Ministry for Primary Industries
Manatū Ahu Matua

Geographic distribution of commercial catches of cartilaginous fishes in New Zealand waters, 2008−13

New Zealand Aquatic Environment and Biodiversity Report No. 156.

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ISSN 1179-6480 (online)
ISBN 978-1-77665-040-8 (online)

September 2015

New Zealand Government

Growing and Protecting New Zealand

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The first objective of the National Plan of Action for the Conservation and Management of Sharks is to "Develop and implement a risk assessment framework to identify the nature and extent of risks to shark populations". The Ministry for Primary Industries (MPI) intends to develop that framework progressively through expert-based and quantitative methods. The first step in that process was the convening by MPI in November 2014 of an expert panel to conduct a qualitative risk assessment of New Zealand shark species (defined as all cartilaginous fishes). In preparation for the risk assessment workshop, a number of resources were collated, including information on commercial catches and catch rates, biological productivity, and trends in stock biomass and status of each species. This report documents the collation, summarising and plotting on distributional maps of information on commercial catches, fishing effort, and catch-per-unit effort (CPUE).

The five-year period October 2008 to September 2013 was used to quantify the geographic distribution of 'recent' commercial catches of sharks. For a longer term perspective, data were also summarised for 'old' commercial trawl catches made during the previous 19-year period (fishing years 1989−90 to 2007−08). Commercial fishing, observer and protected species bycatch reports were analysed. Distribution maps of fishing effort, and shark catch and CPUE were generated by species, data resolution (latitude/longitude, statistical area), data source (commercial, observer and protected species bycatch) and fishery. Fisheries were defined based on fishing method, length of vessel and target species. Maps were also produced by species for all methods combined, and for groupings of fisheries using the same method (trawl, surface longline, bottom longline and purse seine).

In 877 020 fishing events reported during 2008−13, there were 662 391 shark species records (75.5% incidence). A 'record' was defined as a row of data representing the catch in weight of a single species in a single fishing event. The highest incidence rates were found for the following methods (in descending order): surface longline, bottom longline, bottom trawl, set net, and Danish seine. The greatest absolute numbers of shark records came from (in descending order) bottom trawl, bottom longline, set net and surface longline. Estimated catches were dominated by spiny dogfish (23 900 t) followed by school shark (13 300 t), and dark ghost shark, elephantfish, blue shark, rough skate and rig (5000−7000 t). A total of 2024 recent and old distribution maps were generated. Examples of the maps are shown, and the full set of maps and R code are available on request from MPI.

1. INTRODUCTION

One of the goals of the National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) is to "Maintain the biodiversity and longterm viability of New Zealand shark populations based on a risk assessment framework with assessment of stock status, measures to ensure any mortality is at appropriate levels, and protection of critical habitat" (Ministry for Primary Industries 2013). Objective 1.1 to achieve this goal during the five-year term of the NPOA-Sharks is to "Develop and implement a risk assessment framework to identify the nature and extent of risks to shark populations". The Ministry for Primary Industries (MPI) intends to develop that framework progressively through expert-based and quantitative methods. The first step in that process was in November 2014 when MPI convened an expert panel to conduct a qualitative risk assessment of all New Zealand cartilaginous fishes (Ford et al. 2015). In preparation for the risk assessment workshop, a number of resources were collated, including information on commercial catches and catch rates, biological productivity, and trends in stock biomass and the status of each species. This report documents the collation, summarising and plotting on distributional maps of information on commercial catches, fishing effort, and catch-per-unit effort (CPUE).

2. METHODS

In this report, and for consistency with the definition in the NPOA-Sharks, the term 'sharks' is used to mean all species of cartilaginous fishes (chondrichthyans – including sharks, skates, rays and ghost sharks) present in New Zealand's Exclusive Economic Zone (EEZ).

The five-year period October 2008 to September 2013 (i.e. fishing years 2008−09 to 2012−13) was used to quantify the geographic distribution of 'recent' commercial catches of sharks. For a longer term perspective on catches, data were also summarised for 'old' commercial trawl catches made during the previous 19-year period (fishing years 1989−90 to 2007−08).

A data extract covering the recent period was obtained from the MPI commercial catch-effort database *warehou* on 22 July 2014 (rep log 9590), and an analogous extract covering the old period was obtained on 2 October 2014 (rep log 9694). These extracts contained information on date, fishing effort for all vessels (not just those catching sharks), location (latitude and longitude for most form types, but New Zealand statistical area for most Catch Effort Landing Returns (CELRs)), length of vessel, target species, and estimated catch weight of sharks (including sharks reported discarded at sea). Estimated catches are provided by fishers, and they are often not weighed. However, estimated catches often provide better coverage of catches of minor or unwanted species than do landed catches. MPI fishing return forms typically include estimated catches for only the top five or eight species caught (depending on the form type). Furthermore, estimated catches are meant to be whole (green) weight but some fishers incorrectly report processed weight. These factors will introduce unquantified errors into our results. Form types used to report catches from outside the EEZ were removed from the dataset before analysis.

Observer data collected aboard commercial fishing vessels were obtained from the MPI database *COD* on 21 September 2014. The data fields extracted were similar to those for commercial fishing returns above. The most intensive observer coverage is on offshore trawlers and tuna longliners, with little coverage of small inshore vessels.

Shark catches were also extracted from the MPI Non-Fish/Protected Species Catch Return forms (NFPSCR) on 22 July 2014 (rep log 9590). These forms are used by commercial fishers to report captures of all protected species (including fishes and sharks as well as seabirds, marine mammals and turtles). Only three shark species were reported on NFPSCR forms (basking shark, spinetail devilray and white shark).

Fishing methods that never reported shark catch in 2008−13 were omitted from further analysis. For all form types, a 'record' was defined as a row of data representing the catch in weight of a single species in a single fishing event. A 'fishing event' was defined as the deployment of a unit of fishing gear (e.g. a trawl tow, a longline set, a set of pots). If more than one species of shark was caught in the same fishing event, there were multiple records per event. Information on the number of individual sharks caught in fishing events is not available (except on recent NFPSCR forms), so the number of records is used here as a proxy for the frequency of species encounters.

All records of manta ray (RMB, MNT) were converted to spinetail devilray (MJA), because there are no confirmed records of manta rays being caught by New Zealand commercial fisheries (Jones & Francis 2012). Records of Greenland shark (SMI) were converted to southern sleeper shark (SOP) in accordance with current taxonomic knowledge. Records of silky shark (CAF) are dubious because silky sharks have not been confirmed to occur in New Zealand (C. Duffy, Department of Conservation, pers. comm.). In this report, such records were converted to unspecified carcharhinid sharks (RSH), but the maps generated for the risk assessment workshop in 2014 were labelled CAF. The two species of blind electric ray (TTY, TAY) were combined under the single code BER.

For recent data, distribution maps were generated by species, data resolution (latitude/longitude, statistical area), data source (commercial, observer and NFPSCR) and fishery. Fisheries were defined based on fishing method, length of vessel and target species (Table 1). Maps were also produced by species for all methods combined, and for groupings of fisheries using the same method (trawl, surface longline, bottom longline and purse seine). Maps were produced only for combinations of species, fisheries and spatial data resolution having non-trivial numbers of catch records. Three data types were plotted on the maps:

1. Fishing effort expressed as the aggregated number of records
2. Aggregated estimated catch weight
3. CPUE, expressed as aggregated catch divided by aggregated effort using the following effort measures:
    a. Thousands of hooks for lining methods;
    b. Thousands of metres of net for static nets and purse seine;
    c. Number of tows/lifts for mobile methods (trawling, dredging) and pots.

Fishing effort and CPUE were not plotted for observer and NFPSCR data, as these sources were not considered representative of the entire fishery. However, catches from these sources were plotted as they provide useful information on the distribution of taxa that are not often reported on commercial fishing returns. For fishing events having locations specified in latitude and longitude, data were summarised for plotting in half-degree rectangles. The remaining fishing events were summarised by statistical areas. A log10 scale, scaled to the maximum aggregated value, was used for plotting effort, and for plotting catches and CPUE available at latitude/longitude precision. A linear scale was used for plotting catches and CPUE having statistical area precision.

