautical mile grid and a two-phase stratified random dredge design.

Database documentation indicates that:

1. *Fixed stations on a 1.0 nautical mile grid*: at each station two 5 minutes dredges are made in random compass directions. Double tows at each station are used as indicators of onsite variance. Scallops are tipped from the dredge onto the sorting tray and sub sampled by dividing the catch into two. One sub sample is accurately measured for the maximum length to nearest millimetre. The remainder of the catch is counted and recorded as undersize (<100 mm) or commercial length (>=100 mm).

2. *Two phase stratified random dredge design*: scallop beds are divided into strata based on their spatial extent. Dredge positions within strata are randomly selected, with about 10% of the dredges being allocated to the second phase. The dredge is towed in a direction and speed chosen by the skipper to optimise the performance of his gear until a distance of 0.5 nautical miles over the ground has been covered. At the completion of each tow, each dredge is retrieved and emptied onto a sorting tray on the boat. All live scallops are removed, counted, and the maximum length and/or height measured to the nearest millimetre.

Key models and datasets

Oyster

Foveaux Strait oyster research survey database maintained by NIWA on behalf of the Ministry of Fisheries

Data gathered as part of project BEN200601

Scallops

MFish scallop database maintained by NIWA on behalf of the Ministry of Fisheries

Data currently available

Oyster

Some industry data (logbooks)

Scallops

Raw scallop trip data from MFish scallop database stored in tables. Any GIS feature class or raster datasets need to be generated from groomed scallop data.

Limitations of the data

Oyster
Most data are recorded on a large spatial scale. Moreover there is incomplete spatial and temporal coverage. MFish data in BEN200601 database have had limited grooming.

Scallops
Mfish scallop research data and CELR data require grooming. MFish data in BEN200601 database have had limited grooming.

Future development

Oyster
More drift video and digital still photography is planned. The database upon which these estimates are based is currently under active development by Keith Michael at NIWA. We recommend that before an attempt is made to complete the assessment of risk to NZ marine habitats from this threat, that the latest estimates are sourced from the NIWA team.

Further Information

Cranfield, H.J.; Rowden, A.A.; Smith, D.J.; Gordon, D.P.; Michael, K.P. (2004). Macrofaunal assemblages of benthic habitat of different complexity and the proposition of a model of biogenic reef habitat regeneration in Foveaux Strait, New Zealand. *Journal of Sea Research 52(2):* 109–125.

Cullen, D.J. (1962). The influencence of bottom sediments upon the distribution of oysters in Foveaux Strait, New Zealand. *New Zealand Journal of Geology and Geophysics 5(2):* 271–275.

Mackay, K.A. (2000). Database documentation: scallop. NIWA Internal Report No. 71. 34p.

Michael, K.P. (2007). Summary of information in support of the Foveaux Strait Oyster Fishery Plan: The Foveaux Strait ecosystem and effects of oyster dredging. Unpublished Final Research Report for the Ministry of Fisheries, ZBD200504: 120p.

