Ministry for Primary Industries
Manatū Ahu Matua

Incorporating Economics into Traditional CPUE Analyses

New Zealand Fisheries Assessment Report 2013/61

P. D. R. Lallemand

ISSN 1179-5352 (online)
ISBN 978-0-478-42079-1 (online)

October 2013

New Zealand Government

Growing and Protecting New Zealand

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-resources/publications.aspx
http://fs.fish.govt.nz go to Document library/Research reports

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1. INTRODUCTION **2**
2. DEFINITION OF KEY TERMS **3**
2.1 Registered Client (or client ID) 3
2.2 Vessel skipper, owner, operator and notified user 3
2.3 Fishing permit holder 4
2.4 Quota owner and Quota buyer 4
2.5 Included person 4
2.6 ACE owner and ACE buyer 5
2.7 Fishing Segments 6
2.8 Strategic behaviour and structure of fishing operations 6
3. Data and Methods **12**
3.1 Primary data 12
3.2 Data linkage methods 12
3.3 Strategy indices calculation 13
3.4 Structural indexes calculation 19
4. Relevant Economic Trends in the Fisheries **20**
4.1 Quota Holdings 20
4.1.1 Quota Owners 20
4.1.2 Quota Transactions 23
4.1.3 Quota Values 23
4.2 ACE Holdings 26
4.2.1 Ace Prices 27
4.2.2 Ace Traded 30
4.3 Fishing Permit Holders 33
4.4 Fishing vessels 36
4.5 Fishing events 39
4.6 Strategic behaviours 49
4.7 Catch vs. TACC 61
4.7.1 Total Allowable Commercial Catch (TACC) 61
4.7.2 Cumulative catch and ACE transfers 62
4.7.3 Under-Catch 64
4.7.4 Over-Catch and Deemed Values 65
4.8 Port Prices 66
4.9 CPUEs 67
5. CPUE Analysis and Preliminary Results **81**
5.1 Models comparison 81
5.1.1 Data selection process. 81
5.1.2 Economics and other variables tested in the model 82
5.2 FLA_BT_FLA 87
5.2.1 Summary results. 87
5.2.2 Data Subset. 88
5.2.3 Stepwise selection of model terms 89
5.2.4 Influence of model terms on annual CPUE indices 89
5.2.5 Generalised Linear Model Regression parameters 96
5.3 FLA_BT_MIX 97

5.3.1 Summary results. 97
5.3.2 Data Subset. 98
5.3.3 Stepwise selection of model terms 99
5.3.4 Influence of model terms on annual CPUE indices 99
5.3.5 Generalised Linear Model Regression parameters 108
5.4 GUR_BT_MIX 110
5.4.1 Summary results. 110
5.4.2 Data Subset. 111
5.4.3 Stepwise selection of model terms 112
5.4.4 Influence of model terms on annual CPUE indices 112
5.4.5 Generalised Linear Model Regression parameters 120
5.5 GUR_BT_TAR 122
5.5.1 Summary results. 122
5.5.2 Data Subset. 123
5.5.3 Stepwise selection of model terms 124
5.5.4 Influence of model terms on annual CPUE indices 124
5.5.5 Generalised Linear Model Regression parameters 132
5.6 SNA_BT_MIX 134
5.6.1 Summary results. 134
5.6.2 Data Subset. 135
5.6.3 Stepwise selection of model terms 136
5.6.4 Influence of model terms on annual CPUE indices 136
5.6.5 Generalised Linear Model Regression parameters 145
5.7 TAR_BT_TAR 147
5.7.1 Summary results. 147
5.7.2 Data Subset. 148
5.7.3 Stepwise selection of model terms 149
5.7.4 Influence of model terms on annual CPUE indices 149
5.7.5 Generalised Linear Model Regression parameters 157
5.8 TRE_BT_MIX 159
5.8.1 Summary results. 159
5.8.2 Data Subset. 160
5.8.3 Stepwise selection of model terms 161
5.8.4 Influence of model terms on annual CPUE indices 161
5.8.5 Generalised Linear Model Regression parameters 170
5.9 TRE_BT_TAR 172
5.9.1 Summary results. 172
5.9.2 Data Subset. 173
5.9.3 Stepwise selection of model terms 174
5.9.4 Influence of model terms on annual CPUE indices 174
5.9.5 Generalised Linear Model Regression parameters 182
6. SUMMARY AND RECOMMENDATIONS 184
7. ACKNOWLEDGMENT 186
8. REFERENCES 187
9. LIST OF TABLES 189
10. LIST OF FIGURES 191
11. APPENDIX 198

EXECUTIVE SUMMARY

Lallemand, P.D.R. (2013). Incorporating Economics into Traditional CPUE Analyses; 2003–04 to 2009–10.

***New Zealand Fisheries Assessment Report 2013/61.* 226 p.**

The Ministry of Primary Industry - Fisheries (MPI) commissioned this work to recommend ways to incorporate economics into traditional catch per unit effort (CPUE) analyses. Year effects estimated from CPUE analysis are used as indices of abundance for many New Zealand Fishstocks - in some cases as an input into a stock assessment, but often simply to inform fisheries managers on trends in the status of the stock.

Annual indices of abundance are estimated from catch (landings) and effort data by standardising for the effect of factors which influence catch rate and which may vary over time. The traditional analysis sometimes fails to capture patterns in behaviours reflecting economic incentives. In some instances, such forces might explain changes in CPUE that are not due to changes in abundance. For example, fishers may deliberately avoid catching fish from a particular Fishstock for lack of Annual Catch Entitlement (ACE) to cover their catch. Without an informed model incorporating such crucial elements one may incorrectly conclude that the abundance of an “economically undesirable” species is declining.

Through this exploratory work, it is acknowledged that there are gaps in the availability of pertinent economic data. This work concentrates on characterising fishers’ economic behaviours to model CPUE change over time. This approach is tested using statistics and econometric modelling of CPUE for several Fishstocks in New Zealand Central (East) Fisheries (QMA 2). First, fishing activities or segments are characterised for the following five Fishstocks, FLA 2 or flatfish (*Colistiums nudipinnis, Peltorhamphus novaezeelandiae, Colistium guntheri, Rhombosoleas retiaria, Rhombosolea plebeia, Rhombosolea leporina, Rhombosolea tapirina, Pelotretis flavilatus*), GUR 2 or red gurnard (*Chelidonichthys kumu Kumukumu*), SNA 2 or snapper (*Pagrus auratus*), TAR 2 or tarakihi (*Nemadactylus macropterus*) and TRE 2 or trevally (*Pseudocaranx dentex*). These segments are defined by the target species, method used and species caught.

This study speculates that strategic behaviours associated with fishing permit holders’ propensity to cover their catch with ACE and/ or deemed value (DV) should be a key element in explaining changes in their catch rates. Moreover, through economic incentives, these strategies could well lead to behaviours such as fish avoidance, discarding and changes in fishing patterns, to name but a few. Therefore it is argued here that CPUE analysis should take into account these strategic behaviours to avoid misleading conclusions about changes in abundance. Human behaviour cannot be ignored when explaining reported catch rate.

Additionally, this work tested for the influence of other economic variables believed to potentially confound the CPUE-abundance relationship. These variables were chosen as proxies for the availability of ACE and to capture fishers’ economic incentives to catch or avoid fish (i.e. based on ACE prices, deemed values and port prices). Although this work is only exploratory, the analysis shows promising results. Depending on the fishing activities analysed, one or more of these variables were found to have some influence in the model.

This work constitutes a promising basis for further development although these will be challenging due to the lack of economic data currently being collected. At present, the data gathering system needs improvement and additional data and longer time series are required to extend this work.

1. INTRODUCTION

This report explores ways to incorporate economic factors into traditional catch per unit effort (CPUE) analyses. The addition of economic (and possibly other) variables to CPUE analyses is then examined to determine whether they have any explanatory power. However, since there is very little systematic fisheries economic data collection in New Zealand, it was necessary to use proxies to test the influence of such variables in the CPUE model. For example, data on quota lease transactions (quantities and prices) were used as a proxy for fishers' economic behaviours *vis-à-vis* their propensity to target certain fish species. This was used as a measure of economic incentive before and during the fishing activity.

A methodology was then developed to characterise fishing permit holders according to three potential strategic behaviours. These three strategic behaviours were defined as "opportunistic or *ad hoc*", "contracted" and "vertically integrated". The significance of such strategic behaviours was then tested through statistics and econometric modelling of CPUE for five Fishstocks (FLA 2, GUR 2, SNA 2, TAR 2 and TRE 2) in New Zealand Central (East) Fisheries (Area 2) (Figure 1).

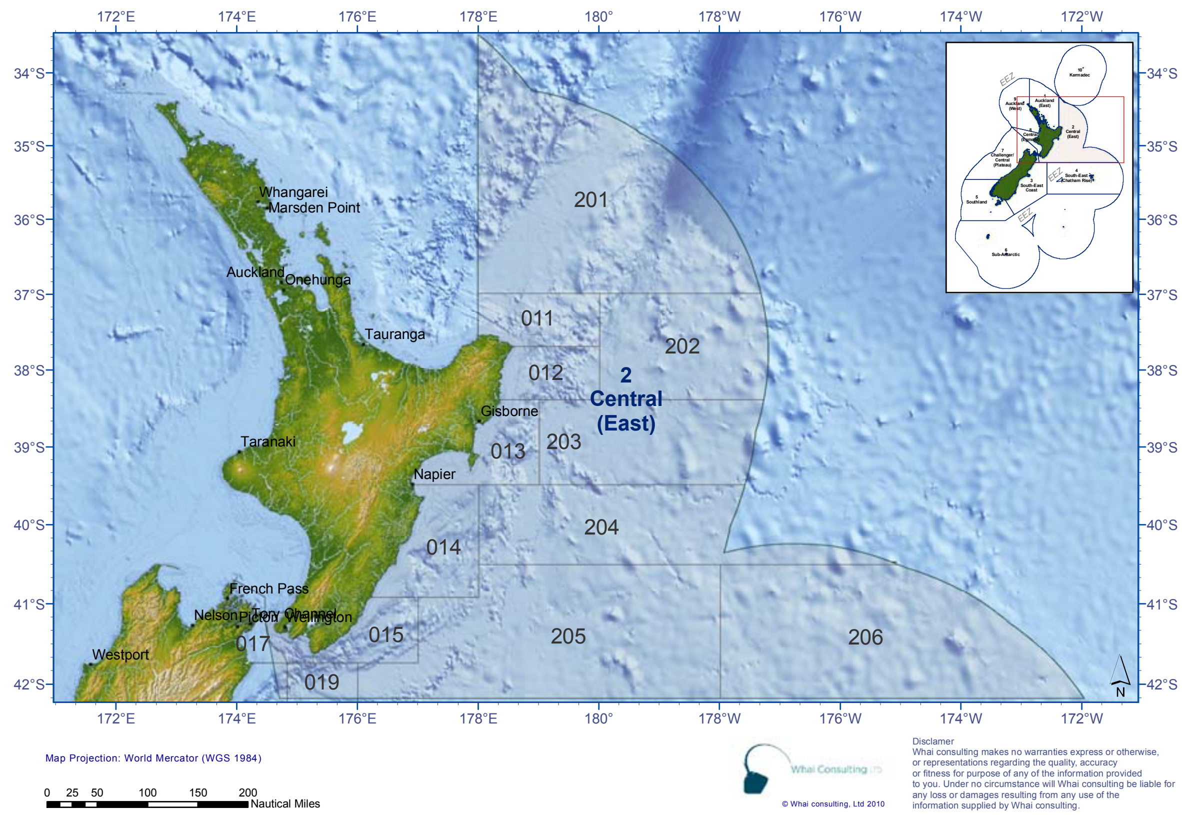


Figure 1: Fisheries Quota Management Area 2, Central-East.

2. DEFINITION OF KEY TERMS

Throughout this study, the following terms are used with a particular meaning: registered client or client ID, vessel skipper, owner and / or operator, fishing permit holder, quota owner and/ or buyer, included (or associated) person, ACE owner and/ or buyer, fishing segment, strategic behaviour and structure of the fishing operations. Below is a brief description of these key terms.

2.1 Registered Client (or client ID)

Before becoming a commercial fisher or trading ACE and quota in New Zealand, one first needs to register as a FishServe client. A client can be a company, incorporated society, partnership, trust, individual or joint individuals. A Company includes a limited liability company, a body corporate or a statutory body with corporate status. Any registered FishServe Client is expected to be aware of how the Quota Management System works and of their responsibilities under the Fisheries Act 1996; among others, some of the responsibilities include:

- for the **Fishing Permit holder**: Supply a current permit, source Annual Catch Entitlement (ACE), pay deemed values (DV), fulfil reporting requirements as specified in regulation;
- for the **Vessel Operator**: Apply to register vessel, employ crew and meet all of their working requirements.

There is no fee to register as a client. Once registered, the client is given a unique client ID and only then may apply for a fishing permit or to register a fishing vessel, obtain ACE or quota shares. In the text the terms client and client ID may both be used to refer to either a fishing permit holder, ACE or quota owner. The analysis concentrates on these three categories of clients which are not mutually exclusive: that is, the same client ID can be use to link information from various databases where the person is at the same time the vessel operator, fishing permit holder, ACE and Quota owner

2.2 Vessel skipper, owner, operator and notified user

Once given a Client ID, a client can register as a vessel owner, operator and/ or notified user.

- The vessel owner is the person or entity that owns the vessel.
- The notified user is the person or entity that intends to use the vessel for the purpose of commercial fishing or transporting fish.
- The vessel operator is the person who by virtue of ownership, a lease, a sublease, a charter, a subcharter, or otherwise, for the time being has lawful possession and control of the vessel. Foreign Charter Vessels (FCVs) are vessels owned or operated by an overseas person, as defined by s103(4) of the Fisheries Act 1996 (the Act). FCVs have different registration requirements than New Zealand owned vessels. Under s103(4) of the Act, prior to the vessel being registered , the Chief Executive of the Ministry of Fisheries (MFish) must consent to the registration. Under this section of the Act, the Chief Executive has the power to place conditions on his consent to register the vessel

Any commercial fishing vessel must be registered to an operator.

- Fishing vessel skippers are in overall charge of boats that catch fish at sea. A skipper and/or crew of a vessel who is using the Operator’s permit does not need to be registered as a Notified User. Skippers’ responsibilities include: planning fishing voyages, operating and maintaining equipment, navigating the vessel, safety and management of the vessel and crew, working closely with onshore agents to land and sell the catch, and making sure that fishing trips return a profit. As such they influence how the boat is run and have a great input into the catch success. Although this work does not look directly at skipper effect on catch, vessel ID is used as a proxy for a series of variables such as vessel characteristics and skipper comparative advantage (referred to as “skipper skill”).

A vessel skipper, owner, operator and/ or notified user can be an overseas person. An “overseas person” is expressly defined in the Fisheries Act 1996 by section 7 of the Overseas Investment Act

2005A vessel owner can also operate the vessel (i.e. can be identified as the vessel owner/operator). Because of the nature of this analysis vessel owners, operators or notified users are not identified, the analysis rather concentrates on the fishing permit holders and the ACE and quota holders linked to them.

2.3 Fishing permit holder

Any registered client can apply to become a permit holder. The fishing permit holder has the responsibility to supply a current permit, source ACE, pay deemed values, and fulfil reporting requirements as specified in regulation. If a vessel operator holds a current fishing permit (i.e. is the fishing permit holder as well), then they have the responsibility to submit Catch Effort Returns for each vessel that is registered to them. There are a number of returns that must be completed by all fishers. To comply with the Fisheries (Reporting) Regulations 2001 and any reporting requirements listed on the individual fishing permit, the correct returns need to be filed. Because of the narrow scope of this analysis, only the following forms were considered: Trawl Catch Effort and Processing Returns (TCEPR), Catch Effort Landing Returns (CELR) and, since October 2007, Trawl Catch Effort Returns (TCER).

If the vessel is registered for only part of a month or the vessel operator holds a permit for only part of a month, it is still required to submit returns for that month. If there is no fishing during a particular month, it is still required to submit a nil return for each vessel registered to an operator holding a fishing permit.

This study is mostly interested in the economic behaviour of the fishing permit holders (FPH). As such it looks at where and when they source their ACE to cover their vessels' catch.

2.4 Quota owner and Quota buyer

The Quota owner or transferor is the person from whom the quota shares are being transferred. The transferor must own the ITQ being transferred. The Quota buyer or transferee is the person to whom the quota shares are being transferred. Both the transferee and transferor must be registered as clients with FishServe before a transfer can be registered.

2.5 Included person

Under the Fisheries Act 1996, specific types of relationships between registered clients have to be declared. "Included persons" constitute any relationships with other persons in the fishing industry, for the purposes of administering sections 59, 60 and 61 (aggregation limits) and sections 78 and 79 (prohibitions and suspensions of permits) of the Fisheries Act 1996.
In the definition of relationships for the purposes of administering Aggregation Limits in accordance with sections 59, 60(4) and 61 of the Fisheries Act 1996, the term person, in relation to a particular person includes:

(a) any person who is in partnership with the person.
(b) any person who is a director or employee of any company of which the person is a director or employee.
(c) any person who is a relative of the person as defined in paragraph (a) of the definition of that term in section OB 1 of the Income Tax Act 1994.
(d) any person who would be an associated person under the test provided in section OD 7 of the Income Tax Act 1994, except that subparagraph (a)(v) of the definition of market value circumstance in section OB 1 of that Act does not apply.
(e) any beneficiary or trustee of any trust of which the person is a trustee or beneficiary.

In the definition of relationships for the purposes of administering Prohibitions and Suspensions of Permits in accordance with sections 78 and 79 of the Fisheries Act 1996, a person or entity is to be treated as a person included with the commercial fisher if the person or entity is:

(a) a subsidiary of the commercial fisher within the meaning of section 5 of the Companies Act 1993; or
(b) a company of which the commercial fisher is a subsidiary within the meaning of section 5 of the Companies Act 1993; or

a partnership or unincorporated joint venture that would be a subsidiary of the commercial fisher, or of which the commercial fisher would be a subsidiary, if the partnership or joint venture were incorporated as a company with shareholdings corresponding to the interests, including returns, of the partners in the partnership or participants in the joint venture.
Note that for the purposes of these sections the Treaty of Waitangi Fisheries Commission is not regarded as being included with any other person.
Any of the following qualifies as a relationship and should be considered as an included person: a partnership, Director/Employee, Trustee/Beneficiary, Relative, Associate, Parent Company, Subsidiary Company, Unincorporated Joint Venture. However not all associations are declared through the "Included Person" rule: For example, any association between a quota owner and an ACE owner might not be subject to the rule if the ACE owner does not own any quota and if their fishing permit has not been suspended or prohibited.

Through the information provided on included persons, it is possible to connect clients together looking at several degrees of separation. This analysis managed to connect fishing permit holders with up to 18 "included persons" through the commutative and transitive properties of relationships, using up to 6 degrees of separation. That is:

- *Commutative property*: if client A declares client B as an included person (i.e. client A is connected to client B) then client B should also declare client A as an included person.

  $$\textit{if } a\,\boldsymbol{R}\,b \textit{ then } b\,\boldsymbol{R}\,a$$

  where "***R***" represents some relationship between a and b
  In fact, after a closer look at the database of included person provided, it became evident that some of these commutative properties were violated when several clients omitted to declare a reciprocal relationship. To correct such omissions, it was necessary to re-establish these links programmatically through SQL queries
- *Transitive property*: : if client A declares client B as an included person and client B declares client C as an included person (i.e. client A is connected to client B and client B to client C) then client A should also declare client C as an included person.

  $$\textit{if } a\,\boldsymbol{R}\,b \textit{ and } b\,\boldsymbol{R}\,c \textit{ then } a\,\boldsymbol{R}\,c$$

Unfortunately it is not always possible to identify such relationships if the declaration of included persons is not required by law. Therefore, this analysis could only take into account included persons that had to be declared under the regulation.

Taking into account such relationships increases the amount of ACE available to fishing permit holders if they are associated with other clients holding ACE. Indeed, using the information on included persons, it was possible to identify several clients with a fishing permit that seemed to be lacking access to ACE when in fact they were connected to companies with enough ACE to cover their catch.

2.6 ACE owner and ACE buyer

The ACE owner or transferor is the person from whom the ACE is being transferred. They may also be referred to as the ACE holder. ACE owners of a Fishstock might or might not own Quota of the same Fishstock. If so, the amount of Quota owned might exceed, equal or be below the amount of the corresponding ACE. The ACE buyer or transferee is the person to whom the ACE is being transferred. The ACE buyer, as for the transferor, must be registered as a client with FishServe before a transfer can be registered. ACE transfers might occur at any time during the fishing year and during the Catch-ACE balancing period at the end of the fishing year.

2.7 Fishing Segments

This project looks at fishing activities or "segments" involving the potential catch of species from the following five Fishstocks: FLA 2 or flatfish, GUR 2 or red gurnard, SNA 2 or snapper, TAR 2 or tarakihi and TRE 2 or trevally. Following the terminology used by Trophia (see Kendrick and Bentley -2010a, 2010b, 2011a, 2011b, 2011c, 2011d, 2011e, 2011f, 2011g and Bentley et al. - 2012), eight so-called "segments" were identified which were labelled following the template "SC_M_ST" from the combination of species caught (SC), method used (M) and species targeted (ST). These eight segments are as follows: FLA_BT_FLA, FLA_BT_MIX, GUR_BT_MIX, GUR_BT_TAR, SNA_BT_MIX, TAR_BT_TAR, TRE_BT_MIX, TRE_BT_TAR where "BT" refers to bottom trawl method, "MIX" refers to cases when more than one species was targeted, FLA, GUR, SNA, TAR and TRE corresponding to the five Fishstocks.

2.8 Strategic behaviour and structure of fishing operations

There is a saying that "Fishers fish for dollars not fish". It is important to acknowledge that the level of participation in any given fishery is dependent on a rational decision based on available choices, and economic or other incentives that fishers face under the quota management system. Although bounded by regulations such as global catch limits, fishers' behaviour may result in catch levels below (or above) their catch entitlement (Quota/ACE) depending foremost on expected profitability and not strictly on expected landings, so long as the net value of a unit of fish generates enough profits.

Somehow, fishers available choices to access ACE and/ or Quota needs to be incorporated into the model to mimic these economic behaviours. Therefore this analysis concentrates on modelling fishers' strategic behaviour reflecting their propensity to acquire ACE to cover their catch for each individual Fishstock.

The primary objective in strategy-structure alignment is for management to design and decide upon an organizational structure that best supports its strategy and to develop processes that facilitate the balance between the two. Because the New Zealand fishing industry faces regulatory, environmental and market risk and uncertainty, flexibility and risk management is the essence. Successful operations will adopt strategies and structures that best fit their situation and are based on their perception and weighing of risk and uncertainty.

Four strategic behaviours relating to ACE acquisition were therefore defined based on willingness to acquire ACE and ease of access to it. These behaviours were rated according to their expected features and described based on their likely implications as follows:

1. Opportunist:
    - acquires ACE from numerous sources on the "open" ACE market;
    - is vulnerable to ACE market price and availability (i.e. supply and demand);
    - catches the species as bycatch or sporadically when market opportunities arise;
    - does not systematically try to target nor avoid catching the species.
2. Contracted:
    - ACE is provided by the contractor;
    - fish under contract to a somewhat strict fishing plan specification;
    - is vulnerable to contractor pressure to meet the fishing plan (might lack the flexibility to pursue market opportunities of its own);
    - needs to target species until fishing plan is met, after that, likely to avoid or discard the species.

3. Vertically integrated:
   - ACE provided in-house or through conglomerate (through the mother company and/ or included/ associated person);
   - fish under a fishing plan defined with more or less flexibility as market opportunities arise;
   - is vulnerable to its own ACE availability, inadequate fishing plans and lost opportunities to lease out (i.e. this is a financial and marketing decision whereby the vertically integrated company decides whether it is more profitable to lease out its ACE and get the revenue from the sale of ACE or use the available ACE to catch fish in-house and get the profit from the sale of fish);
   - needs to target species until fishing plan is met, after that, might avoid or discard species.
4. Accidental or *ad hoc*:
   - might get ACE from the "open" ACE market but more likely to pay deemed value;
   - unintentionally and sporadically catches the species;
   - is vulnerable to transaction cost, ACE prices, availability and deemed value rates;
   - does not target but avoids catching the species more or less successfully (usually catches small amounts of the species).

Later in this analysis strategic behaviours number 1 and 4 are grouped under a single one, indexed 1 describing "opportunistic, independent, accidental and *ad hoc*" behaviour. This was decided for three reasons:

- it was acknowledged that permit holders exhibiting opportunistic and accidental behaviours were equally vulnerable to ACE availability, the difference being mostly the transaction cost faced by the accidental permit holder;
- those behaviours (especially accidental) tended to be the exception rather than the rule;
- grouping categories 1 and 4 under the "independent" label gave a better and more balanced data representation in each of the strategic behaviours identified.

Note that both "contracted" (strategy 2) and "vertically integrated" (strategy 3) behaviours are most likely to follow some sort of fishing plan while the so-called "independent" (strategy 1) behaviour is less likely to follow any. In other words strategies 2 and 3 are mostly constrained by fishing plans while strategy 1 is mostly constrained by ACE availability.

Strategic behaviours towards a specific Fishstock may vary from month to month; however patterns may emerge in each year reflecting the underlying structure of the fishing permit holder. In other words, in the short term (i.e. at the month level), the nature of the relationship between the fishing permit holder and all their ACE providers for that month will determine a short term strategic behaviour for that month. However, persistent relationships (i.e which last the entire year) will indicate a structural connection between the fishing permit holder and his or her ACE provider(s). As with the four core strategic behaviours identified earlier, four core structures behind most fishing operations were identified.

1. Independent quota-owner permit holder:

The fishing permit holder owns quota for the Fishstock and is actively involved in commercial fishing activities for that species operating one or more vessels (Figure 2). Most of the relevant ACE is generated directly from their own quota holding but when required, he or she may have to seek more ACE on the open market. Such structure is not incompatible with any of the short term strategic behaviours identified earlier. That is, an independent quota-owner operator can engage in a contract with a third party partially or for an entire month.

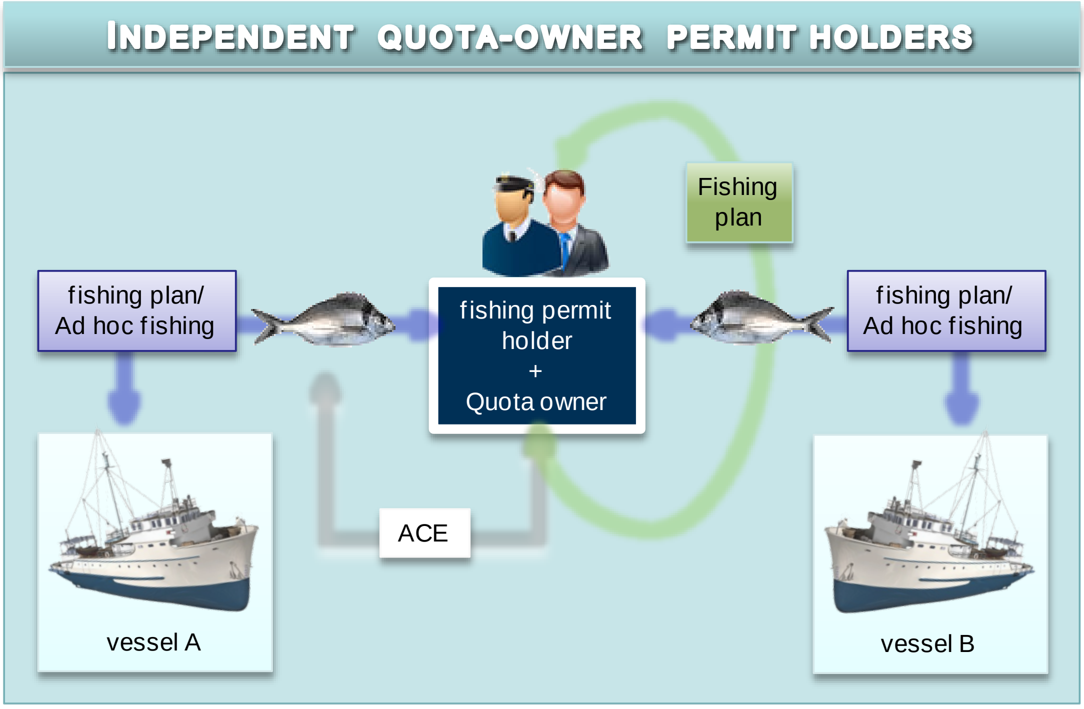


Figure 2: Structure of Independent quota-owner permit holders.

2. Contracted permit holder:

As its name indicates, a contracted ACE-permit holder is a fishing permit holder who depends on a contractor to provide them with ACE to cover all the Fishstocks agreed upon in the contracted fishing plan (Figure 3). The contracted ACE-permit holder will be constrained most of the year by fishing plans and as such, short term behaviour involving opportunistic strategies is very unlikely. Most contractors will put pressure on their contracted ACE-permit holder to honour their fish plan before engaging in independent behaviour even for a short period.

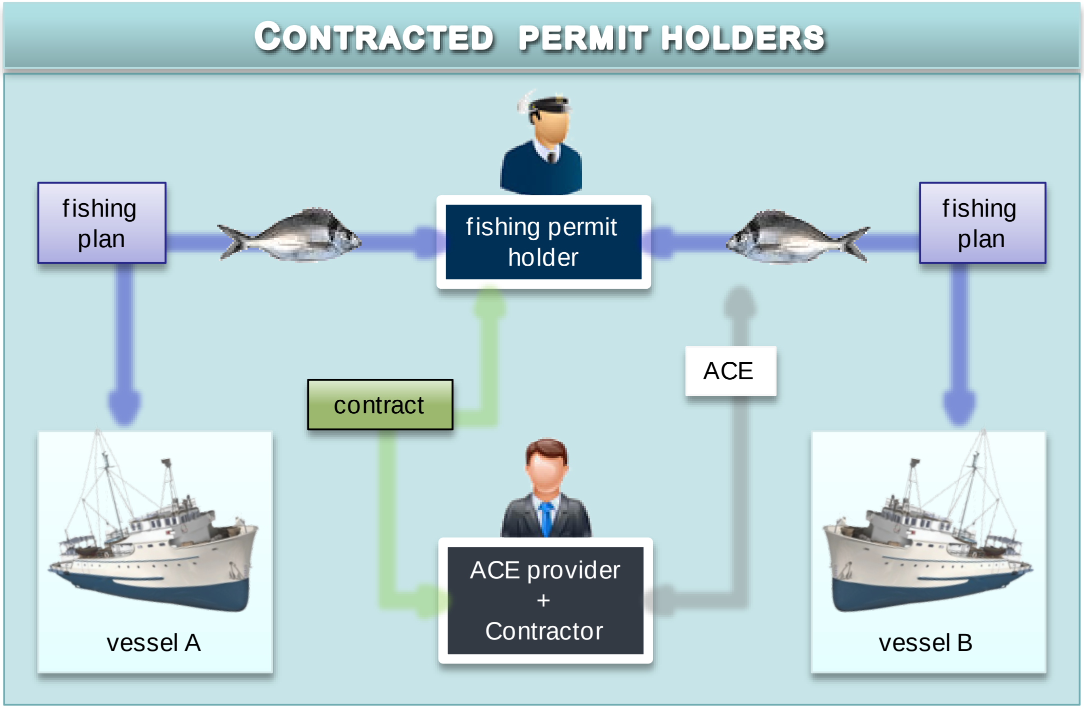


Figure 3: Structure of contracted permit holders.

3. Vertically integrated permit holder

A vertically integrated permit holder may have to follow strict fishing plans as dictated by the mother company's fleet manager or may have some flexibility to pursue fishing opportunities as dictated by the market (Figure 4). These fishing operators may have more flexibility than the contracted ones in deciding what, where and when to fish. They should not be as vulnerable to ACE availability as the independent permit holders.

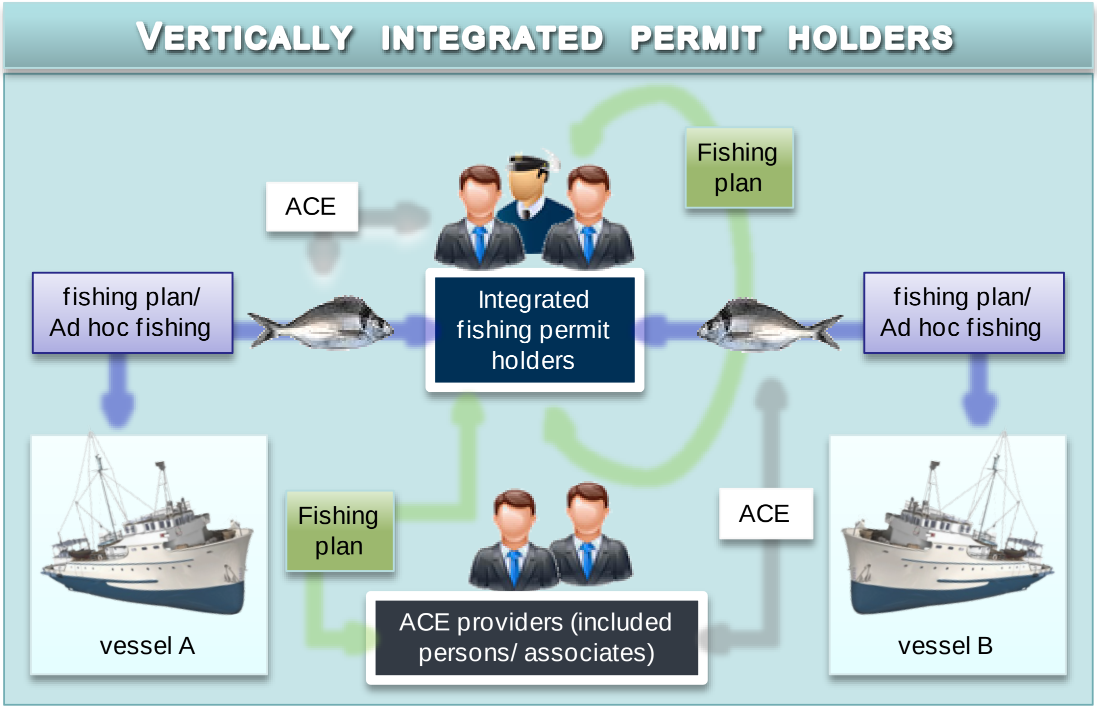


Figure 4: Structure of vertically integrated permit holders.

4. Opportunistic permit holder

This type of permit holder is the most vulnerable to ACE availability. They will target particular species as market opportunities arise and based on their likelihood to acquire ACE from various sources to cover their catch (Figure 5). They may from time to time and for a short period engage in a contract with an ACE provider to fish according to a specific fishing plan, but they are mostly independent fishers seeking ACE to cover their ad-hoc catch from the ACE market.

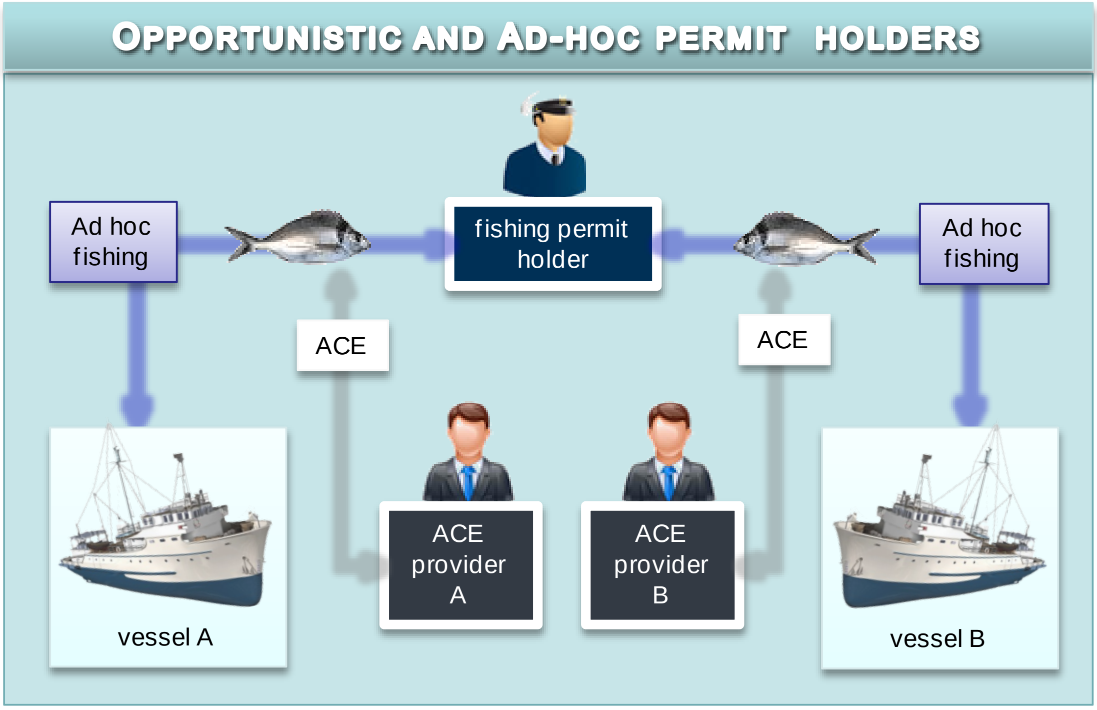


Figure 5: Structure of Opportunistic permit holders.

3. DATA AND METHODS

3.1 Primary data

This study herein focuses on fisheries for which it is suspected that strategic behaviour of fishing permit holders may have an impact on observed CPUE. It was therefore decided to concentrate on five Fishstocks from the QMA 2 Central (East) trawl fishery (FLA 2, GUR 2, SNA 2, TAR 2 and TRE 2) The groomed reconciled catch-effort and landing data (GRCEL) were made available by Nokome Bentley from Trophia Ltd. (ref. replog 8015 for INS 2009-03) via the Ministry of Fisheries (now Ministry for Primary Industries). In the original data held by Trophia and to preserve confidentiality, the vessel identification number or vessel ID had been replaced by a randomly generated vessel key. Subsequently the vessel key was recoded with the original vessel IDs so that the anonymous catch effort data could be linked to actual vessels and clients. The Ministry provided the corresponding fishing permit holder's client ID linked to each record and vessel specification data for vessels catching any of the five species.

The GRCEL data were aggregated into strata; each defined as a unique combination of:

- vessel
- fishing permit holder
- date
- primary method (i.e. Bottom Trawl)
- target species
- statistical area.

The monthly ACE-Catch balancing and Quota holdings for any registered clients involved in catching and/or trading either ACE or quota in the five Fishstocks was also provided. This included most of the fishing permit holders identified in the catch-effort and landing database (some fishing permit holders were absent from this database, probably because they were balancing their catch exclusively using deemed value payments).

A comprehensive dataset was also available, recording ACE transfers of any of the five Fishstocks from and to registered clients including quantity and price. This database included most but not all fishing permit holders appearing in the catch-effort and landing database.

From the included person database, it was possible to link fishing permit holders to their associated persons and estimate aggregated ACE and Quota holdings from the Fisheries Register Extract Database (FRED). It was assumed that the aggregated ACE holdings could potentially be made available by the included person to the permit holder. If this were the norm, this would translate to a de-facto increase in ACE holdings/ access for the permit holder.

In parallel to collecting these primary data, data were also compiled on:

- Deemed values, ACE and quota prices from the Blue Book maintained by FishServe
- Ex-vessel prices from the Ministry of Fisheries port survey
- ACE and Quota transactions from the Blue Book updated by FishServe.

3.2 Data linkage methods

The data used to model CPUE were generated from various data sources:

- Groomed and Reconciled Catch-Effort and Landing data (GRCEL) provided by the Ministry of Fisheries' Research Data Management (RDM) team (catch and effort were processed using Starr (2007)'s effort restratification and landed catch allocation algorithm).

- Vessel specifications (VS) provided by MFish's RDM.
- List of included persons (IP) provided by FishServe.
- Market ACE prices (AP) from FishServe's Blue Book.
- ACE transfers data (AT) provided by MFish's RDM.
- Catch-ACE-balancing (CAB) data provided by MFish's RDM.
- Monthly Quota and ACE holdings (QAH) data provided by MFish's RDM.
- Surveyed Port Prices and Deemed value rates (PPDV) provided by MFish (see Ministry of Fisheries. Annual Prices survey and deemed values (2001–2011)).

For all the data sets the common denominator was the Client ID which, based on the context, may represent a quota owner (QAH, IP), an ACE holder (QAH, CAB, AT), an ACE seller or buyer (AT) or a fishing permit holder (QAH, GRCEL, VS). The vessel ID was also used to link VS to GRCEL. The diagram below (Figure 6) summarises those relationships; the fields used to link the various tables are highlighted in blue where "FY" stands for fishing year, "M" for month, "FS" for Fishstock. The direction of the arrow indicates the type of join between the two tables: an arrow going from left to right corresponds to a *right join* (or injective relationship) similar to the symbol used in MS ACCESS query "Design view". The tables were generated through queries in MS ACCESS or calculated in MS EXCEL to be later imported into MS ACCESS. For more details on the steps followed to generate the data used to model CPUE, see figures in the Appendix.

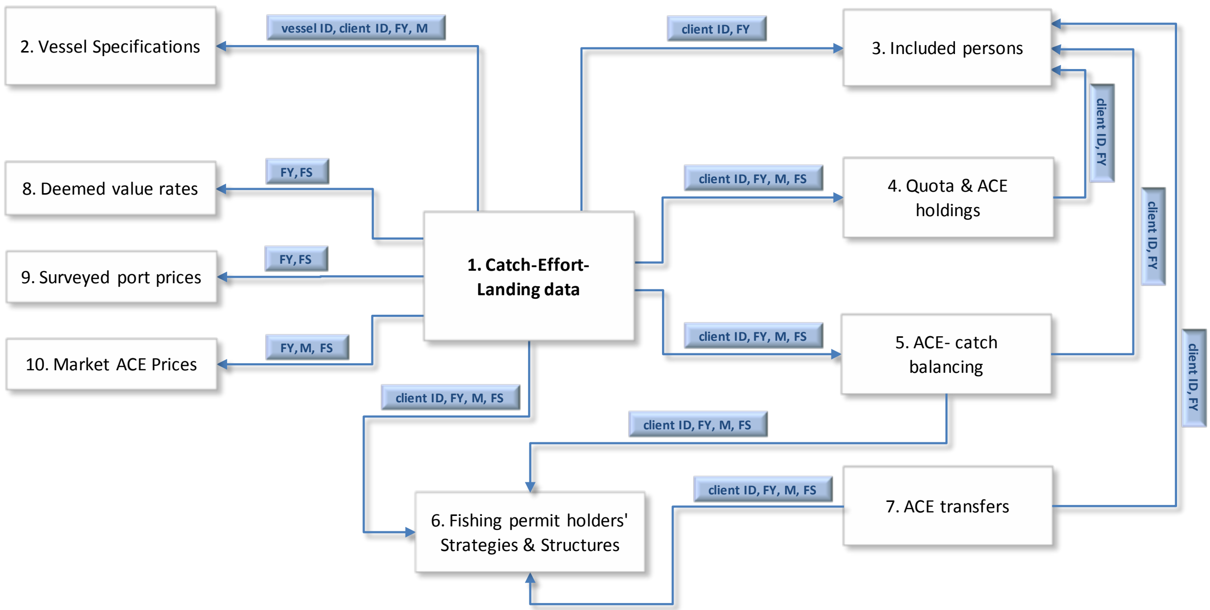


Figure 6: Diagram showing the relations linking the tables used to model CPUE.

3.3 Strategy indices calculation

Patterns arising from looking at ACE transfers can tell us a lot about the type of fishing activity and strategy behind a fishing permit holder (FPH). If the pattern shows a strong relationship to a particular ACE provider(s) then it is most likely that the FPH is under some kind of contract or is vertically integrated. Either way, such patterns suggest the FPH will probably fish under a fishing plan which will be more or less constraining depending on the FPH's type of relationship with the ACE provider.

If the FPH tends to acquire ACE from various sources without clear pattern, it is most likely that the FPH's strategic behaviour is opportunistic or ad-hoc. In such circumstances, the FPH will be highly dependent on ACE availability and prices from the ACE market but their fishing patterns may show enough flexibility to end up being highly unpredictable.