Table 1: Classification of commercial and observer records into fisheries (last column) based on fishing method, vessel length and target species. Species codes are defined in Appendix 1.

Method	Method code	Vessel length	Target species	Fishery
Beach seine	BS	All	All	BS
Bottom longline	BLL	>= 40 m	All	BLL_GT40
Bottom longline	BLL	< 40 m	BCO, TRU	BLL_LT40_BCO
Bottom longline	BLL	< 40 m	BNS, HPB, HAP, BAS, BYX, SKI, SPE	BLL_LT40_BNS
Bottom longline	BLL	< 40 m	LIN, RIB, HAK	BLL_LT40_LIN
Bottom longline	BLL	< 40 m	SCH, SPO, ELE, SPD, RSK	BLL_LT40_SCH
Bottom longline	BLL	< 40 m	SNA, GUR, TRE, TAR, RSN, RRC, KIN, KAH, JDO, BRA	BLL_LT40_SNA
Bottom longline	BLL	< 40 m	Other BLL targets	BLL_LT40_OTH
Bottom longline	BLL	Length N/A	All	BLL_OTH
Danish seine	DS	All	All	DS
Diving	DI	All	All	DI
Inshore drift net	DN	All	All	DN
Dredge	D	All	All	D
Drop line	DL, TL	All	All	DL
Fish pot	FP	All	All	FP
Fyke net	FN	All	All	FN
Hand line	HL	All	All	HL
Pole and line	PL	All	All	PL
Pot	CP, CRP, RLP	All	All	POT
Purse seine	PS	All	SKJ, ALB	PS_SKJ
Purse seine	PS	All	Other PS targets	PS_OTH
Ring net	RN	All	All	RN
Set net	SN	All	All	SN
Surface long line	SLL	>= 48 m	All	SLL_GT48
Surface long line	SLL	< 48 m	All	SLL_LT48
Surface long line	SLL	Length N/A	All	SLL_OTH
Trawl	MW, BT, BPT	All	JMA, EMA	MW_JMA
Trawl	MW, BT	All	ORH, OEO, CDL, SSO, BOE, SOR, SND	TWL_DW
Trawl	BT, BPT	All	FLA, FLO, LSO, SFL, ESO, YBF, TUR, GFL, BRI, BFL	TWL_FLA
Trawl	MW, BT, BPT	All	TAR, GUR, RCO, SNA, BAR, TRE, STA, JDO, ELE, WAR, SPD, SPO, LEA, SKI, SCH, QSC, MOK, RSK, HPB, HAP, PAD, BCO, KAH, CAR, BOA, THR, SPZ, KIN, BRA, WRA, WHE, TRU, SCA, MAK, BWS, ALB, SFI	TWL_IN
Trawl	MW, BT	All	RAT, CDO, JAV, TRA, SCO, RBM, FRO, SDO, SBO, SSK, MDO, RBT, BNS, LDO, RBY, WWA, SPE, BYX, HAK, SWA, LIN, GSH, HOK, GSC	TWL_MD
Trawl	MW, BT	All	SBW	TWL_SBW
Trawl	BT	All	SCI	TWL_SCI
Trawl	MW, BT	All	SQU	TWL_SQU
Trawl	BT, BPT	All	Other trawl targets	BT_OTH
Troll	T	All	All	T

For old data, maps of effort and catch (but not CPUE) were generated for commercial trawl fishing only. Data were processed and plotted using purpose-written R code (R Development Core Team 2008).

The half-degree rectangles used for plotting results are not the same size throughout the EEZ because lines of longitude converge towards the south. The area of a half-degree rectangle at 30 ^{o}S (near the northern limit of fishing effort) is 1.51 times the area of a half-degree rectangle at 55 ^{o}S. Consequently, the aggregated effort and estimated catch in southern rectangles are biased low relative to the values for northern rectangles. This bias is ameliorated considerably by use of a log10 scale for plotting. Graphs of the distribution of CPUE are not affected by the bias because they present a ratio of catch and effort.

3. RESULTS

About 117 species of sharks occur in New Zealand waters (Appendix 1). The exact number is uncertain because of ongoing changes in the taxonomic understanding of the species, and new discoveries. Commercial fishers or observers reported that 77 of these species were caught during 2008−2013 (Appendix 2). However, fishers also used 15 generic reporting codes (Appendix 2), so the real number of species caught may have been larger.

In 877 020 fishing events reported during 2008−13 (excluding methods that never reported shark catch), there were 662 391 shark species records (75.5% incidence) (Appendix 2). The highest incidence rates were found for the following methods (in descending order): surface longline, bottom longline, bottom trawl, set net, and Danish seine. The greatest absolute numbers of shark records came from (in descending order) bottom trawl, bottom longline, set net and surface longline. Estimated catches were dominated by spiny dogfish (23 900 t) followed by school shark (13 300 t), and dark ghost shark, elephantfish, blue shark, rough skate and rig (5000−7000 t) (Appendix 3).

A total of 2024 recent and old distribution maps were generated. Effort distributional maps are shown for the main fishing methods in Appendix 4. Examples of catch and CPUE maps for both latitude/longitude data and statistical area data are shown in Appendices 5 and 6 respectively. The full set of maps (as jpg files) and R code are available on request from MPI.

4. DISCUSSION

The maps generated by this project were used as an important input into the workshop of experts convened by MPI to develop qualitative risk assessments for all New Zealand sharks (Ford et al. 2015). Data used here have not been groomed (except for a few obvious coding mistakes mentioned on page 3). The distribution maps produced here were used as a broad guide, in conjunction with other information, by an expert group who were able to interpret the reliability of these data. Any detailed analysis of catch and CPUE for individual species may require data grooming before they are accurate enough to be interpreted without such specialist expertise. Future mapping of catch and effort data at the spatial scale of the EEZ should also account for the latitudinal variation in the area covered by half-degree rectangles.

5. ACKNOWLEDGMENTS

I thank David Fisher and the MPI Research Data Manager for providing the data extracts required for this study. This work was completed under Ministry for Primary Industries projects SEA2013-16 and SEA2014-01. Thanks to Rich Ford for coordinating the projects.

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APPENDIX 1: List of shark (chondrichthyan) species found in New Zealand waters

Also included (at the bottom of the table on next page) are 'generic' categories and codes used for recording catch not reported to species level.