Other potential information sources

Oyster
Bluff oyster fishery industry data

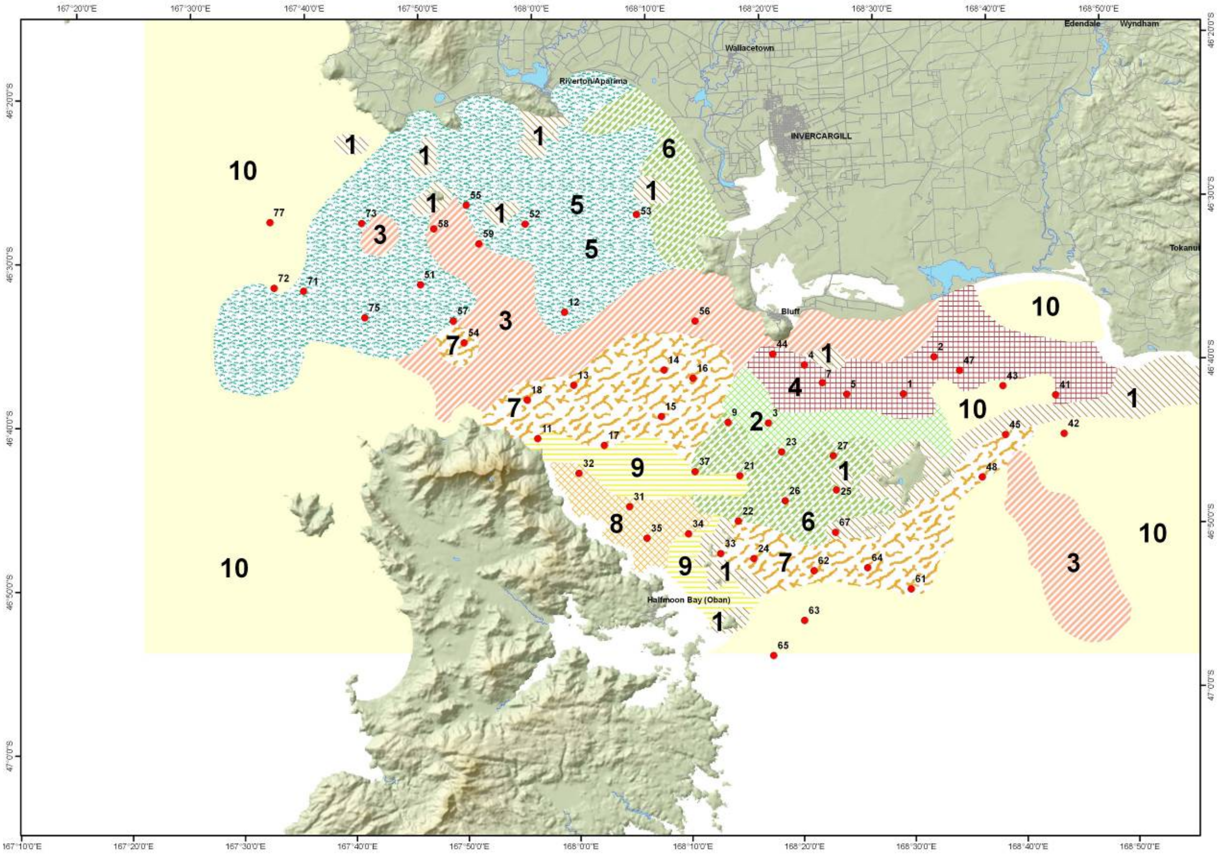

Figure A4.8: The distribution of subjective habitat classes based on sediment composition, structure and stability from video transects and the sediment map of Cullen (1962). 1, rocky patch reef with epifauna, usually surrounded by sand and fine gravels; 2, flat gravels with clean shell (usually *Ostrea chilensis*, *Pseudoxyperas elongata*, and *Glycimeris modesta*); 3, flat gravels and encrusted shell (usually bound by small encrusting bryozoans (Cranfield et al. (2004), and Dennis Gordon, NIWA, pers. comm.); 4, flat gravels red algae and kaeos (*Pyura pachydermatina*); 5, gravels waves or lowly undulating gravels with clean shell in the troughs; 6, flat sand and gravel; 7, flat sand and gravel with biogenic patches; 8, biogenic areas; 9, large sand waves; and 10, sand ripple. (Note that this image is available for this project only and is not to be distributed)

A4.7 Climate change: sea-level rise

Key contacts

- Rob Bell, Doug Ramsay (NIWA),
- Prof John Hannah (Surveying School, Univ of Otago)
- Ministry for the Environment

Description of the data

- Processed sea-level rise trends for several ports in New Zealand where sea-level records span several decades, from processed annual mean sea levels. For the future, assimilate IPCC and other recent projections of sea level rise to 2090s - see MfE (2008). Coastal Hazards and Climate Change: A Guidance Manual for Local Government http://www.mfe.govt.nz/publications/climate/#local
- Tide gauge measurements in main ports and at about 35 other gauges around New Zealand.
- IPCC WG1 Fourth Assessment Report predictions for sea-level rise over this century to the 2090s, relative to the 1980–1999 global average.

Methodology for generating the data

- Remove tides and barometric pressure effects, calculate mean annual sea levels, calculate trends.
- Download IPCC projections and climate-ocean model results - extract regional departure of sea-level rise from the global mean sea-level rise

Key models and datasets

- Sea-level records from various ports around NZ
- Climate-ocean models used for the IPCC 4th Assessment Report

Limitations of the data

- Restricted access to some port sea-level records
- Quality of data and datums
- Variability in climate-ocean model results

Future development

- Ongoing revision of sea-level rise trends and acceleration
- Revision of sea level rise projections

Further Information

Hannah J. (2004). An updated analysis of long-term sea level change in New Zealand. *Geophysical Research Letters, Vol. 31.*

Ministry for the Environment (2008). Coastal Hazards and Climate Change. A Guidance Manual for Local Government in New Zealand. 2nd edition. Revised by Ramsay, D, and Bell, R. (NIWA). Prepared for Ministry for the Environment. viii+127 p.

Figure A4.9: Indicative areas that will require risk analysis to establish their likely vulnerability to coastal inundation as a result of sea-level rise – either directly (e.g., inundation during storm events) or by the impact of sea-level rise on the drainage of low-lying coastal lands. The shaded red and orange areas show approximate land levels less than 5 m and 10 m above sea level, respectively: they have been extracted from reprocessed topography data collected by the Space Shuttle Radar Topography Mission (NASA). Accuracy of the topography is around 5–8 m (Ministry for the Environment)

A4.8 INVASIVE SPECIES: SPACE OCCUPIERS, COMPETITORS

Key contacts

Louise Hunt (MAF-BNZ)
Graham Inglis (NIWA)

Description of the data

Two types of data are available from Biosecurity New Zealand, a part of the Ministry of Agriculture and Forestry. The first (BIODS Port Surveys database) contains data on the location and numerical presence (numbers per sampling unit) of invasive species in selected harbours around New Zealand. The second (BIODS Surveillance database) contains data on the presence or absence of specific targeted invasive species within selected harbours around New Zealand (Figure A4.10).

Methodology for generating the data

The Baseline database (BIODS: port survey) contains data based on surveys of selected harbours throughout New Zealand, targeted because of their probable susceptibility to invasive species. A wide range of organisms are surveyed, including wharf piling fouling species, infaunal species and planktonic species.

Key models and datasets

BIODS Port Surveys database
BIODS Surveillance database

Data currently available

For each record, data on the Order, Family, Genus, species, latitude and longitude are available.

Limitations of the data

Both data sets are focused on ports. There is little systematic information available from other areas except where an invasive species is a part of a broader study. Some information on distribution of invasive species may be available from other sources including unpublished theses, and reports as well as published papers. We have not collated these.

Future development

The focus of broad surveys will remain on ports because these are the most likely areas for invasives to first occur. From time to time more wide ranging surveys to determine the extent or spread of specific invasive species may be carried out. As surveys occur each year, an updated list and distribution of invasive species should be obtained from MAF-BNZ before it is used in risk analysis.

Further Information

Beamount, J.; Oliver, M.; MacDIarmid, A.B. (2008). Mapping the values of New Zealand's coastal waters. 1. environmental values. Biosecurity New Zealand technical Paper No: 2008/16. 73 pp.

Inglis, G. (2001). Criteria for selecting New Zealand ports and other points of entry that have a high risk of invasion by new exotic marine organisms., Final research report for Ministry of Fisheries research project ZBS2000/01A, objectives 1&2. . NIWA, Wellington, p. 27.

Inglis, G.; Gust, N.; Fitridge, I.; Floerl, O.; Woods, C.; Hayden, B.; Fenwick, G. (2006). Dunedin Harbour (Port Otago and Port Chalmers). Baseline survey for non-indigenous marine species (Research project ZBS2000/4), Biosecurity New Zealand Technical Paper No: 2005/10. NIWA, Wellington, p. 99.

Mack, R.; Simberloff, D.; Lonsdale, W.; Evans, H.; Clout, M.; Bazzaz, F. (2000). Biotic invasions: causes, epidemiology, global consequences and control. *Ecological Applications 10:* 689–710.