We define the strategy index $s_{i,f}^{y,m}$ of the i^{th} fishing permit holder FPH_i in a given month *m* and fishing year *y* based on patterns observed in the entire year when acquiring the amount of ACE for Fishstock *f* ACE_{i,f,n_m}^{y} from n_m clients such that,

$$ACE_{i,f,n_m}^{y} = \sum_{j=1}^{n_m} ACE_{i,f,j}^{y}$$

where,
j is the subscript for the j^{th} ACE seller/ transferor,
n_m is the total number of clients selling ACE of Fishstock *f* to client *i* in month *m* and who may also sell them ACE the rest of the year.
Note that later in the text we drop the year superscript for clarity purpose.
Here we want to identify how often (i.e. following what kind of patterns) the client *i* sources their ACE of Fishstock *f* throughout the year *y* from the n_m clients identified in month *m*. To calculate $s_{i,f}^{m}$, we assume that there was at least one ACE transfer $ACE_{i,f}^{m}$ recorded in the month (i.e. $n_m \geq 1$). When no transfer was recorded for that month, we use alternative methods to estimate $s_{i,f}^{m}$ defined below.
As mentioned earlier, we calculate $s_{i,f}^{m}$ by looking at the different options offered to the FPH_i to acquire $ACE_{i,f}^{m}$.

From the different types of information that were compiled and analysed, it is possible to deduce the most likely source of $ACE_{i,f}^{m}$ or the most plausible method(s) used by the FPH_i to cover their catch (this includes deemed value and $ACE_{i,f}^{m}$ generated from his or her own quota holdings). The monthly ACE-Catch balancing database gives the net position of the FPH_i at the end of the month so it is possible to identify ACE generated from quota when there is no recorded ACE transfer. When at least one ACE transfer *t* occurs in a month, the ACE transaction database gives information on each transfer from and to the FPH_i : this includes both the ACE transferee and transferor client IDs *i* and *j* respectively, the amount of ACE transferred $ACE_{i,f,j}^{t}$ and at what price $p_{i,f,j}^{t}$. Because ACE transfers might not occur every month we need to infer what the strategy index might have been especially if it occurred during a month when the FPH_i was reporting catching fish.

Therefore, for each month when the FPH_i was or should have been landing fish it was necessary to calculate (when the information was available), or at least derive some proxy for, the FPH_i's strategy index $s_{i,f}^{m}$. To do so, we estimated at the stratum level (i.e. vessel ID, Client ID or FPH_i, date, method, target species, statistical area and species caught), aggregated catch landed from the GRCEL database including nil catch if we expected some catch of the FPH_i's target species. We then associated each row in the database with the FPH_i's strategy index $s_{i,f}^{m}$ estimated using, when available, the information on ACE acquisition for that month. In other words:

- if we are able to observe at least one transfer of $ACE_{i,f}^{t}$ in month *m*, we use that information to calculate $s_{i,f}^{m}$;
- if we do not observe any transfer for that month but from the ACE-catch balancing database we can identify that the $ACE_{i,f}^{m}$ came from the FPH_i 's own quota, we can then cross-check that the FPH_i was indeed a quota owner who did not transfer out all their ACE to enable us to assess the relative level of $ACE_{i,f}^{m}$ compared to their overall ACE holding in order to infer $s_{i,f}^{m}$;
- if there was no transfer history of any $ACE_{i,f}^{t}$ for FPH_i in the fishing year y and FPH_i was not a quota owner and there was no $ACE_{i,f}^{m}$ showing in the ACE-catch balancing database, we deduce that the FPH_i must have been paying deemed value;
- if we were unable to observe at least one transfer of $ACE_{i,f}^{t}$ in that month m for FPH_i but we could observe at least one transfer in previous months, we can use that information to extrapolate $s_{i,f}^{m}$;
- Moreover, when a transfer of $ACE_{i,f}^{t}$ occurred, we can test whether or not the declared price for the month $p_{i,f,j}^{t}$ was "usual" (i.e. within an acceptable price range for any transaction taking place within a competitive environment) or "unusual" (i.e. outside the acceptable price range of any transaction taking place within a competitive environment). In other words, we labelled a "usual ACE price", any price which falls within the normal range defined by the observed lower and upper market ACE prices for that Fishstock in fishing year y corrected from outliers, or,

  if $p_f^{l,y} \le p_{i,f,j}^{t} \le p_f^{u,y}$ then $p_{i,f,j}^{t}$ was deemed usual

  if $p_{i,f,j}^{t} < p_f^{l,y}$ or $p_{i,f,j}^{t} > p_f^{u,y}$ then $p_{i,f,j}^{t}$ was deemed unusual

  where,

  $p_f^{l,y}$ is the lower bound of observed ACE market price for the Fishstock *f* in the fishing year *y* corrected from outliers

  and

  $p_f^{u,y}$ is the upper bound of observed ACE market price for the Fishstock *f* in the fishing year *y* corrected from outliers

  These ACE price ranges $p_f^{l,y}$ and $p_f^{u,y}$ are reported in the FishServe's "Blue Book" for each Fishstock by month.

Finally, the strategy indices $s_{i,f}^{m}$ were calculated as follows:

Step 1: we first filter the relevant ACE transfers from the ACE transactions database; for example we ignore any regulatory transfers from or to the Crown. Each record in the database corresponds to a transfer *t* of Fishstock *f* showing the date, the buyer's and seller's client IDs *i* and *j* respectively as well as the amount transferred $ACE_{i,f,j}^{t}$ at price $p_{i,f,j}^{t}$.

Step 2: from that information we calculate for each transfer *t* the ratio $r_{i,f,j}^{y}$ of aggregated ACE $ACE_{i,f,j}^{y}$ bought in the year *y* from the same client *j* over the aggregated annual ACE bought $ACE_{i,f}^{y}$ by client *i* such that:

$$ACE^{y}_{i,f,j} = \sum_{t=1}^{T} ACE^{t}_{i,f,j}$$

and:

$$ACE^{y}_{i,f} = \sum_{j=1}^{n} ACE^{y}_{i,f,j}$$

where,

$ACE^{t}_{i,f,j}$ is the amount of ACE of Fishstock *f* transferred from client *j* to client *i* during transaction *t* which took place in fishing year *y*,

$ACE^{y}_{i,f,j}$ is the aggregated annual amount of *T* transfers of ACE for Fishstock *f* from client *j* to client *i* in fishing year *y*

and

$ACE^{y}_{i,f}$ is the aggregated annual amount of transfers of ACE for Fishstock *f* from *n* clients to client *i* in fishing year *y*.

then,

$$r^{y}_{i,f,j} = \frac{ACE^{y}_{i,f,j}}{ACE^{y}_{i,f}}$$

Step 3: we then estimate the strategy index associated with each individual transfer *t* $s^{t}_{i,f}$. To do so we use an arbitrary rule of thumb as follows:

1. The strategy index $s^{t}_{i,f}$ is equal to 1 if the FPH_i is exhibiting "opportunistic or ad-hoc" like behaviour when acquiring ACE of the Fishstock *f* during transaction *t*. We then ask the question: was the FPH_i most likely to be catching the Fishstock sporadically knowing their strategic behaviour regarding ACE acquisition? To test for this, we look to see if there were numerous clients providing $ACE^{t}_{i,f,j}$ to client *i* and no client *j* stood out as the leading provider of FPH_i 's annual ACE $ACE^{y}_{i,f}$, that is:
   a) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE^{y}_{i,f,j}$ was less than 50% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE^{y}_{i,f}$ and the price $p^{t}_{i,f,j}$ was found to be within an acceptable price range given the competitive nature of the transaction. In other words:

$$ACE^{y}_{i,f,j} < 0.5 \times ACE^{y}_{i,f}$$

and

$$p^{l,y}_{f} \leq p^{t}_{i,f,j} \leq p^{u,y}_{f}$$

   In this case $p^{t}_{i,f,j}$ is considered "usual" as defined earlier in the text

Or,

   b) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE^{y}_{i,f,j}$ was less than 30% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE^{y}_{i,f}$ regardless of the price $p^{t}_{i,f,j}$. In other words:

$$ACE_{i,f,j}^{y} < 0.3 \times ACE_{i,f}^{y}$$
and
$$p_{i,f,j}^{t} \text{ can take any value}$$

In this case acceptable $p_{i,f,j}^{t}$ could be either "usual" or "unusual" as defined earlier in the text

2. The strategy index $s_{i,f}^{t}$ was equal to 2 if the FPH_i was exhibiting "contracted" like behaviour when acquiring ACE of the Fishstock *f* during transaction *t.* We then ask the question: was the FPH_i most likely to be fishing under a contracted fishing plan knowing their strategic behaviour regarding ACE acquisition? To test for this, we look to see if the client *j* providing $ACE_{i,f,j}^{t}$ to client *i* was most likely to be providing a large portion of their annual ACE $ACE_{i,f}^{y}$, that is:
   a) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE_{i,f,j}^{y}$ was greater or equal to 50% but less than 75% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE_{i,f}^{y}$ and the price $p_{i,f,j}^{t}$ was found to be "usual". In other words:
$$ACE_{i,f,j}^{y} \geq 0.5 \times ACE_{i,f}^{y} \text{ and } ACE_{i,f,j}^{y} < 0.75 \times ACE_{i,f}^{y}$$
and
$$p_{f}^{l,y} \leq p_{i,f,j}^{t} \leq p_{f}^{u,y}$$

Or,

   b) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE_{i,f,j}^{y}$ was less than 50% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE_{i,f}^{y}$ and the price $p_{i,f,j}^{t}$ was found to be "unusual". In other words:
$$ACE_{i,f,j}^{y} < 0.5 \times ACE_{i,f}^{y}$$
and
$$p_{i,f,j}^{t} < p_{f}^{l,y} \text{ or } p_{i,f,j}^{t} > p_{f}^{u,y}$$

3. Finally, the strategy index $s_{i,f}^{t}$ was equal to 3 if the FPH_i was exhibiting "vertically integrated" like behaviour when acquiring ACE of the Fishstock *f* during transaction *t.* We then ask the question: was the FPH_i most likely to be fishing under a fishing plan knowing their strategic behaviour regarding ACE acquisition? To test for this, we look to see if the client *j* providing $ACE_{i,f,j}^{t}$ to client *i* was most likely to be a strong ACE provider the rest of the fishing year *y,* that is:
   a) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE_{i,f,j}^{y}$ was greater than or equal to 75% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE_{i,f}^{y}$. In other words:

$$ACE^{y}_{i,f,j} \geq 0.75 \times ACE^{y}_{i,f}$$

Or,

b) the total amount of ACE bought by FPH_i from client *j* during the fishing year *y* $ACE^{y}_{i,f,j}$ was greater than or equal to 50% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE^{y}_{i,f}$ and the price $p^{t}_{i,f,j}$ was found to be unusual. In other words:

$$ACE^{y}_{i,f,j} \geq 0.5 \times ACE^{y}_{i,f}$$

and

$$p^{t}_{i,f,j} < p^{l,y}_{f} \text{ or } p^{t}_{i,f,j} > p^{u,y}_{f}$$

Or,

c) the FPH_i was associated with client *j*, (i.e. the ACE transferor was an included person of the FPH_i) and the total amount of ACE bought from client *j* of Fishstock *f* for the entire fishing year *y* $ACE^{y}_{i,f,j}$ was at least 50% of the total amount of ACE acquired by client *i* in that year from all clients combined $ACE^{y}_{i,f}$. In other words:

$$FPH_i \;\; R \text{ client } j$$

$$ACE^{y}_{i,f,j} \geq 0.5 \times ACE^{y}_{i,f}$$

Or,

d) there was no ACE transfer recorded but FPH_i owns quota of Fishstock *f* which generated ACE $ACE^{m}_{i,f,i}$ which was available to FPH_i at the beginning of the month (i.e. was not transferred out) and the aggregated annual ACE generated through the client's own quota $ACE^{y}_{i,f,i}$ constitute at least 50% of the total amount of ACE held or acquired by client *i* in that year from all clients combined $ACE^{y}_{i,f}$. In other words:

$$ACE^{y}_{i,f,i} \geq 0.5 \times ACE^{y}_{i,f}$$

Step 4: for each month *m* we estimate the most likely strategic behaviour to occur for the FPH_i by looking at the distribution of all transfers for that month and the explicit strategic index $s^{t}_{i,f}$ from Step 3 associated with each transfer *t*. To do so, we weight each individual strategy index $s^{t}_{i,f}$ with the corresponding amount $ACE^{t}_{i,f}$.

Step 5: we then identify the strategy index $s^{a}_{i,f}$ with the highest likelihood of occurrence in the month *m*; namely, the strategy index that is most likely to represent accurately FPH_i 's behaviour that month. In other words,

$$\exists ?\; s^{a}_{i,f} : \; prob\left(s^{a}_{i,f}\right) \geq prob(s^{b}_{i,f}) \;\; \forall s^{b}_{i,f} \neq s^{a}_{i,f}$$

or

$$\exists ?\ a: \frac{\sum_{t=t_a}^{n_a} ACE_{i,f}^{t}}{\sum_{t=1}^{n_m} ACE_{i,f}^{t}} \geq \frac{\sum_{t=t_b}^{n_b} ACE_{i,f}^{t}}{\sum_{t=1}^{n_m} ACE_{i,f}^{t}} \quad \forall b \neq a$$

where,
a refers to the a^{th} strategy index with the highest probability of occurrence and *a*=1, 2 or 3
n_a and n_b represents the total number of ACE transactions occurring under strategies *a* and *b* respectively. Note that when $prob(s_{i,f}^{a}) = prob(s_{i,f}^{b})$, it was arbitrarily decided that the strategy with the highest index would be the one to represent the FPH_i 's strategic behaviour for that month

Similarly $\sum_{t=t_a}^{n_a} ACE_{i,f}^{t}$ and $\sum_{t=t_b}^{n_b} ACE_{i,f}^{t}$ are the total amount of ACE transferred under strategies *a* and *b* respectively. t_a and t_b refers to the index of the first transaction occurring under strategies *a* and *b* respectively. The end result was to identify $s_{i,f}^{m}$ equal to $s_{i,f}^{a}$.

3.4 Structural indices calculation

Similarly to identifying strategy indices for the FPH_i, we use the individual strategy index $s_{i,f}^{t}$ as the starting point to estimate the FPH_i 's structural index $Z_{i,f}^{y}$ .for year *y.*

Step 1: for each fishing year *y* we estimate the most likely structure to represent FPH_i 's situation by looking at the distribution of all transfers in year *y* and the explicit strategic index $s_{i,f}^{t}$ associated with each transfer *t*. To do so, we weight the individual strategy index $s_{i,f}^{t}$ with the corresponding amount $ACE_{i,f}^{t}$.

Step 2: we then identify the structural index $Z_{i,f}^{a}$ with the highest likelihood of occurrence in the year y; namely the structural index that is most likely to represent accurately FPH_i 's situation that year. In other words,

$$\exists ?\ Z_{i,f}^{a}:\ prob(Z_{i,f}^{a}) \geq prob(Z_{i,f}^{b})\ \ \forall Z_{i,f}^{b} \neq Z_{i,f}^{a}$$

or

$$\exists ?\ a: \frac{\sum_{t=t_a}^{n_a} ACE_{i,f}^{t}}{\sum_{t=1}^{n_y} ACE_{i,f}^{t}} \geq \frac{\sum_{t=t_b}^{n_b} ACE_{i,f}^{t}}{\sum_{t=1}^{n_y} ACE_{i,f}^{t}} \quad \forall b \neq a$$

where,
a refers to the a^{th} structural index with the highest probability of occurrence and *a* =1, 2 or 3. The end result was to identify $Z_{i,f}^{y}$ equals to $Z_{i,f}^{a}$. Note that when $prob(Z_{i,f}^{a}) = prob(Z_{i,f}^{b})$, it was arbitrarily decided that the structure with the highest index would be the one to represent the FPH_i 's situation for that year.

4. RELEVANT ECONOMIC TRENDS IN THE FISHERIES

4.1 Quota Holdings

Information on quota holdings was obtained from the FishServe FRED database which reported monthly ACE positions, end-of-year balancing and quota holdings for the fishing years between 2003–04 and 2009–10.

4.1.1 Quota Owners

Quota owners are in fact like the landlords of a common linked by the share of the Fishstocks they own. Some owners may be absentee landlords (not taking any active part in commercial fishing directly, leasing all their quotas to fishers in exchange for a resource rent payment also called ACE or Quota Lease Price), some may be somehow involved either directly through the activity of fishing or further downstream (at the financing, managing, processing and/ or marketing stages, etc.). The type and level of integration will affect the pressure on supply and demand for quotas and ACE depending on how active the quota and ACE markets are (i.e. number of participants, fishing pressure on the stock, discards practice, etc.). Earlier, quota owners who are also involved directly in commercial fishing activity of the underlying Fishstock for which they have a share were referred to as “quota-owner permit holders”. In the past two fishing years, more than a quarter of all FMA2 quota owners were somehow linked financially to one or more quota owners and/ or ACE holders operating anywhere in New Zealand. About half of those FMA2 quota owners were directly financially associated with one another (source: FishServe’s list of included persons).

Quota ownership has been relatively stable in the past seven years for most Fishstocks studied here (Figure 7). Flatfish (FLA 2) shows consistently the largest number of quota owners while snapper (SNA 2) and trevally (TRE 2) the lowest. The total number of quota owners who are also involved in commercial fishing experienced a steady decline between 2003–04 and 2009–10 (Figure 8); FLA 2 shows the highest level of participation of quota-owners in commercial fishing with 32% in 2009–10, a noticeable decrease compared to 2003–04 (50%). The other four Fishstocks show a low level of participation ranging between 14% (SNA 2) and 19% (TAR 2) in recent years. In the same period, the number of fishing permit holders has been relatively stable (see later Figure 21). However, when we compare the proportion of permit holders who own quota (Table 1) during the same period, the numbers suggest a relatively strong vertical integration or more contractual commercial finfish fishing activity in Area 2. Quota owners not involved in harvesting often represent companies involved in commercial fishing further up or down-stream (at the management, financing, processing and/ or marketing stages); in such cases, they will lease their quota to permit holders who, under contract, may have to follow a fishing plan and sell their catch back to the contractor.

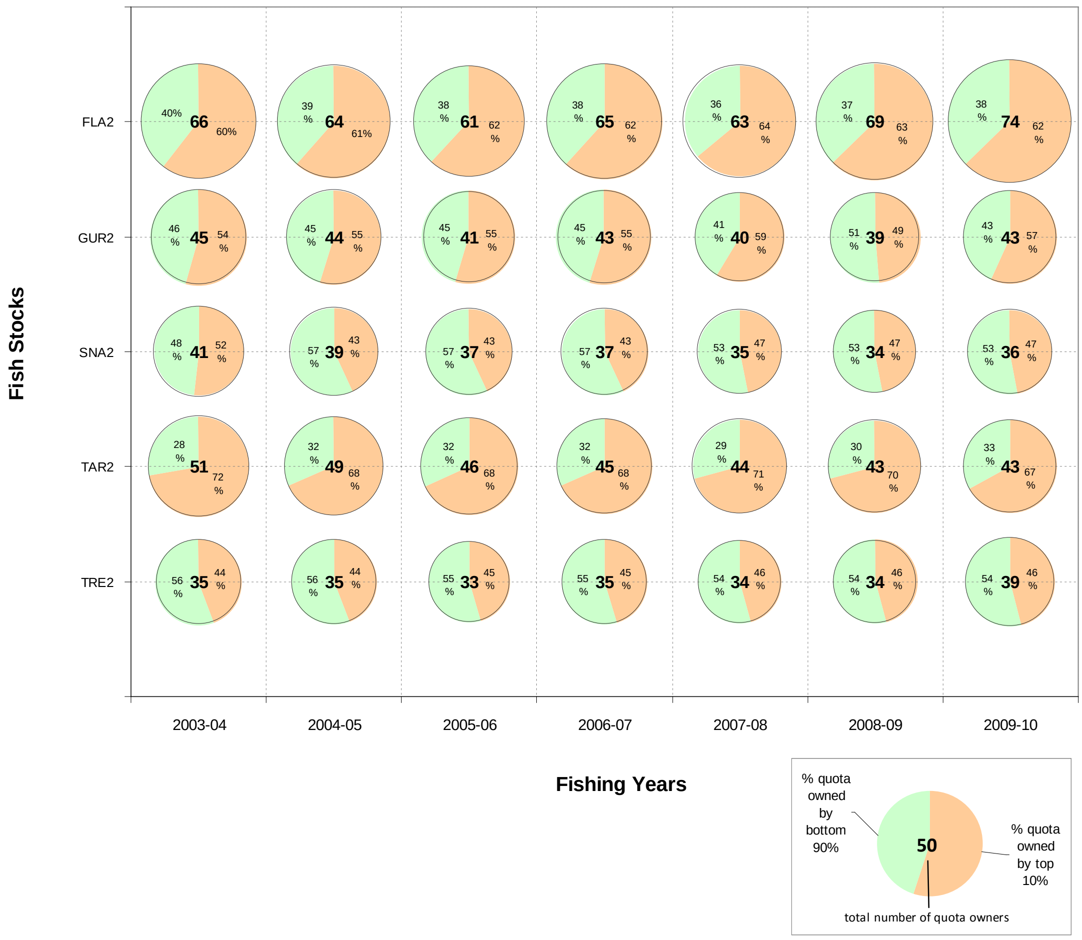


Figure 7: **Trends in the number of quota owners and concentration of quota by Fishstock and fishing year.**

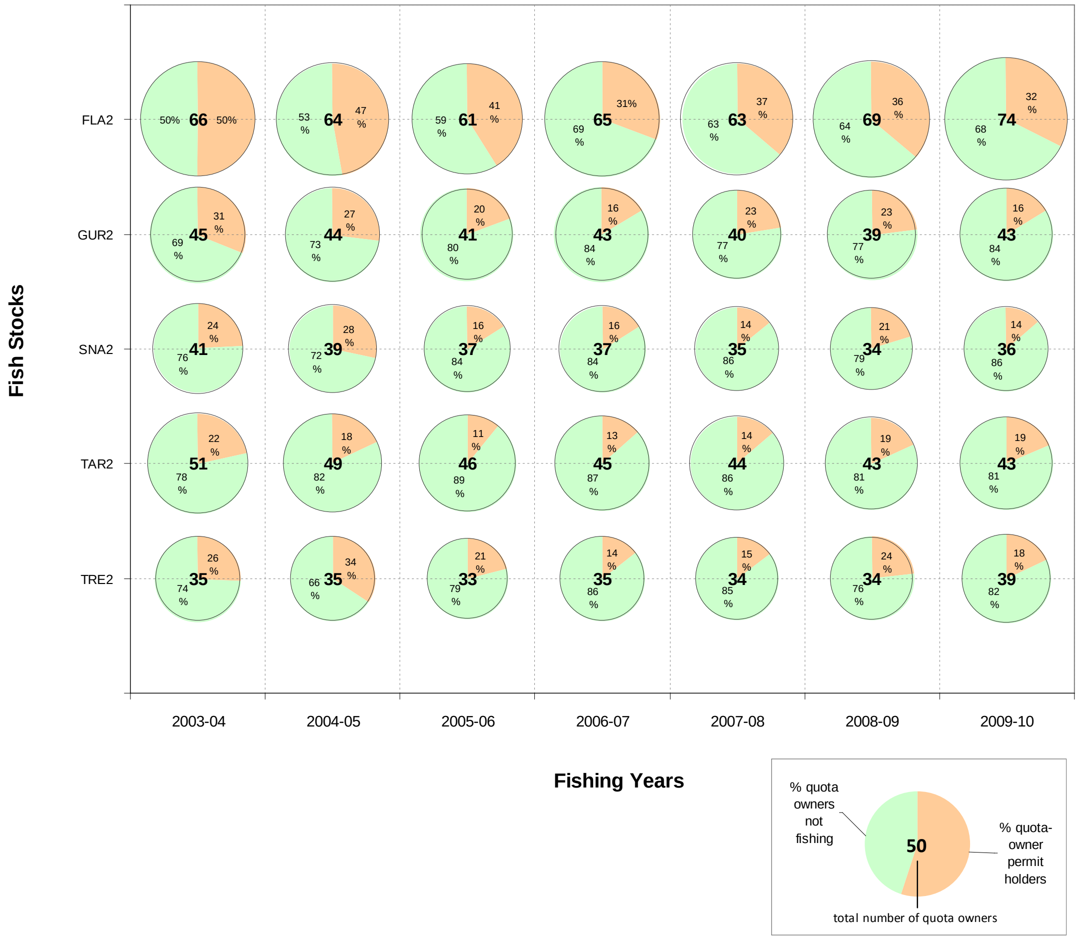


Figure 8: Trends in the number of quota owners and proportion of those who hold fishing permits by Fishstock and fishing year.

Table 1: Proportion of permit holders who own quota by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	29.2%	27.3%	25.3%	19.4%	22.8%	24.3%	23.8%
GUR2	21.9%	22.4%	17.4%	14.6%	15.8%	18.8%	15.2%
SNA2	27.0%	29.7%	21.4%	18.8%	13.5%	21.9%	15.2%
TAR2	18.3%	15.5%	10.0%	10.9%	10.3%	16.3%	14.3%
TRE2	19.6%	24.5%	15.9%	11.9%	11.9%	17.4%	17.1%

In the past seven fishing years and for most Fishstocks, less than a quarter of all fishing permit holders owned quota in the Fishstock they were fishing - implying that more than three quarters of all fishing operators relied on ACE transfers (bought or under contract) to cover their catch. However these figures do not take into account structure where a permit holder's ACE comes from a mother company or an associated company managing their quota. Therefore caution should be taken in interpreting some of those numbers.

4.1.2 Quota Transactions

For some of the fish stocks, there was little or no information reporting quota transactions between 2003–04 and 2009–10 which means that for many Area 2 Fishstocks, quota owners tended to hold on to their quota during this period. Without observed quota transactions (price and/ or volume), it was not possible to systematically collect quota values for each Fishstock. However, using information on readily available average ACE lease price, it was possible to estimate a baseline quota value for each stock.

4.1.3 Quota Values

In theory, quota values should reflect the shadow value of the Fishstocks estimated by adding the discounted stream of income (or the equivalent opportunity costs for a quota-operator) generated by leasing quota (i.e. selling ACE). The discount rate used in this calculation should in theory reflect not only the opportunity cost of the investment (i.e. the risk-free rate or long-term deposit rate), but also a risk premium (reflecting uncertainty) and a growth factor (reflecting the expected return on capital). Based on their own perception, quota investors determine subjectively their discount rate when deciding whether to buy quota shares at the offered market price, or whether to invest their money elsewhere (e.g. in alternative quotas or simply put that amount in a bank's term deposit (see http://www.rbnz.govt.nz/) offering a known return on investment). In New Zealand the current risk-free rate of long-term deposit is about 6%.

The baseline quota value ($/t) shown in Table 2 was calculated based on the present value (PV) of streams of observed average annual ACE revenue ($/kg) from the FishServe's "Blue Book" discounted by a rate of 6% over an infinite time horizon such that:

$$V_{i,j} = \frac{\sum_{t=0}^{\infty} p_{i,j}}{(1+r)^t}$$

where,

$V_{i,j}$ is the calculated quota value of Fishstock *j* in fishing year *i* expressed in $/t

$p_{i,j}$ is the observed average ACE price of fish stock *j* in fishing year *i* expressed in $/t

and

r is the discount rate.

The calculated quota value $V_{i,j}$ (Table 2) is based on the risk (and growth) free rate and should be contrasted to the observed average quota value $\hat{V}_{i,j}$ (Table 3) and its underlying discount rate $\hat{r}$ (Figure 9) where:

$$\hat{V}_{i,j} = \frac{\sum_{t=0}^{\infty} p_{i,j}}{(1+\hat{r})^t}$$

if $\hat{V}_{i,j} > V_{i,j}$ then $\hat{r} < r$ which means that the underlying discount rate $\hat{r}$ includes a positive net growth or $\hat{r} = r - \overline{g}$ where $\overline{g}$>0 is the estimated net growth expressed as a percentage. On the other hand, if $\hat{V}_{i,j} < V_{i,j}$ then $\hat{r} > r$ which means that the underlying discount rate $\hat{r}$ includes a positive net risk premium or $\hat{r} = r + \overline{\delta}$ where $\overline{\delta}$ >0 is the estimated net risk premium expressed in %.

The underlying discount rate can be generalised such that:

$\hat{r} = r - g + \delta$ where

$\bar{g} = g - \delta$ >0 if $g > \delta$

<0 otherwise

and

$\bar{\delta} = \delta - g$ >0 if $\delta > g$

<0 otherwise

the relative value of δ and g will dictate the direction of the inequality between $\hat{r}$ and r.

Table 2: Risk and Growth Free Quota value ($/t) by Fishstock and fishing year calculated from the Present Value of observed annual ACE returns discounted at the risk-free rate of 6%.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$5,937	$4,693	$7,340	$5,293	$5,658	$6,590	$5,572
GUR2	$5,752	$6,325	$6,185	$9,303	$6,540	$5,525	$6,758
SNA2	$41,750	$39,288	$42,638	$38,407	$45,668	$45,645	$60,243
TAR2	$17,125	$17,605	$18,625	$16,972	$25,605	$22,940	$24,145
TRE2	$8,382	$7,970	$8,395	$6,653	$9,672	$8,220	$12,553

Table 3 summarises the average quota values observed from annual transactions. There were no reported quota values from transactions in 2009–10. When comparing Table 2 and Table 3, we can identify when quotas were sold above or below their risk and growth free quota value counterpart.

Table 3: Average Observed Quota value ($/t) by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2			$2,411	$2,383	$1,460	$2,122	
GUR2		$3,929	$3,487	$6,162	$5,858	$10,628	
SNA2		$36,000		$37,524	$45,556		
TAR2			$19,187	$17,867			
TRE2			$6,963	$5,596		$11,937	

The calculated underlying discount rate (Figure 9) gives an indication of the “economic status” of a Fishstock. That is, the higher the rate, the riskier the investment and/or the least growth potential. On the other hand, the lower the rate, the less risky the investment in quota and/or the greater the growth potential in returns from the quota. We would expect contracted or vertically integrated permit holders to target those Fishstocks with more growth potential and less risk based on the targeted quota holdings of their ACE providers. From Figure 9 we see that any fishing activities involving FLA 2 would be perceived as more risky while those activities involving SNA 2 would be more attractive from an investor or Quota owner’s point of view.

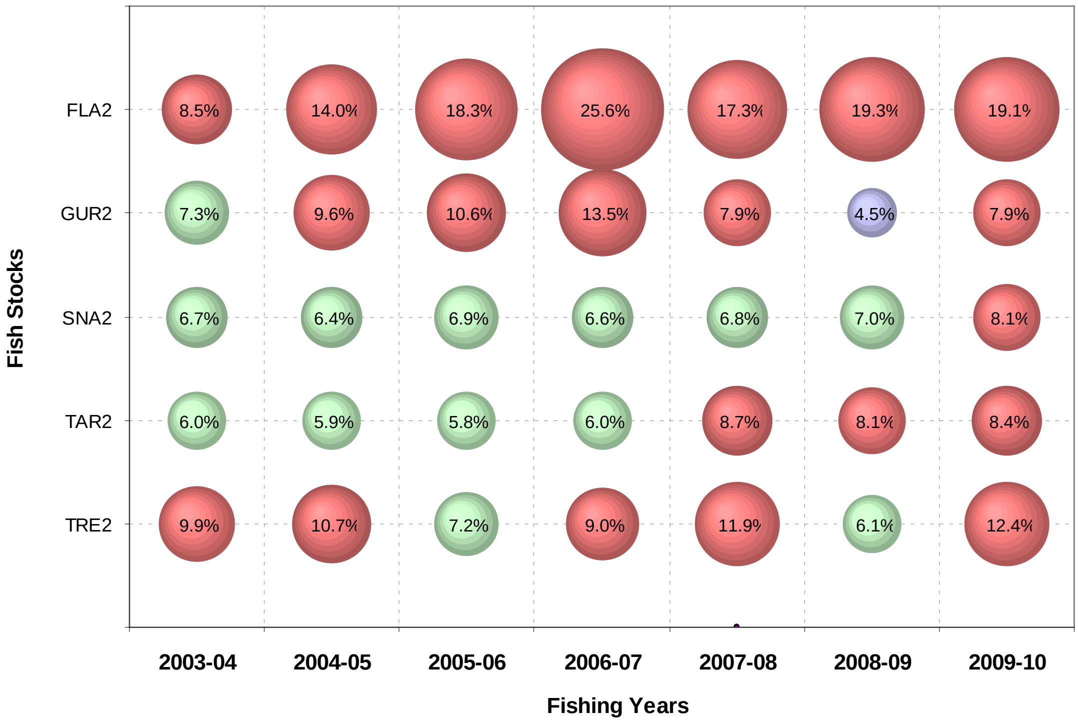


Figure 9: Calculated Underlying Discount Rate from observed Quota value and ACE price by Fishstock and fishing year.

Note: Bubbles in **green** correspond to discount rates close to the risk-free rate (discount rate $\in [5\%, 7.5\%]$)
Bubbles in **red** correspond to discount rates which include a substantial net risk premium (discount rate >7.5%)
Bubbles in **blue** correspond to discount rates which include a substantial net capital growth (discount rate <5%)

Table 4: Risk and Growth Free Quota value ($) by Fishstock and fishing year calculated by multiplying the risk and growth free quota value per tonne by the TACC.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$4,309,426	$3,406,891	$5,328,106	$3,842,431	$4,107,384	$4,783,681	$4,044,473
GUR2	$4,172,616	$4,588,547	$4,486,982	$6,749,215	$4,744,521	$4,008,178	$4,902,914
SNA2	$13,151,250	$12,375,825	$13,431,075	$12,098,100	$14,385,525	$14,378,175	$18,976,650
TAR2	$27,961,700	$31,618,580	$33,450,500	$30,481,113	$45,986,580	$41,200,240	$43,364,420
TRE2	$2,022,186	$1,922,866	$2,025,403	$1,605,203	$2,333,415	$1,983,182	$3,028,655

Table 5: Observed Quota value ($) by Fishstock and fishing year calculated by multiplying the observed average quota value per tonne by the TACC.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2			$1,750,000	$1,730,000	$1,060,000	$1,540,000	
GUR2		$2,849,992	$2,529,993	$4,469,988	$4,249,988	$7,709,979	
SNA2		$11,340,000		$11,820,000	$14,350,000		
TAR2			$34,460,000	$32,090,000			
TRE2			$1,679,979	$1,349,983		$2,879,964	

From Table 2 to Table 5 we can see that SNA 2 shows a remarkable stability for most years with the observed average quota value very close to its risk and growth free rate equivalent which means that quota buyers were not expected to pay a premium to acquire SNA 2 quotas nor did they seem to consider that investment a risky one: this could mean that SNA 2 is considered a safe investment. This could also suggest that the market did not anticipate an increase in ACE price after the implementation of a considerably higher differential deemed value in 2007–08. We can also see that the observed quota value for flatfish (FLA 2) reflects a high-risk premium (or negative growth) between 2005–06 and 2008–09: This could be the direct consequence of the catch being well below the TACC the entire time bringing a very low pressure on the ACE market (ACE prices had been well below deemed value).

4.2 ACE Holdings

Table 6 to Table 8 show the trends in Ace Holdings and amount of ACE carried forward from one fishing year to the next for the 5 Fishstocks between 2003 and 2010. The existence of ACE carried forward shows that none of the 5 FishStock have been under pressure during those years (especially FLA2 and GUR2). However as mentioned earlier, quota-less operators (or "ACE-permit holders") are becoming more common in Area 2 which expose them more, to not only quota lease price fluctuations and ACE availability, but also to potential changes in deemed value settings. Given the trend in quota owners' disengagement and/ or the increase in vertical integration of commercial finfish harvesting activities, there is a risk that unreported catch may increase as well. Indeed there is an incentive for ACE-permit holders to illegally discard unwanted species and a disincentive to seek additional ACE or to pay deemed value. Discards, while recognized to a certain extent as common practice in most fisheries, correspond to forgone revenue that would have been generated if the fish had been landed instead. Moreover, the disparity between TACC and catch may actually capture behavioural decisions such as discarding rather than issues related to abundance. Misreported catch will also affect CPUE estimates, which may in turn bring about a misinformed decision to reduce the TACC. Later on, the forgone revenue associated with under-catching the TACC by Fishstock and fishing year (see later Table 16) is estimated.

Table 6: Annual ACE Holdings (t) by Fishstock and fishing year.

Stock_Code	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	802	798	798	798	797	800	793
GUR2	787	786	781	788	794	799	789
SNA2	327	328	317	315	324	318	327
TAR2	1,675	1,883	1,970	1,869	1,935	1,975	1,849
TRE2	249	249	250	250	248	259	242

Table 7: Quantity of ACE (t) carried forward by Fishstock and fishing year.

Stock_Code	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	76	73	73	72	71	74	67
GUR2	61	60	55	62	68	73	63
SNA2	11	12	2		9	2	11
TAR2	42	87	173	73	139	179	53
TRE2	8	8	9	8	7	18	1

Table 8: Quantity of ACE carried forward as a percent of TACC by Fishstock and fishing year.

Stock_Code	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	>10%	>10%	>10%	9.9%	9.8%	>10%	9.2%
GUR2	8.4%	8.3%	7.6%	8.5%	9.4%	>10%	8.7%
SNA2	3.5%	3.8%	0.6%		2.9%	0.6%	3.5%
TAR2	2.6%	4.8%	9.6%	4.1%	7.7%	10.0%	3.0%
TRE2	3.3%	3.3%	3.7%	3.3%	2.9%	7.5%	0.4%

4.2.1 ACE Prices

For certain Fishstocks, estimates of average ACE prices (Table 9) may be more an artifact of vertical integration (see comments earlier in Section 2.8) rather than the combined effect of supply and demand.

Table 9: Average annual ACE Price ($/kg) at a glance by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$0.36	$0.28	$0.44	$0.32	$0.34	$0.40	$0.33
GUR2	$0.35	$0.38	$0.37	$0.56	$0.39	$0.33	$0.41
SNA2	$2.51	$2.36	$2.56	$2.30	$2.74	$2.74	$3.61
TAR2	$1.03	$1.06	$1.12	$1.02	$1.54	$1.38	$1.45
TRE2	$0.50	$0.48	$0.50	$0.40	$0.58	$0.49	$0.75

Figure 10 to Figure 14 give some insights into the way ACE prices vary inter and intra annually, constrained by deemed value rates and range (for Fishstocks with differential deemed value only), but also from the pressure on the ACE market (law of supply and demand) and timing (beginning and end of the fishing year). The survey port prices are plotted on each graph as an indication of ex-vessel prices for the species; however considering how and for what purpose these are collected, surveyed port prices are not very reliable, showing little to no variation between fishing years (see Section 4.8). Three out of the five Fishstocks, SNA 2, TAR 2 and TRE 2 show a drastic change in deemed value rates in fishing year 2007–08 which clearly influenced ACE price trends.

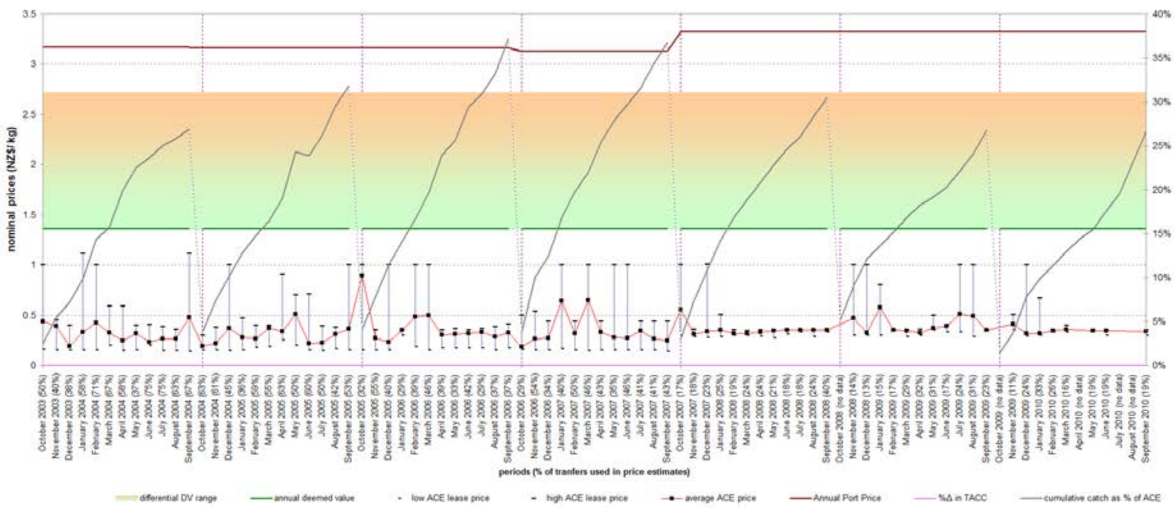


Figure 10: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for FLA 2 (flatfish) between fishing years 2003–04 and 2009–10.

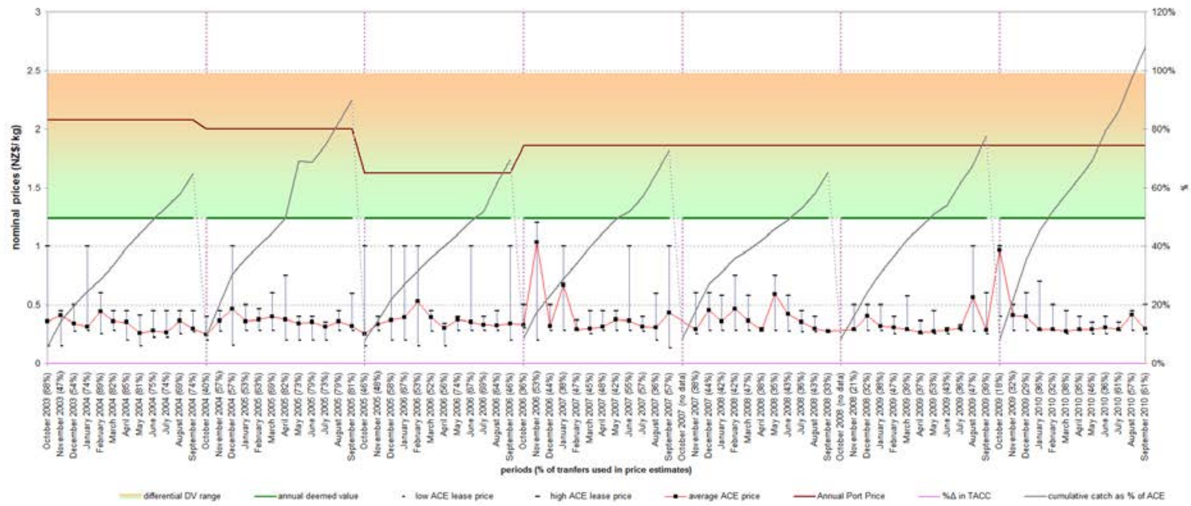


Figure 11: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for GUR 2 (red gurnard) between fishing years 2003–04 and 2009–10.

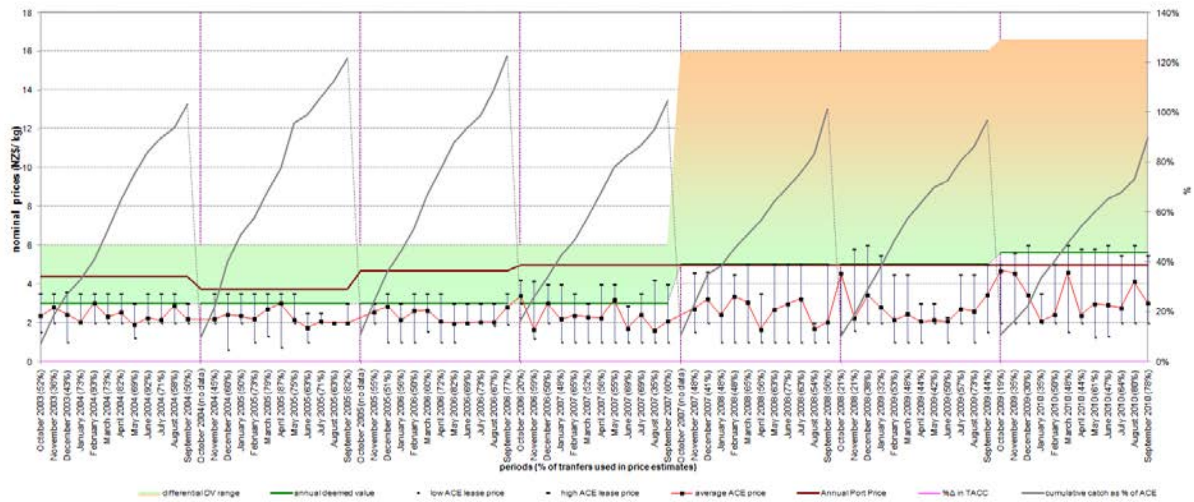


Figure 12: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for SNA 2 (snapper) between fishing years 2003–04 and 2009–10.