Group	Family	Species	Common name	Code
Chimaera	Callorhinchidae	*Callorhinchus milii Bory de St Vincent 1823*	Elephantfish	ELE
Chimaera	Rhinochimaeridae	*Harriotta haeckeli Karrer 1972*	Smallspine spookfish	HHA
Chimaera	Rhinochimaeridae	*Harriotta raleighana Goode & Bean 1895*	Longnose spookfish	LCH
Chimaera	Rhinochimaeridae	*Rhinochimaera pacifica (Mitsukuri 1895)*	Pacific spookfish	RCH
Chimaera	Chimaeridae	*Chimaera carophila Kemper et al. 2014*	Brown chimaera	CHP
Chimaera	Chimaeridae	*Chimaera lignaria Didier 2002*	Purple chimaera	CHG
Chimaera	Chimaeridae	*Chimaera panthera Didier 1998*	Leopard chimaera	CPN
Chimaera	Chimaeridae	*Hydrolagus bemisi Didier 2002*	Pale ghost shark	GSP
Chimaera	Chimaeridae	*Hydrolagus homonycteris* Didier 2008	Black ghost shark	HYB
Chimaera	Chimaeridae	*Hydrolagus novaezealandiae (Fowler 1910)*	Dark ghost shark	GSH
Chimaera	Chimaeridae	*Hydrolagus trolli Didier and Seret 2002*	Pointynose blue ghost shark	HYP
Chimaera	Chimaeridae	*Hydrolagus* sp. D [Didier]	Giant black ghost shark	HGB
Shark	Chlamydoselachidae	*Chlamydoselachus anguineus Garman 1884*	Frill shark	FRS
Shark	Hexanchidae	*Heptranchias perlo (Bonnaterre 1788)*	Sharpnose sevengill shark	HEP
Shark	Hexanchidae	*Hexanchus griseus (Bonnaterre 1788)*	Sixgill shark	HEX
Shark	Hexanchidae	*Notorynchus cepedianus (Peron 1807)*	Broadnose sevengill shark	SEV
Shark	Echinorhinidae	*Echinorhinus brucus (Bonnaterre 1788)*	Bramble shark	BRS
Shark	Echinorhinidae	*Echinorhinus cookei Pietschmann 1928*	Prickly shark	ECO
Shark	Squalidae	*Cirrhigaleus australis White Last & Stevens 2007*	Southern mandarin dogfish	MSH
Shark	Squalidae	*Squalus acanthias Linnaeus 1758*	Spiny dogfish	SPD
Shark	Squalidae	*Squalus griffini Phillipps 1931*	Northern spiny dogfish	NSD
Shark	Squalidae	*Squalus raoulensis Duffy & Last 2007*	Kermadec spiny dogfish	SQA
Shark	Squalidae	*Squalus* sp. 5	Green-eye dogfish	SQA
Shark	Centrophoridae	*Centrophorus harrissoni McCulloch 1915*	Harrissons dogfish	
Shark	Centrophoridae	*Centrophorus squamosus (Bonnaterre 1788)*	Leafscale gulper shark	CSQ
Shark	Centrophoridae	*Deania calcea (Lowe 1839)*	Shovelnose dogfish	SND
Shark	Centrophoridae	*Deania histricosa (Garman 1906)*	Rough longnose dogfish	SNR
Shark	Centrophoridae	*Deania quadrispinosa (McCulloch 1915)*	Longsnout dogfish	DEQ
Shark	Etmopteridae	*Centroscyllium* sp. cf. *kamoharai*	Fragile dogfish	
Shark	Etmopteridae	*Etmopterus granulosus (Günther 1880)*	Baxters dogfish	ETB
Shark	Etmopteridae	*Etmopterus lucifer Jordan & Snyder 1902*	Lucifers dogfish	ETL
Shark	Etmopteridae	*Etmopterus molleri (Whitley 1939)*	Moller's lantern shark	EMO
Shark	Etmopteridae	*Etmopterus pusillus (Lowe 1839)*	Smooth lantern shark	ETP
Shark	Etmopteridae	*Etmopterus* cf. *unicolor*	Bristled lantern shark	
Shark	Etmopteridae	*Etmopterus viator* Straube 2012	Blue-eye lantern shark	EVI
Shark	Somniosidae	*Centroscymnus coelolepis Bocage & Capello 1864*	Portuguese dogfish	CYL
Shark	Somniosidae	*Centroscymnus owstonii Garman 1906*	Owston's dogfish	CYO
Shark	Somniosidae	*Centroselachus crepidater (Bocage & Capello 1864)*	Longnose velvet dogfish	CYP
Shark	Somniosidae	*Scymnodalatias albicauda Taniuchi & Garrick 1986*	Whitetail dogfish	SLB
Shark	Somniosidae	*Scymnodalatias sherwoodi (Archey 1921)*	Sherwood's dogfish	SHE
Shark	Somniosidae	*Scymnodon macracanthus* Regan 1906	Largespine velvet dogfish	SCM
Shark	Somniosidae	*Scymnodon plunketi (Waite 1910)*	Plunket's shark	PLS
Shark	Somniosidae	*Scymnodon ringens Bocage & Capello 1864*	Knifetooth dogfish	SRI
Shark	Somniosidae	*Somniosus antarcticus Whitley 1939*	Southern sleeper shark	SOP
Shark	Somniosidae	*Somniosus longus (Tanaka 1912)*	Little sleeper shark	SOM
Shark	Somniosidae	*Zameus squamulosus (Günther 1877)*	Velvet dogfish	ZAS
Shark	Oxynotidae	*Oxynotus bruniensis (Ogilby 1893)*	Prickly dogfish	PDG
Shark	Dalatiidae	*Dalatias licha (Bonnaterre 1788)*	Seal shark black shark	BSH
Shark	Dalatiidae	*Euprotomicrus bispinatus (Quoy & Gaimard 1824)*	Pygmy shark	EBI
Shark	Dalatiidae	*Isistius brasiliensis (Quoy & Gaimard 1824)*	Cookie cutter shark	IBR
Shark	Heterodontidae	*Heterodontus portusjacksoni (Meyer 1793)*	Port Jackson shark	PJS
Shark	Rhincodontidae	*Rhincodon typus (Smith 1828)*	Whale shark	WSH
Shark	Odontaspidae	*Odontaspis ferox (Risso 1810)*	Deepwater sand tiger shark	ODO
Shark	Pseudocarchariidae	*Pseudocarcharias kamoharai (Matsubara 1936)*	Crocodile shark	CRC
Shark	Mitsukurinidae	*Mitsukurina owstoni Jordan 1898*	Goblin shark	GOB
Shark	Alopiidae	*Alopias superciliosus (Lowe 1839)*	Bigeye thresher	BET
Shark	Alopiidae	*Alopias vulpinus (Bonnaterre 1788)*	Thresher shark	THR
Shark	Cetorhinidae	*Cetorhinus maximus (Gunnerus 1765)*	Basking shark	BSK
Shark	Lamnidae	*Carcharodon carcharias (Linnaeus 1758)*	White shark white pointer	WPS
Shark	Lamnidae	*Isurus oxyrinchus Rafinesque 1810*	Mako shark shortfin mako	MAK
Shark	Lamnidae	*Lamna nasus (Bonnaterre 1788)*	Porbeagle shark	POS

APPENDIX 1 (continued).