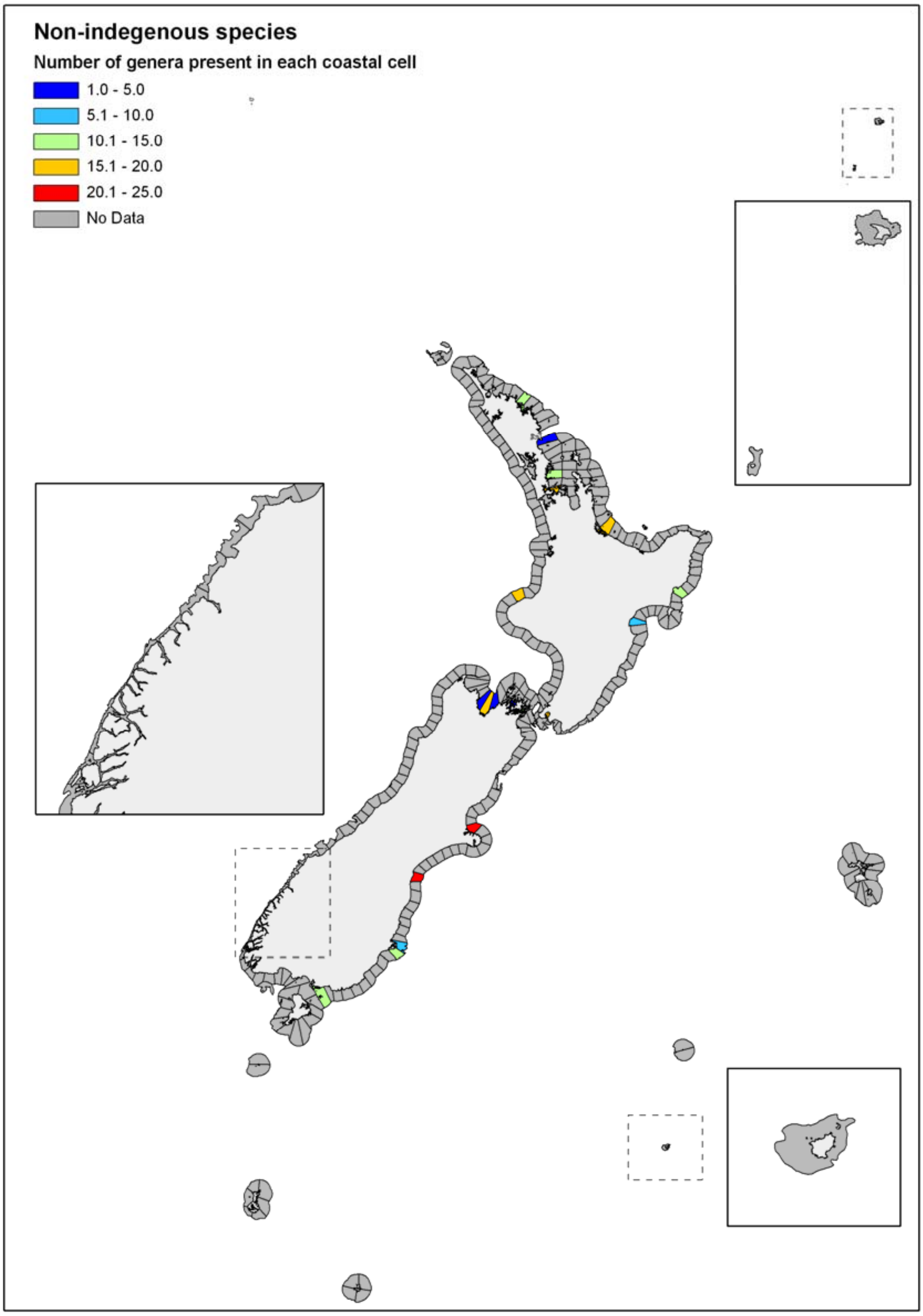

Figure A4.10: Non-indigenous species: Number of non-indigenous genera recorded in coastal cells in project ZBS200503 for MAF-BNZ from Beamount et al. 2008. Note that data were only available from ports.

A4.9 Algal blooms – both toxic and massive

Key contacts

NIWA: Jill Schwarz, Matt Pinkerton, Simon Wood, Mark Gall and Phil Boyd

NASA Ocean Color / Ocean biology and MODIS groups
http://oceancolor.gsfc.nasa.gov/
http://ladsweb.nascom.nasa.gov

Description of the data

Estimates of surface chlorophyll concentration from remote sensed data (Figure A4.11).

Methodology for generating the data

Upwelling radiance is measured by satellite-borne sensors in a range of visible, near- and far-infrared channels. An atmospheric correction is applied with optical models for various aerosol types, Rayleigh scattering, surface reflectance/sunglint and land/cloud adjacency effects. Derived water-leaving radiances are normalised to nadir viewing. Blue and green channels are used in empirical, 4-th order polynomial algorithms to derive surface chlorophyll concentration.

Key models and datasets
Sea-viewing, wide-field of view sensor data (SeaWiFS);
Moderate-resolution imaging spectrometer data (MODIS) primarily from the Aqua satellite platform.

Data currently available

NASA distributes all SeaWiFS and MODIS data freely.
SeaWiFS approximately 1 km resolution data are available from August 1997 to December 2005. SeaWiFS approximately 4 km resolution data are available from August 1997 to the present.
MODIS approximately 1 km resolution data are available from June 2002.
Pseudo-500 m MODIS data are also available, but signal-to-noise ratios are lower than for the 1 km data.

Limitations of the data

Error on the chlorophyll algorithm is currently approximately 33% (global empirical dataset). In coastal waters the optical conditions are complicated by inputs of diverse coloured material. Water colour is determined by a highly variable mixture of land-derived dissolved substances, inorganic sediments from rivers and the sea-floor, bottom-reflectance in shallow waters and by phytoplankton blooms. This places most coastal waters into the optical class of Case II waters. Atmospheric correction of ocean colour data in this region is spurious because red light is scattered back out of the water by sediments, rendering the “blue water approximation” void (Gordon & Wang, 1994; Gordon et al., 1997; Pinkerton et al., 2006). Similarly, the standard algorithms for deriving chlorophyll concentration, which rely on the assumption that chlorophyll and other phytoplankton-related substances dominate the determination of water colour, do not perform well in optically complex, coastal waters. There are currently no universal algorithms for handling such optically complex conditions.