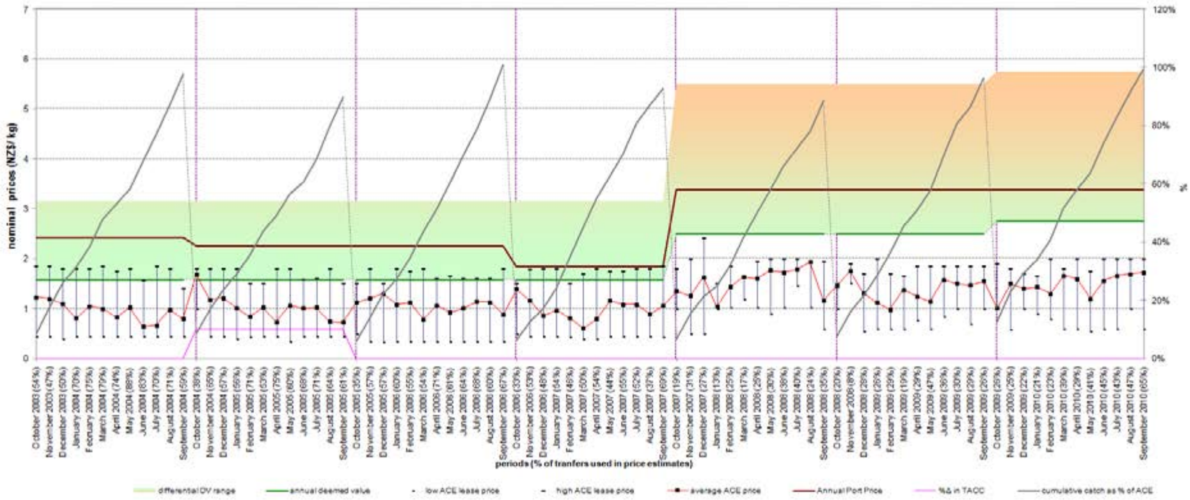


Figure 13: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for TAR 2 (tarakihi) between fishing years 2003–04 and 2009–10.

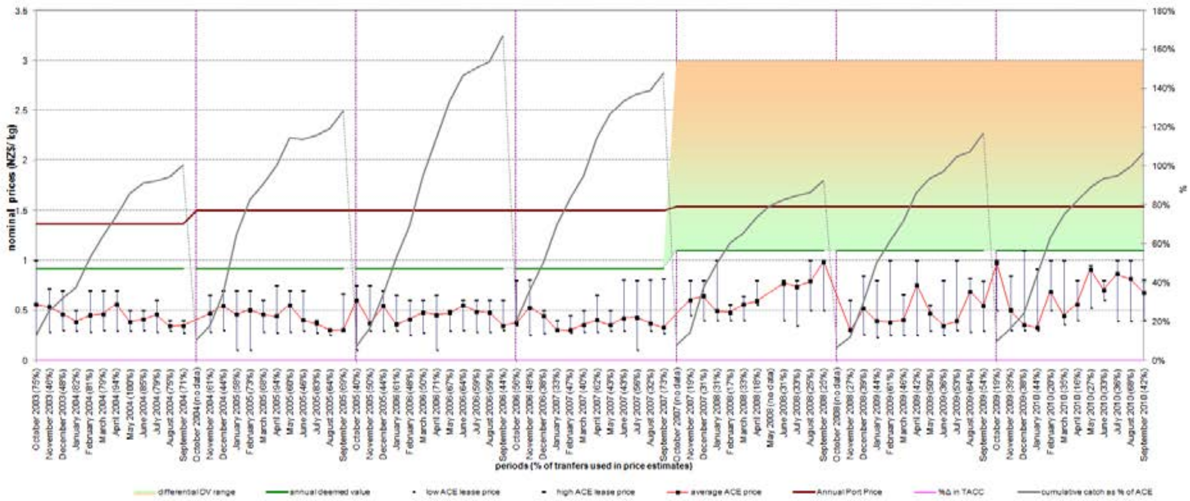


Figure 14: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for TRE 2 (trevally) between fishing years 2003–04 and 2009–10.

4.2.2 ACE Traded

The quantity of ACE traded in one year (Table 10) may be greater than the available ACE (approximately equal to the TACC depending on the amount of ACE carried forward) for that fishing year (Table 11 and Table 12). For example a ratio of 200% in a year means that on average the same ACE holding changed hands twice in that year. The higher the ratio, the more active the market is. A ratio less than 100% may mean one of two things: either the stock is under-caught and ACE demand becomes inferior to the available ACE, or quota owners are fishing their own quota (i.e. using their own ACE) so that it becomes an internal transaction which would not appear in FishServe's Blue Book. The general trend in overall increase in ACE turn-over (except in the last fishing year) would be consistent with the fact that the proportion of ACE-permit holders increased over time in proportion to Quota-owner permit holders.

Table 10: Quantity of ACE Traded (t) by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	845	807	937	999	793	831	679
GUR2	997	1,336	1,271	1,227	1,186	1,348	1,283
SNA2	388	440	469	496	530	560	499
TAR2	2,001	2,504	2,834	2,738	2,505	3,117	2,726
TRE2	370	499	409	374	341	418	368

Table 11: Ratio between volume of ACE traded and available ACE by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	105%	101%	117%	125%	100%	104%	86%
GUR2	127%	170%	163%	156%	149%	169%	163%
SNA2	119%	134%	148%	157%	163%	176%	153%
TAR2	119%	133%	144%	146%	129%	158%	147%
TRE2	148%	200%	163%	150%	137%	161%	152%

Table 12: Ratio between volume of ACE traded and TACC by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	116%	111%	129%	138%	109%	114%	94%
GUR2	137%	184%	175%	169%	163%	186%	177%
SNA2	123%	140%	149%	157%	168%	178%	159%
TAR2	123%	139%	158%	152%	139%	174%	152%
TRE2	153%	207%	170%	155%	141%	173%	152%

Figure 15 to Figure 19 show month-by-month and between fishing years, the correlation between catch and amount and numbers of ACE traded. Most ACE transfers occur at the beginning of the fishing year suggesting that perhaps most fishing plans are decided early on and fishing permit holders acquire the necessary ACE needed to cover their catch plan. Also there is an increase in the number of *transfers* (although not necessarily the amount) near or at the end of the fishing year suggesting a large number of small adjustments by fishing permit holders in their ACE holdings to balance their catch before year's end.

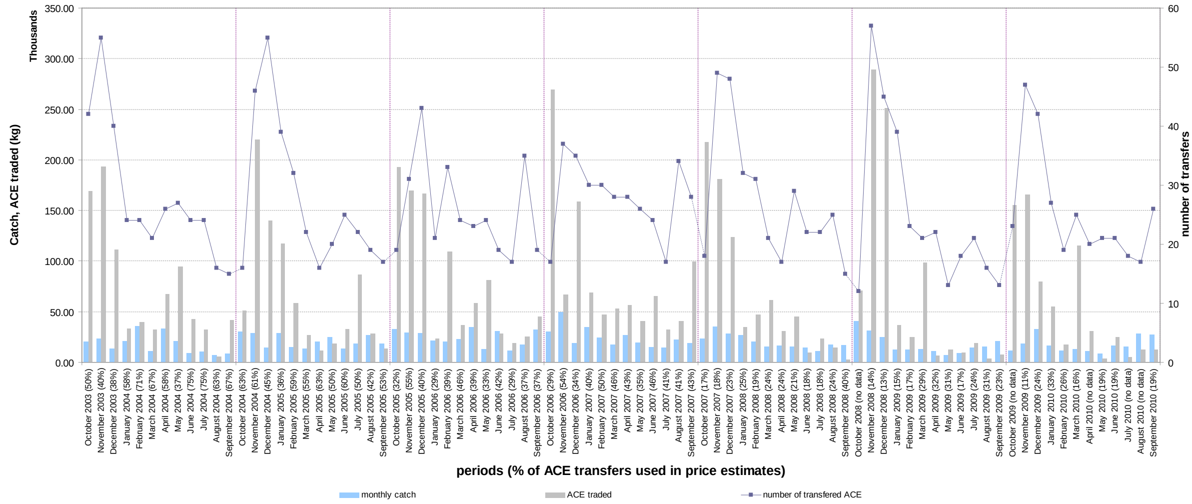


Figure 15: Trends in monthly catch, quantity and numbers of ACE traded for FLA 2 (flatfish) between 2003–04 and 2009–10.

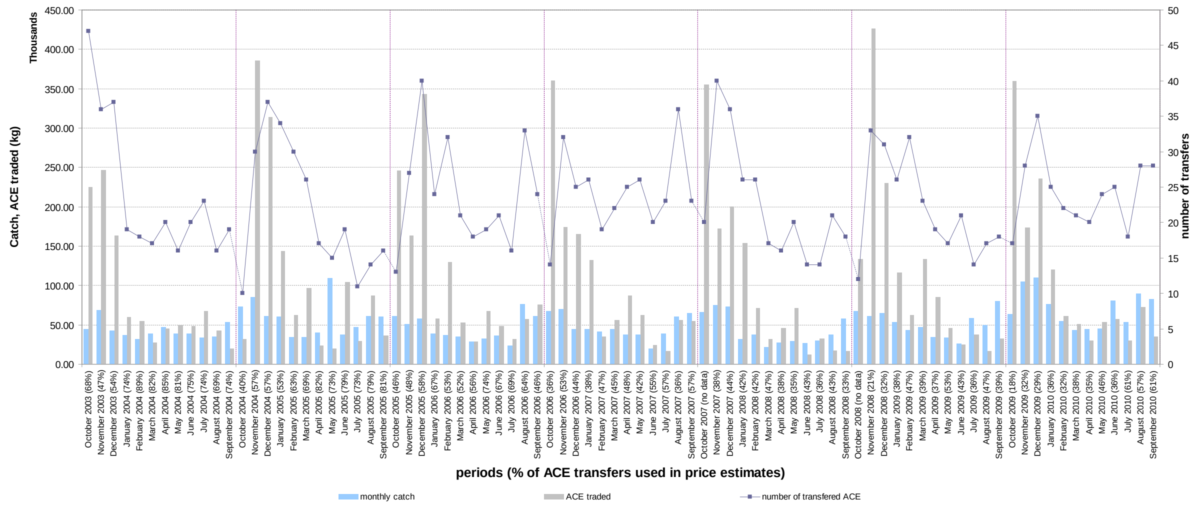


Figure 16: Trends in monthly catch, quantity and numbers of ACE traded for GUR 2 (red gurnard) between 2003–04 and 2009–10.

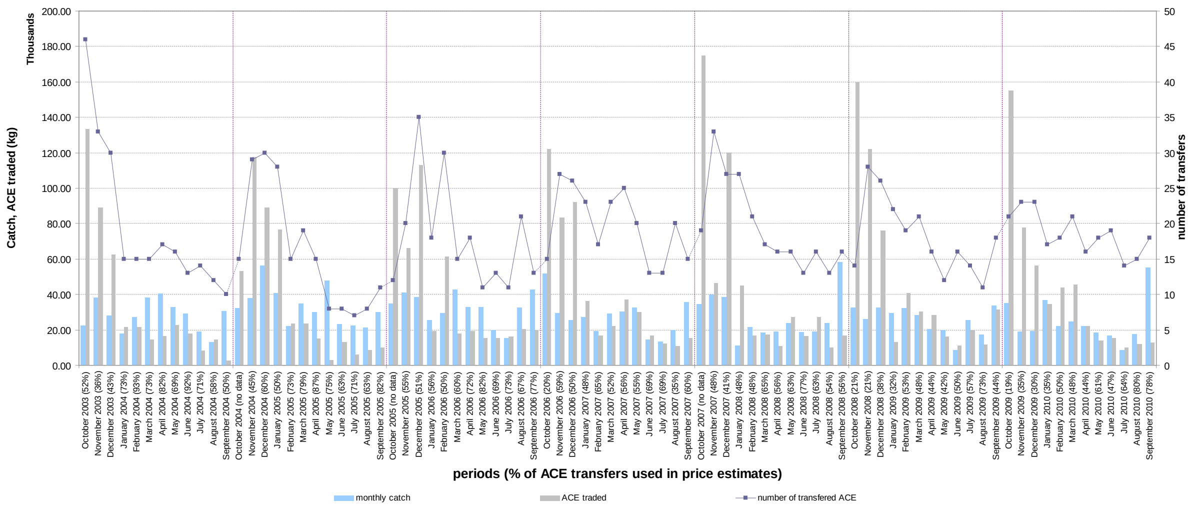


Figure 17: Trends in monthly catch, quantity and numbers of ACE traded for SNA 2 (snapper) between 2003–04 and 2009–10.

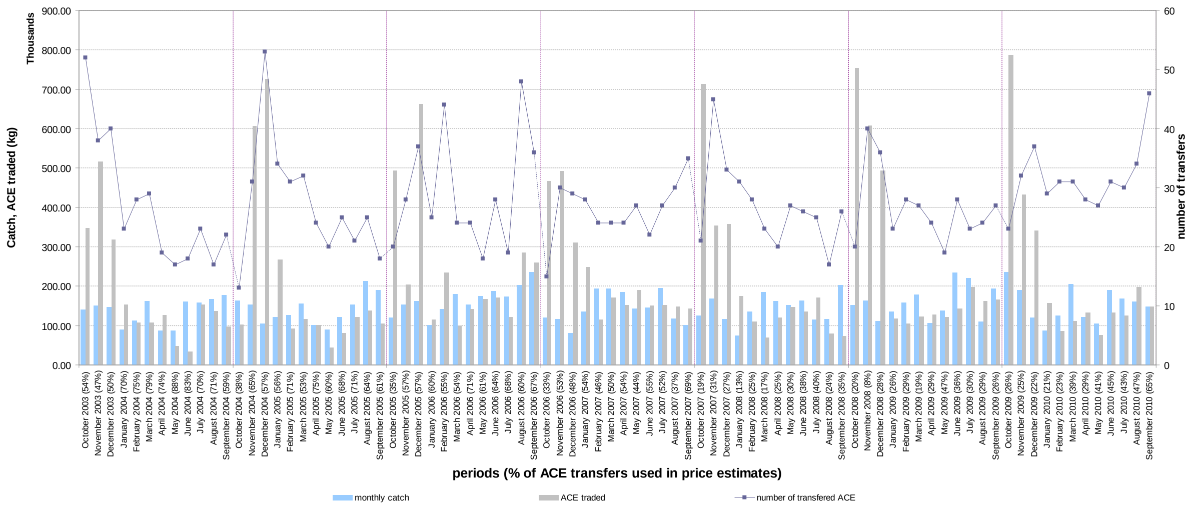


Figure 18: Trends in monthly catch, quantity and numbers of ACE traded for TAR 2 (tarakihi) between 2003–04 and 2009–10.

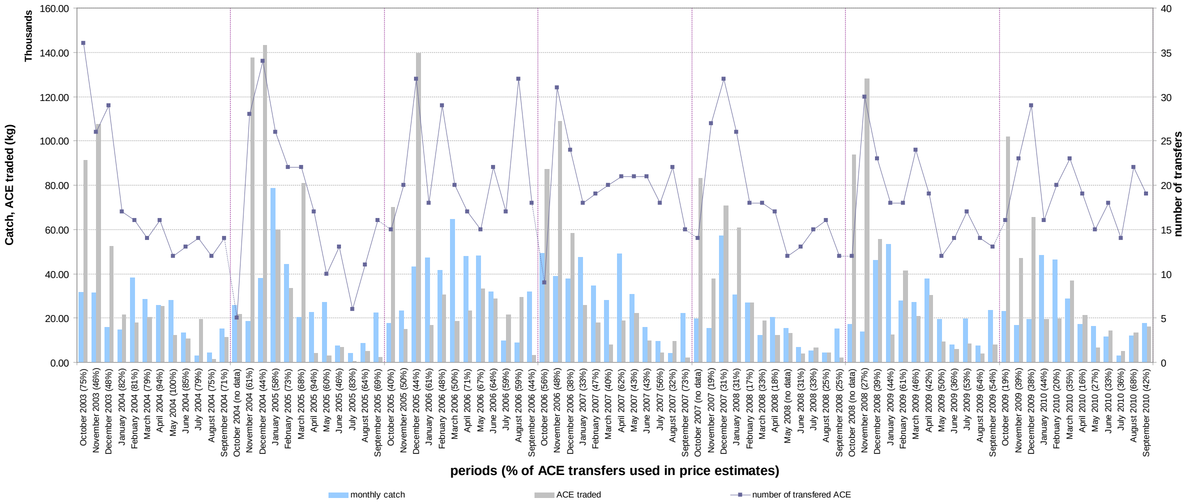


Figure 19: Trends in monthly catch, quantity and numbers of ACE traded for TRE 2 (trevally) between 2003–04 and 2009–10.

4.3 Fishing Permit Holders

It appears that in recent years, quota owners have reduced their direct engagement in commercial fishing. As a consequence, there has been an increase in the proportion of quota-less fishing permit holders (Figure 20). This change could reflect an increase in vertical integration and contractual fishing activities across the area (Figure 21 and Figure 22). This latest finding seems to be consistent with the observed steady decline in the numbers of ACE holders, indicating the rationalisation of commercial fishing activities often resulting from vertical integration.

Finally, forgone revenue resulting from the TACC being under-caught was estimated to be around $4 Million/ year in the past three fishing years. Sections 4.1.3 and 4.9 covering quota valuation and standardised CPUE estimates by Fishstock respectively, need to be developed further. This report is only a preliminary attempt to describe economic forces at play in Area 2 influencing fishing operators and quota owners. Further work should be developed to explain and interpret more accurately CPUE variation over time.

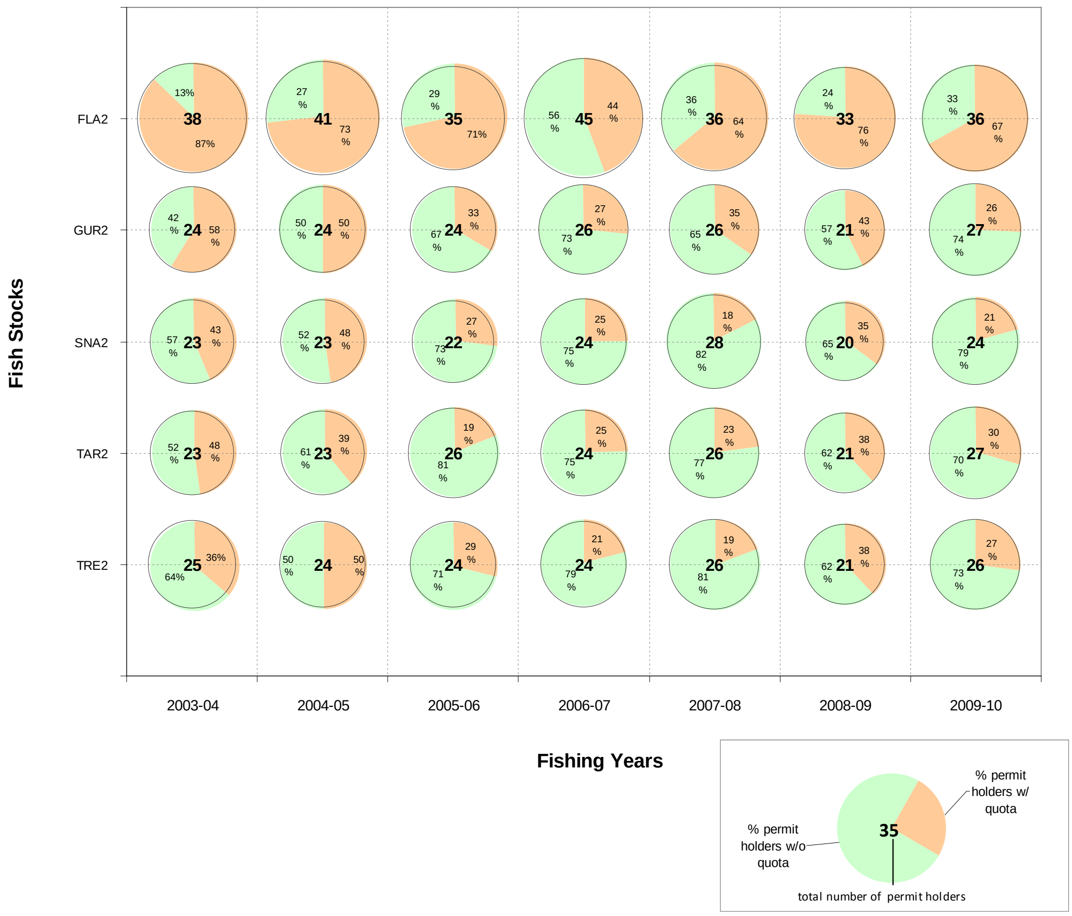


Figure 20: Trends in the total number of permit holders and proportion with and without quota by Fishstock and fishing year.

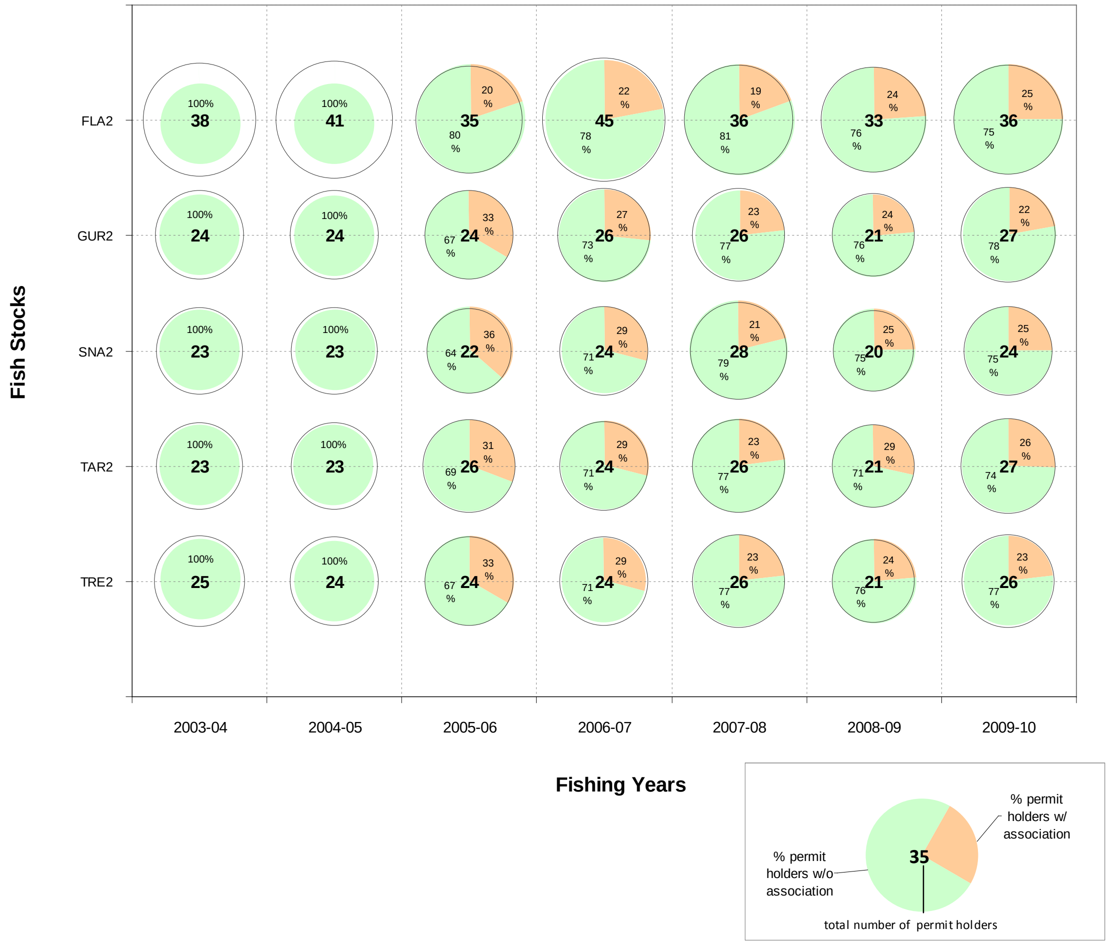


Figure 21: Trends in the number of fishing permit holders and proportion with and without included person by Fishstock and fishing year.

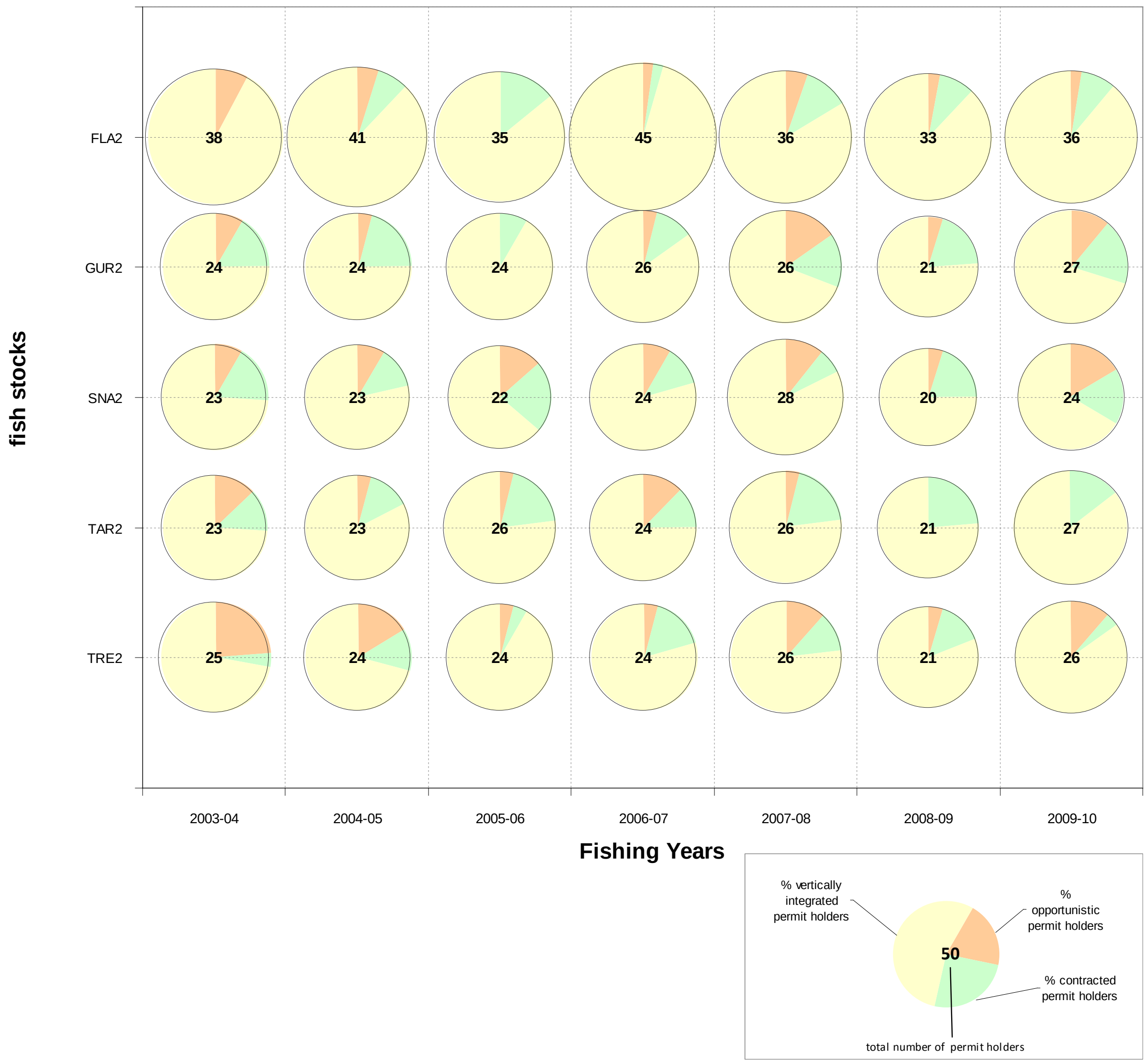


Figure 22: Trends in the number of permit holders and their structure types by Fishstock and fishing year.

4.4 Fishing vessels

There has been anecdotal evidence indicating a slow decline in the number of fishing vessels across the domestic fleet (Figure 23) which could well corroborate the observed diminution in the number of participants involved in Area 2 commercial finfish harvesting (i.e. a rationalisation of the fleet capacity).

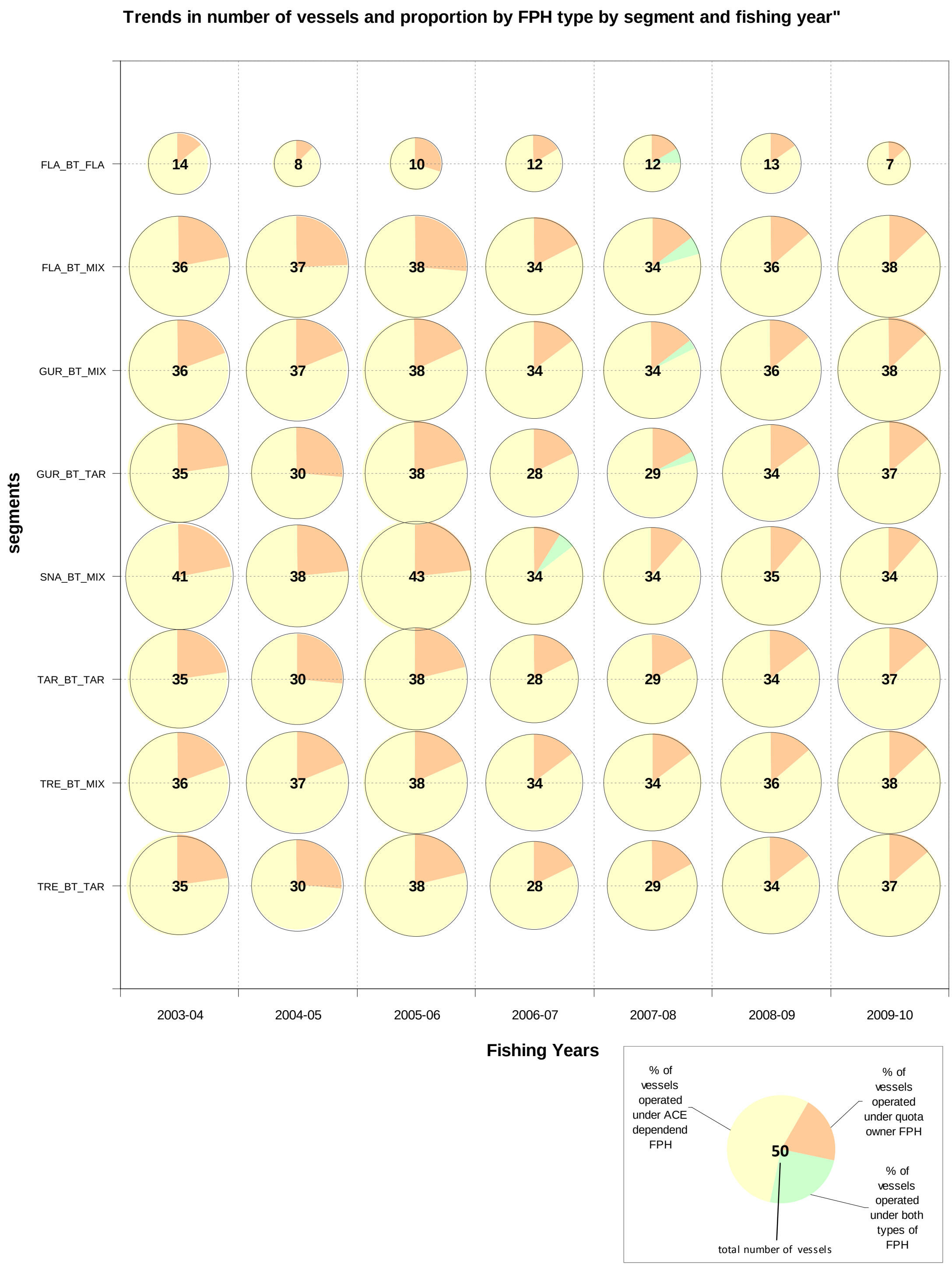
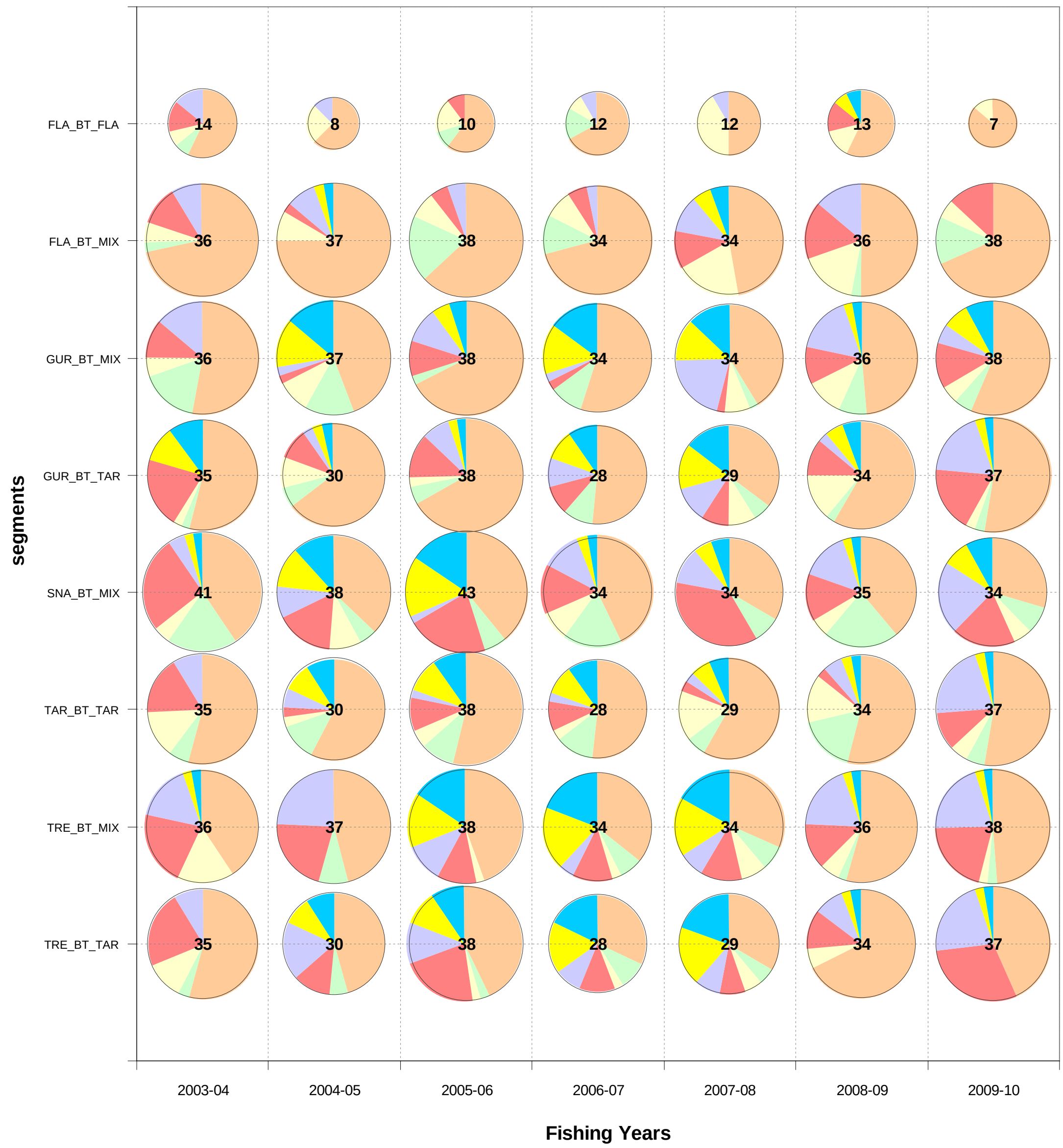


Figure 23: Trend in the number of vessels and proportion operated under a) quota owner FPH, b) ACE dependent FPH, c) both types of FPH by Fishstock and fishing year.



	Strategies		
Mixed strategies index	**Opportunistic**	**contracted**	**vertically integrated**
001			X
010		X	
011		X	X
100	X		
101	X		X
110	X	X	
111	X	X	X

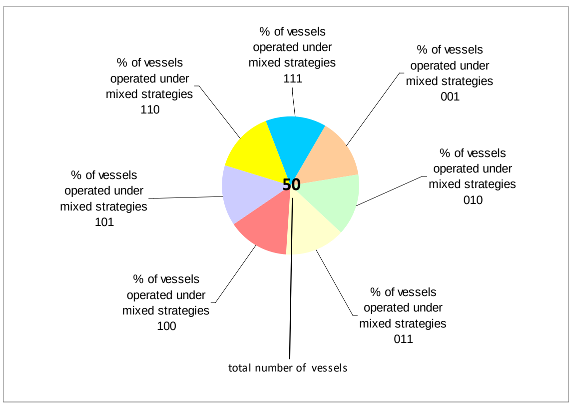


Figure 24: Trend in the number of vessels and the mixed strategies they are operated under by segment and fishing year.

4.5 Fishing events

At this stage, fishing events statistics by Fishstocks shown in Figure 25 to Figure 39 might report events with no catch of that particular species but for which, on specific stratum and based on the target species, we expected to record some catch.

Overall, the emerging trend seems to be that larger vessels are now numerically dominating these fisheries, spending less time on the water, regardless of the target species. This trend suggests a rationalisation of the fleet and a shift towards larger vessels, perhaps because they are safer and/ or more efficient. It is possible that the larger vessels, due to their increased capacity and often faster speed compared to small craft, bring about attractive economies and returns to scale for those who contract and/ or operate them. Also larger vessels tend to be able to operate in worse weather than smaller vessels when safety is of concern.

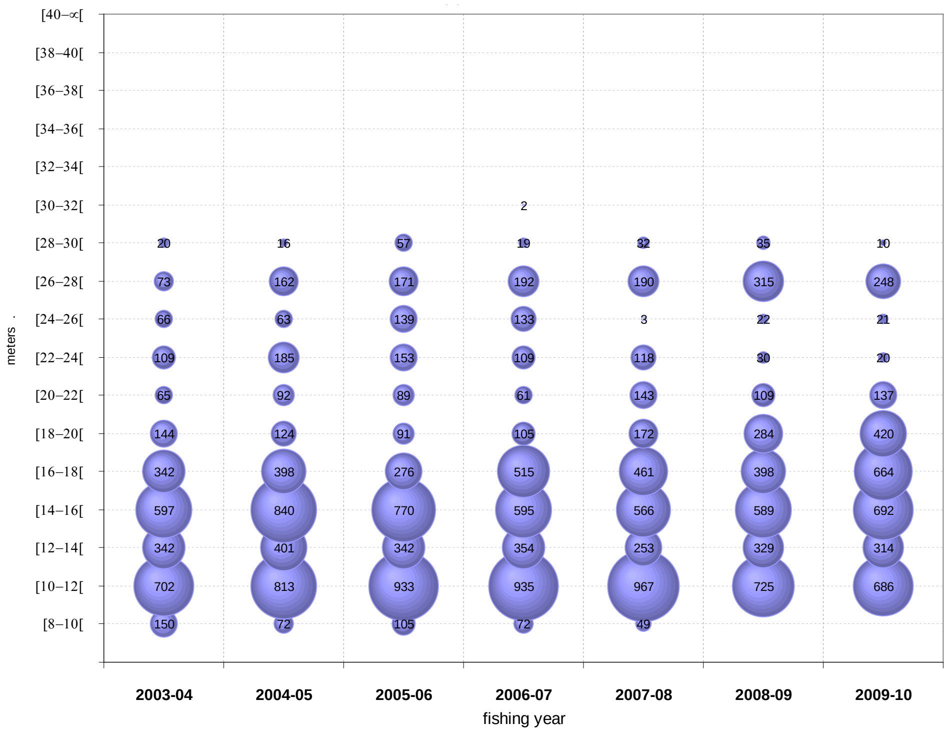


Figure 25: Trends in total number of aggregated records by stratum in each vessel length range for FLA 2.

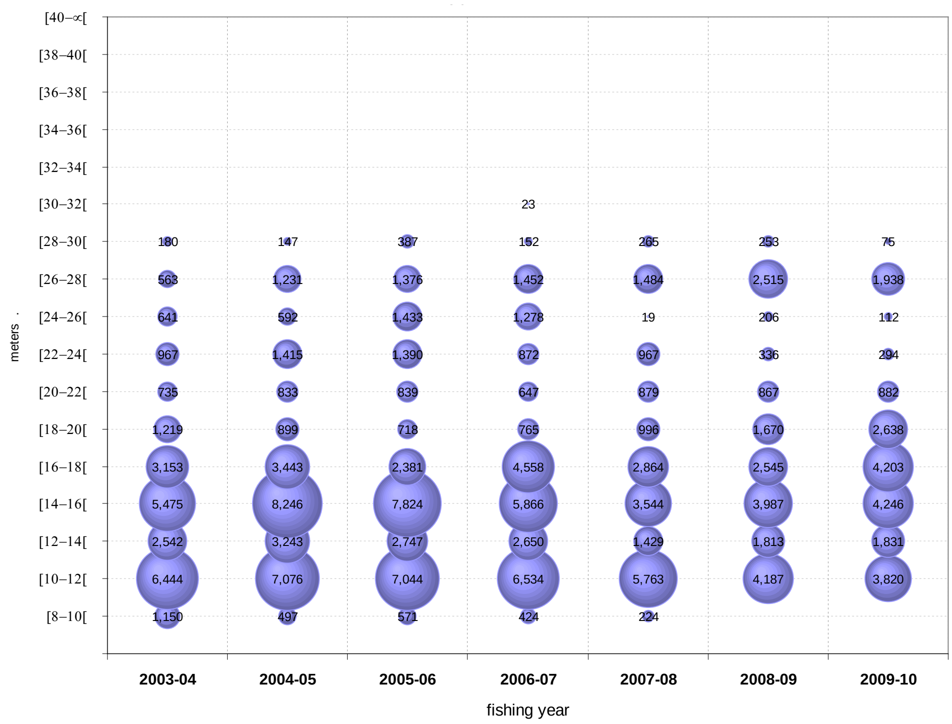


Figure 26: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for FLA 2.

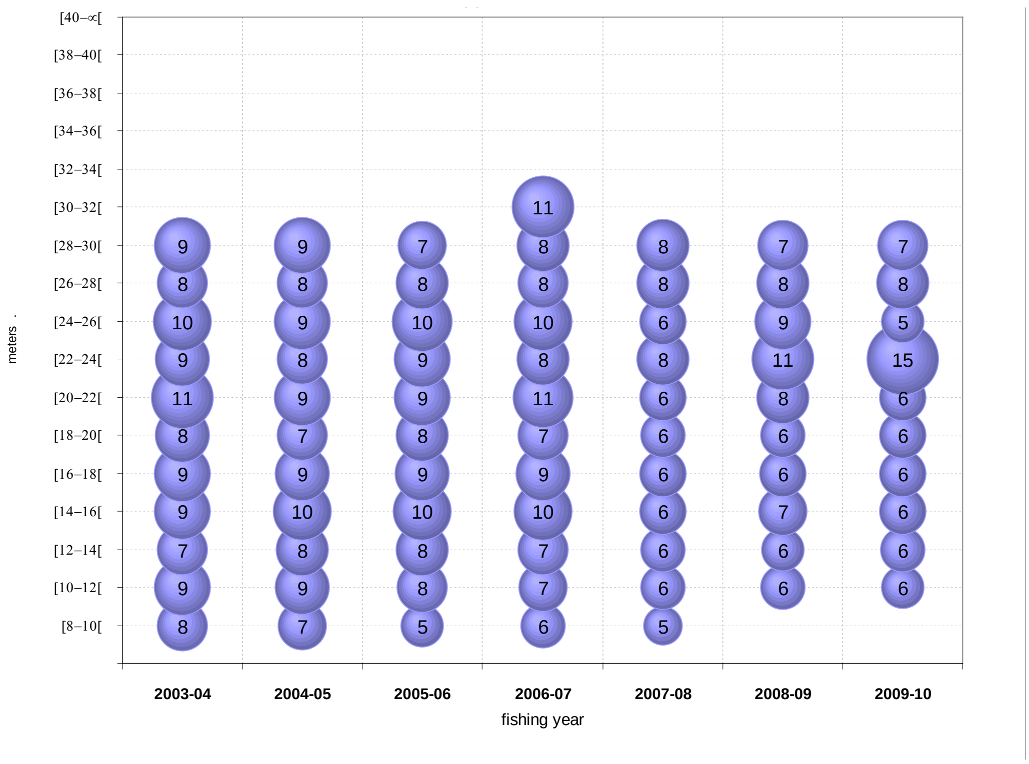


Figure 27: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for FLA 2.