Shark	Scyliorhinidae	*Apristurus ampliceps Sasahara Sato & Nakaya 2008*	Roughskin cat shark	APR
Shark	Scyliorhinidae	*Apristurus cf. australis Sato Nakaya & Yorozu 2008*	Pinocchio cat shark	APR
Shark	Scyliorhinidae	*Apristurus exsanguis Sato Nakaya and Stewart 1999*	Pale catshark	APR
Shark	Scyliorhinidae	*Apristurus melanoasper Iglésias Nakaya & Stehmann 2004*	Fleshynose cat shark	APR
Shark	Scyliorhinidae	*Apristurus pinguis Deng Xiong & Zhan 1983*	Cat shark	APR
Shark	Scyliorhinidae	*Apristurus sinensis* Chu & Hu 1981	Freckled cat shark	APR
Shark	Scyliorhinidae	*Apristurus* sp.	Cat shark	APR
Shark	Scyliorhinidae	*Bythaelurus dawsoni (Springer 1971)*	Dawsons cat shark	DCS
Shark	Scyliorhinidae	*Cephaloscyllium isabellum (Bonnaterre 1788)*	Carpet shark	CAR
Shark	Scyliorhinidae	*Cephaloscyllium* sp.	Swellshark	
Shark	Scyliorhinidae	*Parmaturus bigus Seret & Last 2007*	Shorttail cat shark	
Shark	Scyliorhinidae	*Parmaturus macmillani Hardy 1985*	McMillan's cat shark	PCS
Shark	Scyliorhinidae	*Parmaturus* sp.	Rough-backed cat shark	
Shark	Scyliorhinidae	*Parmaturus* sp.		
Shark	Pseudotriakidae	*Gollum attenuatus (Garrick 1954)*	Slender smooth hound	SSH
Shark	Pseudotriakidae	*Pseudotriakis microdon Capello 1868*	False cat shark	PMI
Shark	Triakidae	*Galeorhinus galeus (Linnaeus 1758)*	School shark	SCH
Shark	Triakidae	*Mustelus lenticulatus Phillipps 1932*	Rig	SPO
Shark	Triakidae	*Mustelus* sp.	Kermadec Rig	
Shark	Carcharhinidae	*Carcharhinus brachyurus (Günther 1870)*	Bronze whaler	BWH
Shark	Carcharhinidae	*Carcharhinus galapagensis (Snodgrass & Heller 1905)*	Galapagos shark	CGA
Shark	Carcharhinidae	*Carcharhinus longimanus (Poey 1861)*	Oceanic whitetip shark	OWS
Shark	Carcharhinidae	*Carcharhinus obscurus (Le Sueur 1818)*	Dusky shark	DSH
Shark	Carcharhinidae	*Galeocerdo cuvier (Peron & Le Sueur 1822)*	Tiger shark	TIS
Shark	Carcharhinidae	*Prionace glauca (Linnaeus 1758)*	Blue shark	BWS
Shark	Sphyrnidae	*Sphyrna zygaena (Linnaeus 1758)*	Hammerhead shark	HHS
Batoid	Narkidae	*Typhlonarke aysoni (Hamilton 1902)*	Blind electric ray	TAY
Batoid	Narkidae	*Typhlonarke tarakea Phillipps 1929*	Oval electric ray	TTA
Batoid	Torpedinidae	*Torpedo fairchildi Hutton 1872*	Electric ray	ERA
Batoid	Arhynchobatidae	*Arhynchobatis asperrimus Waite 1909*	Longtail skate	LSK
Batoid	Arhynchobatidae	*Bathyraja richardsoni (Garrick 1961)*	Richardson's skate	RIS
Batoid	Arhynchobatidae	*Bathyraja shuntovi Dolganov 1985*	Longnose deepsea skate	PSK
Batoid	Arhynchobatidae	*Bathyraja* sp.	Blonde skate	
Batoid	Arhynchobatidae	*Brochiraja albilabiata Last & McEachran 2006*		
Batoid	Arhynchobatidae	*Brochiraja asperula (Garrick & Paul 1974)*	Smooth deepsea skate	BTA
Batoid	Arhynchobatidae	*Brochiraja leviveneta Last & McEachran 2006*		
Batoid	Arhynchobatidae	*Brochiraja microspinifera Last & McEachran 2006*		
Batoid	Arhynchobatidae	*Brochiraja spinifera (Garrick & Paul 1974)*	Prickly deepsea skate	BTS
Batoid	Arhynchobatidae	*Notoraja sapphira* Seret & Last 2009	Sapphire skate	BTH
Batoid	Arhynchobatidae	*Notoraja* [subgenus C] sp. A [Last & McEachran]		BTH
Batoid	Arhynchobatidae	*Notoraja* [subgenus C] sp. B [Last & McEachran]		BTH
Batoid	Arhynchobatidae	*Notoraja* [subgenus C] sp. C [Last & McEachran]		BTH
Batoid	Arhynchobatidae	*Notoraja* [subgenus D] sp. A [Last & McEachran]		BTH
Batoid	Rajidae	*Amblyraja cf. hyperborea (Collette 1879)*	Arctic skate	DSK
Batoid	Rajidae	*Dipturus innominatus (Garrick & Paul 1974)*	Smooth skate	SSK
Batoid	Rajidae	*Zearaja nasuta (Banks in Müller & Henle 1841)*	Rough skate	RSK
Batoid	Dasyatidae	*Dasyatis brevicaudata (Hutton 1875)*	Shorttail stingray	BRA
Batoid	Dasyatidae	*Dasyatis thetidis Ogilby in Waite 1899*	Longtail stingray	WRA
Batoid	Dasyatidae	*Pteroplatytrygon violacea (Bonaparte 1832)*	Pelagic stingray	DAS
Batoid	Myliobatidae	*Myliobatis tenuicaudatus Hector 1877*	Eagle ray	EGR
Batoid	Mobulidae	*Manta birostris (Donndorff 1798)*	Manta ray	RMB
Batoid	Mobulidae	*Mobula japanica (Müller & Henle 1841)*	Spinetail devilray	MJA
Chimaera	Chimaeridae	*Chimaera* spp.	Cimaeras	CHI
Chimaera	Chimaeridae	*Hydrolagus* spp.	Ghost sharks	HYD
Shark		Shark	Deepsea sharks	CEN
Shark		Shark	Deepwater dogfish	DWD
Shark		Shark	Other sharks and dogs	OSD
Shark		Shark	Sharks	SHA
Shark	Etmopteridae	*Etmopterus* spp.	Lantern sharks	ETM
Shark	Scyliorhinidae	Scyliorhinidae	Catsharks	CSH
Shark	Carcharhinidae	Carcharhinidae	Whaler sharks	RSH
Batoid		Batoids	Other skates	OSK
Batoid		Batoids	Rays	RAY
Batoid		Batoids	Skates	SKA
Batoid		Batoids	Stingrays	STR
Batoid	Narkidae	*Typhlonarke* spp.	Blind electric rays	BER

APPENDIX 2: Numbers of records of shark species caught by method, 2008−2013

Species are sorted in descending order of the total catch records (last column), and methods are sorted (left to right) in descending order of the number of shark records per fishing event (last row). For species and method codes, see Appendix 1 and Table 1 respectively.

Species	SLL	BLL	BT	SN	DS	BPT	TL	DL	MW	RN	D	DN	HL	CRP	CP	BS	PS	RLP	FN	POT	FP	PL	T	DI	Sum
SCH	254	28021	51931	19535	767	606	61	1627	454	9	2	0	157	0	119	0	0	16	0	0	0	0	4	0	103563
SPO	0	4778	59839	31456	3314	470	1	24	51	1165	18	4	67	6	4	14	2	4	0	0	0	0	1	0	101218
RSK	0	4021	91827	3437	1165	49	0	83	45	0	144	0	2	0	4	0	2	0	0	0	0	0	0	0	100779
SPD	0	19030	59475	11473	450	23	49	240	6975	0	72	0	39	0	11	0	4	3	0	0	0	0	0	0	97844
ELE	0	27	36612	5182	730	2	0	3	4	0	0	1	6	0	0	0	2	0	0	0	0	1	0	0	42570
CAR	2	3187	25282	5656	188	106	4	26	2	0	272	0	11	192	584	0	0	1667	0	0	8	0	0	0	37187
GSH	0	3126	26619	5520	221	11	0	11	162	0	4	0	0	0	0	0	1	1	0	0	0	0	2	0	35678
SSK	0	8431	15142	960	148	14	0	48	62	2	29	0	0	0	0	0	3	0	0	0	0	0	0	0	24839
OSD	13	6622	12285	302	1	2	2	13	1236	3	0	0	1	0	3	0	0	20	0	0	0	0	1	0	20504
BWS	15049	1019	32	169	0	0	0	11	53	1	0	0	4	0	0	0	9	0	0	0	0	0	31	0	16378
BSH	9	4507	5586	3410	0	0	3	109	459	0	0	0	1	59	1	0	0	0	0	0	0	0	0	0	14144
GSP	2	3691	7552	53	0	0	0	0	36	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	11337
MAK	6951	469	56	227	19	0	2	15	84	0	0	0	3	0	0	0	35	0	0	0	0	0	35	0	7896
EGR	0	496	3280	2883	102	118	0	0	10	345	3	2	1	1	0	15	0	0	1	0	0	0	0	2	7259
SND	0	4032	2423	312	0	0	0	96	286	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7150
ERA	0	4	6269	61	89	18	0	0	18	4	20	0	0	0	0	0	4	0	0	0	0	0	0	0	6487
POS	4380	342	39	51	0	0	0	0	325	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	5141
NSD	0	2630	840	1029	8	99	0	21	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4634
DWD	0	0	3760	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3804
THR	767	35	944	463	11	81	0	0	145	2	0	0	0	0	0	0	5	0	0	0	0	0	2	0	2455
HHS	10	713	135	872	37	10	0	0	0	8	0	0	2	0	0	1	1	0	0	0	0	0	0	0	1789
SEV	0	339	312	788	0	5	0	6	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1453
BWH	73	113	45	949	4	3	0	0	1	19	0	0	0	0	1	1	2	0	0	0	0	0	0	0	1211
BRA	5	96	925	90	5	57	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1180
LCH	0	1	988	1	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1011
WRA	0	181	368	119	141	90	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	902
DAS	894	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	894
RAY	786	2	42	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	831
CYO	523	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	526
STR	0	44	283	31	10	0	0	0	3	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	376
CHI	0	96	196	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	293
PSK	0	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200
ETB	0	46	112	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159
CHG	0	141	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	154
SSH	1	10	101	4	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119
OSK	0	103	9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113
ETL	1	9	47	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59
CSQ	0	0	25	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48
HYD	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42
ECO	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
BSK	0	5	10	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	18
CYP	7	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
CHP	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
MJA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
HEX	1	2	4	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
SHE	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
TIS	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
BET	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
DSK	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
PDG	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
PLS	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
APR	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
SOP	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
CSH	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
DSH	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
BER	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
HEP	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
CYL	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
DCS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
EMO	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
HYB	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
RCH	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TTA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Shark records	29742	96417	413701	95038	7410	1764	122	2335	10518	1559	567	7	296	258	729	31	94	1711	1	1	8	1	79	2	662391
Fishing events	13805	87265	385988	117645	11010	3862	268	5613	43187	12233	10325	154	6762	7421	25265	1317	4751	110150	63	103	1555	346	22648	5284	877020
Shark records per event (%)	215.4	110.5	107.2	80.8	67.3	45.7	45.5	41.6	24.4	12.7	5.5	4.5	4.4	3.5	2.9	2.4	2.0	1.6	1.6	1.0	0.5	0.3	0.3	0.0	75.5