In the absence of *in situ* data to provide ground-truthing, the best use of ocean colour data in the coastal region is to calculate surface chlorophyll conditions in the usual manner, as though the water were less complex, and to supplement this information with 'true colour' composites of the water-leaving radiance data to provide insight into the performance of the chlorophyll algorithm (O'Reilly et al. 1998, Franz et al. 2007) .

Future development

Algorithm development continues at many institutes worldwide. NASA will launch the next-generation sensor sometime in the next 5 years. Higher spectral and spatial resolution data are available, but with overpass repeat times of approximately 14 days.

Further Information

Chlorophyll maps can be produced almost instantaneously for a specified region or time frame or time series at: http://reason.gsfc.nasa.gov/Giovanni/

EU Globcolor project - attempting to merge multiple sensors, multiple scales of chlorophyll and other ocean colour products.

Franz, B.A.; Bailey, S.W.; Werdell, P.J.; McClain, C.R. (2007). Sensor-independent approach to the vicarious validation of satellite ocean color radiometry. *Applied Optics 46(22):* 5068–5082.

Gordon, H.R.; Wang, M. (1994). Retrieval of water-leaving radiance and aerosol optical thickness over the oceans with SeaWiFS: A preliminary algorithm. *Applied Optics 33:* 443–452.

Gordon, H.R.; Du, T.; Zhang, T. (1997). Remote sensing of ocean color and aerosol properties: resolving the issue of aerosol absorption. *Applied Optics 36:* 8670–8684.

O'Reilly, J.E.; Maritorena, S.; Mitchell, B.G.; Siegel, D.A.; Carder, K.L.; Garver, S.A.; Kahru, M.; McClain, C. (1998). Ocean color chlorophyll algorithms for SeaWiFS. *J. Geophysical Research 103(C11):* 24 937–24 953.

Pinkerton, M.H.; Moore, G.F.; Lavender, S.J.; Gall, M.P.; Oubelkheir, K.; Richardson, K.M.; Boyd, P.W.; Aiken, J. (2006). A method for estimating inherent optical properties of New Zealand continental shelf waters from satellite ocean colour measurements. *New Zealand Journal of Marine and Freshwater Research 40:* 227–247.

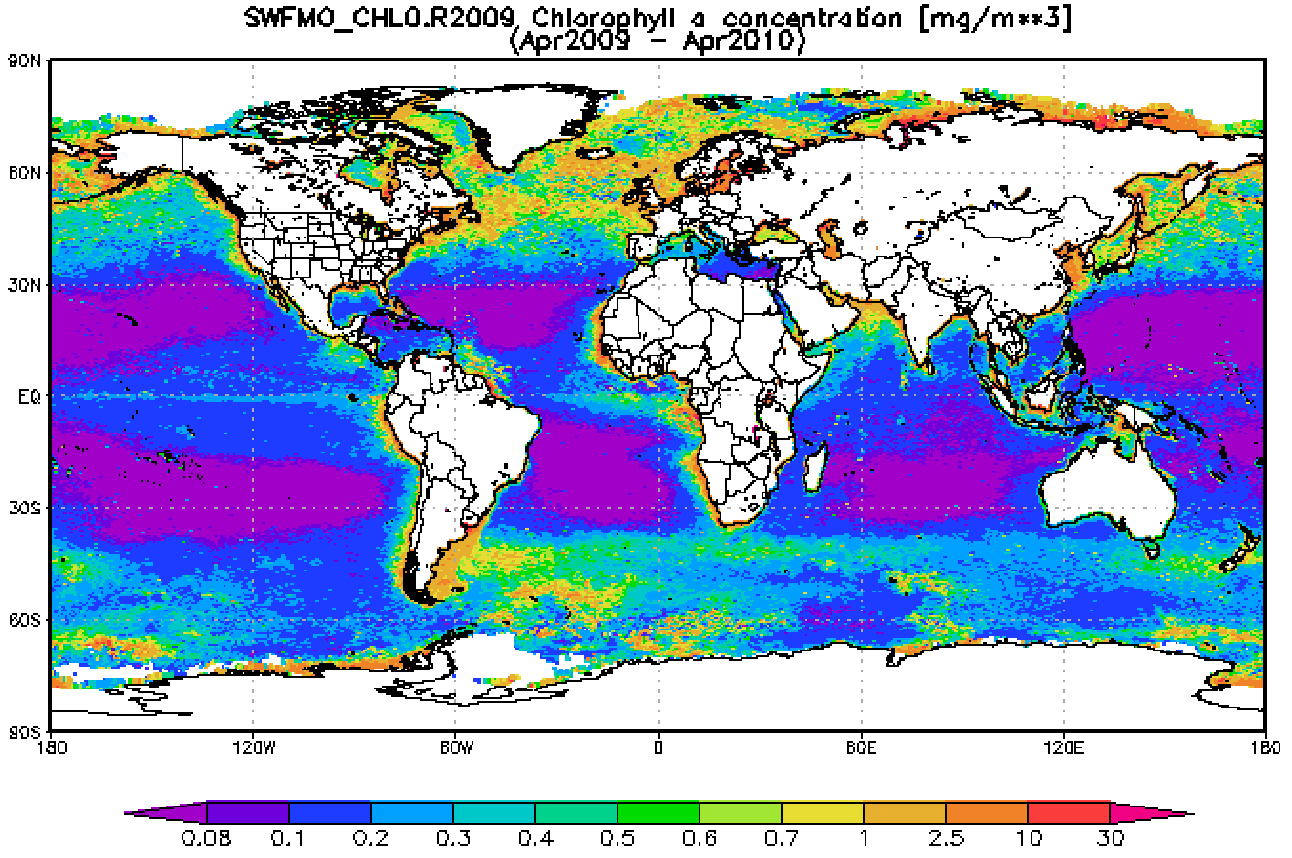

Figure A4.11: Remote sensed chlorophyll-a concentration in the world's oceans.

A4.10 Turbidity

Key contacts

Jill Schwarz (NIWA)

Description of the data

Remote sensed ocean colour (Figure A4.12)

Methodology for generating the data

Upwelling radiance is measured by satellite-borne sensors in a range of visible, near- and far-infrared channels. Because coastal waters are optically complex, ground truthing of suspended sediments and chlorophyll-a concentrations are necessary.