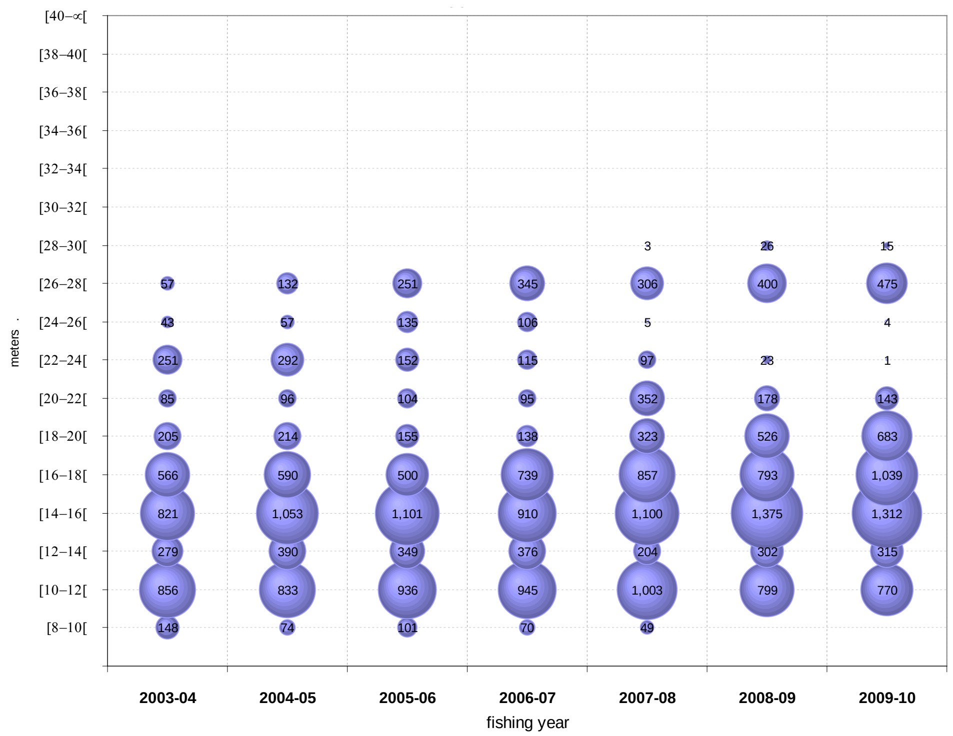


Figure 28: Trends in total number of aggregated records by stratum in each vessel length range for GUR 2.

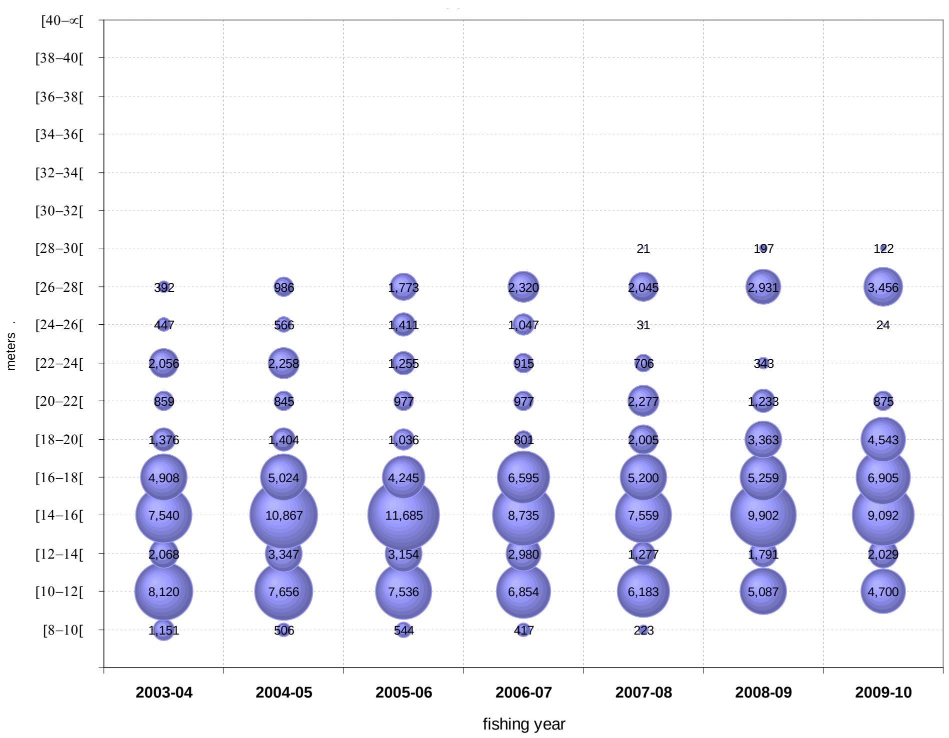


Figure 29: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for GUR 2.

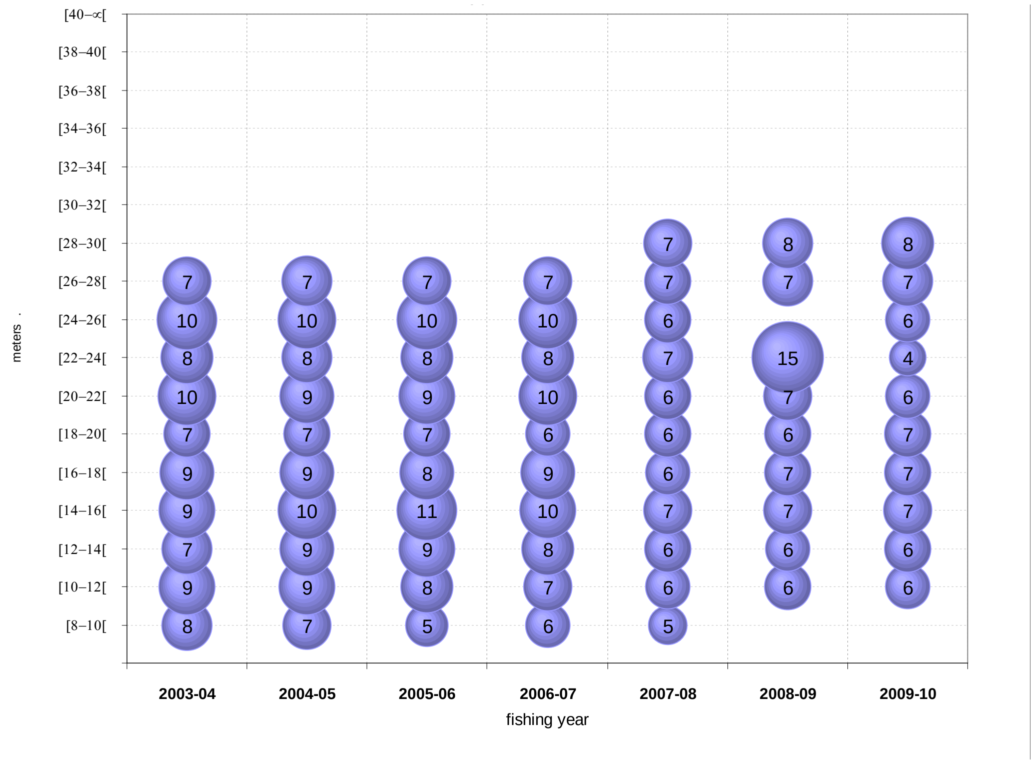


Figure 30: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for GUR 2.

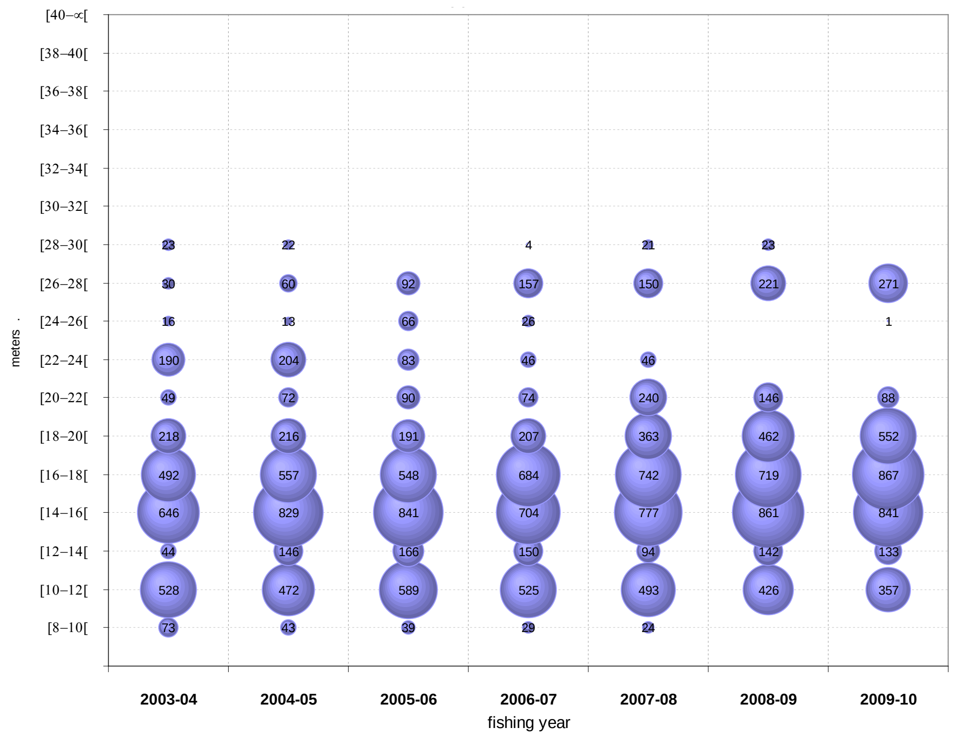


Figure 31: Trends in total number of aggregated records by stratum in each vessel length range for SNA 2.

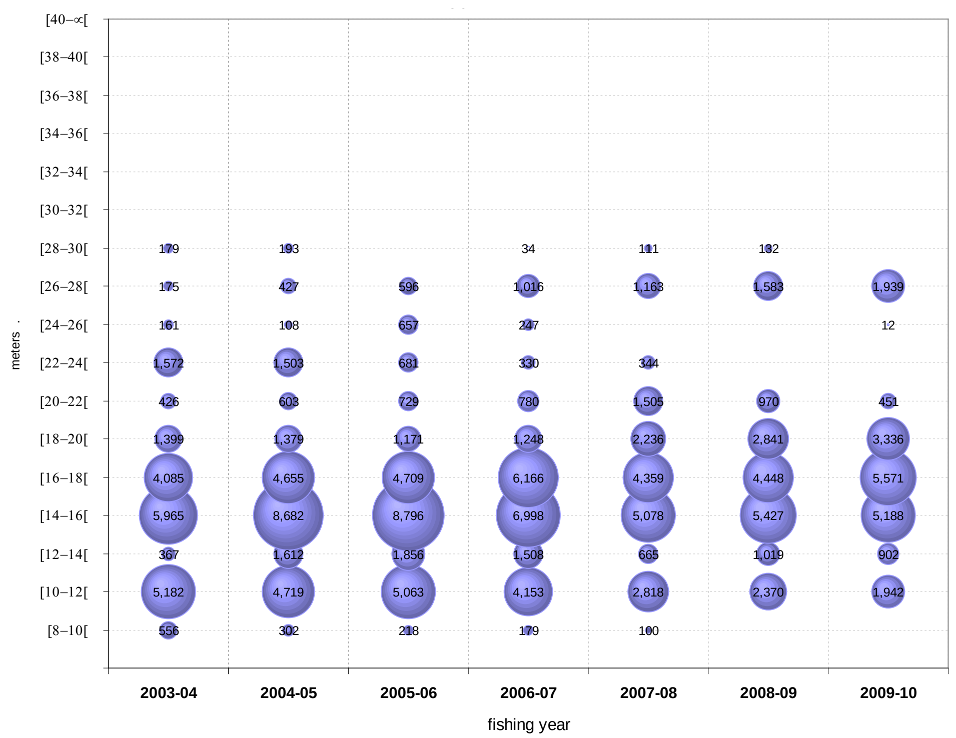


Figure 32: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for SNA 2.

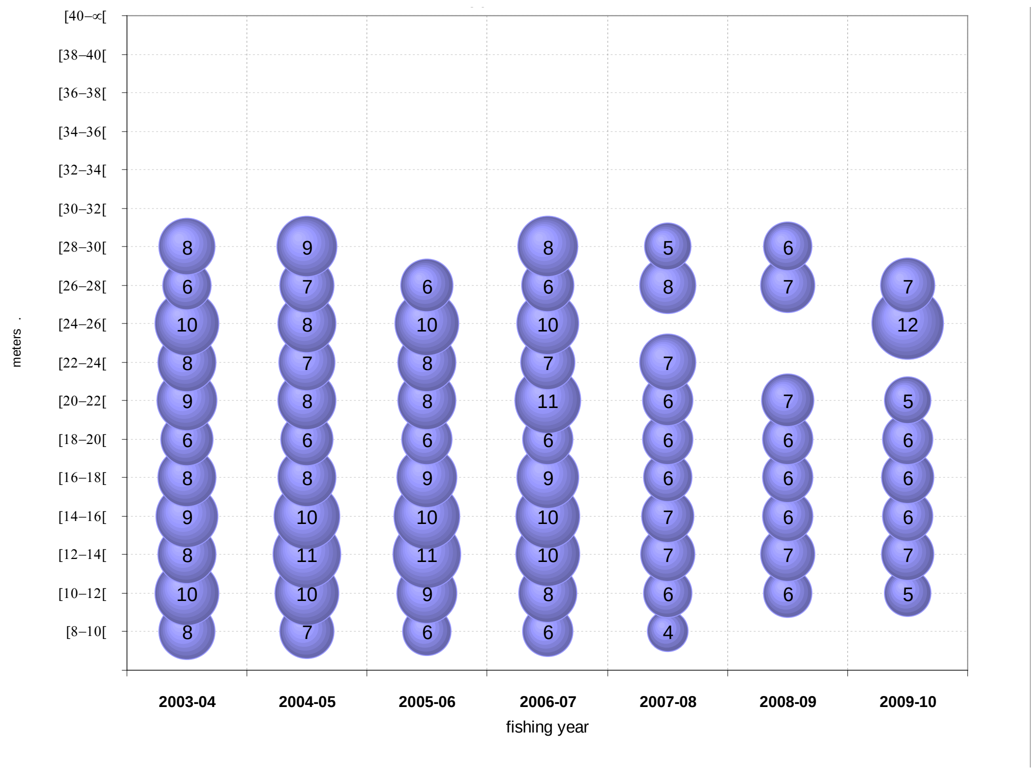


Figure 33: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for SNA 2.

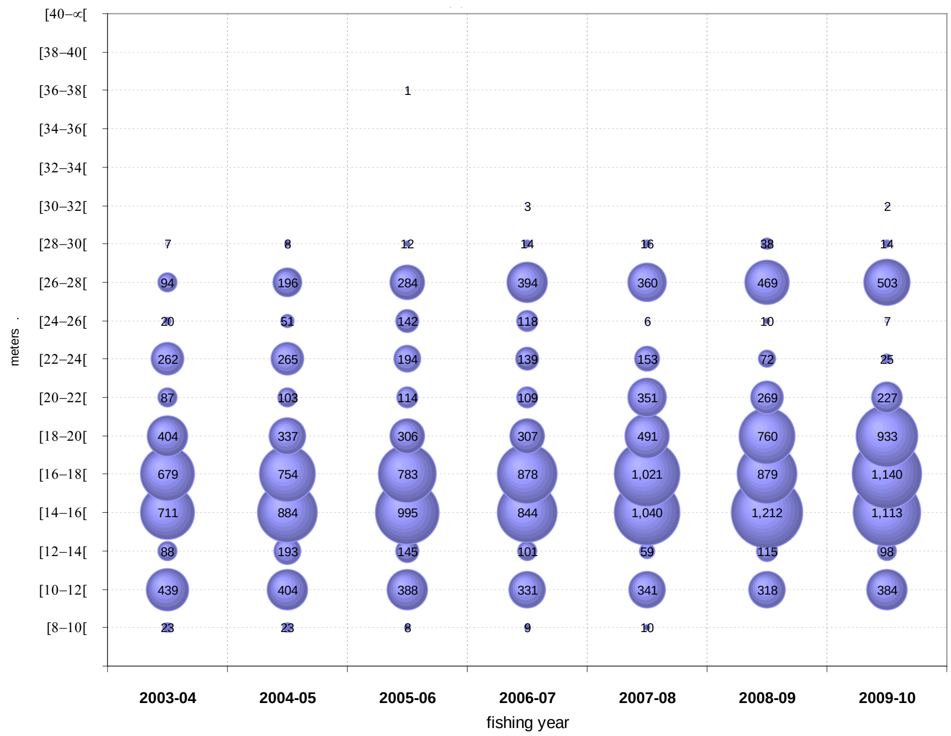


Figure 34: Trends in total number of aggregated records by stratum in each vessel length range for TAR 2.

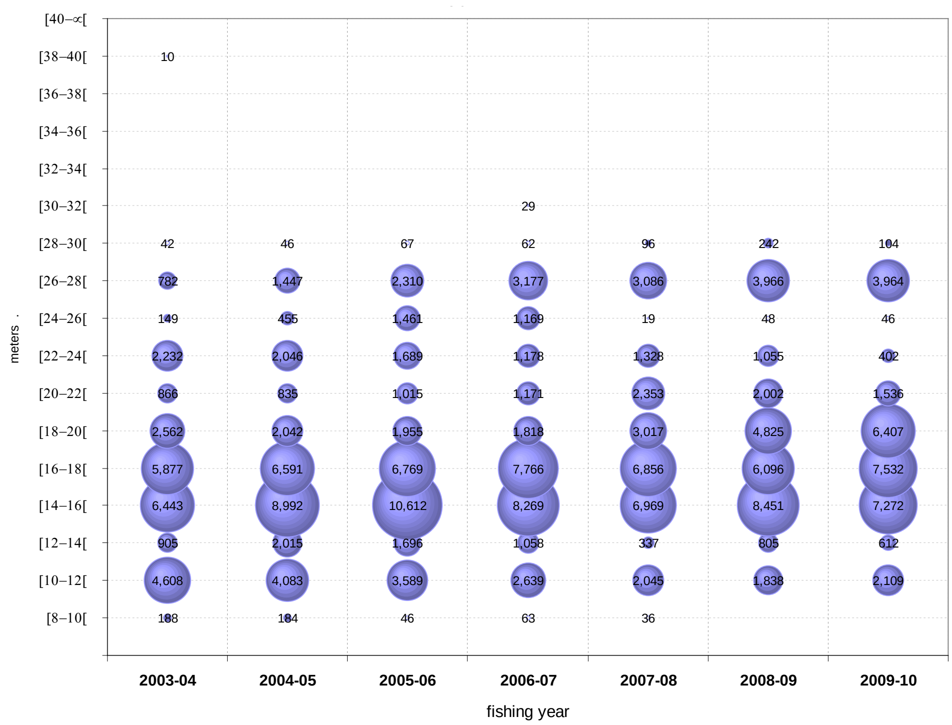


Figure 35: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for TAR 2.

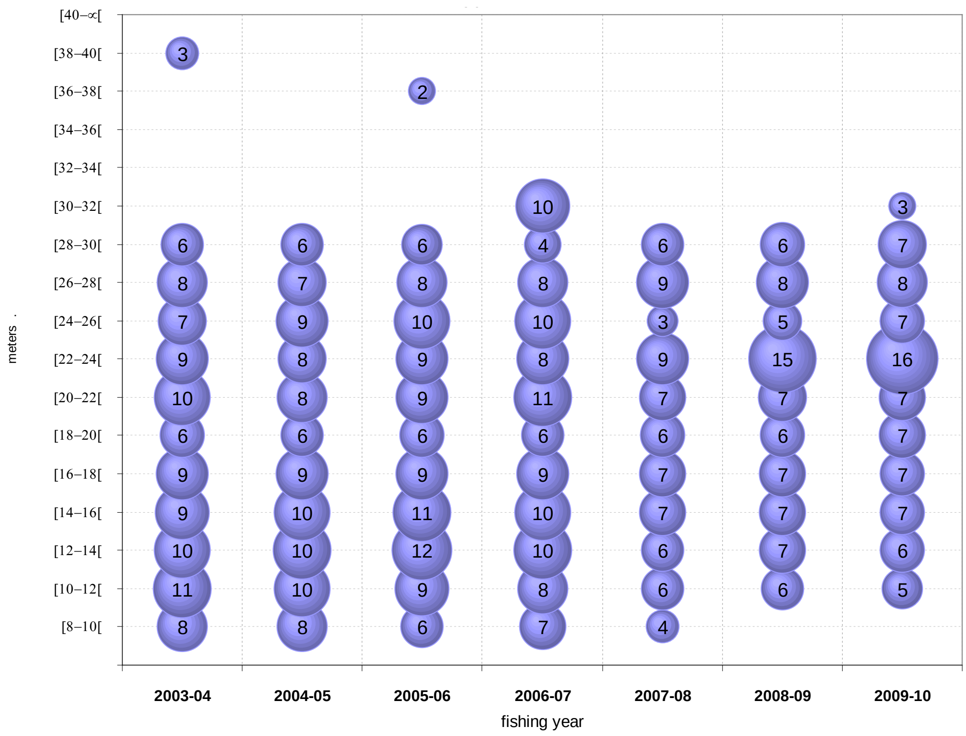


Figure 36: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for TAR 2.

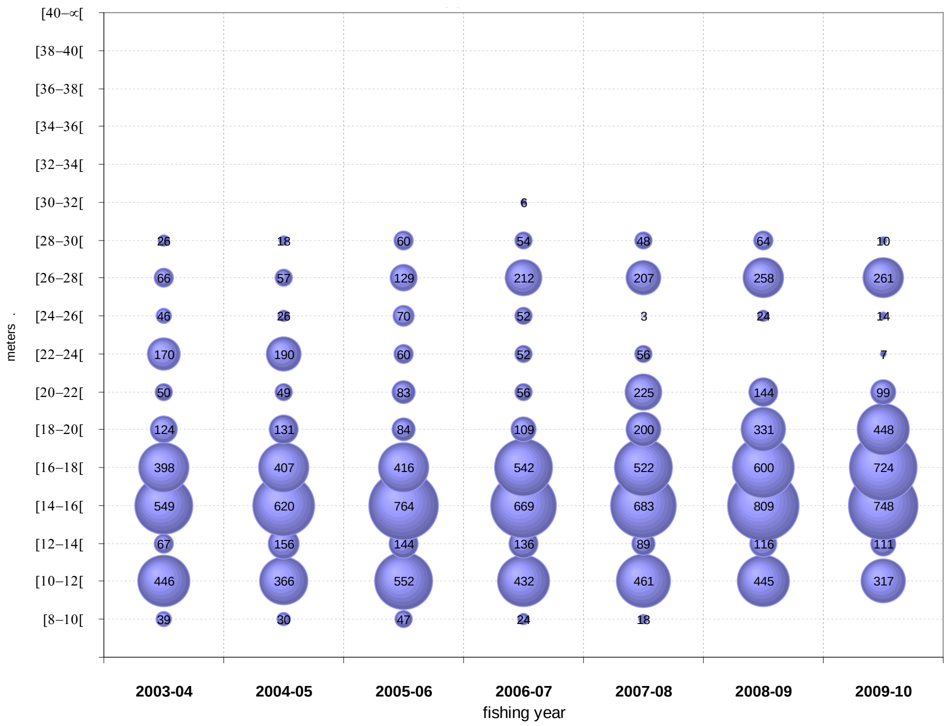


Figure 37: Trends in total number of aggregated records by stratum in each vessel length range for TRE 2.

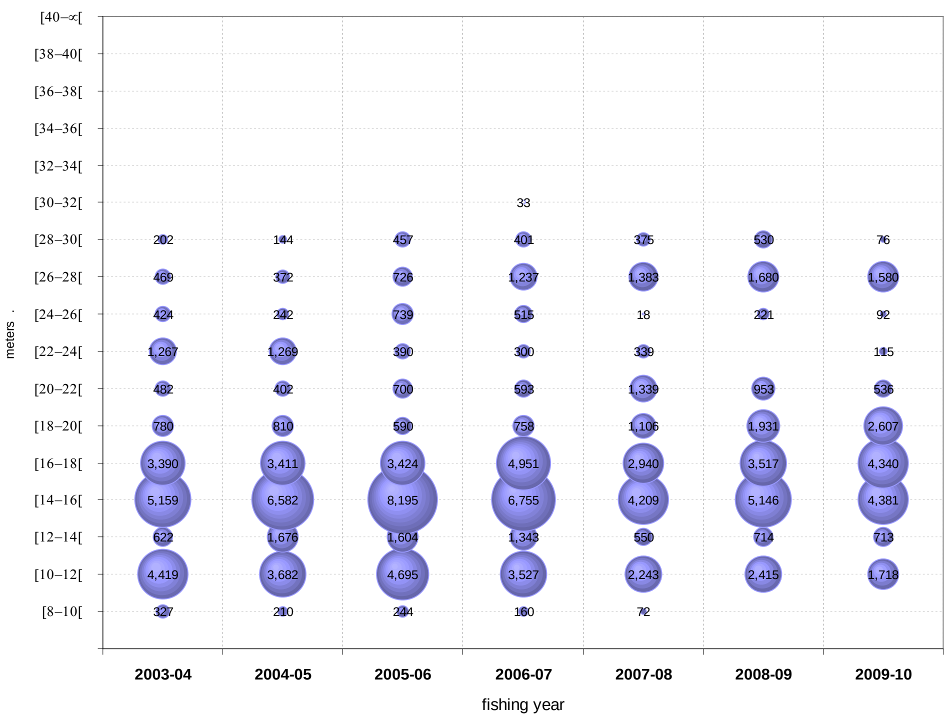


Figure 38: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for TRE 2.

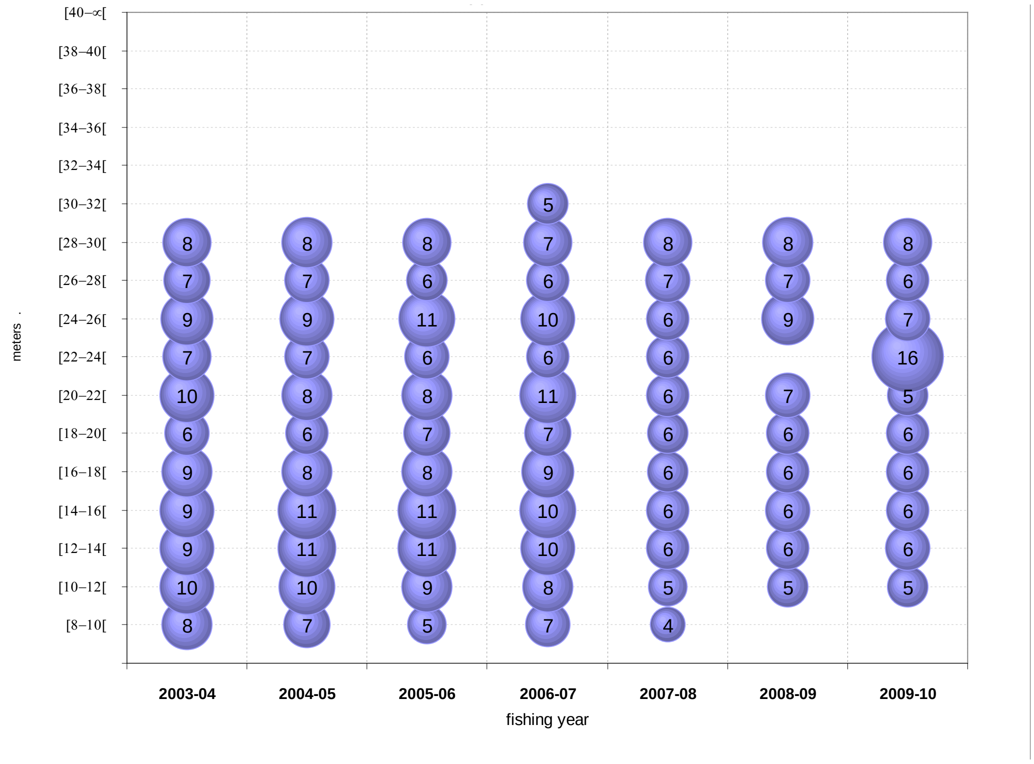


Figure 39: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for TRE 2.

4.6 Strategic behaviours

Fishing permit holders' strategic behaviours were defined earlier in Section 2.8. This section shows trends in fishing activity described by different strategic behaviours. We first look at how those strategic behaviours are represented in the RECL data at the stratum level and by segment and fishing year (Figure 40). Note that strategies 1 and 4 were combined and referred to as "strategy 1" elsewhere in the text.

Figure 40 shows that more than half the time, the data is categorised as vertically integrated strategic behaviour. The segment "SNA-BT_MIX" shows the highest proportion of the data under contracted strategic behaviour while "GUR_BT_TAR" and "TRE_BT_TAR" shows the lowest proportion. Figure 41 to Figure 55 show ACE price distributions weighted by the amount of ACE bought through the transfers for each of the five Fishstocks over the entire period (2003–04 to 2009–10) and covering the three different strategic behaviours. Each group shows on the top left quadrant an overall price distribution graph (October to September) aggregated over all fishing years and three price distribution graphs representing successive periods in the fishing years: the top right quadrant shows the price distribution graphs for the first four months (October to January) aggregated over all fishing years, the bottom left quadrant shows the price distribution graphs for the following four months (February to May) aggregated over all fishing years and the bottom right quadrant shows the price distribution graphs for the last four months (June to September) aggregated over all fishing years. Each price distribution line (blue-grey line on the top left, then green, blue and brown for the other quadrant following the periods) is contrasted with the "usual" ACE price range over the entire period (vertical orange and purple dotted line respectively): these represent the observed lower and upper ACE prices corrected for outliers and available through the FishServe Blue Book. Similarly, the figures show the deemed value range (i.e. base rate and highest differential if any) expressed in $/kg (vertical black dotted lines). Also, all the percentage figures enclosed in horizontal arrows pointing outward on each graph correspond to the percentage of transfers that took place in the range delimited by each boundary (usual ACE price and deemed value ranges); only the top left graph in each group shows the breakdown between period (percentage in black for the years, in green for October to January, blue for February to May, brown for June to September). Finally, the modal price expressed in $/kg is shown for each distribution inside a box outlined in grey at the end of a grey vertical dotted line.

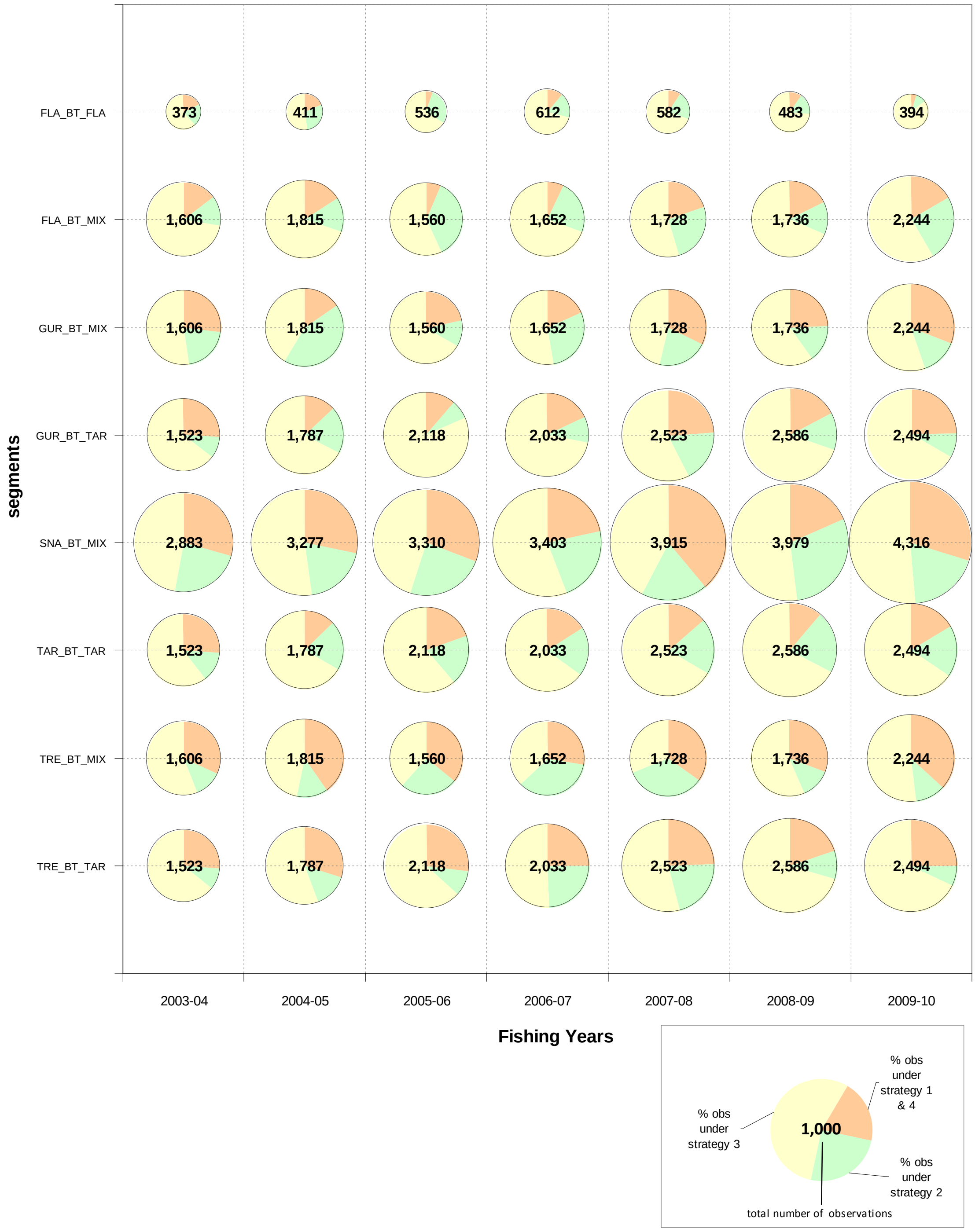


Figure 40: Trends in observed strategic behaviour for all strata by segment and fishing year.

From Figure 41 to Figure 55 we can see that, except for in FLA 2, ACE prices paid by clients exhibiting opportunistic strategic behaviours tend to be distributed inside or close to the "usual" price range (the modal price tend to be within that range). Moreover, except for FLA 2 again, ACE prices paid by clients exhibiting vertically integrated strategic behaviours in the last part of the year (June to September) when most ACE-Catch balancing takes place, tend to be distributed inside or close to the "usual" price range (the modal price tends to be within that range): this would corroborate the fact that even vertically integrated fishing permit holders might have to turn to the ACE market to balance their catch at the end of the fishing year when their fishing plan exceeds the available ACE from the company's holding. We note that modal ACE prices from both vertically integrated and contracted fishing permit holders tend to be outside the "usual" ACE market price range (mostly well below) at least during the first two thirds of the year: the modal price paid by contracted fishing permit holders appears to be systematically equal to zero suggesting that ex-vessel prices and ACE prices are determined together by the contractor as part of the contract.

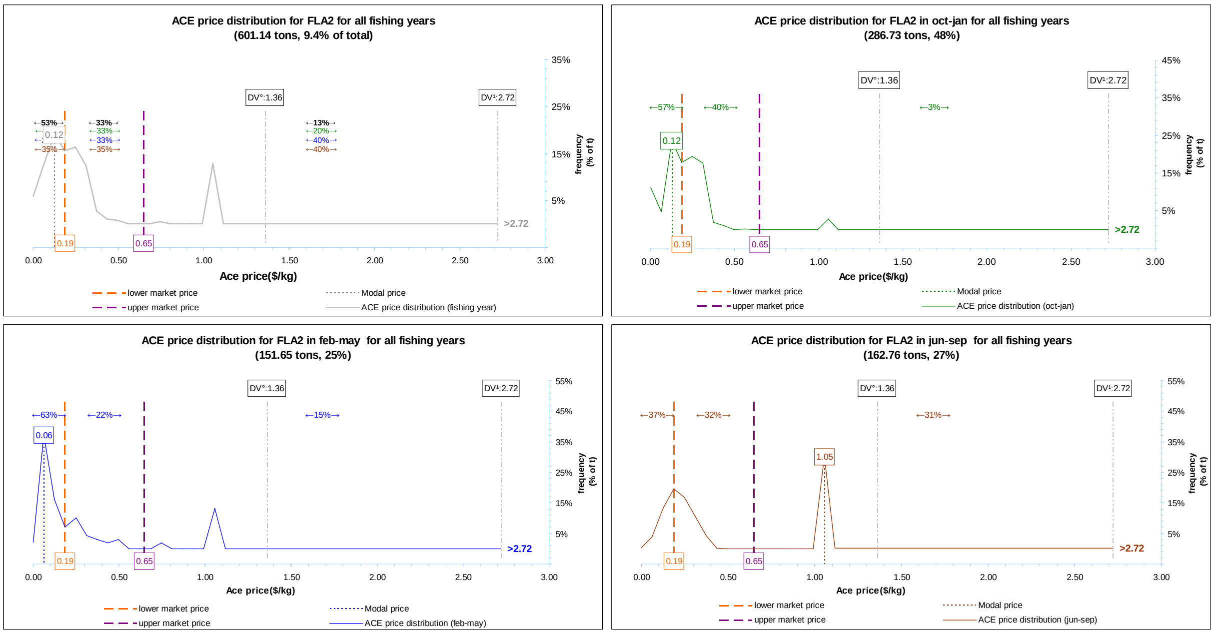


Figure 41: FLA 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10.

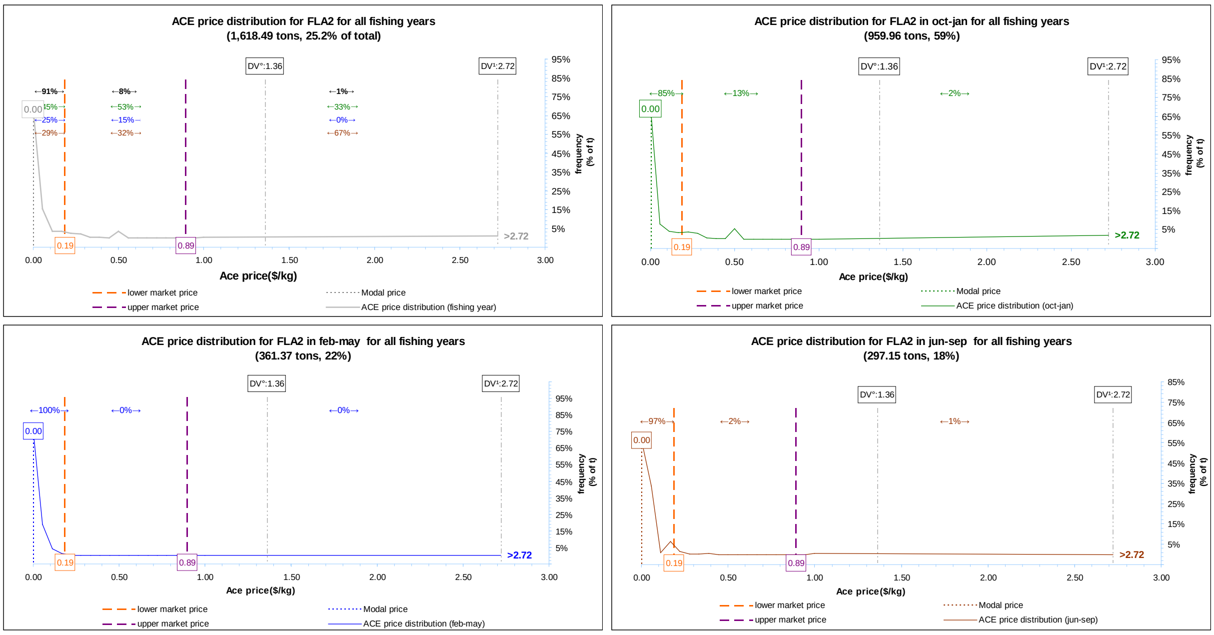


Figure 42: FLA 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10.

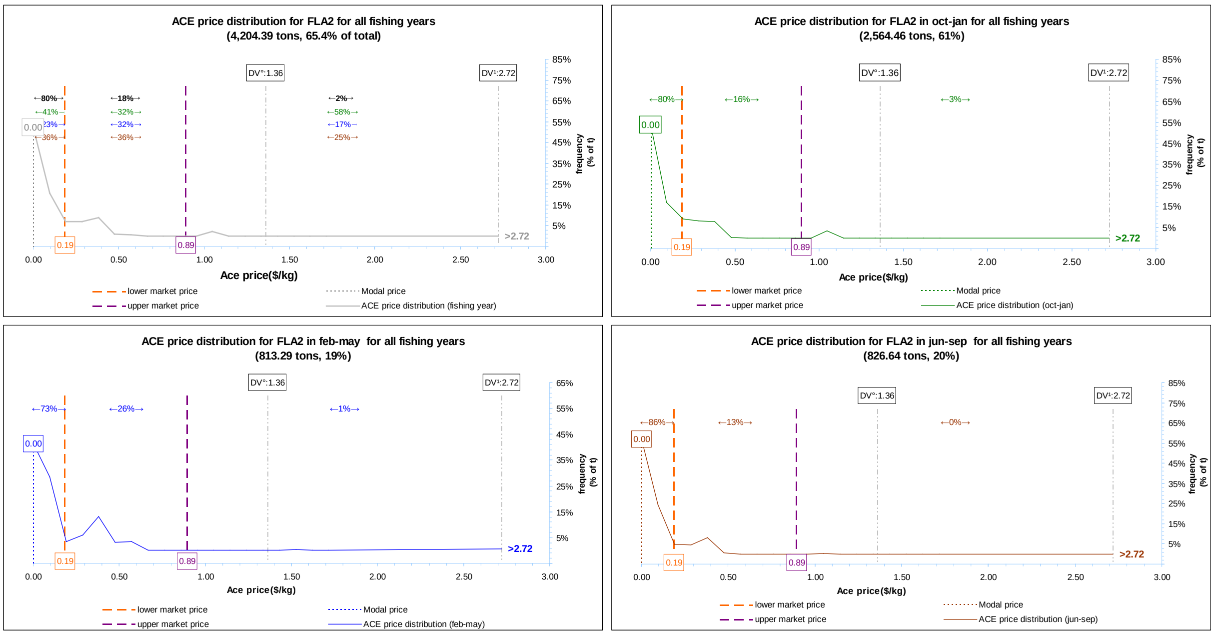


Figure 43: FLA 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10.