Some values exceed 100% because multiple species were caught per event

APPENDIX 3: Numbers of records and reported catch weights by species, 2008−2013

Data from MPI commercial fishing returns, the observer database, and NFPSCR forms (NFB). Species are sorted in descending order of commercial weight.

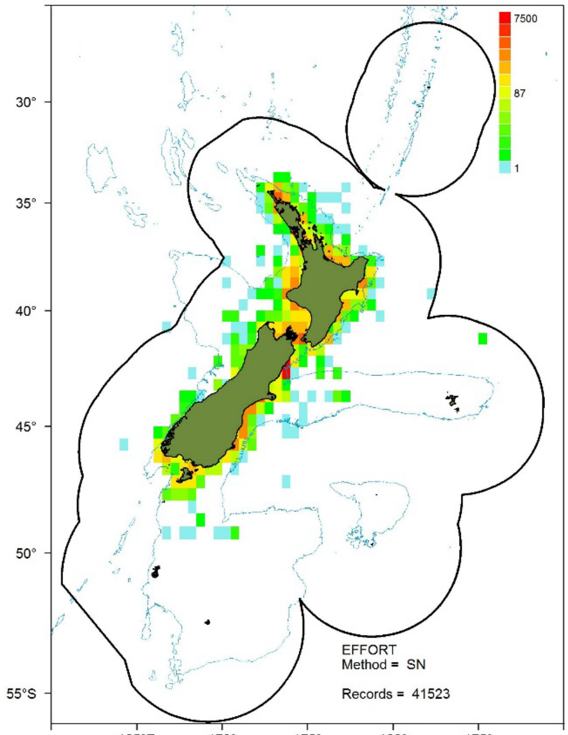
Species	Code	Comm. records	Comm. weight (t)	Obs. records	Obs. weight (t)	NFB records
Spiny dogfish	SPD	97845	23865.7	22186	6314.2	0
School shark	SCH	103567	13447.5	5659	306.9	0
Dark ghost shark	GSH	35678	6898.9	7389	997.8	0
Elephantfish	ELE	42572	6429.6	243	12.0	0
Blue shark	BWS	16378	6284.2	39959	192.7	0
Rough skate	RSK	100786	5511.2	7149	262.8	0
Rig	SPO	101219	5329.4	387	19.8	0
Other sharks and dogs	OSD	20504	1837.5	3052	277.5	0
Pale ghost shark	GSP	11337	1537.8	9574	716.0	0
Seal shark	BSH	14144	1156.6	3782	172.4	0
Carpet shark	CAR	37187	1122.3	2953	75.6	0
Smooth skate	SSK	24839	1021.0	7566	350.7	0
Mako shark shortfin mako	MAK	7896	753.8	2374	70.9	0
Shovelnose dogfish	SND	7150	713.5	5525	412.7	0
Porbeagle shark	POS	5141	435.2	3603	90.5	0
Deepwater dogfish	DWD	3804	380.9	1672	152.5	0
Northern spiny dogfish	NSD	4634	366.7	812	40.7	0
Eagle ray	EGR	7259	248.8	412	7.5	0
Thresher shark	THR	2455	192.8	569	44.1	0
Electric ray	ERA	6487	89.8	2150	21.3	0
Longnose spookfish	LCH	1011	81.8	5042	130.2	0
Purple chimaera	CHG	154	57.7	270	4.6	0
Broadnose sevengill shark	SEV	1453	50.6	132	3.7	0
Bronze whaler	BWH	1211	43.7	64	6.6	0
Shorttail stingray	BRA	1180	38.6	70	3.6	0
Longtail stingray	WRA	902	32.9	96	4.5	0
Stingrays	STR	376	31.9	85	2.7	0
Hammerhead shark	HHS	1789	31.3	48	0.8	0
Baxters dogfish	ETB	159	27.8	7810	554.7	0
Cimaeras	CHI	293	26.7	351	24.2	0
Rays	RAY	831	24.0	78	2.8	0
Slender smooth hound	SSH	119	16.1	834	36.3	0
Basking shark	BSK	18	14.8	28	138.0	23
Pelagic stingray	DAS	894	14.0	645	0.1	0
Ghost sharks	HYD	42	11.2	141	1.2	0
Longnose deepsea skate	PSK	200	9.0	422	11.6	0
Leafscale gulper shark	CSQ	48	8.4	2410	169.2	0
Lucifers dogfish	ETL	59	8.4	4904	54.0	0
Owston’s dogfish	CYO	526	8.2	2990	20.6	0
Other skates	OSK	113	7.9	901	10.5	0
Portuguese dogfish	CYL	1	6.6	328	10.0	0
Spinetail devilray	MJA	15	5.5	56	6.4	53
Southern sleeper shark	SOP	4	1.9	13	7.5	0
Prickly dogfish	PDG	6	1.5	1455	11.8	0
Tiger shark	TIS	8	1.2	0	0.0	0

APPENDIX 3 (continued).