Key models and datasets

Sea-viewing, wide-field of view sensor data (SeaWiFS);
Moderate-resolution imaging spectrometer data (MODIS) primarily from the Aqua satellite platform.

Data currently available

NASA distributes all SeaWiFS and MODIS data freely.
SeaWiFS approximately 1 km resolution data are available from August 1997 to December 2005. SeaWiFS approximately 4 km resolution data are available from August 1997 to the present.
MODIS approximately 1 km resolution data are available from June 2002.
Pseudo-500 m MODIS data are also available, but signal-to-noise ratios are lower than for the 1 km data.

Limitations of the data

In coastal waters the optical conditions are complicated by inputs of diverse coloured material. Water colour is determined by a highly variable mixture of land-derived dissolved substances, inorganic sediments from rivers and the sea-floor, bottom-reflectance in shallow waters and by phytoplankton blooms. This places most coastal waters into the optical class of Case II waters. Atmospheric correction of ocean colour data in this region is spurious because red light is scattered back out of the water by sediments, rendering the 'blue water approximation' void (Gordon & Wang 1994; Gordon et al., 1997; Pinkerton et al., 2006). Satellite observations of ocean colour require calibration before they can be reliably used to estimate sea surface turbidity. Sediment and phytoplankton concentrations need to measured *in situ* for comparison with remote sensed data.

Future development

Algorithm development continues at many institutes worldwide. NASA will launch the next-generation sensor sometime in the next 5 years. Higher spectral and spatial resolution data are available, but with overpass repeat times of approximately 14 days.

Further Information

Gordon, H.R.; Wang, M. (1994). Retrieval of water-leaving radiance and aerosol optical thickness over the oceans with SeaWiFS: A preliminary algorithm. *Applied Optics 33:* 443–452.

Gordon, H.R.; Du, T.; Zhang, T. (1997). Remote sensing of ocean color and aerosol properties: resolving the issue of aerosol absorption. *Applied Optics 36*: 8670–8684.

Pinkerton, M.H.; Moore, G.F.; Lavender, S.J.; Gall, M.P.; Oubelkheir, K.; Richardson, K.M.; Boyd, P.W.; Aiken, J. (2006). A method for estimating inherent optical properties of New Zealand continental shelf waters from satellite ocean colour measurements. *New Zealand Journal of Marine and Freshwater Research 40:* 227–247.

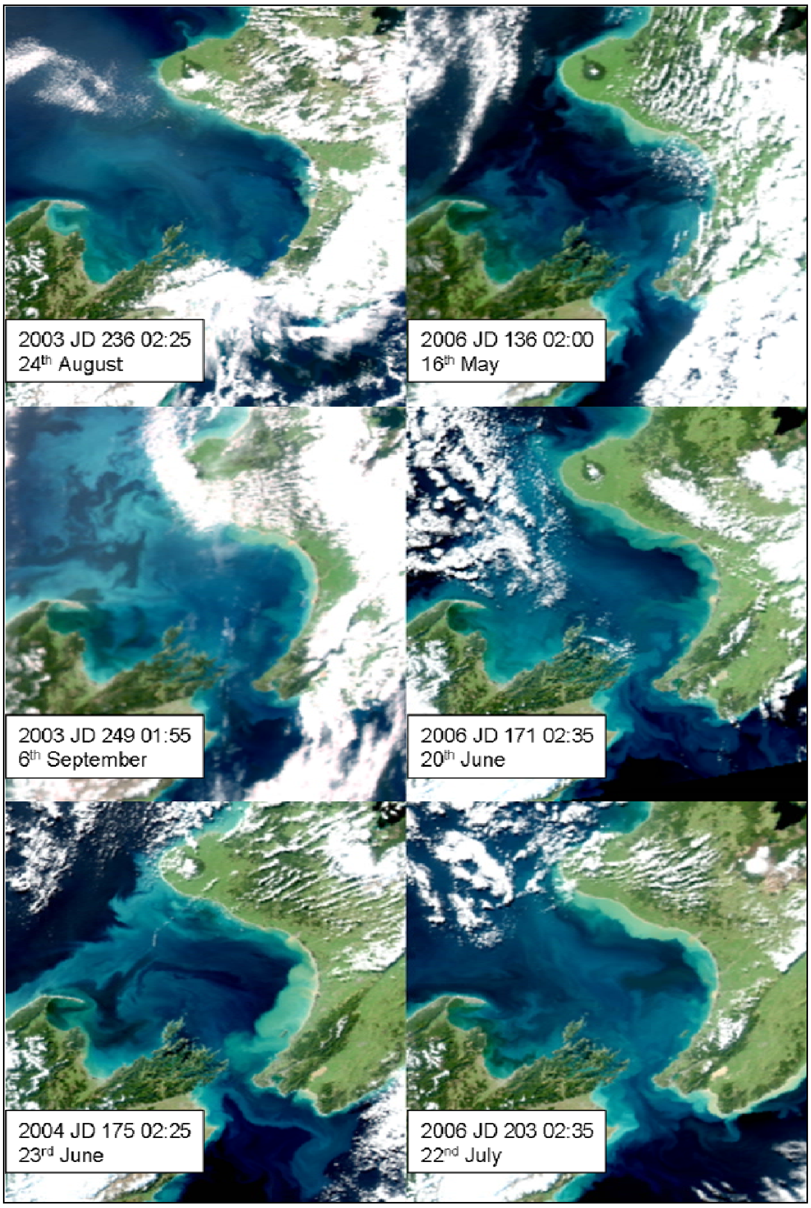

Figure A4.12: Instances of extreme turbidity in the South Taranaki Bight (MODIS –Aqua) as an example of the problems in interpreting remote sensed coastal waters. Sediments from river plumes and from wind-driven resuspension brighten the water by scattering; terrigenous humic substances absorb strongly at blue wavelengths; phytoplankton cells contribute to both absorption and scattering.

A4.11 Set netting

Key contacts

Mfish database – rdm@fish.govt.nz

Description of the data

Data can be requested as single events (i.e. haul-by-haul) or they can be aggregated into groups, such as statistical area, date ranges, mesh sizes, etc. It should be noted that since 2007 the NCELR form requires latitude and longitudes for each catch/effort event, whereas the CELR asks only for statistical areas (apart from special circumstances). The only location data required for the landing section of the form is the fish stock.