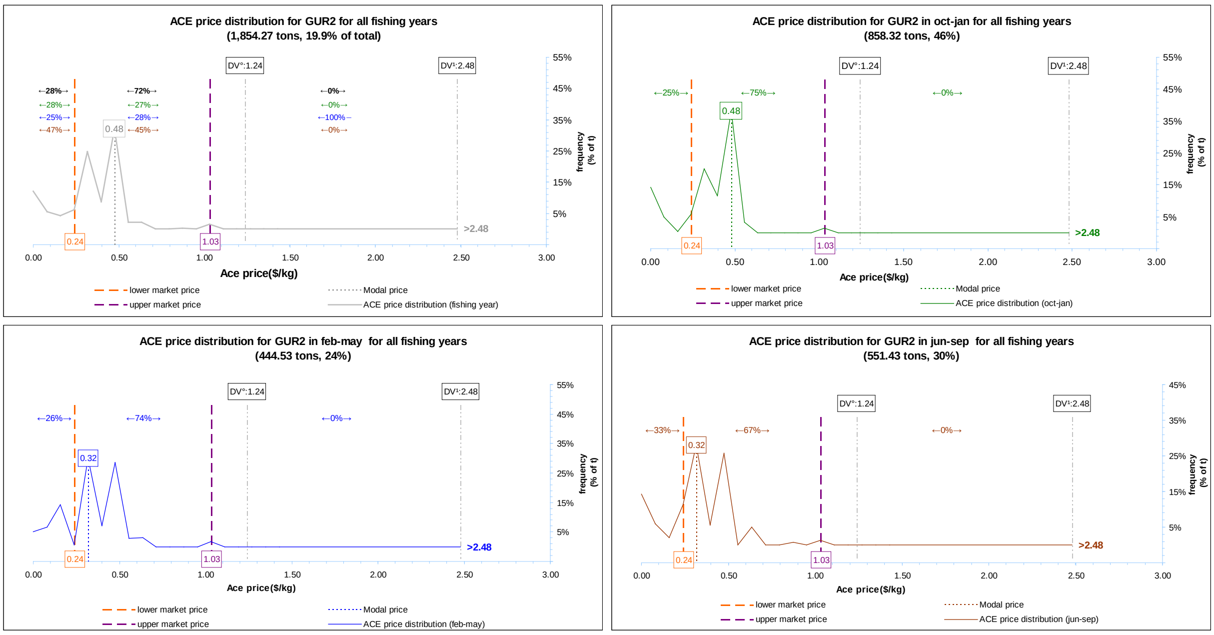


Figure 44: GUR 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10.

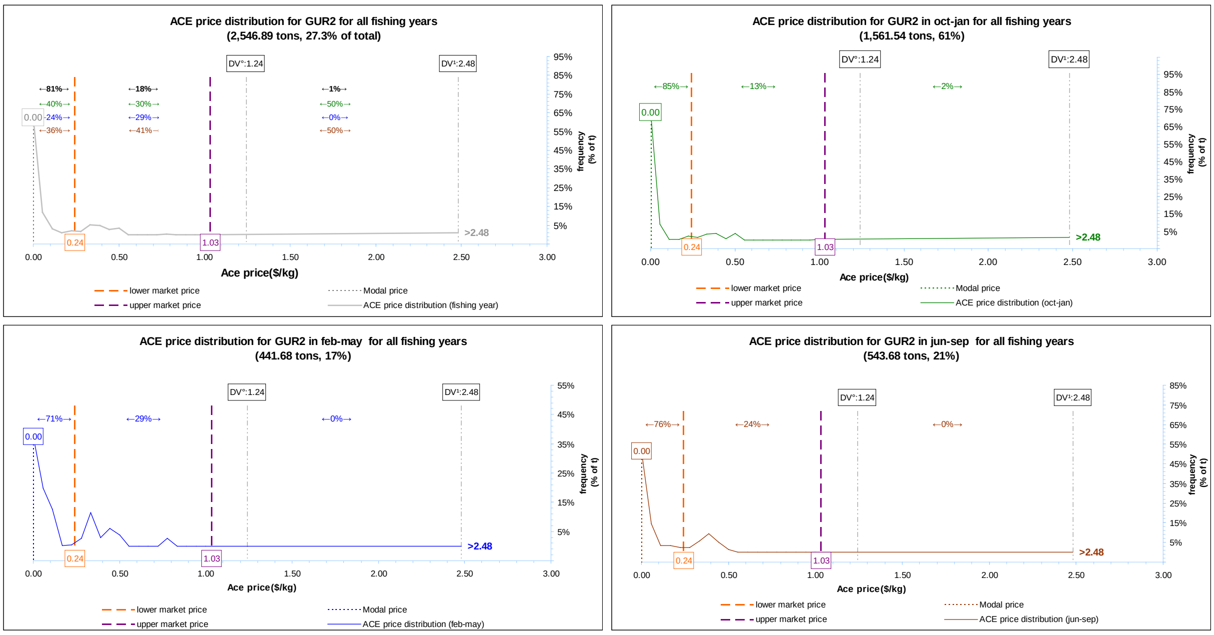


Figure 45: GUR 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10.

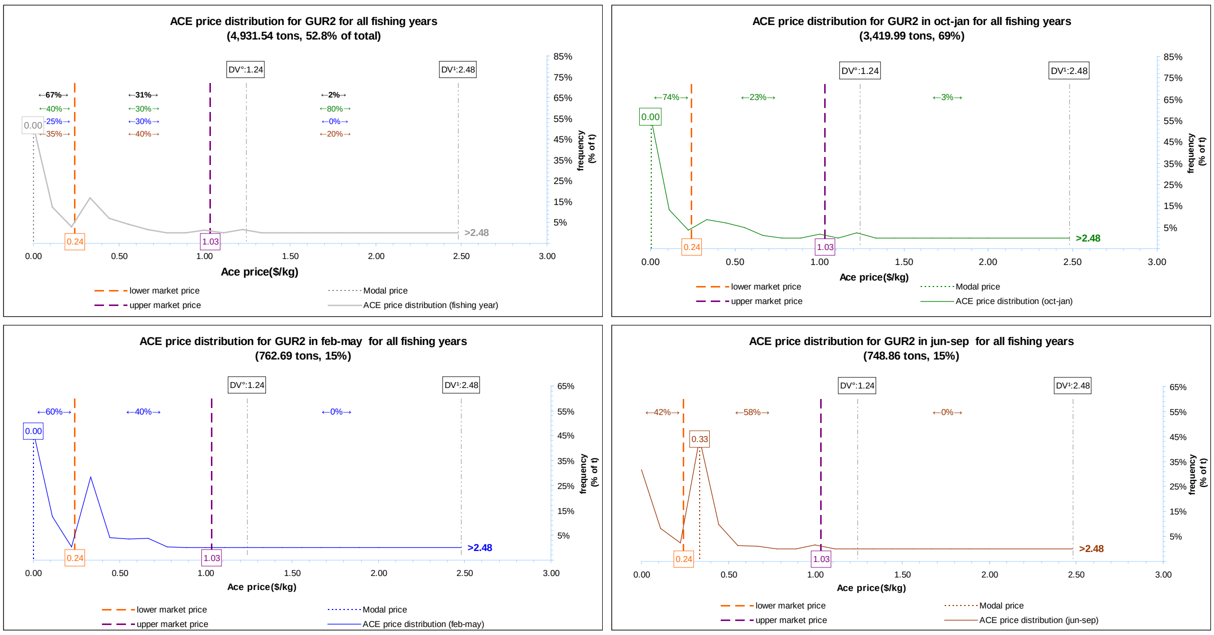


Figure 46: GUR 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10.

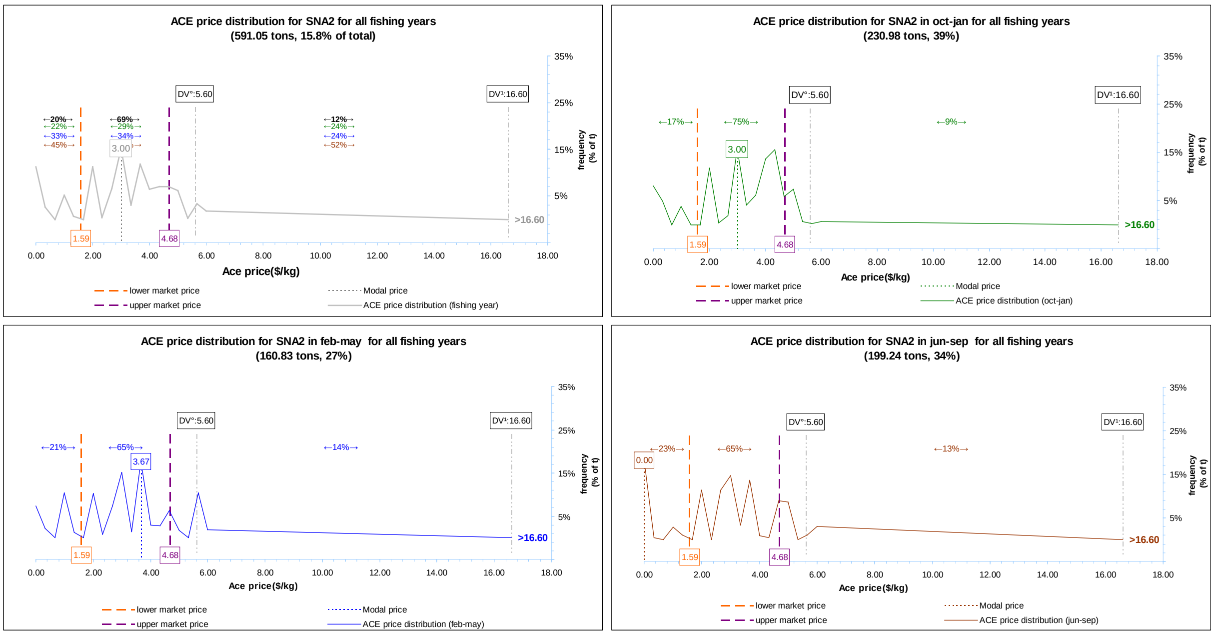


Figure 47: SNA 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10.

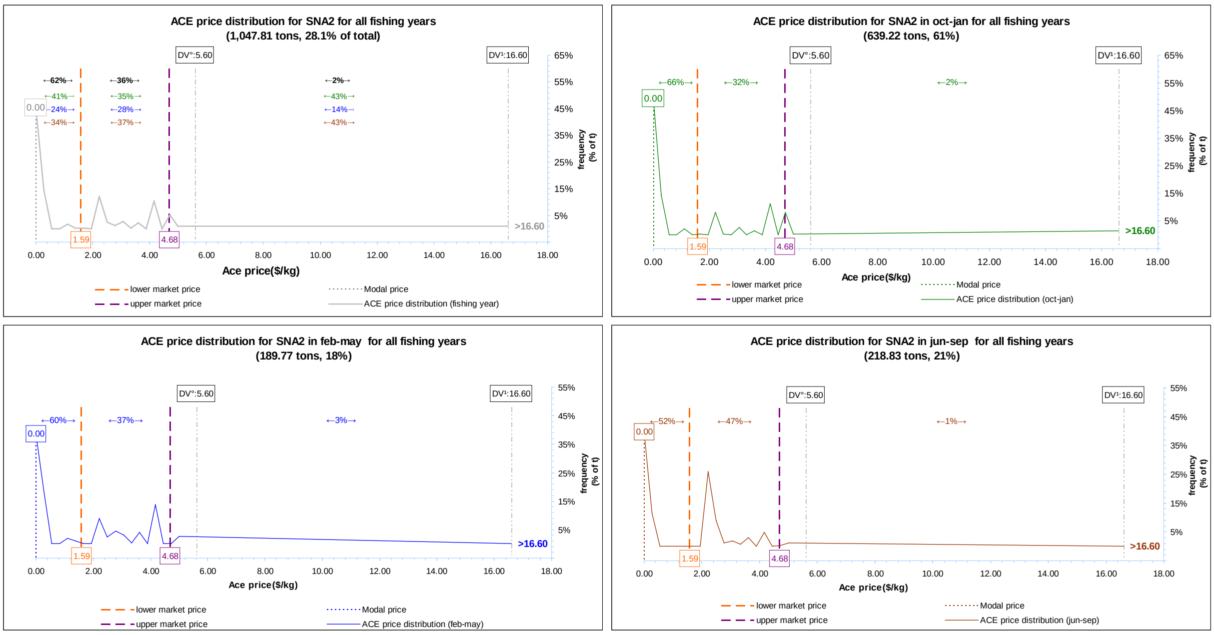


Figure 48: SNA 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10.

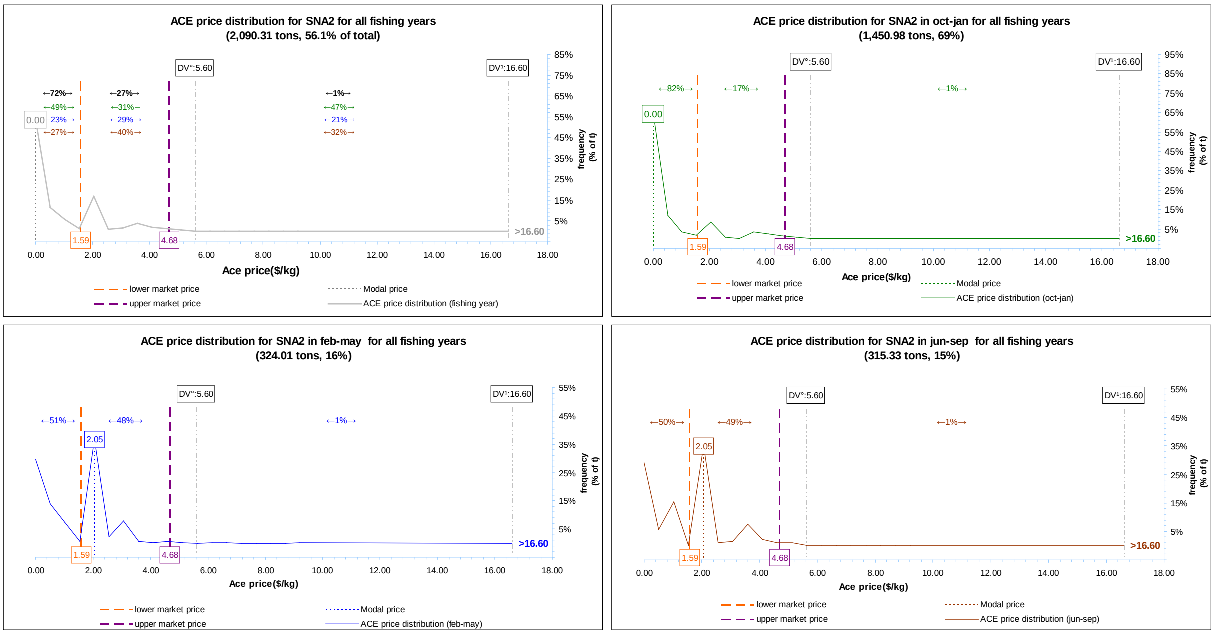


Figure 49: SNA 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10.

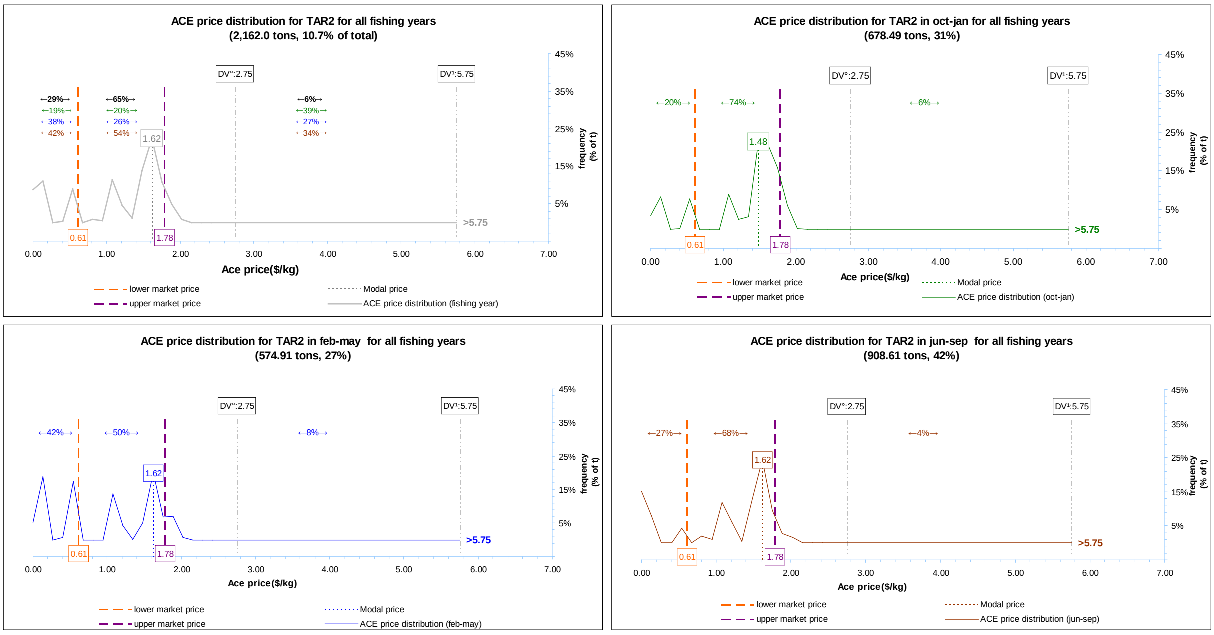


Figure 50: TAR 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10.

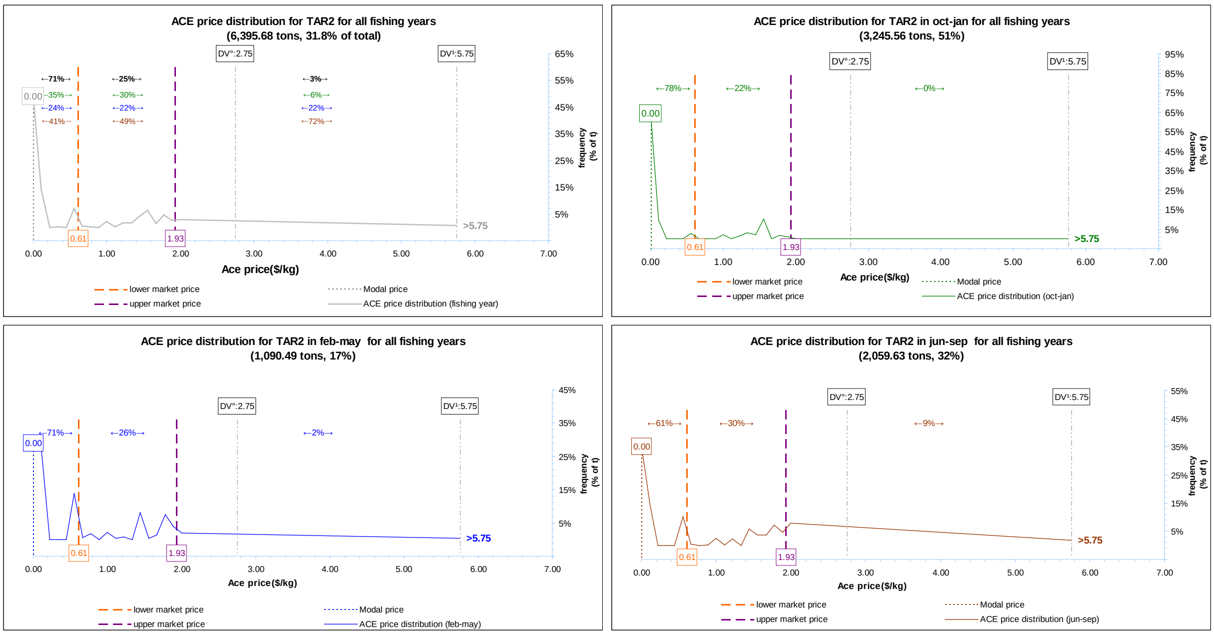


Figure 51: TAR 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10.

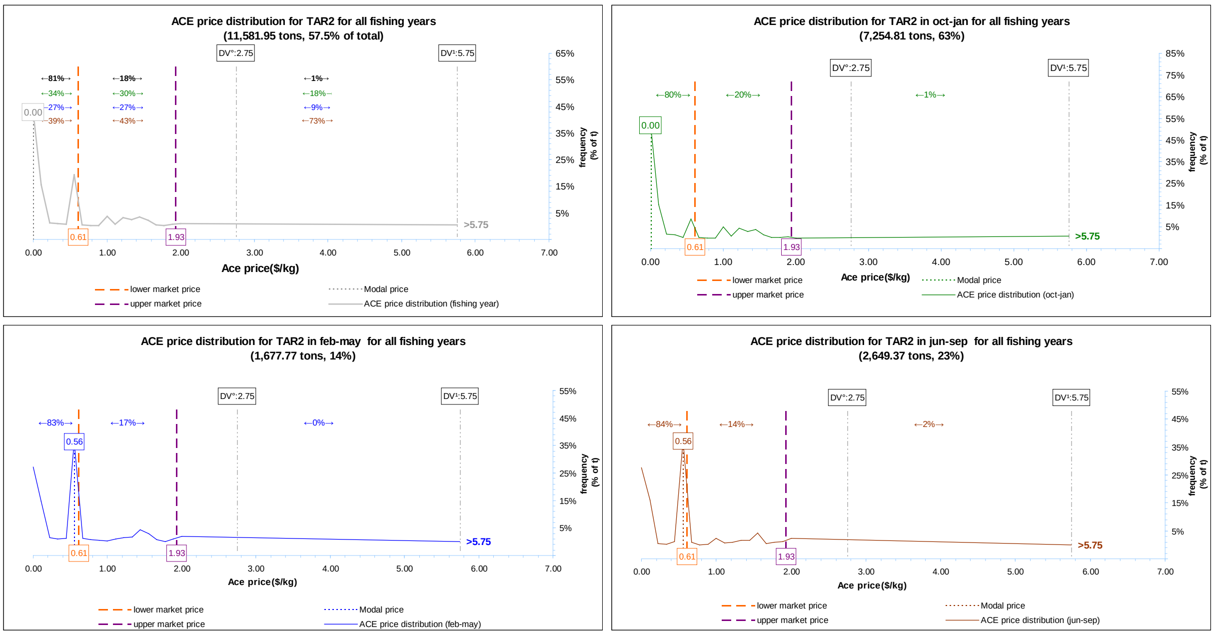


Figure 52: TAR 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10.

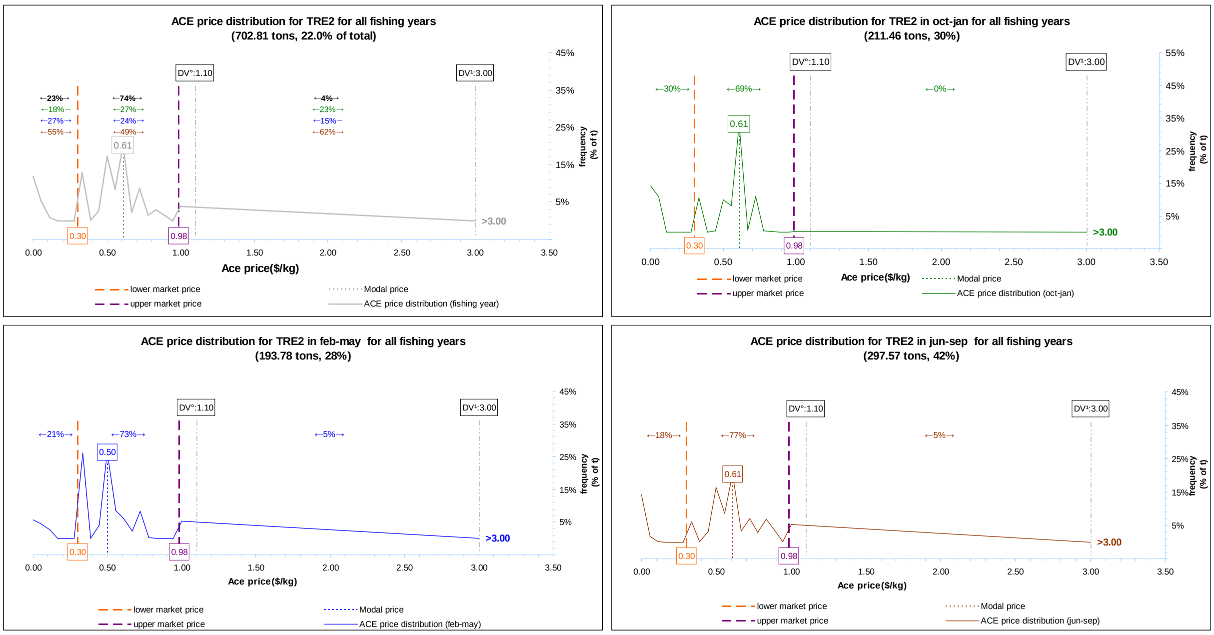


Figure 53: TRE 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10.

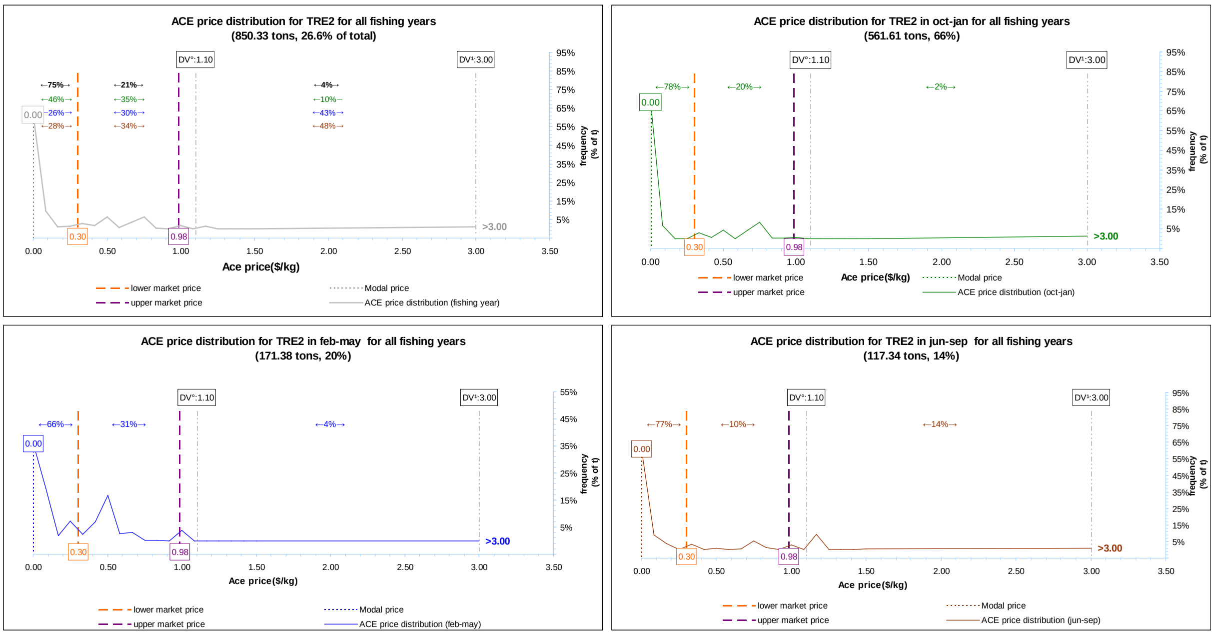


Figure 54: TRE 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10.

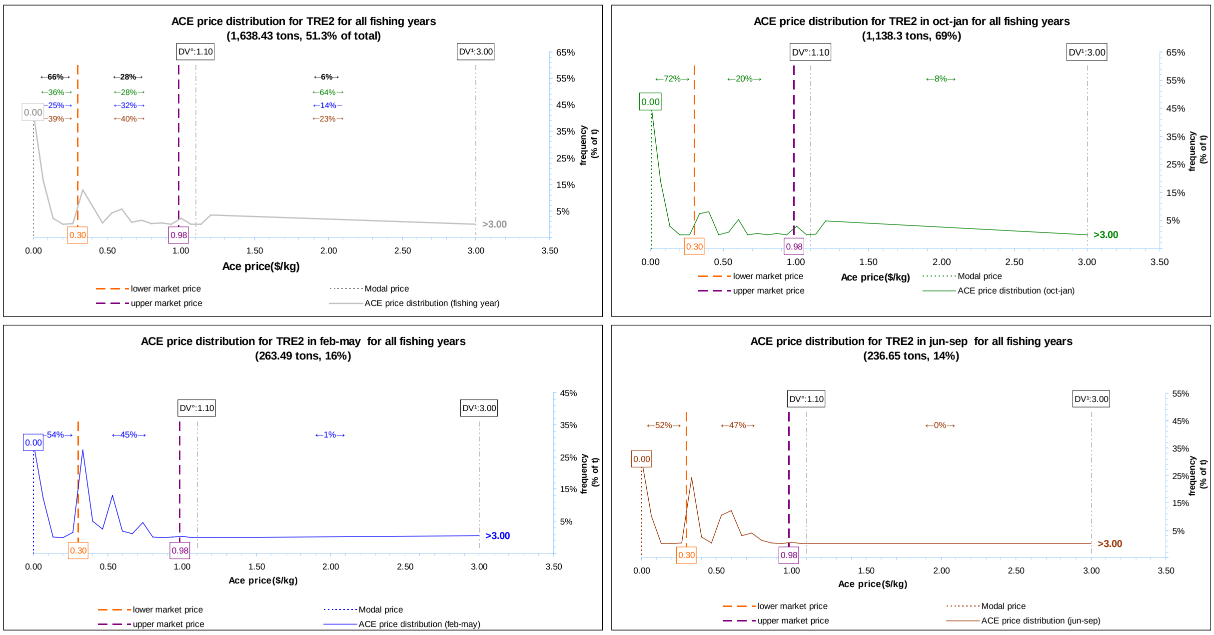


Figure 55: TRE 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10.

4.7 Catch compared with TACC

In this section reported landed catch is compared with TACC by Fishstock and fishing year.

4.7.1 Total Allowable Commercial Catch (TACC)

There has not been any TACC adjustment for any of the five Fishstocks in the past seven years except TAR 2 which was increased between 2003–04 and 2004–05 (Table 13).

Table 13: TACC (t) by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	726	726	726	726	726	726	726
GUR2	725	725	725	725	725	725	725
SNA2	315	315	315	315	315	315	315
TAR2	1,633	1,796	1,796	1,796	1,796	1,796	1,796
TRE2	241	241	241	241	241	241	241

We must note that the "ACE carried forward rule" applies to all Fishstocks studied in this report. This rule provides for up to 10% carry forward of uncaught fish Annual Catch Entitlement (ACE) to the following fishing year. In this context, underfishing refers to situations when reported landed catch is inferior to the TACC. In such circumstances, an allocation of up to 10% carry forward entitlement will be given to those fishing operators who hold ACE for a Fishstock at the close of the ACE register for the fishing year, as calculated under section *67A*(2) of the Act. Section *67A* of the Fisheries Act states:

> *Allocation of additional annual catch entitlement in case of underfishing*
>
> *(…)*
>
> *(2) If the amount of annual catch entitlement referred to in subsection (1)(a) is greater than the reported catch referred to in subsection (1)(b), the chief executive must –*
>
> > *(a) Calculate the difference between that annual catch entitlement and that reported catch; and*
> >
> > *(b) Subject to subsection (5), allocate to the person an amount of annual catch entitlement for the stock for the fishing year after the first fishing year ("the second fishing year") that is the lesser of the following:*
> >
> > > *(i) The amount calculated under paragraph (a):*
> > >
> > > *(ii) 10% of the amount of annual catch entitlement referred to in subsection (1)(a).*

Table 14 shows the reported landed catch by Fishstock over the years while Table 15 shows the under- and over-catch.

Table 14: Catch (t) by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	215.73	253.67	296.17	293.34	242.73	213.88	206.41
GUR2	510.83	704.30	542.43	573.48	517.14	621.31	851.76
SNA2	338.44	398.49	388.57	329.31	327.92	307.07	292.78
TAR2	1,638.28	1,691.90	1,981.54	1,729.18	1,714.62	1,900.98	1,838.09
TRE2	250.80	319.11	417.41	368.40	229.74	302.32	258.92

Table 15: Comparison of catch and TACC in tonnes by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	-510.2	-472.2	-429.7	-432.6	-483.2	-512.0	-519.5
GUR2	-214.6	-21.2	-183.0	-152.0	-208.3	-104.2	126.3
SNA2	23.4	83.5	73.6	14.3	12.9	-7.9	-22.2
TAR2	5.5	-104.1	185.5	-66.8	-81.4	105.0	42.1
TRE2	9.5	77.8	176.1	127.1	-11.5	61.1	17.7

Source: FishServe Register Extracts Database
Note: for each fishing year, overcaught TACCs shown in red, undercaught TACCs in blue

4.7.2 Cumulative catch and ACE transfers

Figure 56 to Figure 60 are derived from FishServe's "Blue Book". They contrast cumulative quantities and numbers of parcels of ACE transferred with cumulative catch and TACC by month, inter and intra annual between fishing years 2003–04 and 2009–10. Looking at the trends, we observe that the quantity of ACE transferred is systematically higher than the cumulative catch during the same period: this suggests that the ACE market is active and on average ACE is being transferred several times during the same month. The line showing the cumulative number of ACE transfers also indicates that there are between 200 and 350 ACE transfers every fishing year: we observe an increase in the number of ACE transfers towards the end of each fishing year, suggesting that fishing permit holders put more pressure on the ACE market, seeking additional ACE to balance their catch. Figure 56 shows that FLA 2 has been systematically under caught. At the same time, this releases some pressure on the ACE market where the cumulative amount of ACE has been steadily below the TACC indicative of the total amount of available ACE at the beginning of the fishing year (notwithstanding ACE carried forward). Cumulative catch for all species does not show any sharp increase suggesting that catch is spread out relatively evenly during each fishing year except perhaps in the last month 0of the fishing year. In other words, although the cumulative catch trend shows for most Fishstocks a smooth increase at a decreasing rate, there is a noticeable increase in the last month, most likely caused by the artefact of catch adjustment and book reconciliation (i.e. accurate and reconciled catch-ACE balancing required by regulation).

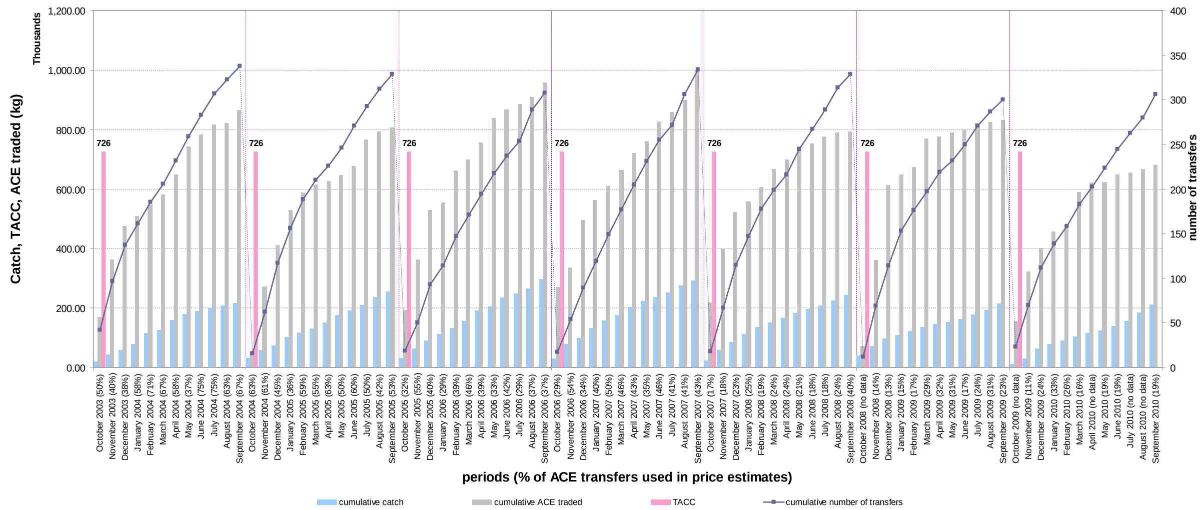


Figure 56: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for FLA 2 (flatfish) between fishing years 2003–04 and 2009–10.

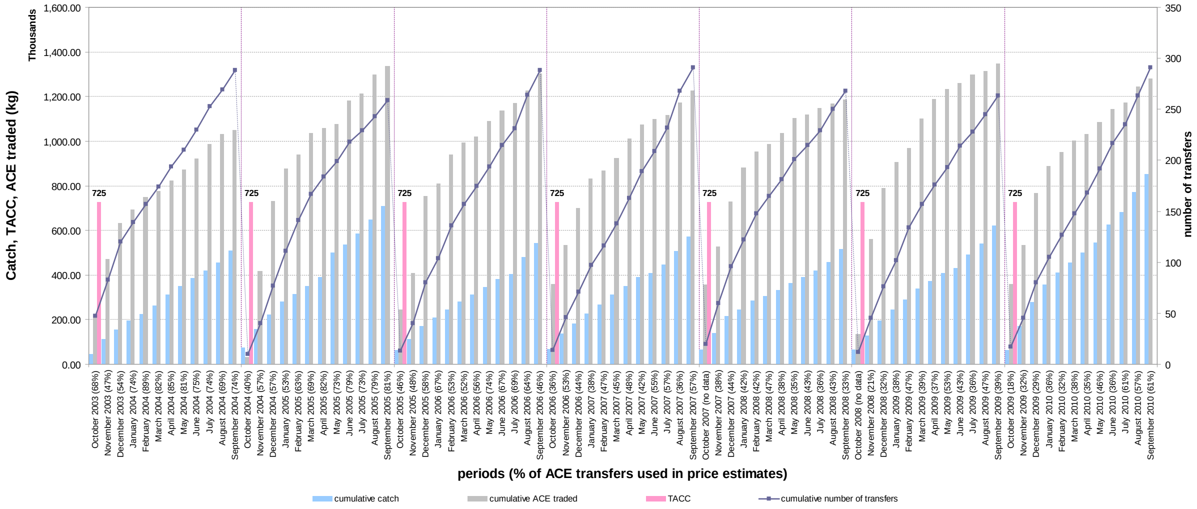


Figure 57: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for GUR 2 (red gurnard) between fishing years 2003–04 and 2009–10.

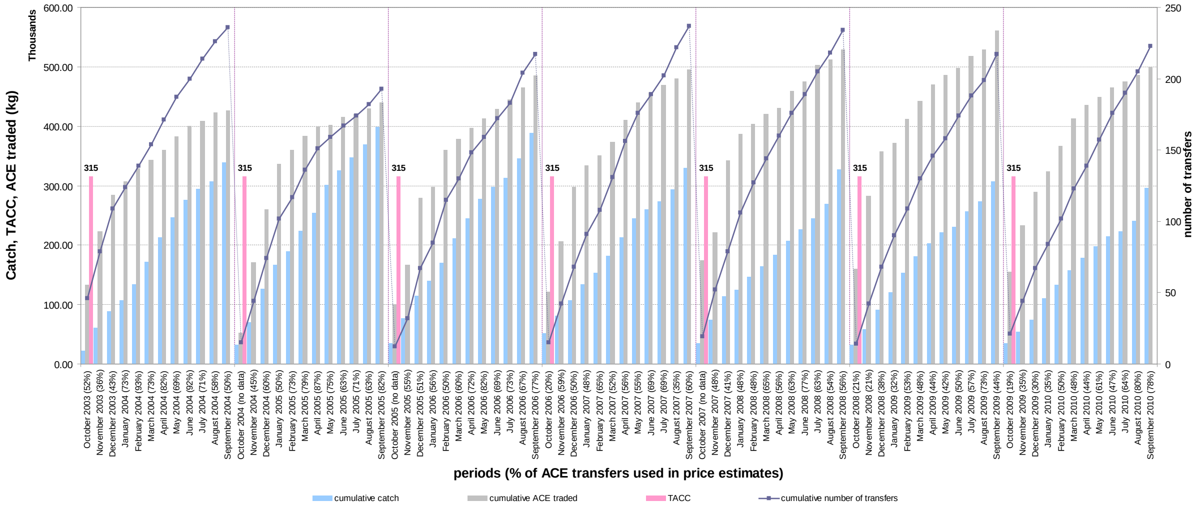


Figure 58: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for SNA 2 (snapper) between fishing years 2003–04 and 2009–10.

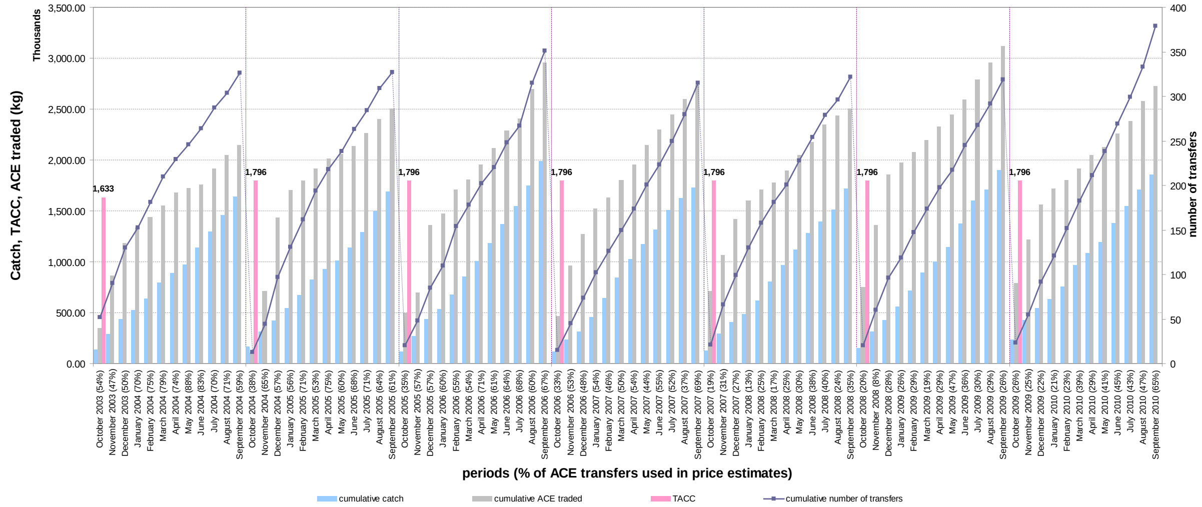


Figure 59: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for TAR 2 (tarakihi) between fishing years 2003–04 and 2009–10.

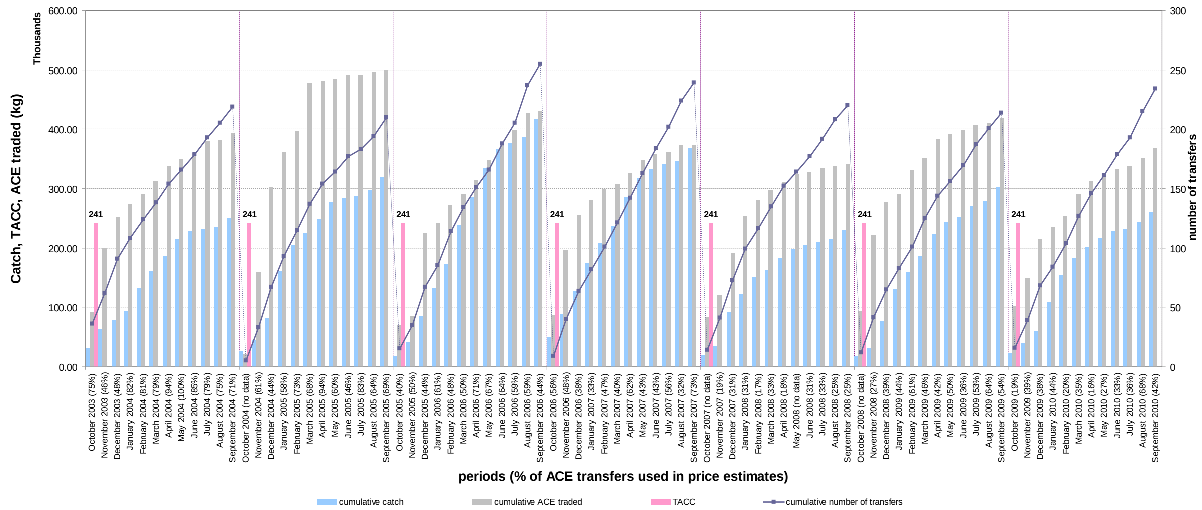


Figure 60: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for TRE 2 (trevally) between fishing years 2003–04 and 2009–10.

4.7.3 Under-Catch

Annual value of forgone revenue resulting from the Fishstock being under-caught was estimated by multiplying the average surveyed port price (see Port Prices4.8) by the annual under-catch defined by the difference between TACC and landed catch.

With the exception of snapper (SNA 2), TACCs have been often under-caught: flatfish (FLA 2) have been systematically under-caught with estimated forgone revenues greater than $1.5 million per fishing year, totalling almost $11 million for the past seven years (Table 16).