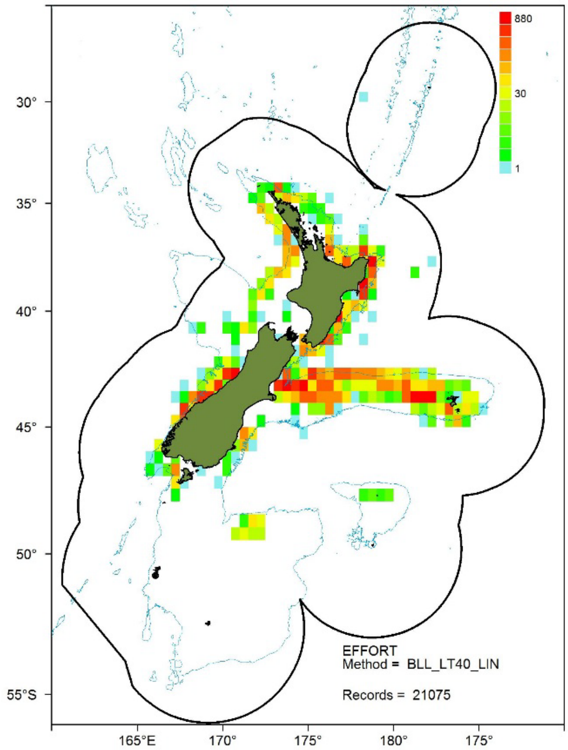
Species	Code	Comm. records	Comm. weight (t)	Obs. records	Obs. weight (t)	NFB records
Roughskin cat shark	APR	4	1.1	722	10.0	0
Longnose velvet dogfish	CYP	18	1.1	2111	60.9	0
Bigeye thresher	BET	6	1.0	23	0.3	0
Prickly shark	ECO	25	0.8	1	0.2	0
Sixgill shark	HEX	10	0.7	194	12.3	0
Brown chimaera	CHP	15	0.3	316	7.8	0
Sherwood’s dogfish	SHE	8	0.3	0	0.0	0
Dusky shark	DSH	3	0.2	0	0.0	0
Plunket’s shark	PLS	5	0.2	1095	48.0	0
Arctic skate	DSK	6	0.1	1629	13.3	0
Black ghost shark	HYB	1	0.1	7	0.0	0
Blind electric rays	BER	2	0.0	589	4.3	0
Bramble shark	BRS	0	0.0	2	0.1	0
Smooth deepsea skate	BTA	0	0.0	366	2.6	0
Sapphire skate	BTH	0	0.0	399	2.1	0
Prickly deepsea skate	BTS	0	0.0	311	3.7	0
Leopard chimaera	CPN	0	0.0	1	0.0	0
Catsharks	CSH	3	0.0	534	11.1	0
Dawsons cat shark	DCS	1	0.0	544	1.9	0
Moller’s lantern shark	EMO	1	0.0	108	1.1	0
Lantern sharks	ETM	0	0.0	90	7.9	0
Smooth lantern shark	ETP	0	0.0	47	0.3	0
Frill shark	FRS	0	0.0	27	0.1	0
Goblin shark	GOB	0	0.0	5	0.1	0
Sharpnose sevengill shark	HEP	2	0.0	115	2.2	0
Giant black ghost shark	HGB	0	0.0	41	9.7	0
Pointynose blue ghost shark	HYP	0	0.0	7	0.0	0
Cookie cutter shark	IBR	0	0.0	47	2.0	0
Longtail skate	LSK	0	0.0	564	4.2	0
Southern mandarin dogfish	MSH	0	0.0	2	0.0	0
Deepwater sand tiger shark	ODO	0	0.0	6	0.3	0
Oceanic whitetip shark	OWS	0	0.0	1	0.0	0
False cat shark	PMI	0	0.0	2	0.2	0
Pacific spookfish	RCH	1	0.0	229	2.5	0
Richardson’s skate	RIS	0	0.0	205	1.4	0
Whaler sharks	RSH	0	0.0	8	0.2	0
Largespine velvet dogfish	SCM	0	0.0	251	9.5	0
Sharks	SHA	0	0.0	140	3.3	0
Skates	SKA	0	0.0	14	0.2	0
Whitetail dogfish	SLB	0	0.0	2	0.0	0
Rough longnose dogfish	SNR	0	0.0	32	0.8	0
Little sleeper shark	SOM	0	0.0	16	0.4	0
Kermadec spiny dogfish	SQA	0	0.0	53	4.0	0
Blind electric ray	TAY	0	0.0	293	1.1	0
Oval electric ray	TTA	1	0.0	100	0.7	0
White shark white pointer	WPS	0	0.0	3	0.0	21
Velvet dogfish	ZAS	0	0.0	43	1.1	0

APPENDIX 4: Examples of distributional maps of fishing effort

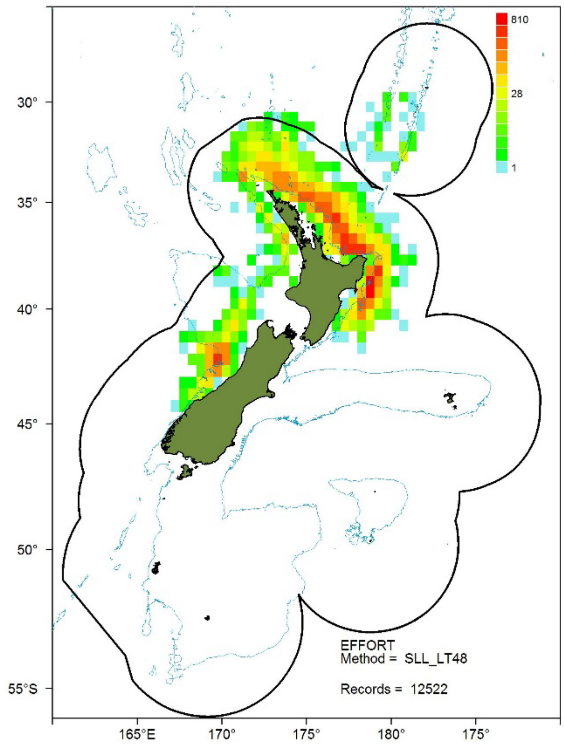
Scale bars are on a log scale, but numerals show untransformed values (number of fishing events).



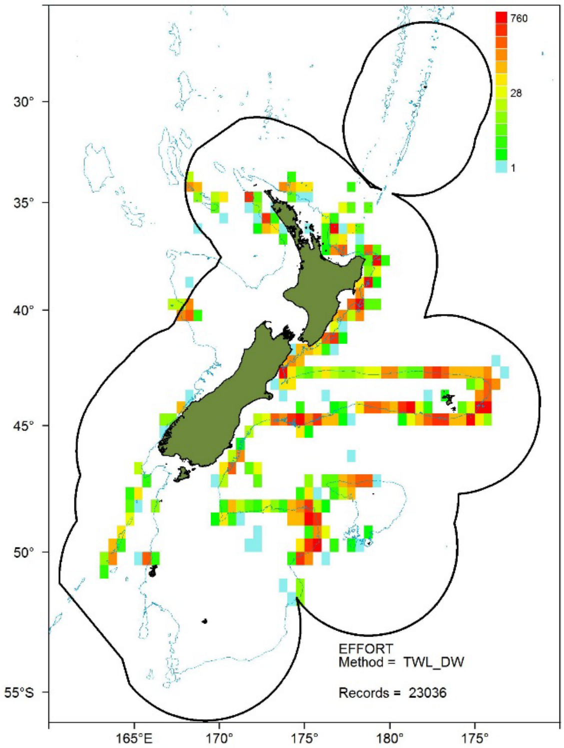
A) Set net fishery



B) Bottom longline, ling fishery (vessels < 40 m)



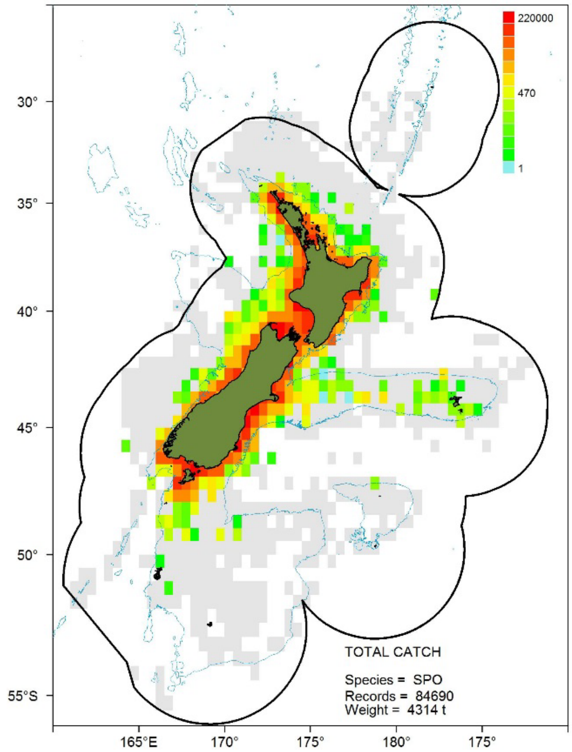
C) Surface longline fishery (vessels < 48 m)