Methodology for generating the data

Commercial fishermen are obliged to report their catch, effort and landings via method specific forms. These are sent to FishServe, which enters the data and supplies a daily update to Mfish to be uploaded into the commercial catch effort database (Warehou).

Set netting fishing effort information is recorded by commercial fishermen on the Mfish NCELR (Netting Catch, Effort and Landing Return) form. The exception is when fishers are using more than one method. In this case they have a dispensation to use a Catch Effort Landing Return (CELR) form with a special set netting template. The CELRs were also the forms used before the introduction of the NCELR and date back to approximately 1989. Data prior to 1989 may be available in the FSU database (stored at NIWA). All commercial fishers using set nets are required to fill in an NCELR or a CELR to report their activities. The form records estimated catch, effort and landing information for those fishing using the set netting (SN), inshore drift netting (DN) or pair set netting (PSN) methods using a vessel 6 metres or more in overall length.

Key models and datasets

Mfish Warehou database

Data currently available

Haul-by-haul or aggregated set netting event data.

Limitations of the data

Data will require a certain amount of grooming before use. Historical data will be at a coarser resolution than more recent data.

Future development

The database is currently under active development at Mfish. We recommend that before an attempt is made to complete the assessment of risk to New Zealand marine habitats from this threat, that the latest estimates are sourced from the Mfish Research Data and Reporting team.

Further Information

Research Data and Reporting Group. 2009. Ministry of Fisheries WAREHOU Database Documentation Catch Effort Base Views and Fields. Ministry of Fisheries report. 72p.

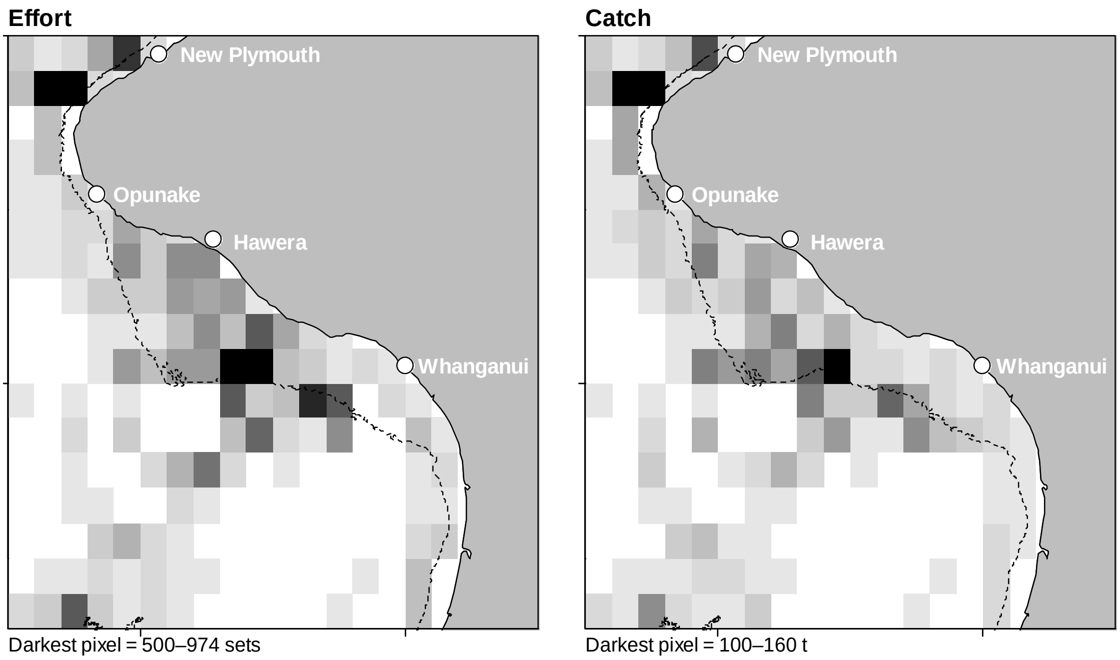

Figure A4.13: Density plots showing as an example, the spread of set netting fishing effort and total catch within the South Taranaki Bight between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour. Data courtesy of the Ministry of Fisheries.

A4.12 Potting or trapping for fish or crayfish

Key contacts

Mfish database – rdm@fish.govt.nz
Lynda Griggs and David Fisher (NIWA)

Description of the data

Data can be requested as single events (i.e. haul-by-haul) or they can be aggregated into groups, such as statistical area, date ranges, etc.

Methodology for generating the data

Commercial fishermen are obliged to report their catch, effort and landings via method specific forms. These are sent to FishServe, which enters the data and supplies a daily update to Mfish to be uploaded into the commercial catch effort database (Warehou).

Potting or trapping fishing effort information is recorded by commercial fishermen using the CELR (Catch Effort Landing Return) Mfish form. These returns are to be completed by permit holders who take fish from a vessel less than 28m in length, or permit holders who take fish without the use of a vessel. These returns record all fish taken by the permit holder on a fishing trip. New forms are completed for each fishing trip. Where no fishing is undertaken in a month, a 'Nil' return is required.

Key models and datasets

MFish Warehou database.

Data currently available

Haul-by-haul or aggregated potting/traping event data can be extracted. Single event data is only released when appropriate justification is given, such as MFish contracted research with a specific need for event-level detail and covered by strict data release conditions. There will be data for anywhere potting/trapping is undertaken and a proportion of those vessels will have had Observers on them. Therefore, there should be no spatial bias other than that caused by the location of the target species.

Limitations of the data

In most cases the data are available only to a statistical area scale. Finer scale data data may be available from individual fishers.

Future development

The Mfish Warehou database is currently under active development. We recommend that before an attempt is made to complete the assessment of risk to NZ marine habitats from this threat that the latest estimates are sourced from the MFish rdm team (RDM@fish.govt.nz).

Further Information

Mfish Research Database Documentation - http://www.fish.govt.nz/en-nz/Research+Services/Research+Database+Documentation/default.htm?wbc_purpose=Basic%2525252525252526WBCMODE

Research Data and Reporting Group, 2010. WAREHOU Database Documentation Catch Effort Base Views and Fields, Version 9, 72p.