Table 16: Estimated Forgone Revenue by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$1,616,738	$1,492,259	$1,357,937	$1,368,203	$1,604,114	$1,699,920	$1,724,713
GUR2	$446,095	$42,334	$366,056	$288,681	$387,486	$193,732	
SNA2						$39,491	$110,666
TAR2		$235,257		$154,494	$275,081		
TRE2					$17,749		

4.7.4 Over-Catch and Deemed Values

Figures in the Appendix show detailed information on individual over-catch trend by Fishstock between 2003 and 2010.

Overall, very few stocks were over-caught. From this analysis, it seems that deemed value payments reflect more the inability or unwillingness of fishers to acquire ACE. Moreover, there has been a decline in deemed value payment in the fishing years between 2007 and 2009 but as shown in Table 17, this tendency was slightly reversed in the last fishing year, 2009–10 (Figure 61).

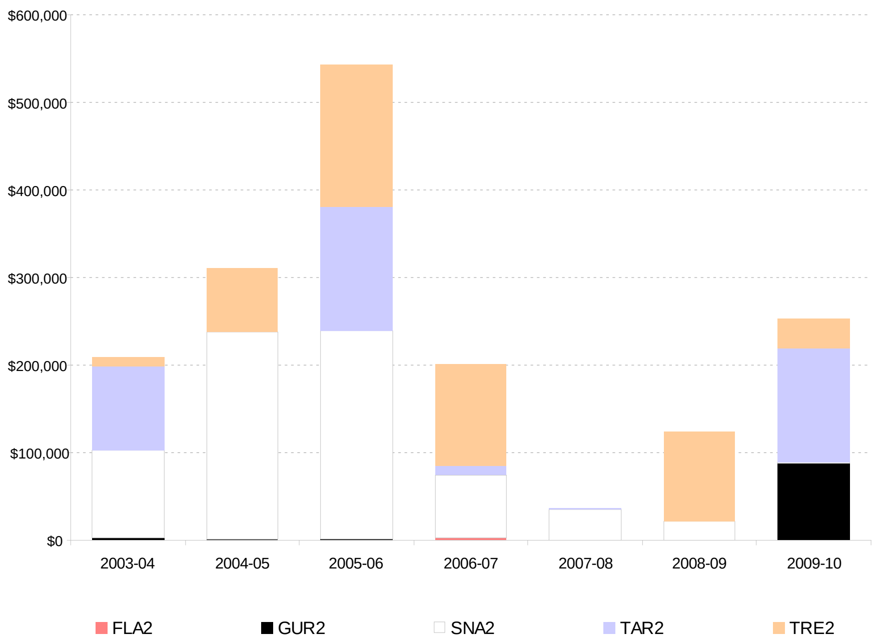


Figure 61: Trend in total deemed value payment by Fishstock and fishing year.

The bulk of the over-catch in 2009–10 relates to GUR 2, TAR 2 and TRE 2 (Table 18). A decline in deemed value payments from one year to the next could be interpreted as follows:

- Discards have been increasing; or
- Fishers are avoiding catching Fishstocks for which they do not have enough ACE.

An increase in deemed value payments as observed in 2009–10 could be an indication of the following:

- The lack of ACE availability at a fair price to cover catch may be exacerbated by the increase in the number of permit holders depending on the market to acquire ACE rendering them more vulnerable to price fluctuation;
- An increase in monitoring and compliance (i.e. less discards, more reporting and landings);
- an increase in the DV rate of some Fishstocks;
- a decrease in TACC of a Fishstock.

Table 19 shows that in 2009–10 there was an increase in the number of permit holders who were over-catching their ACE. However in the case of TRE 2, for example, an increase in the number of deemed value payers does not mean that, on aggregate, more deemed value was paid, which perhaps implies that most over-catch was accidental (i.e. small overcatch).

Table 17: Estimated Deemed Value paid by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$18	$386	$19	$2,104	$83	$117	$172
GUR2	$2,279	$290	$1,088	$110	$119	$356	$88,021
SNA2	$99,805	$236,590	$238,278	$71,627	$35,462	$20,695	$329
TAR2	$96,511	$281	$142,214	$11,295	$626	$162	$130,835
TRE2	$10,189	$73,507	$161,724	$115,991	$546	$103,201	$33,512

Table 18: Operators' Over-Catch in tons (i.e. Catch-ACE) by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	<0.01	0.14	0.01	0.79	0.06	0.04	0.07
GUR2	0.98	0.12	0.45	0.05	0.09	0.18	69.66
SNA2	27.55	73.44	71.29	23.56	6.99	4.14	0.03
TAR2	57.91	0.16	89.99	3.58	0.13	0.03	34.61
TRE2	11.08	79.90	175.79	126.08	0.40	46.40	20.83

Table 19: Number of Operators paying Deemed Value by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	2	2	2	4	3	3	6
GUR2	5	6	3	4	3	3	16
SNA2	11	20	18	9	7	5	3
TAR2	12	8	10	11	11	3	13
TRE2	8	13	12	9	3	9	13

4.8 Port Prices

Port prices (Table 20) are collected on a voluntary basis through annual surveys with licensed fish receivers (LFRs) and are a crude estimate of the value of the fish once landed. As such, the resulting average port price does not discriminate between methods used to catch the fish, market fish sizes, fish quality or season. Any calculation involving port prices thus collected might misestimate the actual value of the fish landed. Port prices used in this report were further averaged by the Ministry of Fisheries using a three year moving average which has the effect of dampening any sudden annual variation. Also, note that the last three years show no variation in port prices (Table 20).

Table 20: Surveyed Port Prices by Fishstock and fishing year.

Fish Stock	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	$3.17	$3.16	$3.16	$3.16	$3.32	$3.32	$3.32
GUR2	$2.08	$2.00	$2.00	$1.90	$1.86	$1.86	$1.86
SNA2	$4.35	$3.73	$3.73	$4.25	$4.98	$4.98	$4.98
TAR2	$2.42	$2.26	$2.26	$2.31	$3.38	$3.38	$3.38
TRE2	$1.36	$1.50	$1.50	$1.45	$1.54	$1.54	$1.54

4.9 CPUE

CPUE indices for the five Fishstocks were obtained from the Ministry of Fisheries Northern Inshore Science Working Group papers (see Kendrick and Bentley 2010a, 2010b, 2011a, 2011b, 2011c, 2011d, 2011e, 2011f, 2011g and Bentley et al. 2012.). Figure 62 to Figure 66 contrast trends in CPUE with trends in calculated underlying discount rate (see Section 4.1.3). If CPUE is an index of abundance and therefore an indication of health of the fishery, we would expect the corresponding underlying discount rate to reflect the status of that fishery. In other words, if CPUE improves over time, we would expect the risk perception associated with that fishery or Fishstock to diminish. Here again, any underlying discount rate greater than the risk-free rate suggests a net risk premium reflecting the status of the Fishstock and/ or perception of the fishery. Symmetrically, any underlying discount rate less than the risk-free rate suggests a healthy stock and/or fishery bringing potential capital growth to the quota owner.

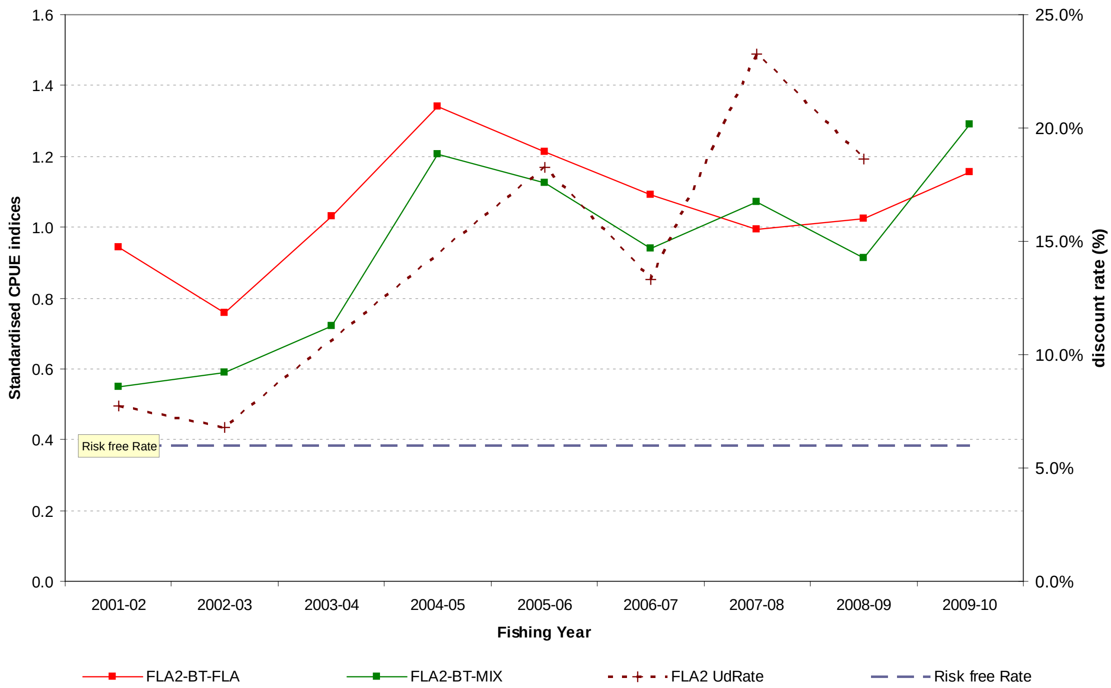


Figure 62: Trend in FLA 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10.

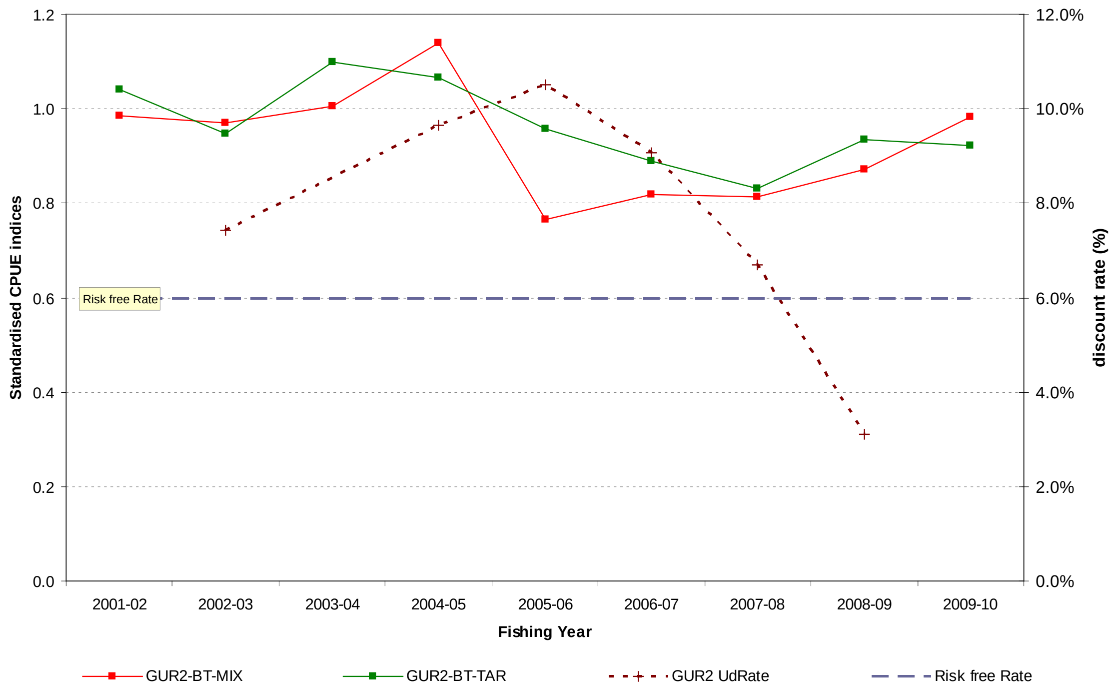


Figure 63: Trend in GUR 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10.

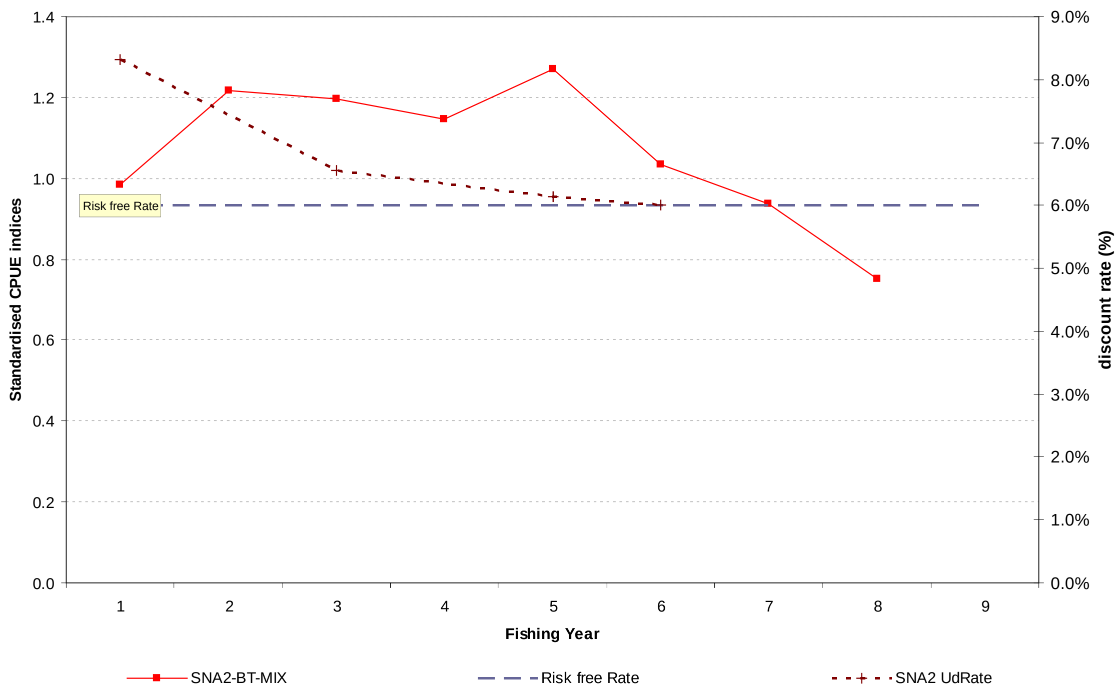


Figure 64: Trend in SNA 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2008–09.

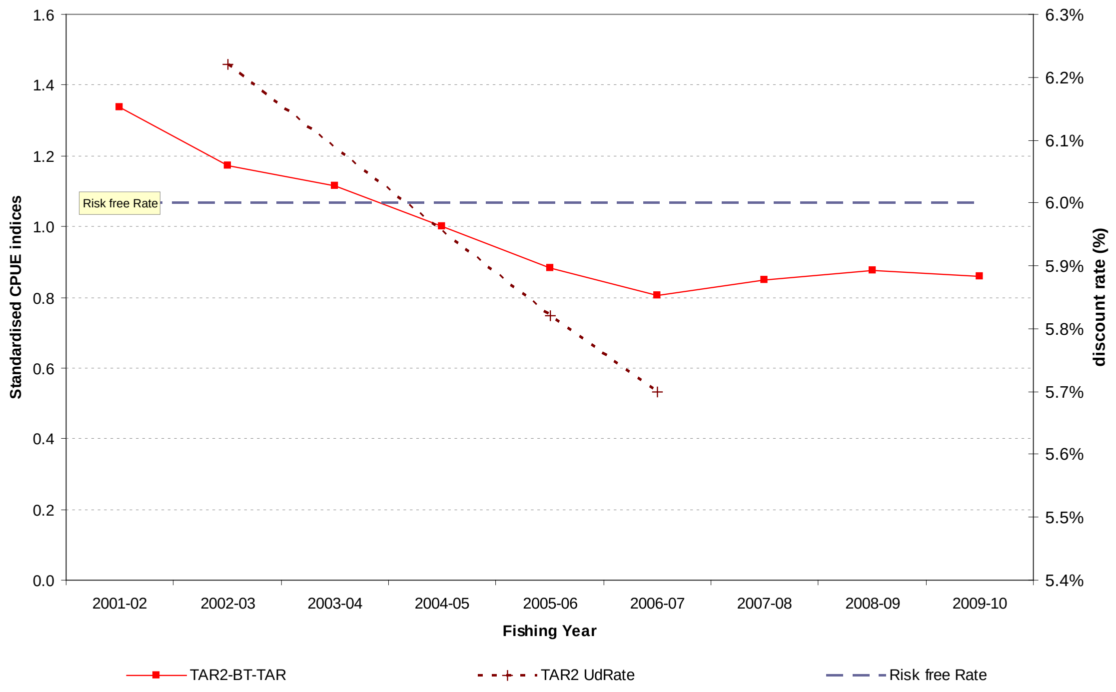


Figure 65: Trend in TAR 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10.

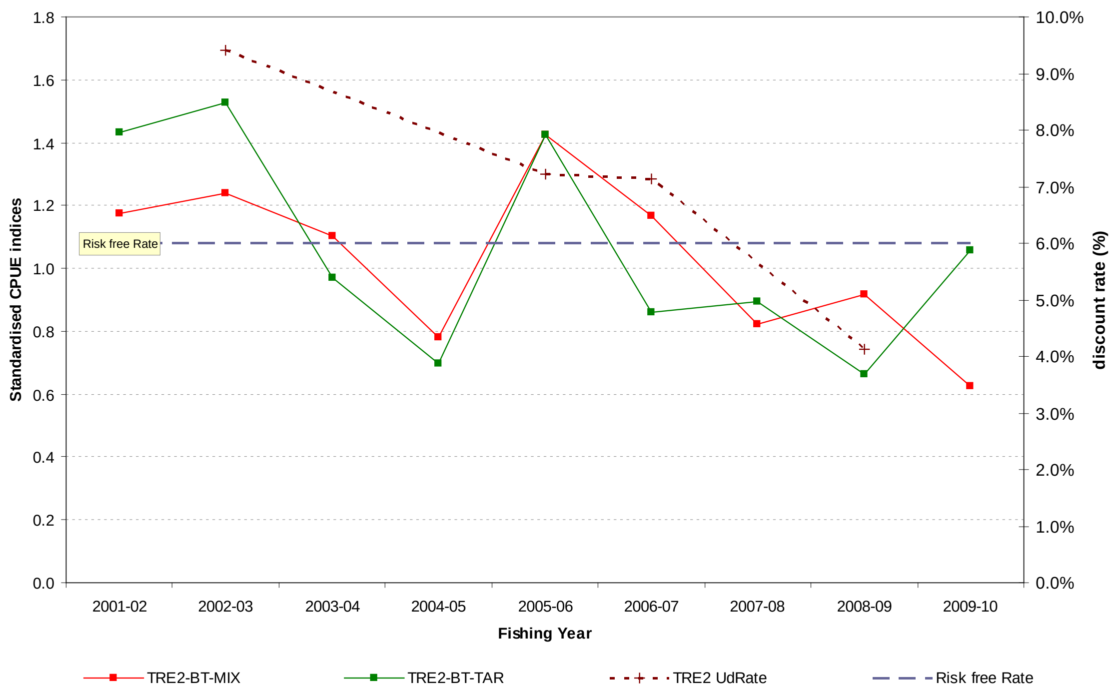


Figure 66: Trend in TRE 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10.

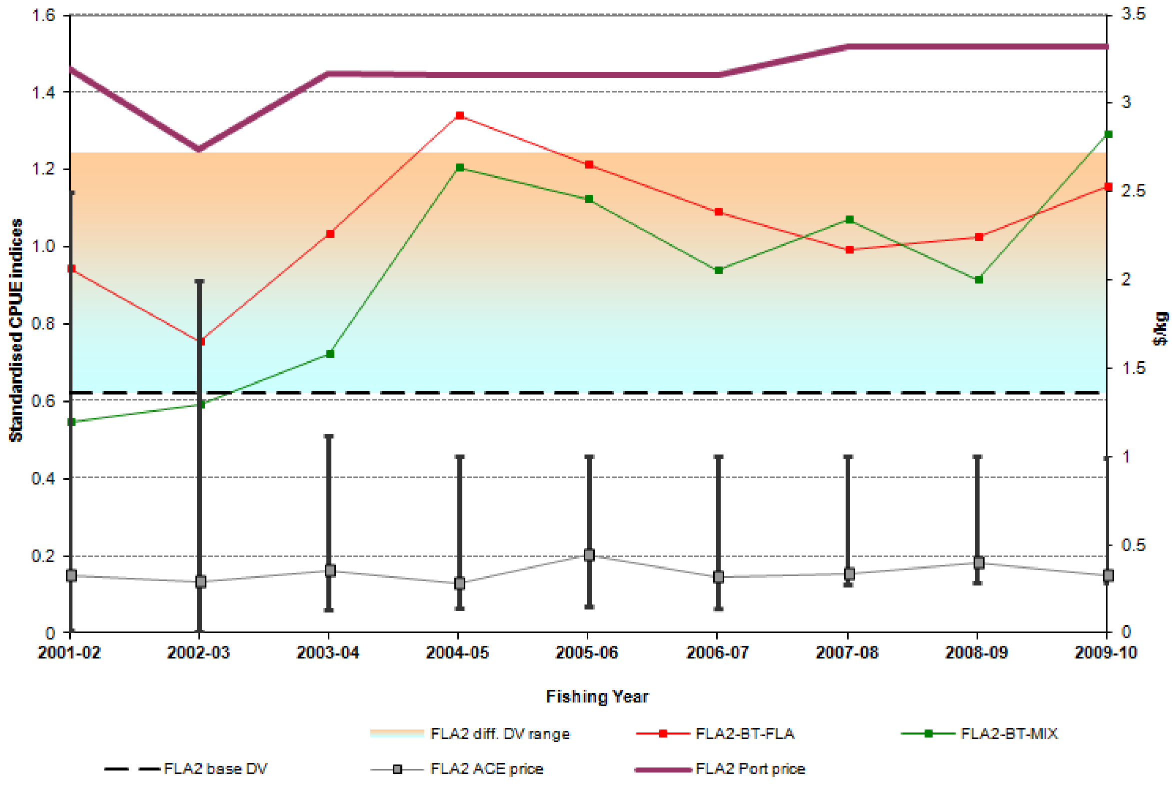


Figure 67: Trend in FLA 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.

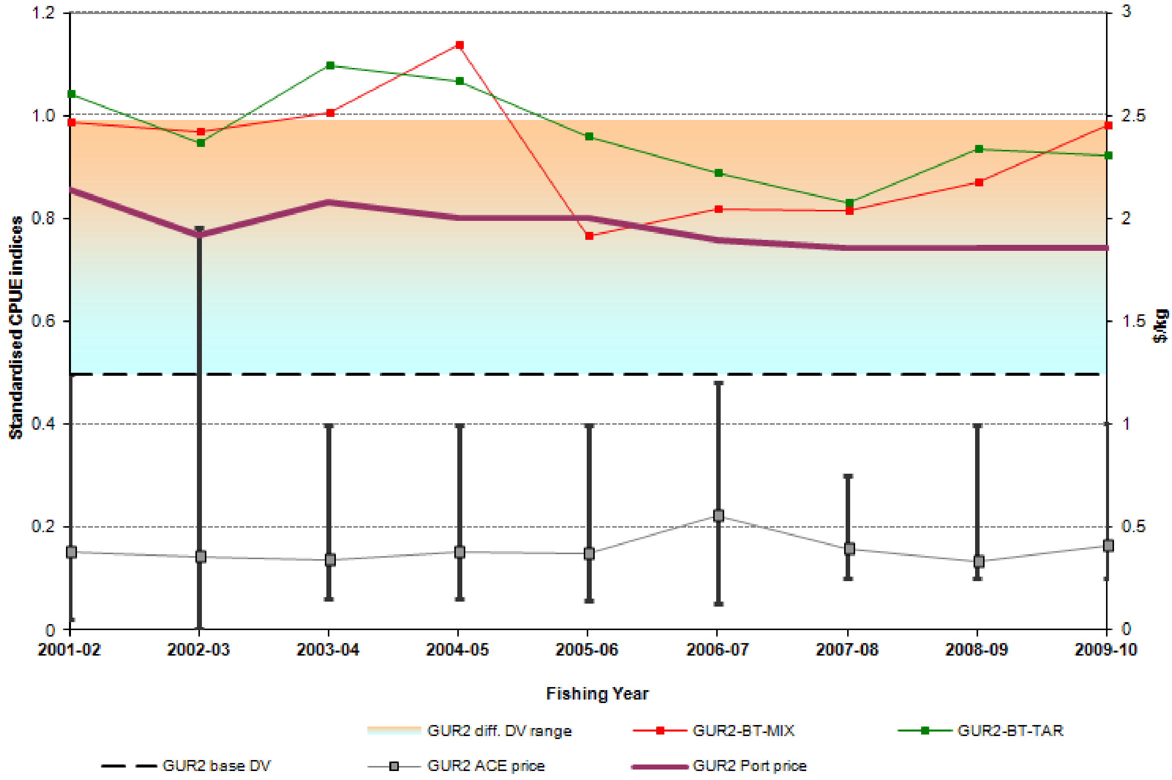


Figure 68: Trend in GUR 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.

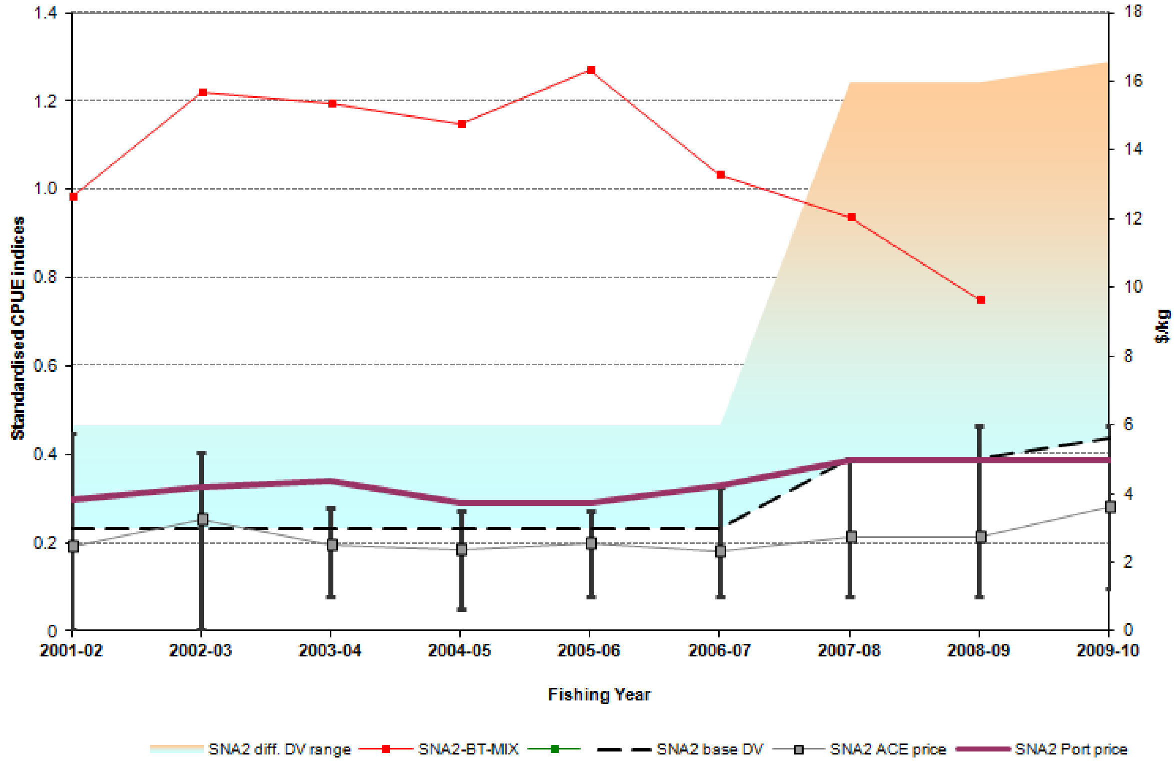


Figure 69: Trend in SNA 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.

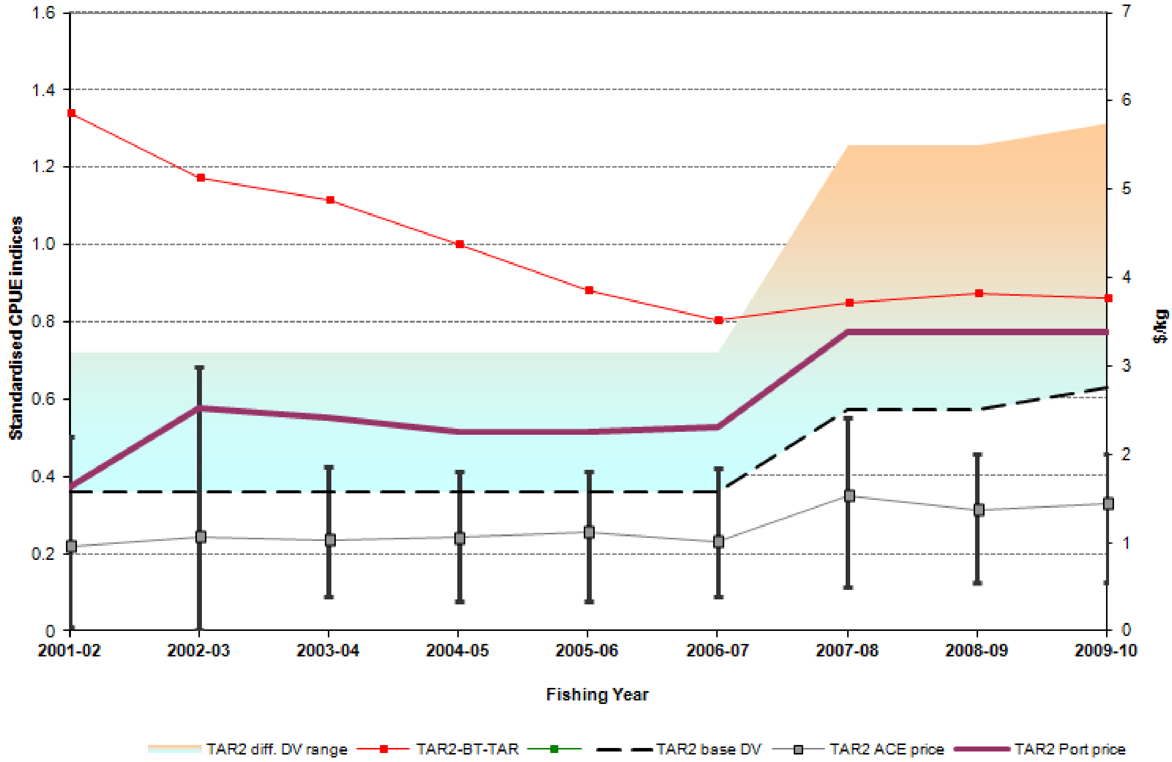


Figure 70: Trend in TAR 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.

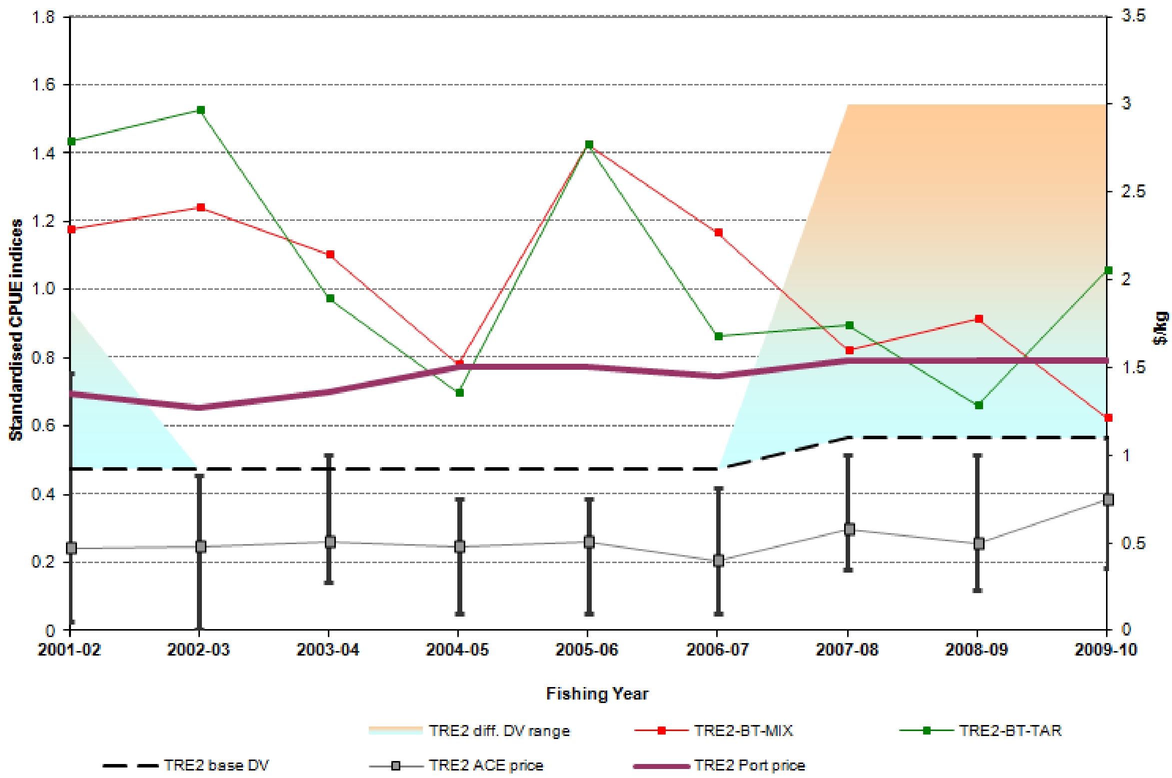


Figure 71: Trend in TRE 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.

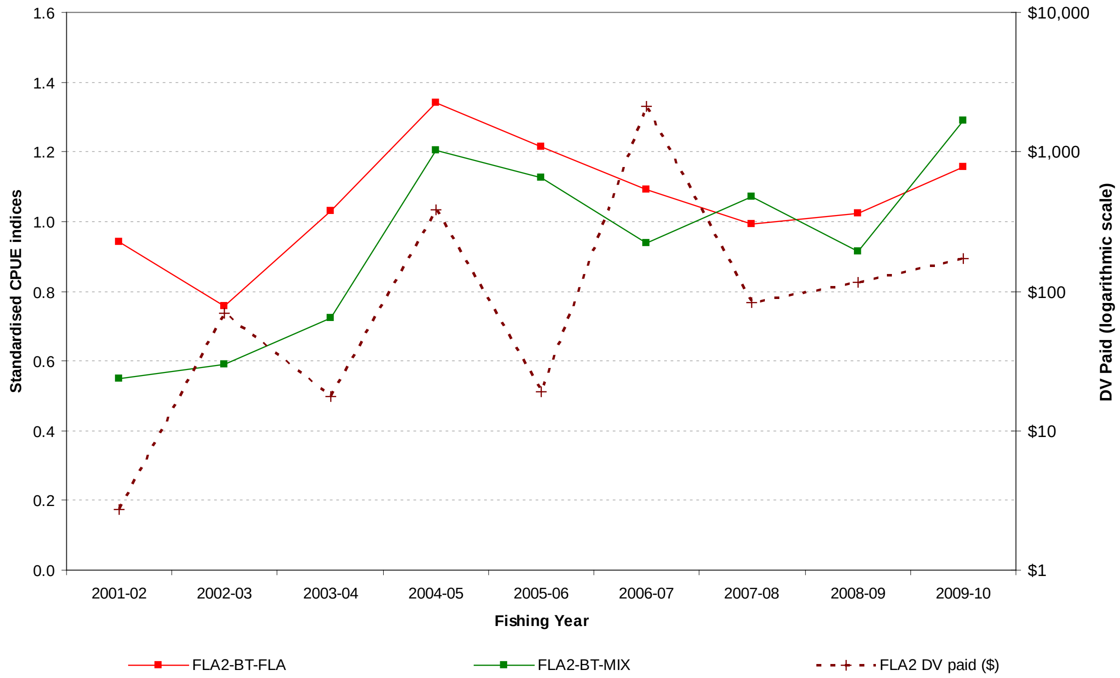


Figure 72: Trend in FLA 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10.

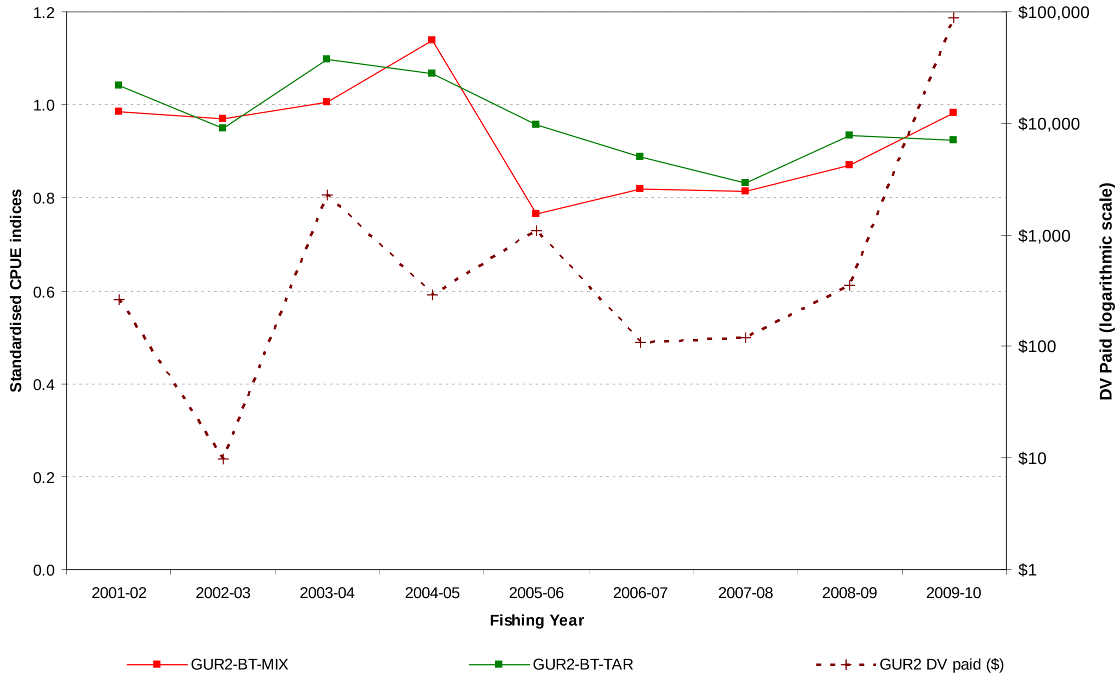


Figure 73: Trend in GUR 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10.

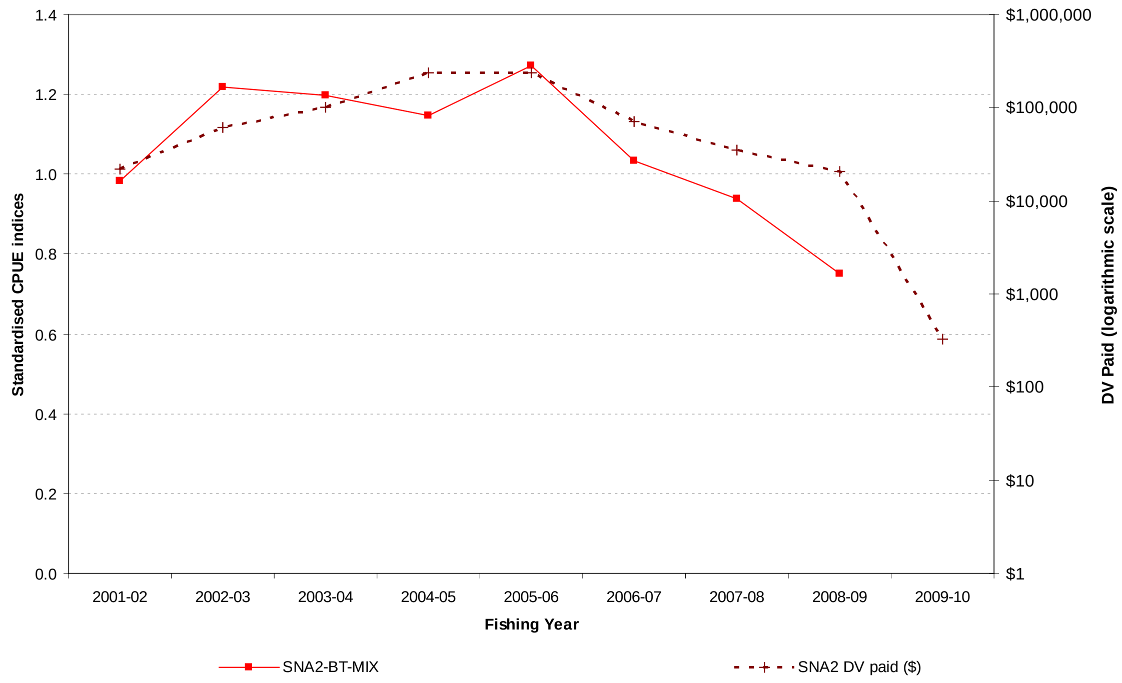


Figure 74: Trend in SNA 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10.

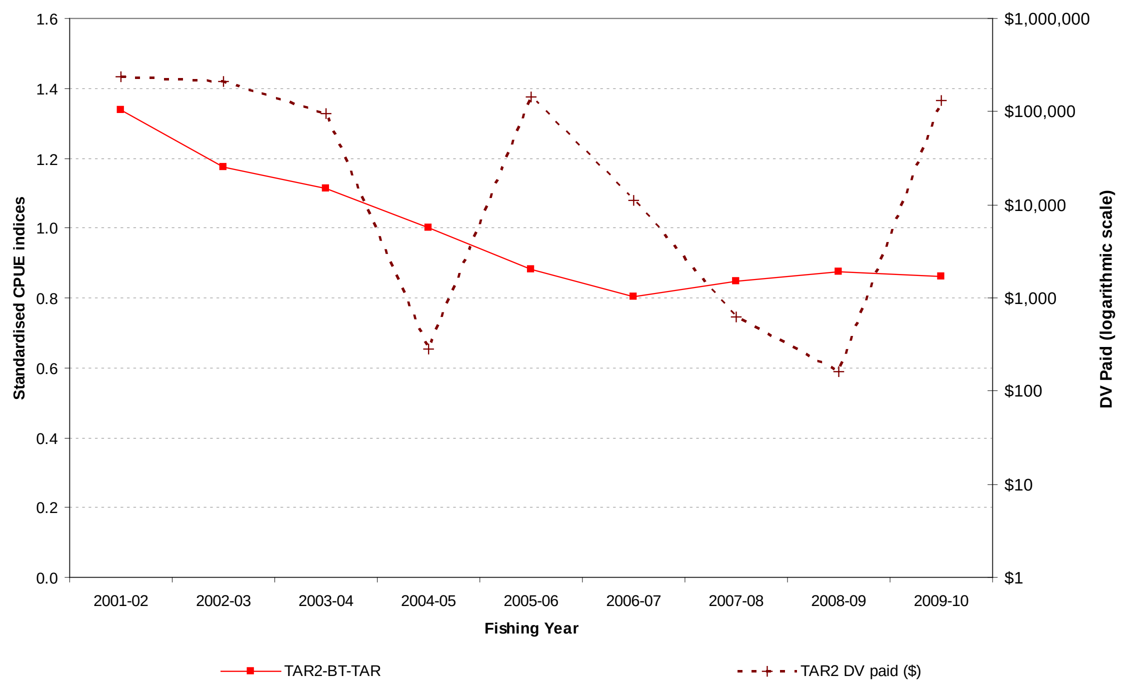


Figure 75: Trend in TAR 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10.