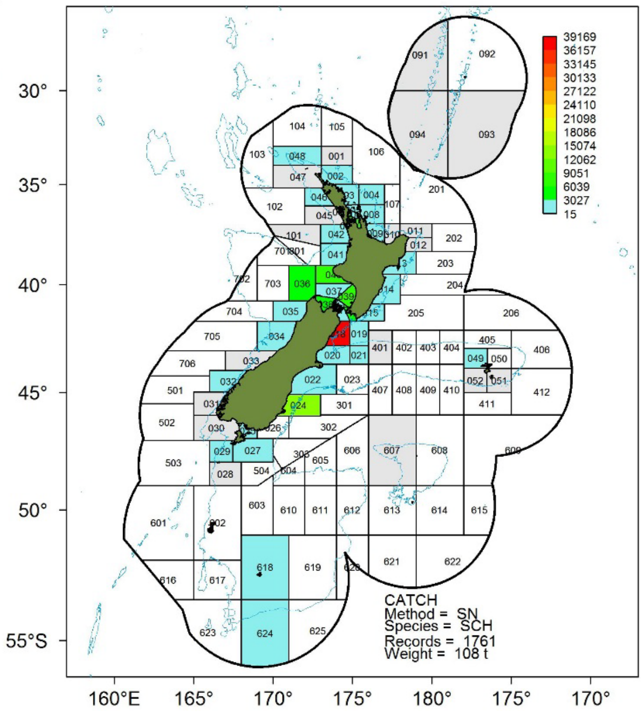
D) Deepwater trawl fishery

APPENDIX 5: Examples of distributional maps of catch

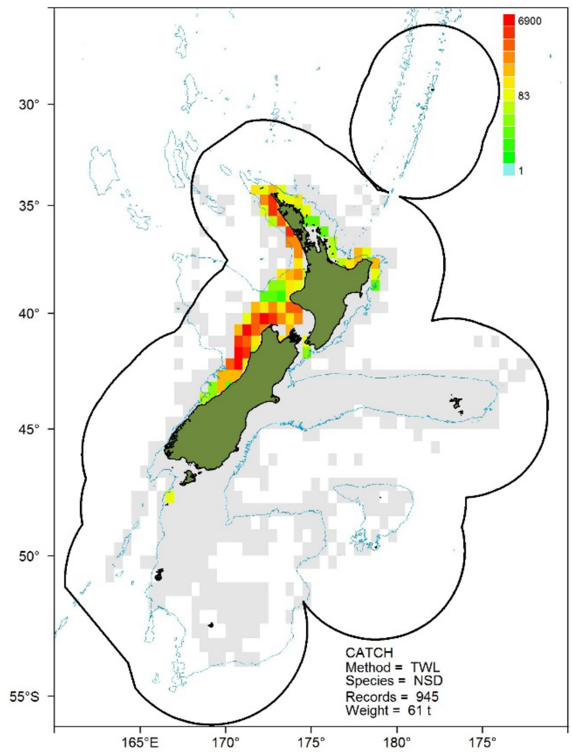
Grey pixels indicate fishing effort that produced no catch. Scale bars are on a log scale (except for B which is on a linear scale), but numerals show untransformed values (catch in kg).



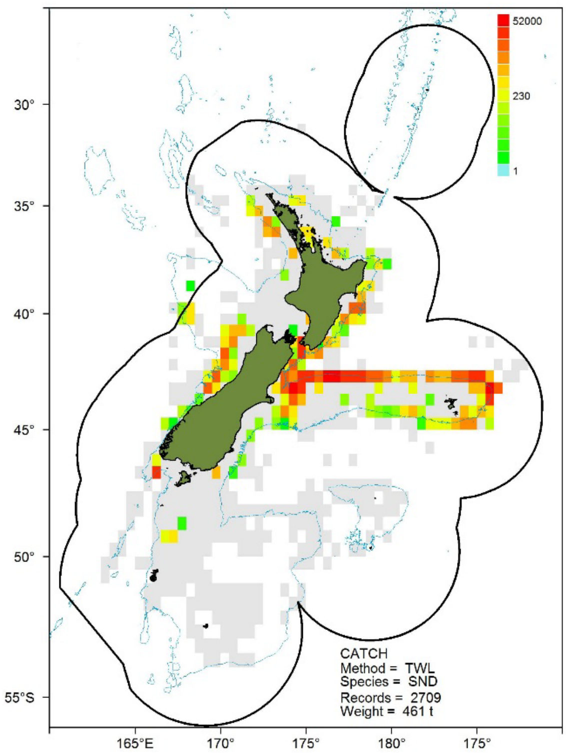
A) Rig total catch



B) School shark set net catch, CELR data at statistical area resolution

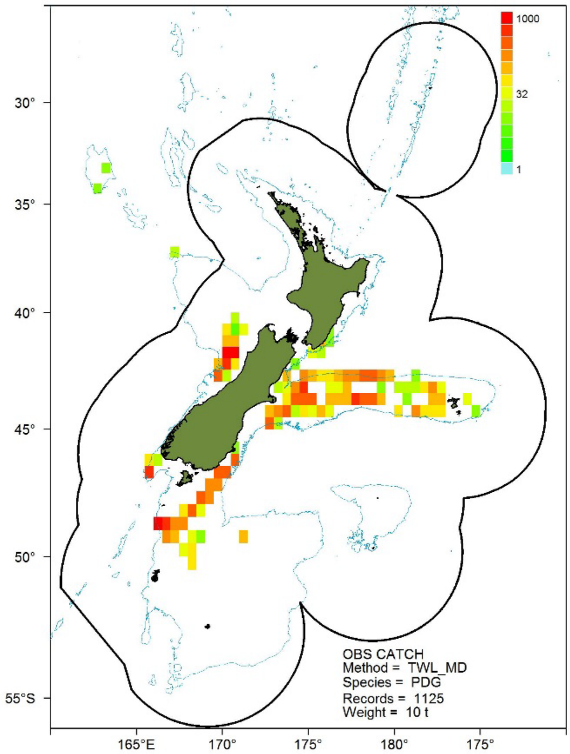


C) Northern spiny dogfish trawl catch

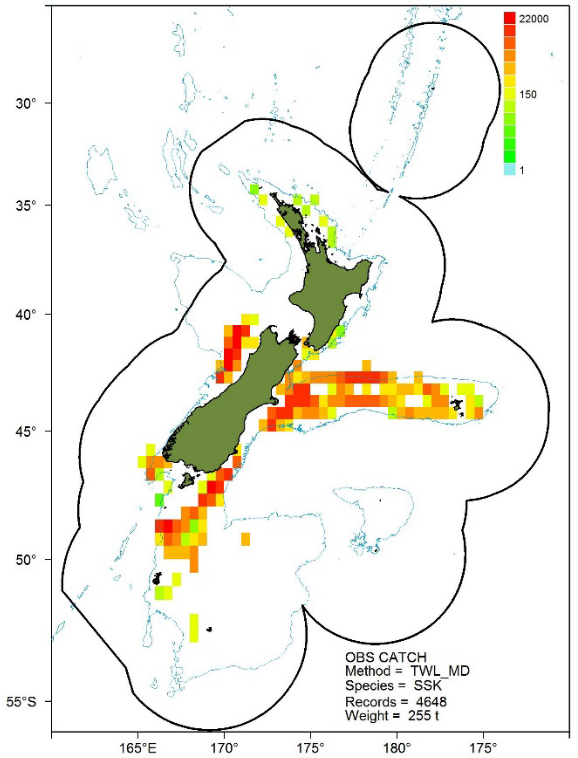


D) Shovelnose dogfish trawl catch

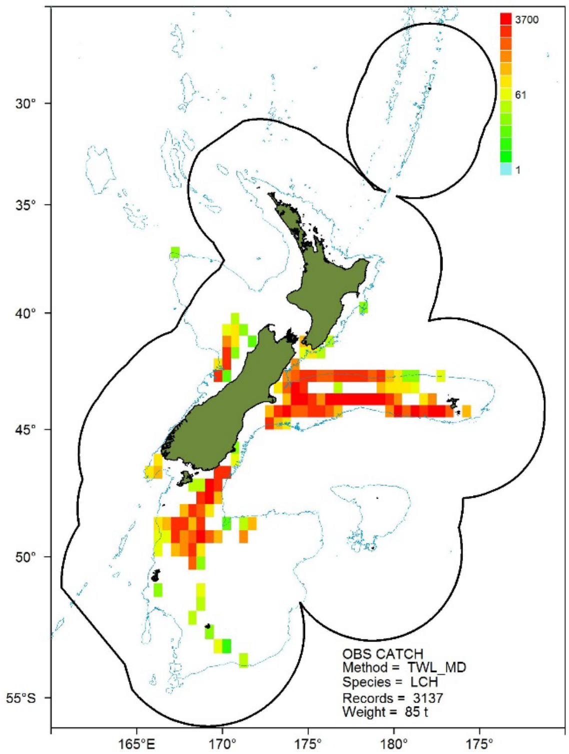
APPENDIX 5 (continued).