A4.13 Long-lining

Key contacts

Mfish database – rdm@fish.govt.nz
Lynda Griggs and K. A. Mackay (NIWA)

Description of the data

Data can be requested as single events (i.e. haul-by-haul) or they can be aggregated into groups, such as statistical area, date ranges, etc. Data cover the entire New Zealand EEZ (Figure A4.14).

Methodology for generating the data

Commercial fishermen are obliged to report their catch, effort and landings via method specific forms. These are sent to FishServe, who data entry the details and supply a daily update to Mfish to be uploaded into the commercial catch effort database (Warehou).

Long line fishing effort information is recorded by commercial fishermen using the following Mfish forms:

CELR (Catch Effort Landing Return) with a long lining template.
These returns are completed by permit holders who take fish from a vessel less than 28m in length, or permit holders who take fish without the use of a vessel. These returns record all fish taken by the permit holder on a fishing trip. New forms are completed for each fishing trip. Where no fishing is undertaken in a month, a 'Nil' return is required.

LCER (Lining Catch Effort Returns)
These returns are completed by permit holders who take fish from a vessel greater than 28m in length by the methods of bottom longlining, surface longlining (targeting species other than tuna or swordfish), and trot lining. These returns record all fishing taken by the permit holder on a fishing trip. New forms are completed for each fishing trip. This form requires more detail than the CELR form, including position (lat/long) data.

TLCER (Tuna Long lining Catch Effort Return).
These returns are completed by permit holders who target tuna and associated species by longlining, regardless of vessel size. "Nil" returns are not submitted using these forms. Fishing positions (lat/long) are recorded.

CLR (Catch Landing Returns)
These returns are completed by permit holders who take fish from a vessel that is more than 28m in length using the method of trawling, or permit holders targeting tuna and associated species using the method of surface longlining, or permit holders taking squid using the method of squid jigging, or permit holders using a lining method that is not surface longlining and targeting tuna. They are used in conjunction with TCEPRs, SJCERs, TLCERs and LCERs. The CLR will reflect the landings associated with the effort that is reported on the TCEPRs, SJCERs, TLCERs or LCERs for that trip. Where no fishing is undertaken in a month, a 'Nil' return is required.

Key models and datasets

Mfish Warehou database.

Data currently available

Haul-by-haul or aggregated long lining event data can be extracted from the database. Single event data is only released when appropriate justification is given, such as Mfish contracted research with a specific need for event-level detail and covered by strict data release conditions. There should be no spatial bias other than that caused by the location of the fish. The data extent is the New Zealand EEZ.

Future development

The Mfish Warehou database is currently under active development. We recommend that before an attempt is made to complete the assessment of risk to NZ marine habitats from this threat that the latest estimates are sourced from the Mfish rdm team (RDM@fish.govt.nz).

Further Information

Mfish Research Database Documentation - http://www.fish.govt.nz/en-nz/Research+Services/Research+Database+Documentation/default.htm?wbc_purpose=Basic%2525252525252526WBCMODE

Research Data and Reporting Group, 2010. WAREHOU Database Documentation Catch Effort Base Views and Fields, Version 9, 72p.

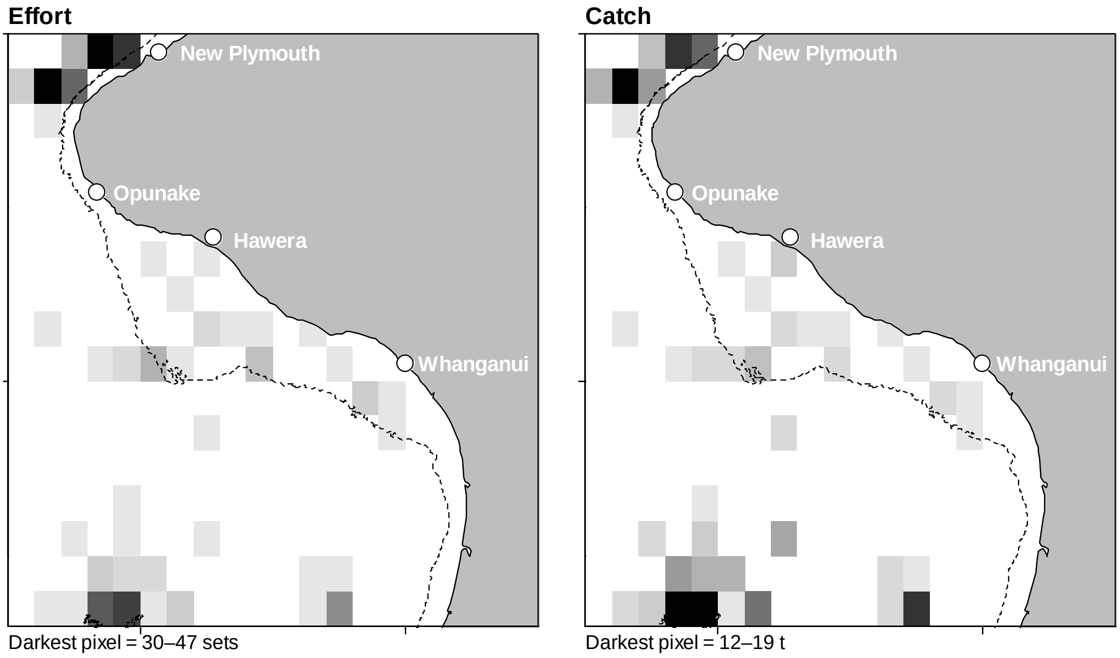

Figure A4.14: Density plots showing the spread of bottom longlining fishing effort and total catch, for example, within the South Taranaki Bight between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

A4.14 Oil spills

Key Contacts

Maritime New Zealand

Description of the data

Assessment of risk of oil spills in a 20km^2 grid around the New Zealand coastline (Figure A4.15).

Methodology for generating the data

The following description of the methodology for assessing the risk of oil spills was taken from the Maritime New Zealand website.

"In 1992 a national risk assessment was completed for New Zealand. This established the basis for the first New Zealand Marine Oil Spill Response Strategy. In 1998 the Maritime Safety Authority completed its second national marine oil spill risk assessment. The purpose of these risk assessments was to provide further information on:

- The level of risk of oil pollution of the sea, coastline and ports of New Zealand;
- The proportions of overall risk which specific oils contribute;
- The proportion of overall risk which specific maritime and oil industry sectors represent; and
- The consequences of a spill on people, their values and the marine environment.