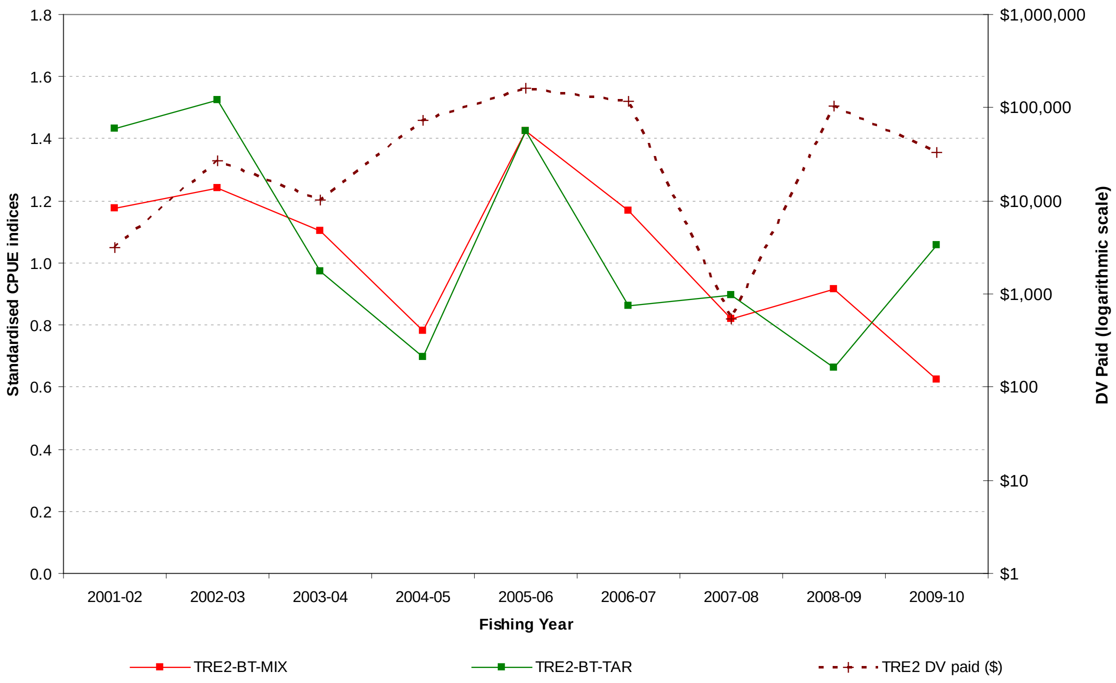


Figure 76: Trend in TRE 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10.

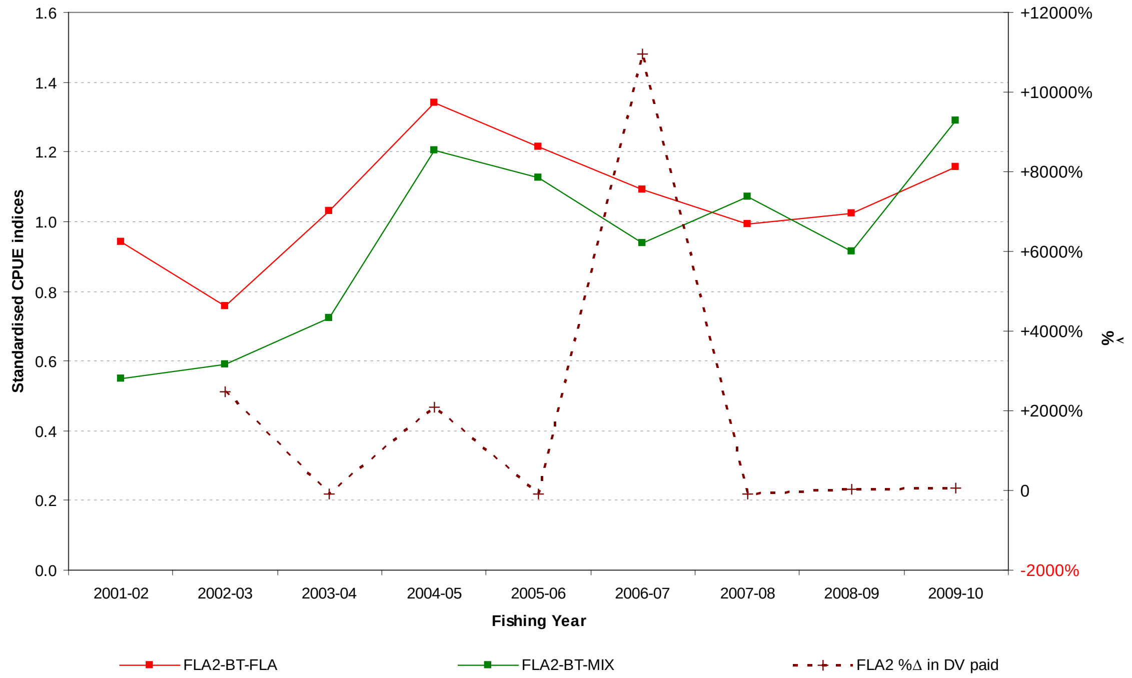


Figure 77: Trend in FLA 2 standardised CPUE indices contrasted with percentage change in deemed value payments between 2001–02 and 2009–10.

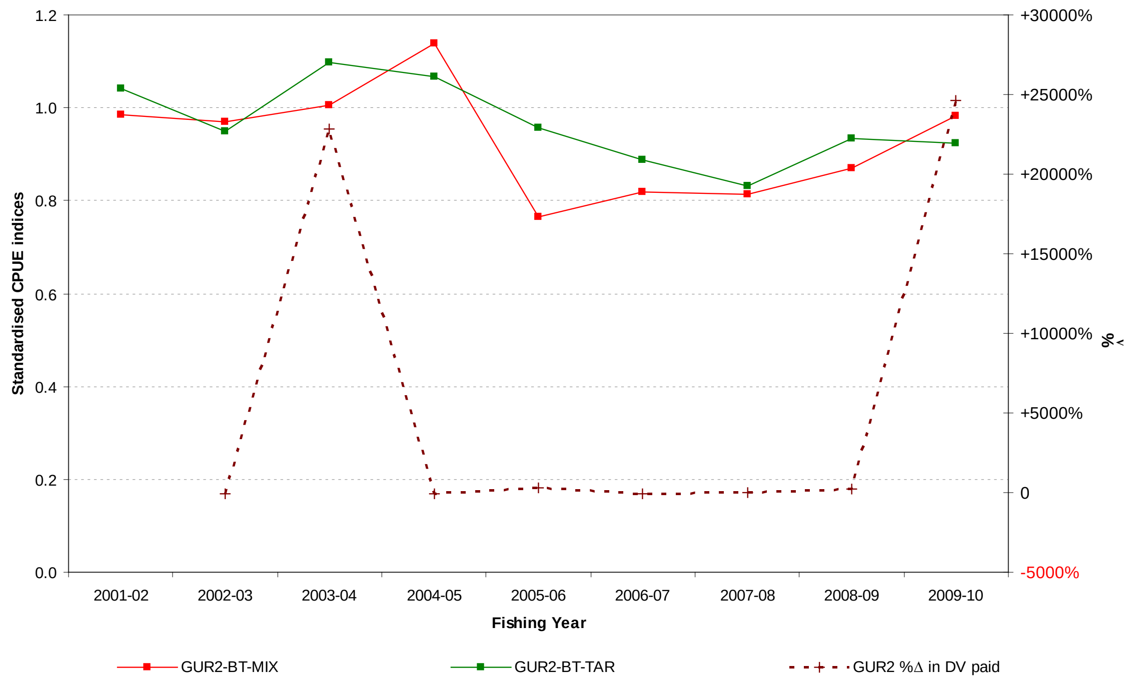


Figure 78: Trend in GUR 2 standardised CPUE indices contrasted with percentage change in deemed value payment between 2001–02 and 2009–10.

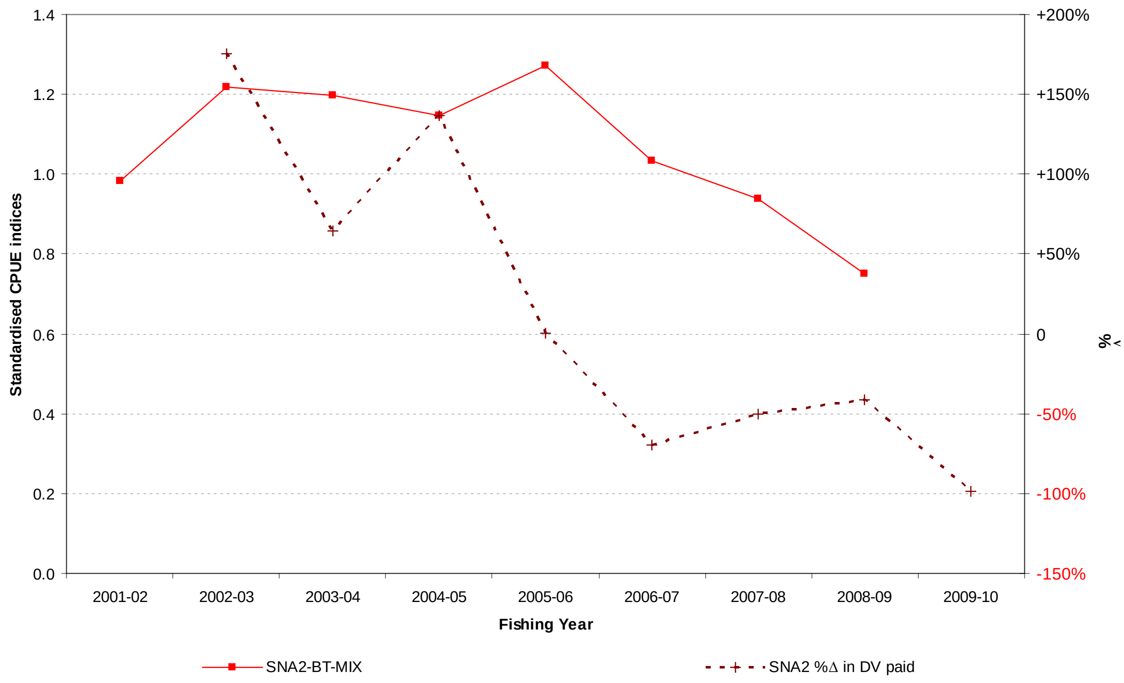


Figure 79: Trend in SNA 2 standardised CPUE indices compared with percentage change in deemed value paid between 2001–02 and 2009–10.

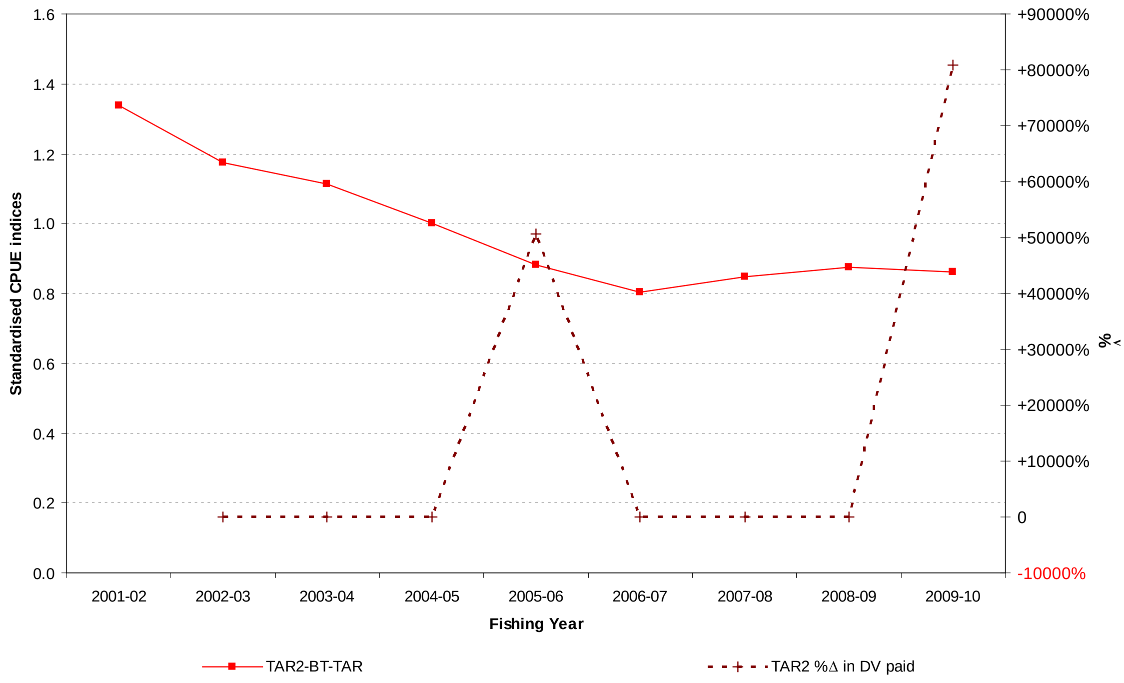


Figure 80: Trend in TAR 2 standardised CPUE indices contrasted with percentage change in deemed value payments between 2001–02 and 2009–10.

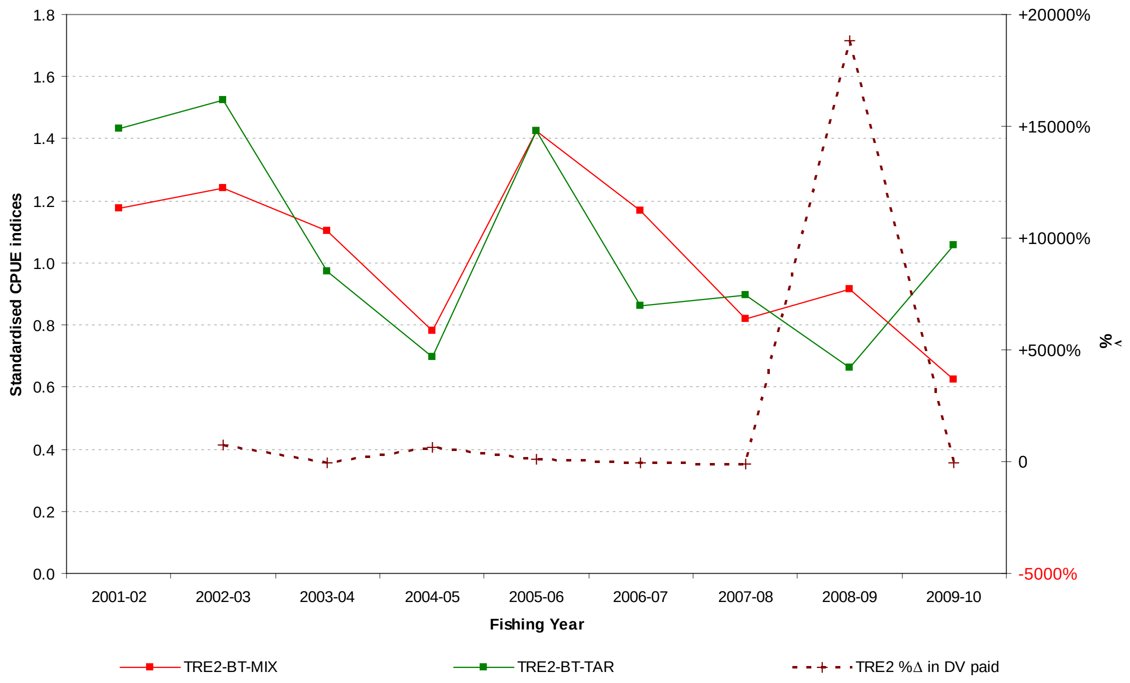


Figure 81: Trend in TRE 2 standardised CPUE indices contrasted with percentage change in deemed value payments between 2001–02 and 2009–10.

5. CPUE ANALYSIS AND PRELIMINARY RESULTS

5.1 Model comparison

5.1.1 Data selection process.

The data used in the traditional approach and the approach incorporating economics were not identical. Table 21 contrasts the data used in two approaches for each segment analysed. One of the main differences in the data scope comes from the selection of the core vessels. Indeed, since in the method incorporating economics a shorter period was covered, it was necessary to relax the constraint on core vessels as defined in the traditional CPUE model. The core fleet was therefore defined as those vessels that had fished at least one trip in each of at least two years. Additionally data was selected where clients (grouped with their included persons) were involved in at least 10 aggregated events by stratum in each of at least two years.

Following the traditional approach, the “forward” stepwise model selection method was used to test the hypothesis. Starting from only the year effect (i.e. the explanatory variable “fyear” is forced into the model), the variable improving the fit the best is added to the model: that is, additional explanatory variables were included in the model if they increased the percent deviance explained by 0.1 %.

The disadvantage of this method is that the compared models are nested and sets of variables which have a significant effect together can be excluded from the model. In other words, since stepwise methods work one variable at a time, it is possible that if two variables together have a significant effect in the model but separately they are not significant, then they can get excluded during stepwise selection.

Because of the constraint in the compared models, forward selection is considered as a "lower variance, higher bias" type of method. Selection is optimized based on the goodness of fit of models, which are described (in this case) by the Akaike Information Criterion (AIC). AIC contains the (maximized) log-likelihood of the sample given the model and a penalty part for the complexity of the model. The remainder of the filtering system (statistical areas, target species) is described in Table 21.

Table 21: Comparative data scope used in the two models: traditional approach and the method incorporating economics.

Fish stock	segment	CPUE model	fishing years	Primary Method	target species	statistical areas	core vessels definition	Core Clients and their associates definition
FLA2	FLA_BT_FLA	traditional	1990:2010	BT	FLA	013, 014	vessels that had fished for at least 3 trips in each of at least 3 years	N/A
		incorporating economics	2003:2010	BT	FLA	013, 014	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
	FLA_BT_MIX	traditional	1990:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 5 years	N/A
		incorporating economics	2003:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016, 037, 039, 040, 041	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
GUR2	GUR_BT_MIX	traditional	1990:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 5 years	N/A
		incorporating economics	2003:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
	GUR_BT_TAR	traditional		BT	TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 6 years	N/A
		incorporating economics	2003:2010	BT	TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
SNA2	SNA_BT_MIX	traditional	1989:2009	BT	SNA, TRE, GUR, TAR	011, 012, 013, 014	vessels that had completed at least 10 qualifying trips (included at least one bottom trawl tow targeted at snapper, trevally, tarakihi or gurnard in zones 011 – 014) in at least 5 years	N/A
		incorporating economics	2003:2010	BT	SNA, TRE, GUR, TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
TAR2	TAR_BT_TAR	traditional	1990:2010	BT	TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 5 years	N/A
		incorporating economics	2003:2010	BT	TAR	011, 012, 013, 014, 015, 016, 017	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
TRE2	TRE_BT_MIX	traditional	1990:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 5 years	N/A
		incorporating economics	2003:2010	BT	GUR, SNA, TRE	011, 012, 013, 014, 015, 016	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years
	TRE_BT_TAR	traditional	1990:2010	BT	TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 5 trips in each of at least 6 years	N/A
		incorporating economics	2003:2010	BT	TAR	011, 012, 013, 014, 015, 016	vessels that had fished for at least 1 trip in each of at least 2 years	clients and there associates who appear in stratum at least 10 times in each of at least 2 years

5.1.2 Economics and other variables tested in the model

Table 22 summarises the details of the regressions used for all eight segments in both the traditional CPUE and the CPUE analysis incorporating economic variables. In addition to the strategy and structure indices discussed earlier, the relevance of several economic indicators were also introduced and tested. These variables include:

- *strategy_*: this is a factor introduced as an independent variable in the regression analysis representing the strategic behaviour of the permit holder as defined in Section 3.3.
- *structure_*: this is a factor introduced as an independent variable in the regression analysis representing the structure of the permit holder as defined in Section 3.4.
- *ACECatchr*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree was used, along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*ACECatchr*" corresponds to the permit holder plus included persons' ACE holding divided by their cumulative catch at the beginning of the month. This is a ratio capturing the relative availability of ACE after catch balancing at the beginning of each month.
- *ACEchgr*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree was used, along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*ACEchgr*" corresponds to the permit holder plus included persons' ACE holding variation from the previous month compared to the beginning of the month. This is a ratio capturing the relative change in ACE holdings between months.
- *ACEPDVr*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree was used, along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*ACEPDVr*" captures the relative price of ACE to deemed value base rate. It is a gross indication of ACE availability by assuming that if ACE price gets close to the deemed value rate (ratio *ACEPDVr* of about 1), demand for ACE might be high and vice-versa, if the demand is low, we expect *ACEPDVr* to be less than 1.
- *PPACEPr*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree was used, along with the logarithmic transformation of the variable to reflect returns to scale. Similar to the variable "*ACEPDVr* ", "*PPACEPr*" corresponds to the relative surveyed port price to ACE price. While "*ACEPDVr"* reflects the opportunity cost of acquiring ACE on the open ACE market, *PPACEPr* captures the marginal rent of ex-vessel price compared to ACE price. A ratio close to or inferior to 1 reflects a marginal cost, while a ratio greater than 1 reflects a marginal benefit. Fishing permit holders are more likely to increase their catch when there are profits to be made (i.e. rent to capture) other things being equal.
- *mDVcv*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree was used, along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*mDVcv*" was generated as a synthetic index by multiplying several individual indices capturing deemed value rate change, range (for differential deemed value only), and relative ACE price to base deemed value ratio. Each index is calculated using 2003–04 as the base 100. If the base deemed value changes from its 2003–04's value and/or the range (i.e the differential) changes and / or either the monthly ACE price or the base deemed value changes, *mDVcv* will capture such changes reinforcing each variation up or down by multiplying each one by the others:

mDVcv in t = [baseDV index in t (base 2003–04)] × [high end DV index in t (base 2003–04)] × ACEPDVr

While each individual index used in this calculation is expressed in base 100, *mDVcv was* scaled down by dividing each index by 100 for obvious scaling reasons.

Moreover, it was necessary to omit this variable in the model used to estimate CPUE in the segments "TRE_BT_MIX" and "TRE_BT_TAR" because of the sudden changes in the deemed value regime in 2007–08. The sudden change in deemed value was creating some bias capturing the entire variation, exaggerating the variance of the estimates unrealistically.

Additionally, the following variables were used in the traditional analysis:

- *catch*: this is the dependent variable in the model and was estimated using the catch greenweight prorated by the trip landing information using the algorithm as described by

Starr (2007). Since we are using a *translog* functional form in the model, we use the logarithm of the catch and therefore any zero or null values were excluded from the analysis.

- *fyear_*: this is a factor introduced as an independent variable in the regression analysis and representing the fishing year expressed by the overlapping calendar years (e.g. 2009–10 for the fishing year October 2009 to September 2010).
- *vessel_* : this is a factor introduced as an independent variable in the regression analysis and corresponding to the vessel catching the fish. The variable "*vessel_*" corresponds to a unique key representing each vessel. These keys have been arbitrarily generated to preserve anonymity of each operation and to keep any individual information as confidential as possible.
- *period_*: this is a factor introduced as an independent variable in the regression analysis and corresponding to the month's order in the fishing year. Since the fishing year starts in October for all eight segments, a period equal to 1 is for October, 2 for November, ..., 12 for September. The previous CPUE analysis used the first three letters of the month instead, sorted starting in October (i.e. oct, nov, …, sep)
- *statarea_*: this is a factor introduced as an independent variable in the regression analysis. The variable "*statarea_*" corresponds to the three digit statistical area where the aggregated events as defined by the stratum took place.
- *tows*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree is used along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*tows*" corresponds to the number of tow within the aggregated events as defined by the stratum.
- *duration*: this is a continuous variable introduced as an independent variable in the regression analysis. A polynomial of the third degree is used along with the logarithmic transformation of the variable to reflect returns to scale. The variable "*duration*" corresponds to the total number of hours fished for the aggregated events as defined by the stratum.
- *target_*: this is a factor introduced as an independent variable in the regression analysis. The variable "*target*" corresponds to the three letter code of the target species of the aggregated events as defined by the stratum.

Table 22: Summary of the regression models used in the traditional CPUE analysis compared with the CPUE analysis incorporating economics.

Fish stock	segment	CPUE model	regression model	functional form type	residuals' distribution assumption
FLA2	FLA_BT_FLA	traditional	log(catch) ~ fyear + poly(log(tows), 3) + vessel + period	translog	gamma
		incorporating economics	log(catch) ~ fyear_ + poly(log(duration), 3) + vessel_ + poly(log(tows), 3) + period_ + statarea_ + strategy_ + poly(log(ACEchgr), 3)	translog	gamma
	FLA_BT_MIX	traditional	log(catch) ~ fyear + period + statarea + vessel + poly(log(tows), 3)	translog	lognormal
		incorporating economics	log(catch) ~ fyear_ + vessel_ + poly(log(tows), 3) + statarea_ + period_ + structure_ + target_ + poly(log(ACECatchr), 3) + poly(log(duration), 3) + strategy_ + poly(log(PPACEPr), 3) + poly(log(ACEPDVr), 3) + poly(log(ACEchgr), 3)	translog	lognormal
GUR2	GUR_BT_MIX	traditional	log(catch) ~ fyear + vessel + poly(log(tows), 3) + target	translog	gamma
		incorporating economics	log(catch) ~ fyear_ + vessel_ + poly(log(duration), 3) + period_ + target_ + poly(log(tows), 3) + statarea_ + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3)	translog	gamma
	GUR_BT_TAR	traditional	log(catch) ~ fyear + vessel + poly(log(tows), 3) + period + statarea	translog	gamma
		incorporating economics	log(catch) ~ fyear_ + vessel_ + poly(log(duration), 3) + statarea_ + period_ + poly(log(tows), 3) + poly(log(ACEchgr), 3) + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + strategy_ + structure_	translog	gamma
SNA2	SNA_BT_MIX	traditional	log(catch) ~ fyear + vessel + poly(log(tows), 3) + target + statarea + period	translog	lognormal
		incorporating economics	log(catch) ~ fyear_ + statarea_ + vessel_ + target_ + poly(log(tows), 3) + period_ + poly(log(ACEchgr), 3) + poly(log(duration), 3) + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + strategy_ + structure_	translog	lognormal
TAR2	TAR_BT_TAR	traditional	log(catch) ~ fyear + poly(log(tows), 3) + vessel + statarea	translog	gamma
		incorporating economics	log(catch) ~ fyear_ + poly(log(tows), 3) + vessel_ + period_ + statarea_ + poly(log(duration), 3) + poly(log(mDVcv), 3) + poly(log(ACECatchr), 3) + strategy_ + poly(log(ACEchgr), 3)	translog	gamma
TRE2	TRE_BT_MIX	traditional	log(catch) ~ fyear + vessel + period + poly(log(tows), 3) + target	translog	lognormal
		incorporating economics	log(catch) ~ fyear_ + vessel_ + period_ + poly(log(tows), 3) + target_ + structure_ + poly(log(duration), 3) + poly(log(PPACEPr), 3) + statarea_ + strategy_ + poly(log(ACEchgr), 3) + poly(log(ACECatchr), 3)	translog	lognormal
	TRE_BT_TAR	traditional	log(catch) ~ fyear + vessel + period + poly(log(duration), 3)	translog	lognormal
		incorporating economics	log(catch) ~ fyear_ + vessel_ + period_ + poly(log(duration), 3) + statarea_ + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + poly(log(ACEchgr), 3) + poly(log(tows), 3) + structure_ + strategy_	translog	lognormal

In addition to the CPUE analysis incorporating economics, a base model was run on each segment to generate standardised CPUE labelled "*new base*" in the subsequent figures to facilitate the comparison with Trophia's standardised CPUE as seen in Kendrick and Bentley (2010a, 2010b, 2011a, 2011b, 2011c, 2011d, 2011e, 2011f, 2011g). The "*new base*" model uses the same functional form as Trophia's (a.k.a. traditional) CPUE analysis on each segment (Table 22).

The following sections show the results for the eight segments starting with summary results, highlighting the similarity with the "*new base*" and standardised CPUEs generated by Trophia. To facilitate the comparison, Trophia's CPUE indices subset (between 2003 and 2010) was normalised to the geometric mean of 1 for that period, the other indices being already normalised.

Despite the difference in data range and core fleet definition, the "base model" shows standardised CPUE trends very similar to Trophia's. For both GUR segments and the SNA segment, the "*incl. economics*" standardised CPUE indices tend to be higher than Trophia's indices especially in the last four years. Finally, other things being equal, the introduction of economic variables in the model does not seem to be affecting the overall trend of the year effect but rather its magnitude.

5.2 FLA_BT_FLA

5.2.1 Summary of results

The model shows some influence of the strategy index variable and the ratio capturing the change in the permit holder's ACE holdings between periods (Table 23 and Table 24).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + poly(log(duration), 3) + vessel_ + poly(log(tows), 3) + period_ + statarea_ + strategy_ + poly(log(ACEchgr), 3)

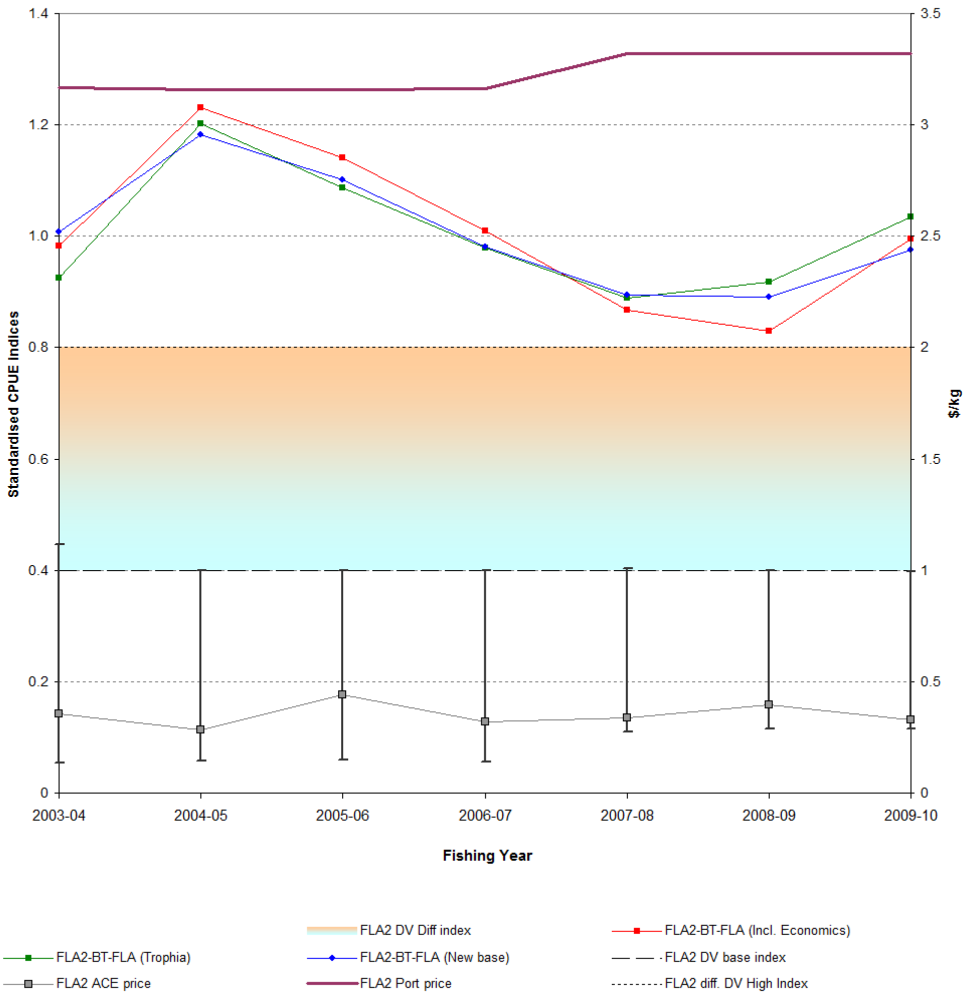


Figure 82: Comparison of FLA_BT_FLA standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.2.2 Data Subset

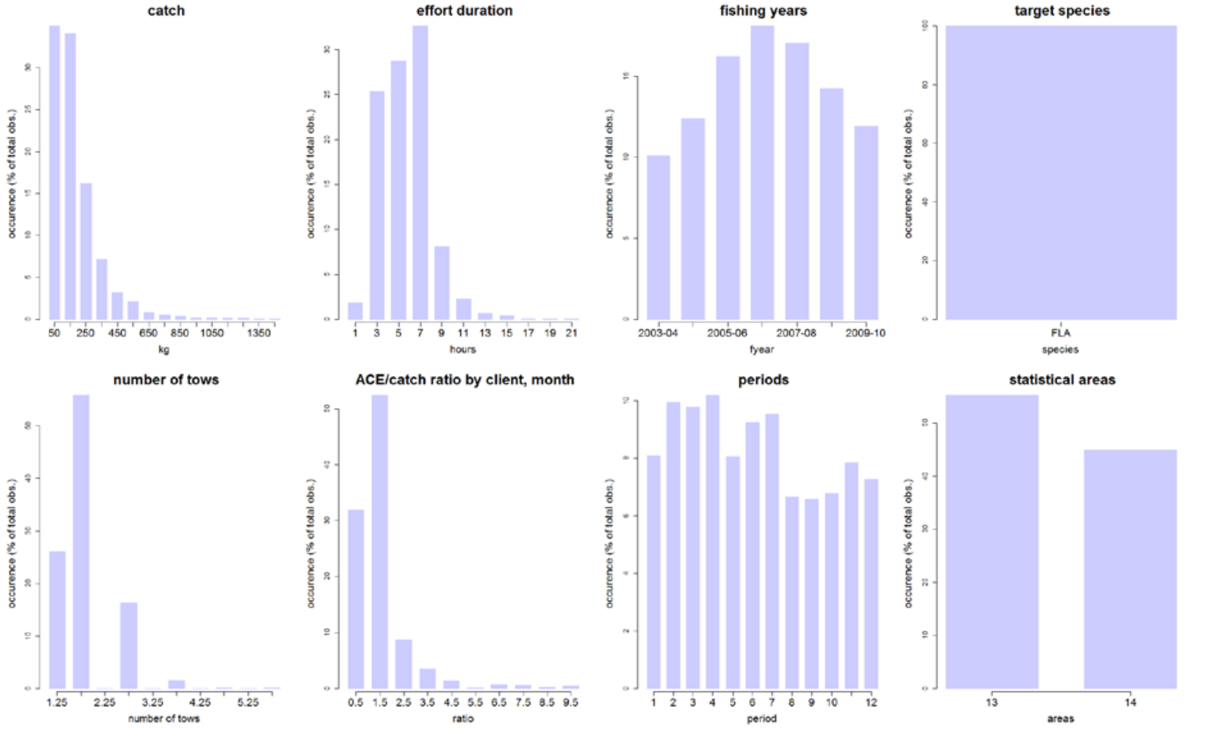


Figure 83: Histograms of Catch-Effort data for all strata included in the "FLA_BT_FLA" CPUE model.

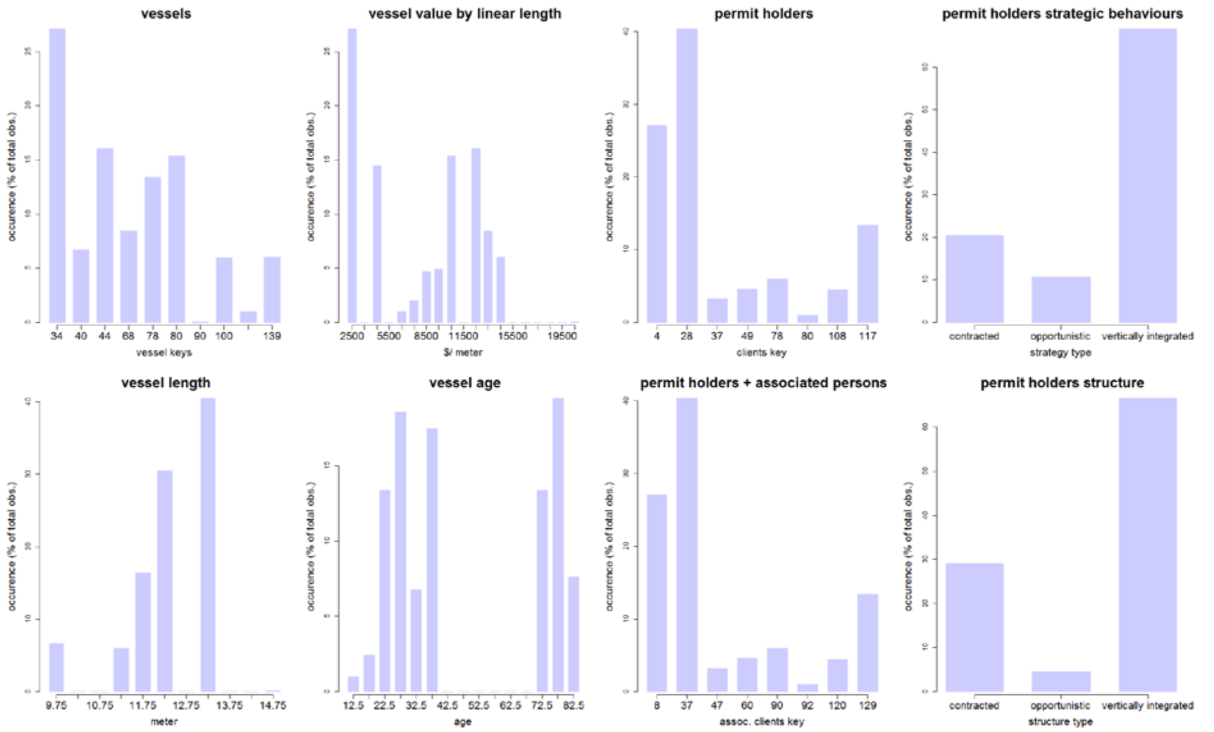


Figure 84: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the "FLA_BT_FLA" CPUE model.

5.2.3 Stepwise selection of model terms

Table 23: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (FLA_BT_FLA). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	2,253	40,370	0	
fyear_	6	-	3282	2,193	40,284	2.66	*
+ poly(log(duration), 3)	3	682	3279	1,511	38,954	32.94	*
+ vessel_	9	157	3270	1,354	38,585	39.91	*
+ poly(log(tows), 3)	3	87	3267	1,266	38,358	43.78	*
+ period_	11	37	3256	1,229	38,276	45.42	*
+ statarea_	1	11	3255	1,219	38,248	45.90	*
+ strategy_	2	7	3253	1,211	38,230	46.23	*
+ poly(log(ACEchgr), 3)	3	3	3250	1,208	38,228	46.36	*

acceptance threshold: 0.1%
based on the translog model

5.2.4 Influence of model terms on annual CPUE indices

Table 24: Summary of the influence of each term in the standardisation model (FLA_BT_FLA).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	60	2.66%	40,284	-	-
poly(log(duration), 3)	3	682	30.28%	38,954	3.27%	-0.02
vessel_	9	157	6.97%	38,585	3.94%	0.01
poly(log(tows), 3)	3	87	3.87%	38,358	4.96%	-0.03
period_	11	37	1.64%	38,276	0.63%	0.00
statarea_	1	11	0.47%	38,248	3.75%	0.02
strategy_	2	7	0.33%	38,230	0.72%	0.00
poly(log(ACEchgr), 3)	3	3	0.13%	38,228	0.77%	0.00

based on the translog model

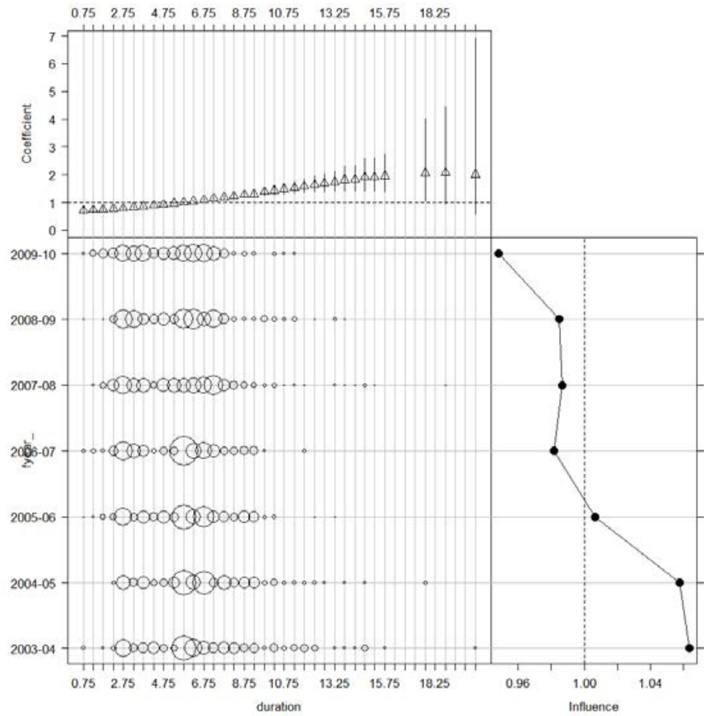


Figure 85: Coefficient-distribution-influence plot for "poly(duration, 3)" (FLA_BT_FLA).

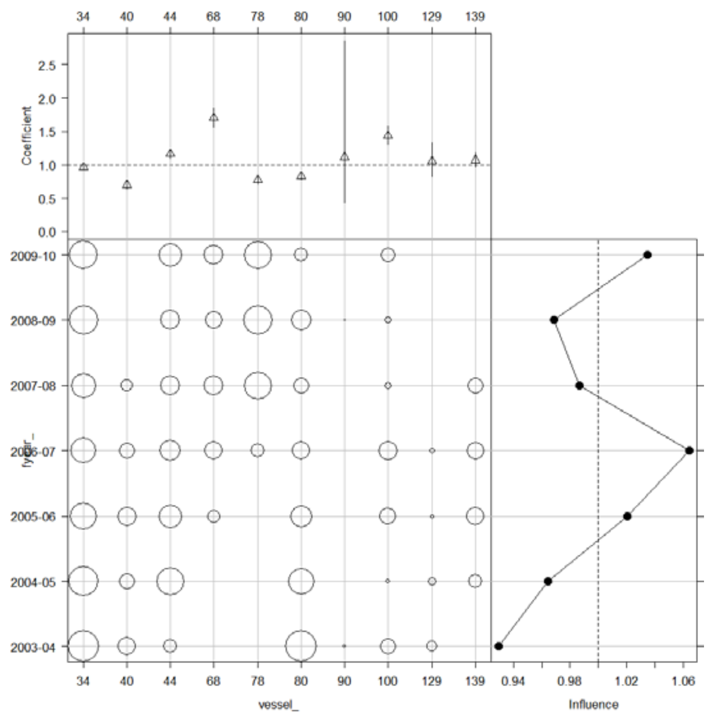


Figure 86: Coefficient-distribution-influence plot for "vessel" (FLA_BT_FLA).

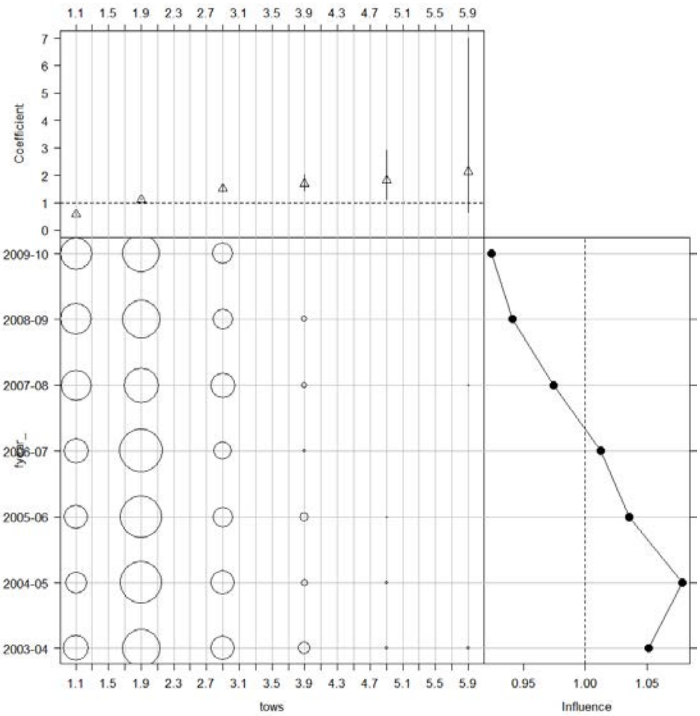


Figure 87: Coefficient-distribution-influence plot for "poly(tows, 3)" (FLA_BT_FLA).