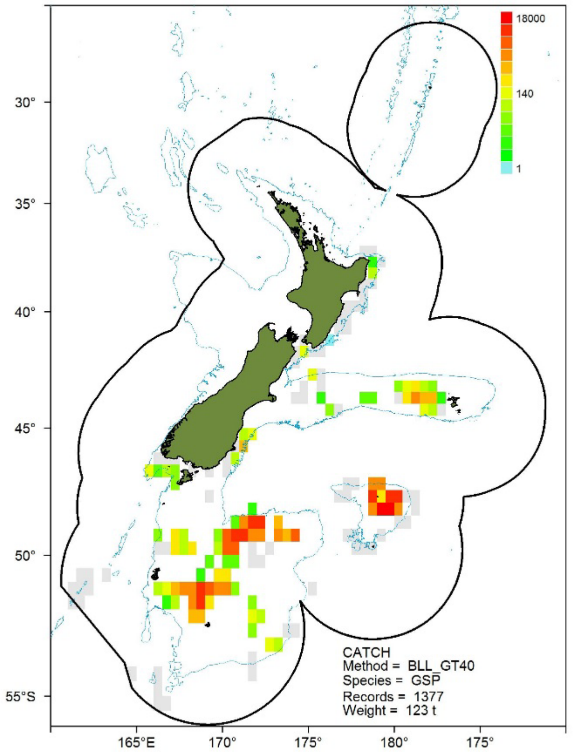
E) Observed prickly dogfish catch, midwater trawl



F) Observed smooth skate catch, midwater trawl



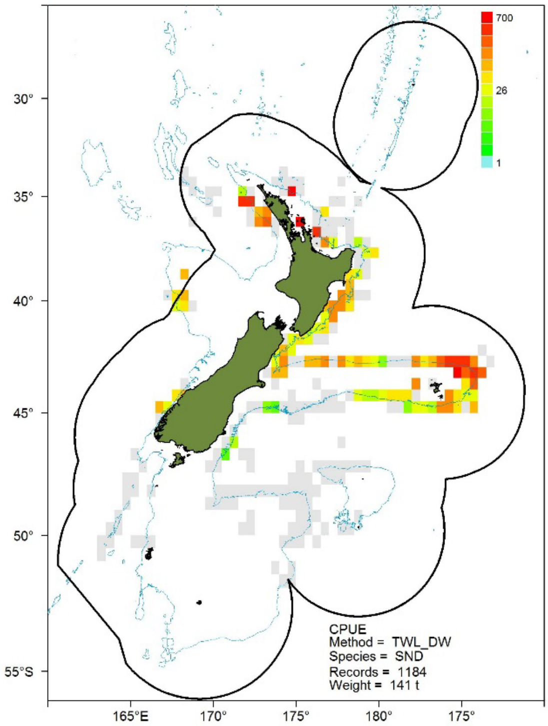
G) Observed longnose chimaera catch, midwater trawl



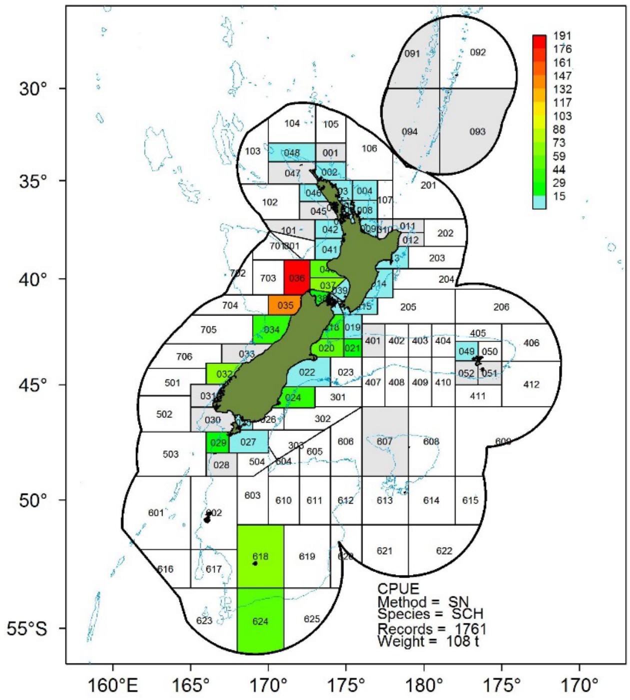
H) Pale ghost shark catch, bottom longline (vessels > 40 m)

APPENDIX 6: Examples of distributional maps of CPUE

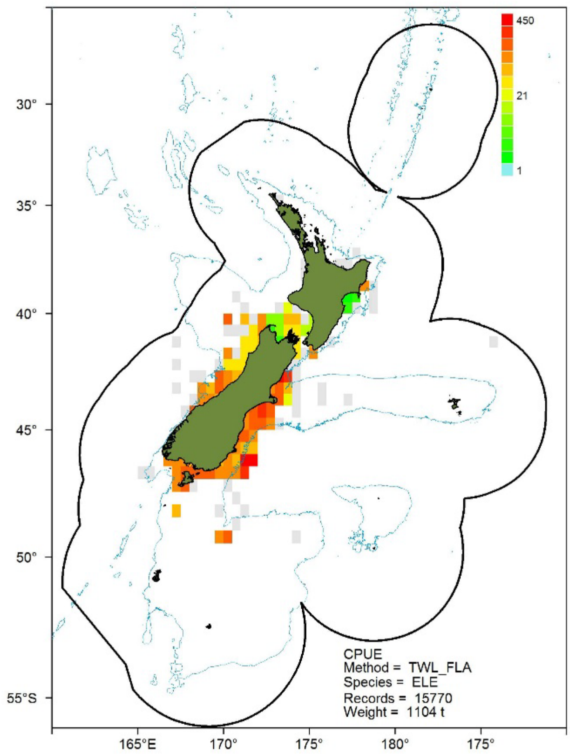
Grey pixels indicate fishing effort that produced no catch. Scale bars are on a log scale (except for B which is on a linear scale), but numerals show untransformed values (CPUE in kg per unit of effort).



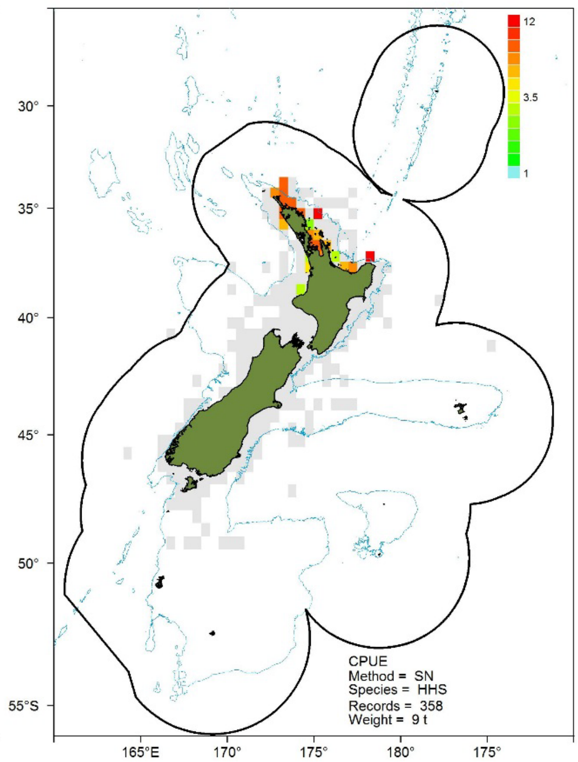
A) Shovelnose dogfish CPUE, deepwater trawl



B) School shark set net CPUE, CELR data at statistical area resolution



C) Elephantfish CPUE, flatfish trawl



D) Hammerhead shark CPUE, set net