The first assessment did not address the possibility of an unpredictable catastrophic spill; however, the 1998 assessment did.

The 1998 risk assessment measured and presented marine oil spill risk in a manner similar to that used for other forms of emergency response. The probability that a spill event of a particular size occurring in any given year (Probability of Exceedence Level or PEL) was estimated and assigned a value.

The 2004 risk assessment demonstrated that while there had been some changes of the risk profile at the national and regional level, overall the risk profile had been predicted. There was a small increase in the volume of crude oil imported to Marsden Point, but overall there were a smaller number of ship visits as the overall size of the tankers had increased. There was also a shift in shipping patterns with the change occurring in the type of vessels for container traffic.

The early risk assessments concentrated upon the chance of oil spills occurring and although mapping environmental sensitivity did not combine the calculated probability with the potential impact of oil on the coastline. The 2009 risk assessment does this, and when combined with the greater level of environmental mapping gives an output that represents environmental risk.

The environmental mapping conducted as part of this current assessment draws on the considerable work done since 2004 (and in part initiated by the findings of that work) by MAF BioSecurity.

The risk assessment that underpins the information on the Maritime New Zealand website (and depicted in Figure A4.15) forms therefore the fourth and most comprehensive assessment of oil spill risk to the New Zealand coastline.

The nature of the offshore oil and gas exploration and production industry changes more quickly than the overall shipping patterns. The Taranaki fields are increasing in production with two floating production, storage and offloading vessels and several well head platforms now in situ. This necessitated a re-evaluation of the risk profile for the Taranaki region and this is reflected in the 2009 risk assessment.

Further, and as a result of the work undertaken on the oil pollution levy review, there is a more complete understanding of the movement of oil around the New Zealand coastline. These data tend to support the conclusions of the 2004 risk assessment.

Also the regional work undertaken on the Port & Harbour risk assessments and safety management systems since 2003/04 is significant to this current risk assessment.

The 2009 Risk Assessment should build on the previous assessments accounting for any new trends and include the oil pollution levy data."

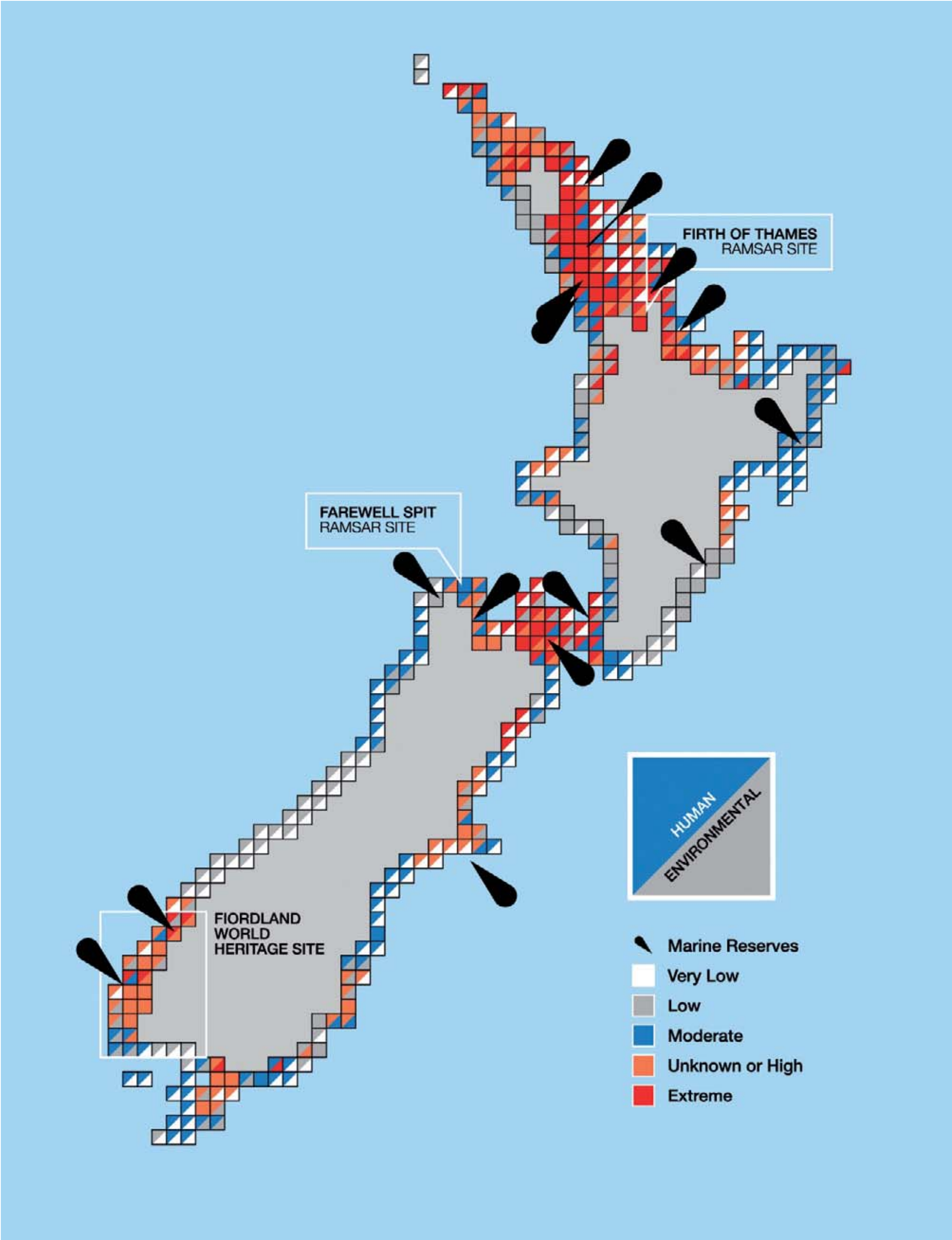

Figure A4.15: Vulnerability of 20km^2 coastal cells to oil spills in terms of environmental factors (i.e. shoreline character, plants and animals) and human factors (i.e. economic, cultural, social, economic and recreational). Map courtesy of Maritime New Zealand.