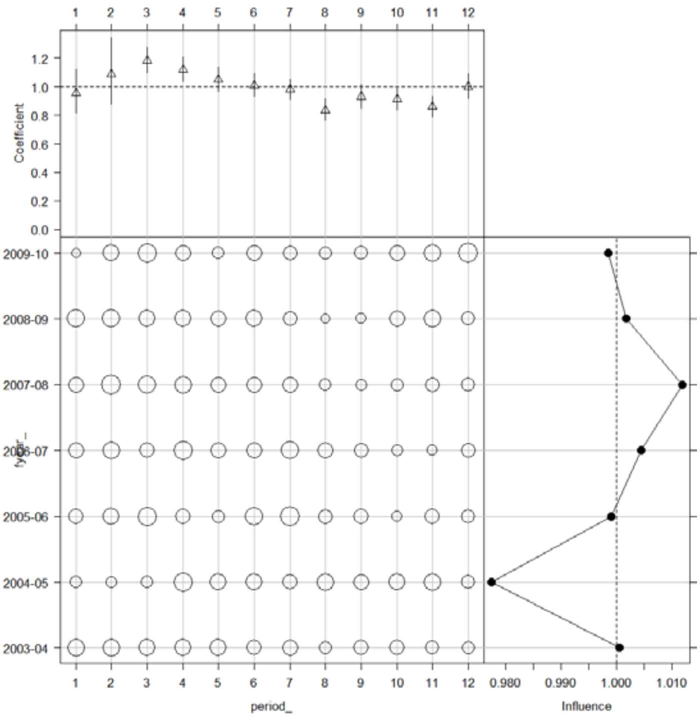


Figure 88: Coefficient-distribution-influence plot for "period" (FLA_BT_FLA).

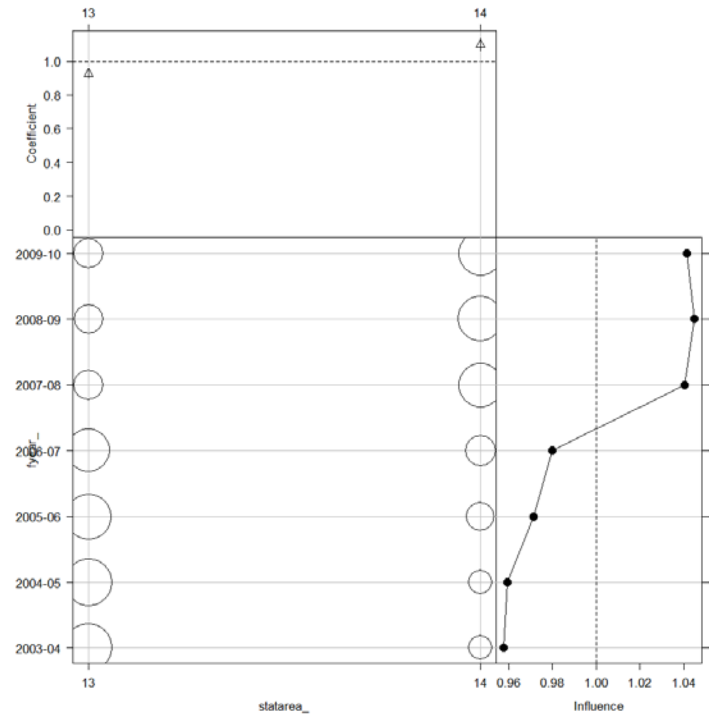


Figure 89: Coefficient-distribution-influence plot for "statsarea" (FLA_BT_FLA).

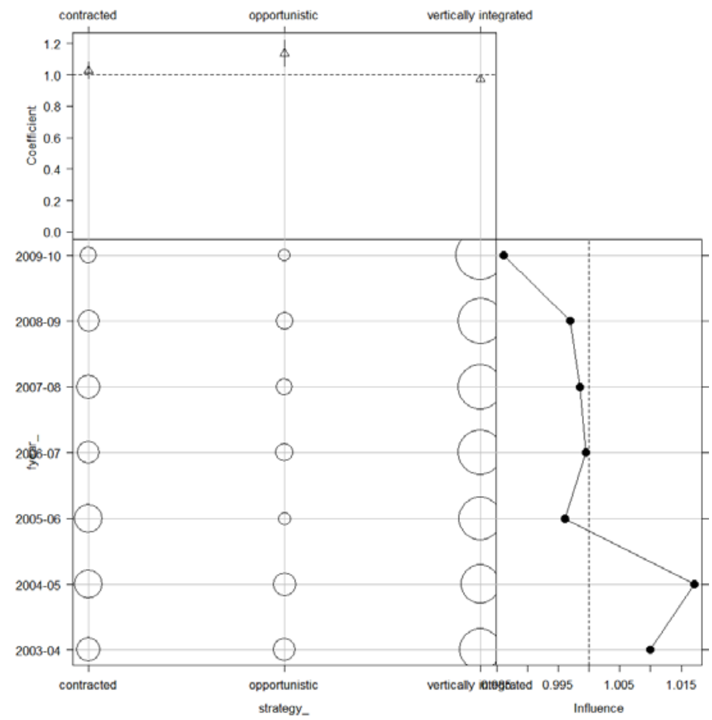


Figure 90: Coefficient-distribution-influence plot for "strategy" (FLA_BT_FLA).

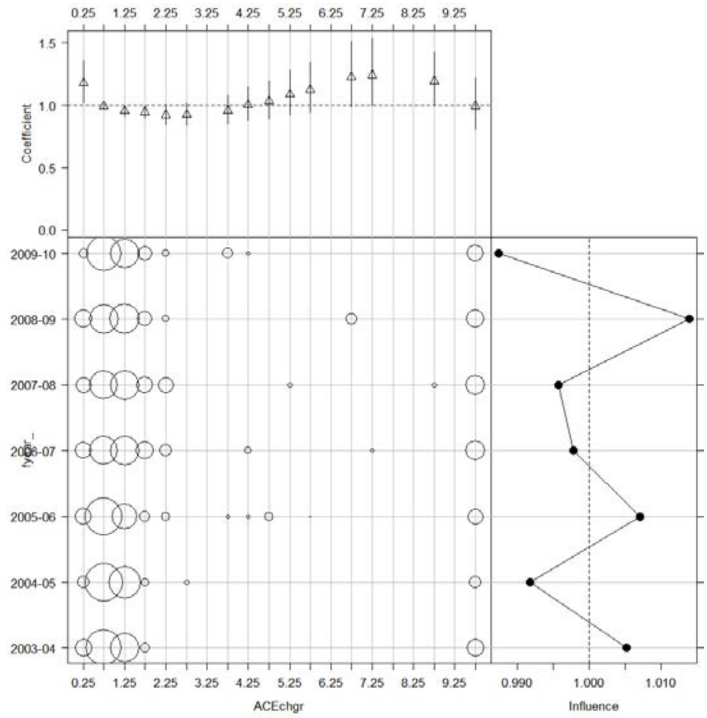


Figure 91: Coefficient-distribution-influence plot for "ACEchgr" (FLA_BT_FLA).

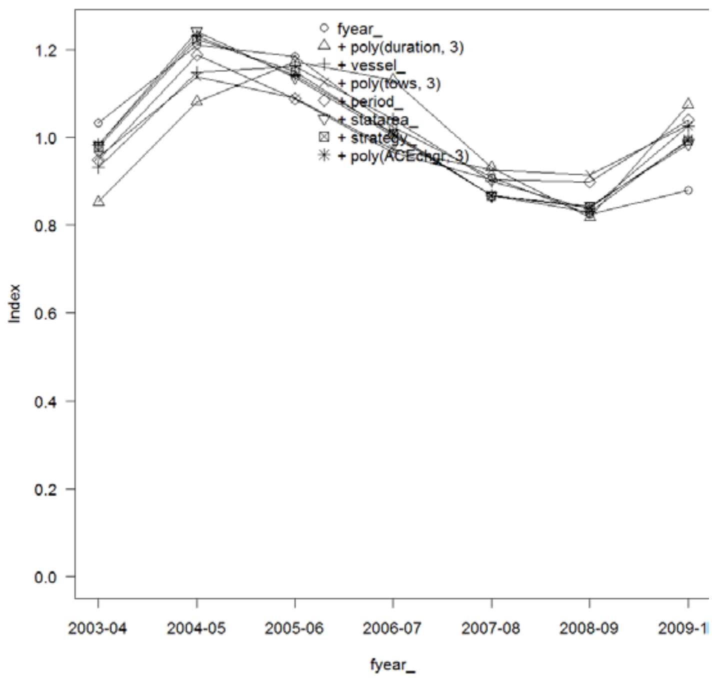


Figure 92: Annual influence for each term in the model (FLA_BT_FLA).

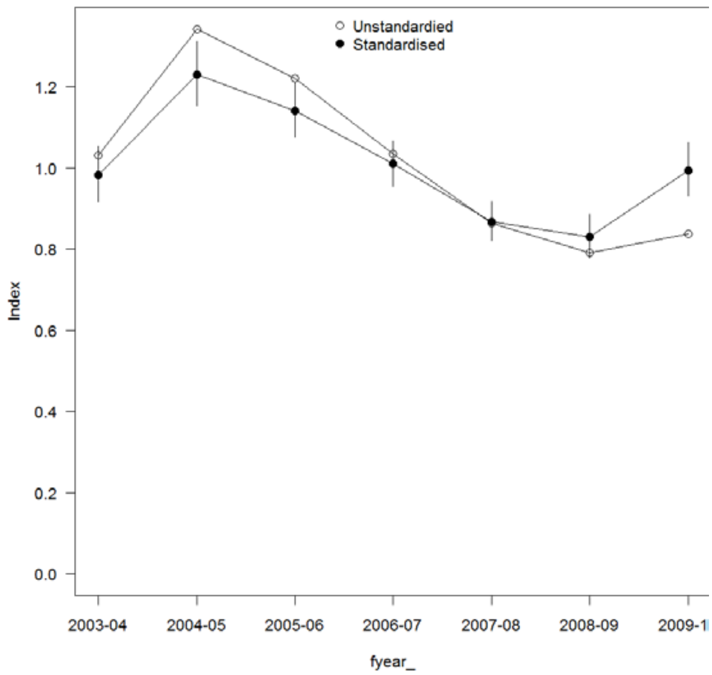


Figure 93: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (FLA_BT_FLA).

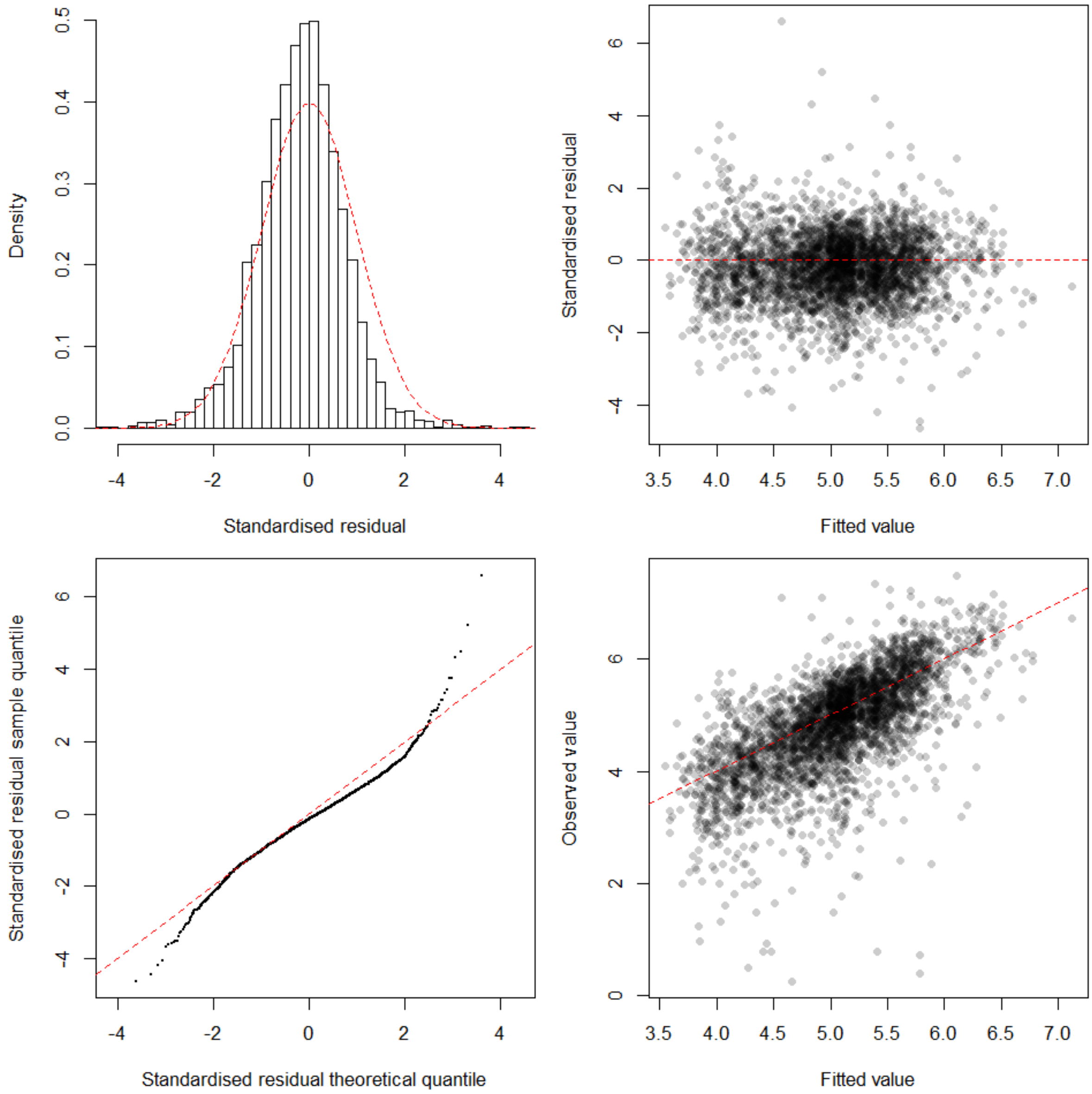


Figure 94: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution.', Bottom left: quantile-quantile plot of standardised residuals.Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (FLA_BT_FLA).

5.2.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.9673  -0.4687  -0.0989   0.2429   4.2410

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                     4.89203    0.09163  53.390  < 2e-16 ***
fyear_2004-05                   0.22398    0.04894   4.577 4.90e-06 ***
fyear_2005-06                   0.14934    0.04750   3.144 0.001681 **
fyear_2006-07                   0.02671    0.04701   0.568 0.570011
fyear_2007-08                  -0.12475    0.05032  -2.479 0.013222 *
fyear_2008-09                  -0.16926    0.05346  -3.166 0.001557 **
fyear_2009-10                   0.01155    0.05439   0.212 0.831876
poly(duration, 3)1              9.59909    1.48042   6.484 1.03e-10 ***
poly(duration, 3)2             -0.27945    1.03621  -0.270 0.787417
poly(duration, 3)3             -0.59931    0.89067  -0.673 0.501075
vessel_40                      -0.32192    0.05505  -5.848 5.47e-09 ***
vessel_44                       0.18626    0.03960   4.704 2.66e-06 ***
vessel_68                       0.56506    0.05022  11.251  < 2e-16 ***
vessel_78                      -0.22087    0.04377  -5.046 4.75e-07 ***
vessel_80                      -0.14849    0.04116  -3.607 0.000314 ***
vessel_90                       0.14241    0.47139   0.302 0.762598
vessel_100                      0.39571    0.05486   7.213 6.80e-13 ***
vessel_129                      0.08580    0.12217   0.702 0.482537
vessel_139                      0.10369    0.06066   1.709 0.087461 .
poly(tows, 3)1                 18.41246    1.43938  12.792  < 2e-16 ***
poly(tows, 3)2                 -5.90639    1.03284  -5.719 1.17e-08 ***
poly(tows, 3)3                  1.62202    0.90756   1.787 0.073992 .
period_2                        0.12852    0.14380   0.894 0.371530
period_3                        0.21196    0.09518   2.227 0.026020 *
period_4                        0.15746    0.09371   1.680 0.092976 .
period_5                        0.09308    0.09773   0.952 0.340962
period_6                        0.05276    0.09464   0.557 0.577239
period_7                        0.02410    0.09134   0.264 0.791888
period_8                       -0.13573    0.09903  -1.371 0.170579
period_9                       -0.02753    0.09585  -0.287 0.773937
period_10                      -0.04627    0.09395  -0.493 0.622390
period_11                      -0.10693    0.09266  -1.154 0.248588
period_12                       0.04439    0.09199   0.483 0.629421
statarea_14                     0.17061    0.03152   5.412 6.68e-08 ***
strategy_opportunistic          0.10013    0.04672   2.143 0.032178 *
strategy_vertically integrated -0.05412    0.03376  -1.603 0.109039
poly(ACEchgr, 3)1              -0.27979    1.94756  -0.144 0.885776
poly(ACEchgr, 3)2               2.04494    1.25787   1.626 0.104106
poly(ACEchgr, 3)3              -2.64294    1.05520  -2.505 0.012305 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Gamma family taken to be 0.4163535)

    Null deviance: 2252.8  on 3288  degrees of freedom
Residual deviance: 1208.4  on 3250  degrees of freedom
AIC: 38228

Number of Fisher Scoring iterations: 8

R-squared: 46.36%
adjusted R-squared: 45.73%
AIC: 38227
Dispersion parameter for Gamma family taken to be 0.4164
    Null deviance: 2252  on 3288  degrees of freedom
Residual deviance: 1208  on 3250  degrees of freedom
```

5.3 FLA_BT_MIX

5.3.1 Summary of results

The model shows some influence of the strategy and structure index variables and all the ratios involving ACE prices, port prices and deemed value and capturing the change in the permit holder's ACE holdings between periods (Table 25 and Table 26).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + vessel_ + poly(log(tows), 3) + statarea_ + period_ + structure_ + target_ + poly(log(ACECatchr), 3) + poly(log(duration), 3) + strategy_ + poly(log(PPACEPr), 3) + poly(log(ACEPDVr), 3) + poly(log(ACEchgr), 3)

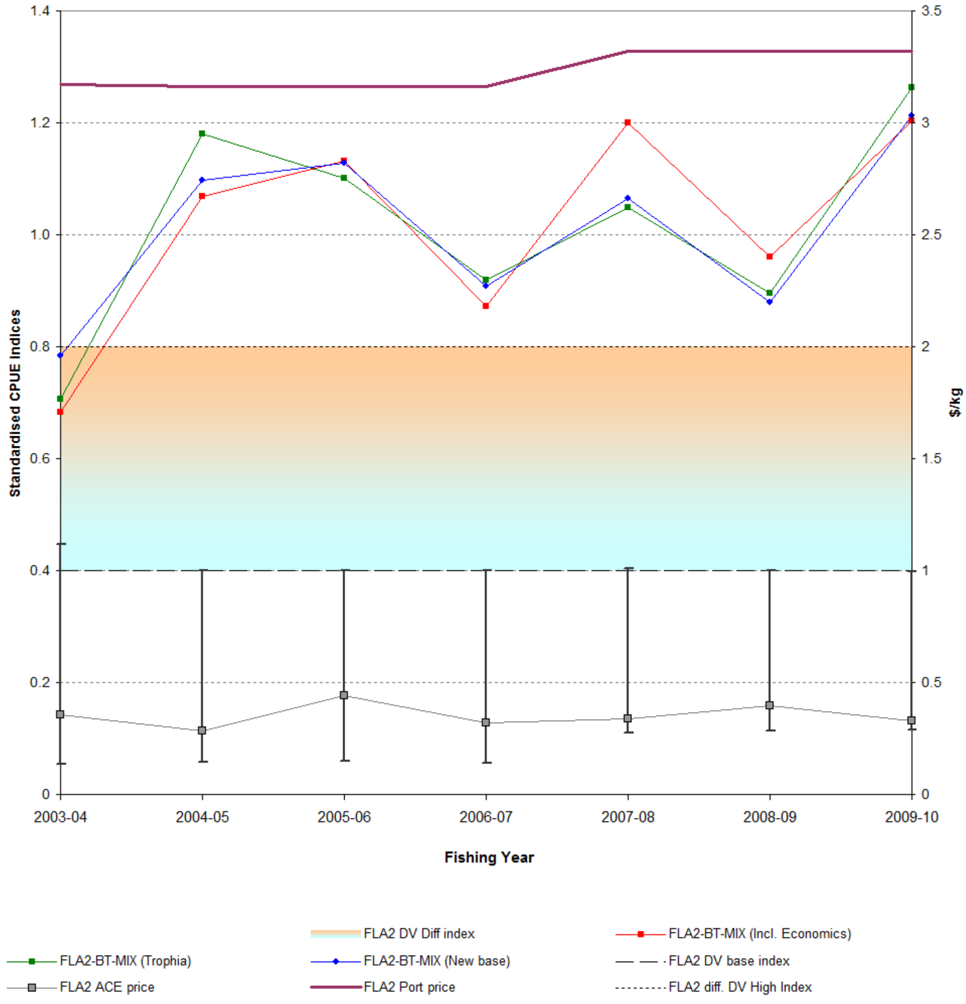


Figure 95: Comparison of FLA_BT_MIX standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.3.2 Data Subset

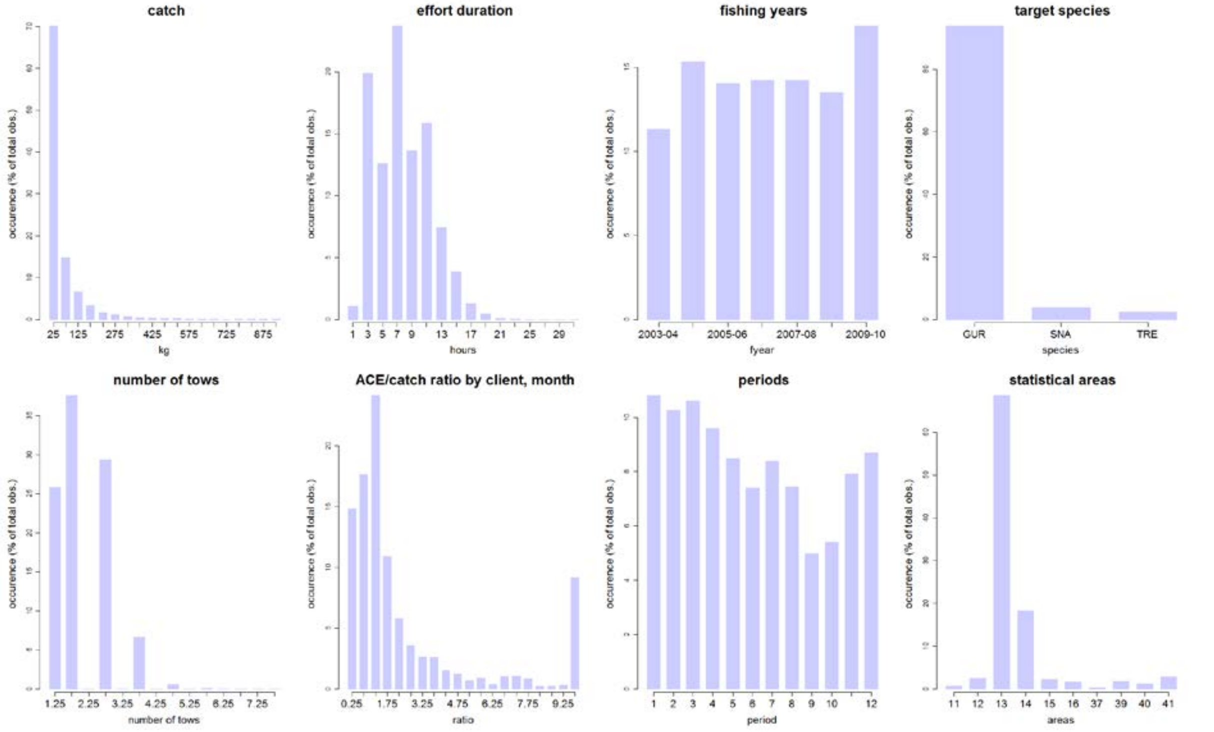


Figure 96: Histograms of Catch-Effort data for all strata included in the "FLA_BT_MIX" CPUE model.

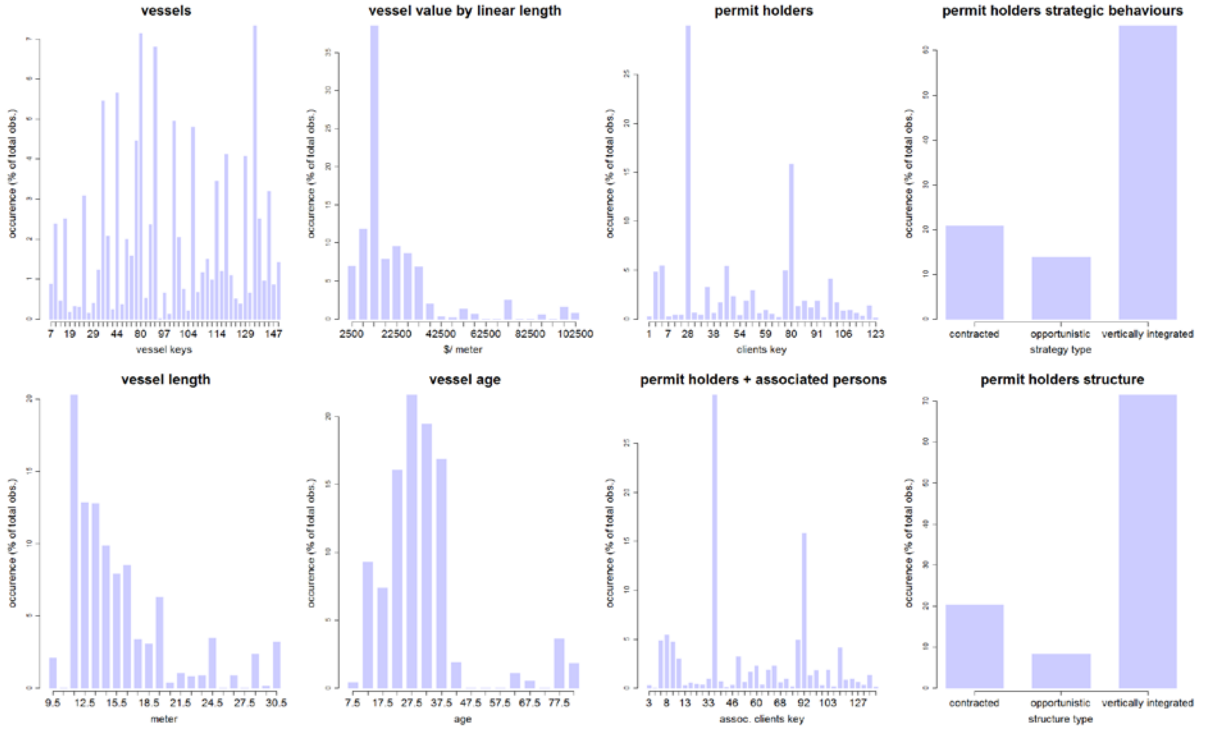


Figure 97: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the "FLA_BT_MIX" CPUE model.

5.3.3 Stepwise selection of model terms

Table 25: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (FLA_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	25,771	33,229	0	
fyear_	6	-	8383	25,399	33,119	1.45	*
+ vessel_	48	6,159	8335	19,240	30,885	25.34	*
+ poly(log(tows), 3)	3	2,113	8332	17,127	29,915	33.54	*
+ statarea_	9	1,000	8323	16,126	29,428	37.42	*
+ period_	11	480	8312	15,646	29,196	39.29	*
+ structure_	2	71	8310	15,575	29,162	39.56	*
+ target_	2	73	8308	15,502	29,127	39.85	*
+ poly(log(ACECatchr), 3)	3	32	8305	15,471	29,116	39.97	*
+ poly(log(duration), 3)	3	26	8302	15,445	29,108	40.07	
+ strategy_	2	16	8300	15,429	29,103	40.13	
+ poly(log(PPACEPr), 3)	3	14	8297	15,415	29,101	40.19	
+ poly(log(ACEPDVr), 3)	2	22	8295	15,393	29,093	40.27	
+ poly(log(ACEchgr), 3)	3	12	8292	15,381	29,093	40.32	

acceptance threshold: 0.1%

based on the translog model

5.3.4 Influence of model terms on annual CPUE indices

Table 26: Summary of the influence of each term in the standardisation model (FLA_BT_MIX).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	372	1.45%	33,119	-	-
vessel_	48	6159	23.90%	30,885	7.99%	-0.04
poly(log(tows), 3)	3	2113	8.20%	29,915	6.98%	-0.03
statarea_	9	1000	3.88%	29,428	2.55%	0.00
period_	11	480	1.86%	29,196	1.24%	0.00
structure_	2	71	0.28%	29,162	6.00%	0.01
target_	2	73	0.28%	29,127	0.41%	0.00
poly(log(ACECatchr), 3)	3	32	0.12%	29,116	1.44%	-0.01
poly(log(duration), 3)	3	26	0.10%	29,108	2.79%	-0.01
strategy_	2	16	0.06%	29,103	0.58%	0.00
poly(log(PPACEPr), 3)	3	14	0.06%	29,101	62.48%	-0.18
poly(log(ACEPDVr), 3)	2	22	0.08%	29,093	52.00%	0.18
poly(log(ACEchgr), 3)	3	12	0.04%	29,093	1.06%	0.00

based on the translog model

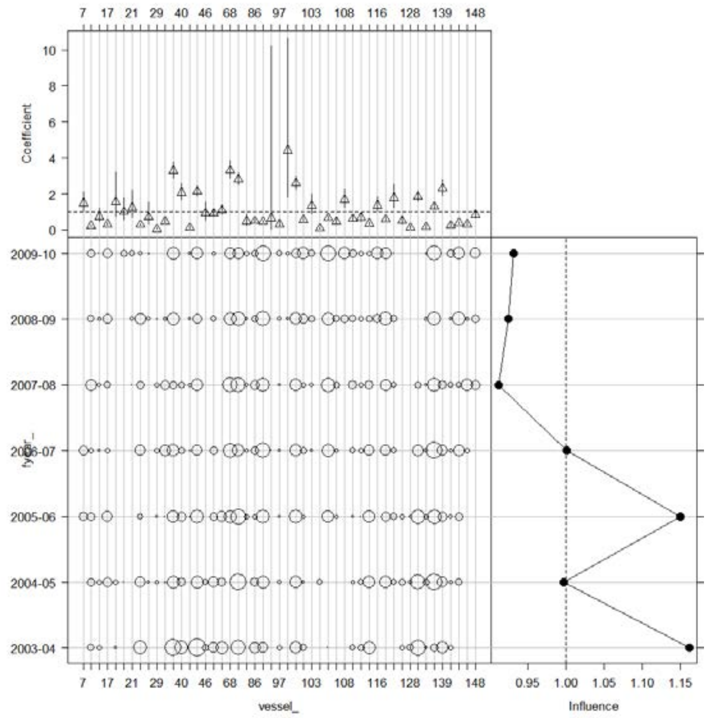


Figure 98: Coefficient-distribution-influence plot for "vessel " (FLA_BT_MIX).

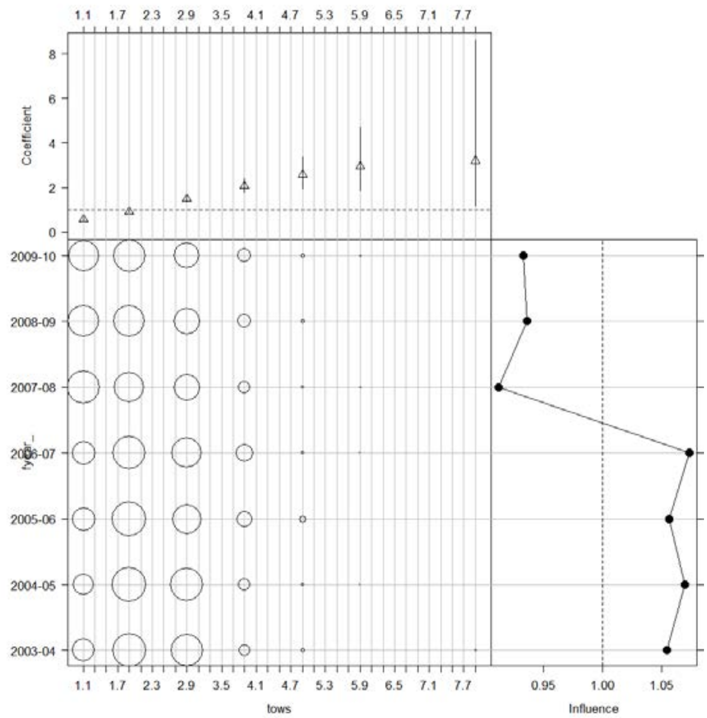


Figure 99: Coefficient-distribution-influence plot for "tows" (FLA_BT_MIX).

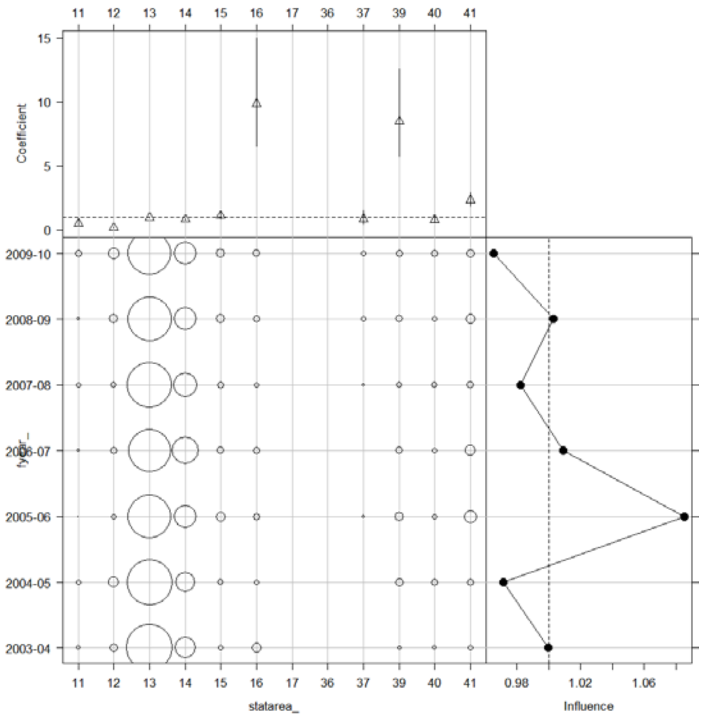


Figure 100: Coefficient-distribution-influence plot for “statarea” (FLA_BT_MIX).

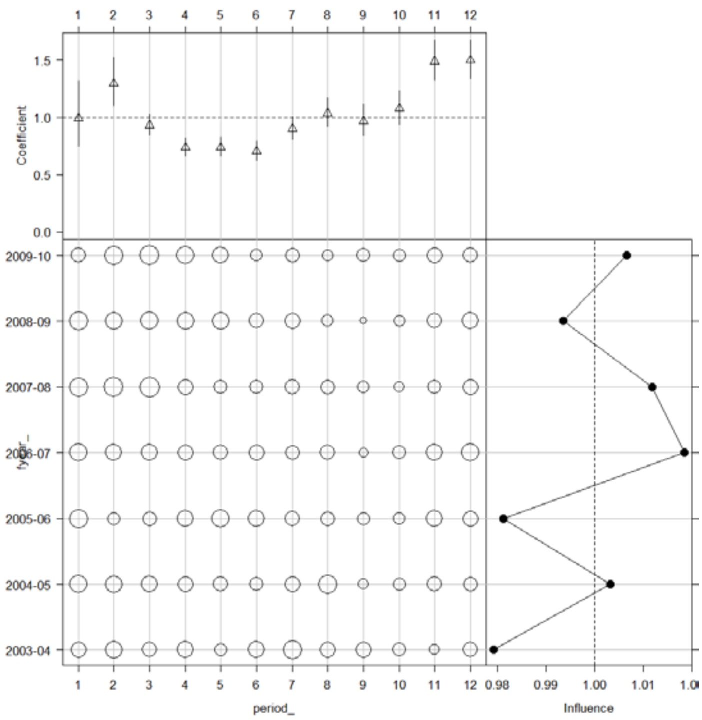


Figure 101: Coefficient-distribution-influence plot for “period” (FLA_BT_MIX).

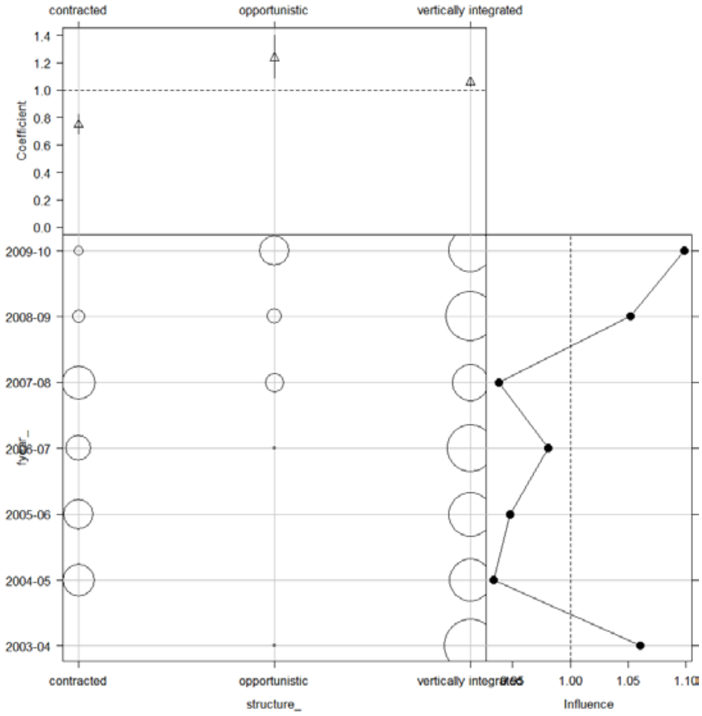


Figure 102: Coefficient-distribution-influence plot for "structure" (FLA_BT_MIX).

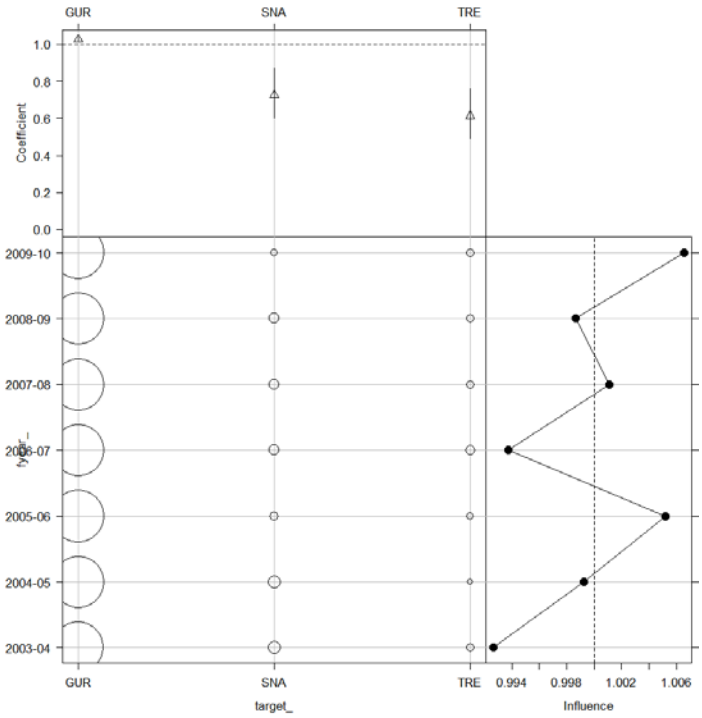


Figure 103: Coefficient-distribution-influence plot for "target" (FLA_BT_MIX).

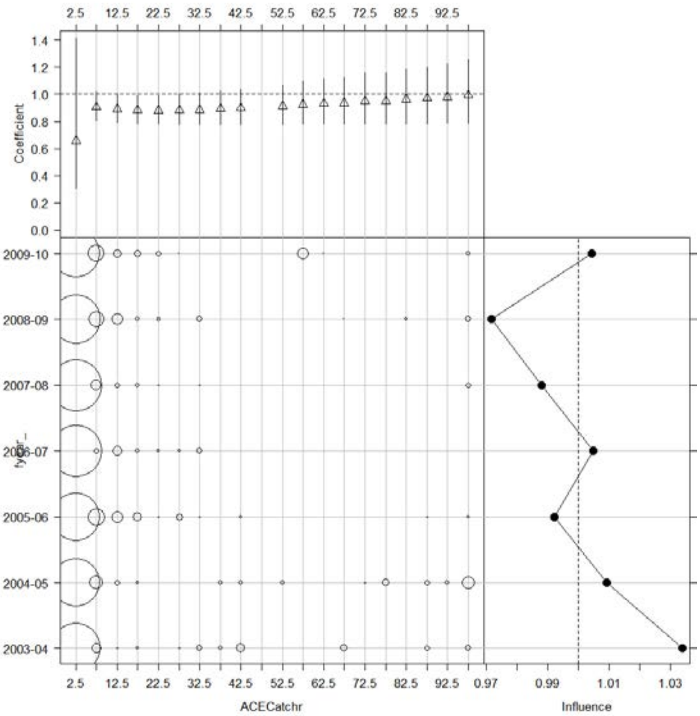


Figure 104: Coefficient-distribution-influence plot for "ACECatchr" (FLA_BT_MIX).

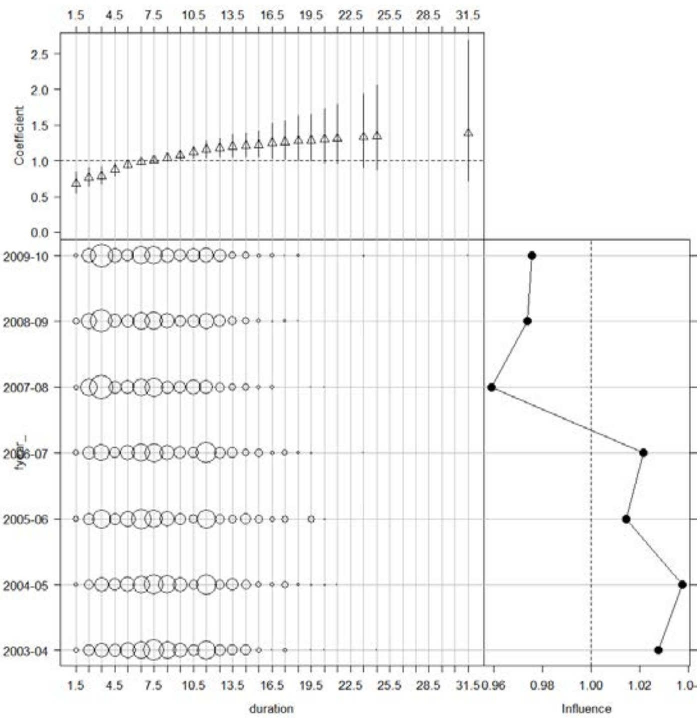


Figure 105: Coefficient-distribution-influence plot for "duration" (FLA_BT_MIX).

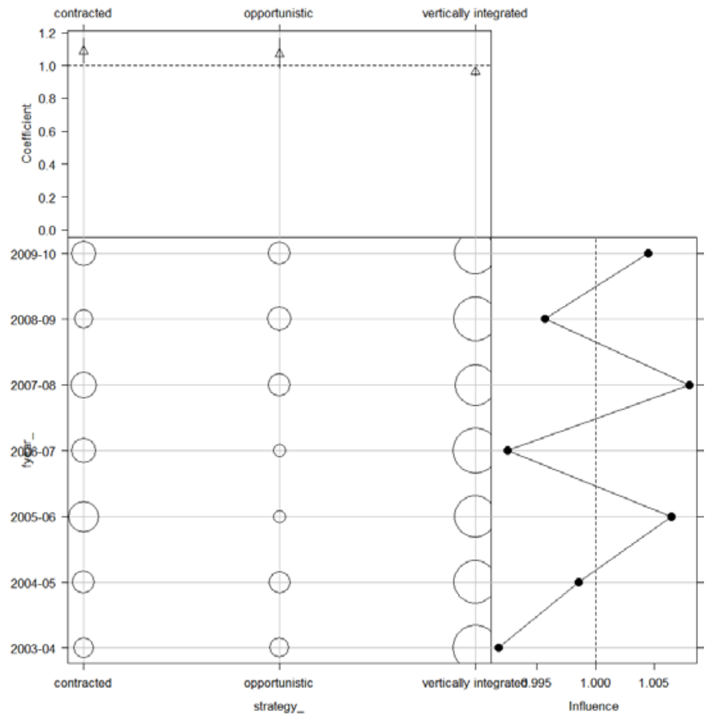


Figure 106: Coefficient-distribution-influence plot for "strategy" (FLA_BT_MIX).

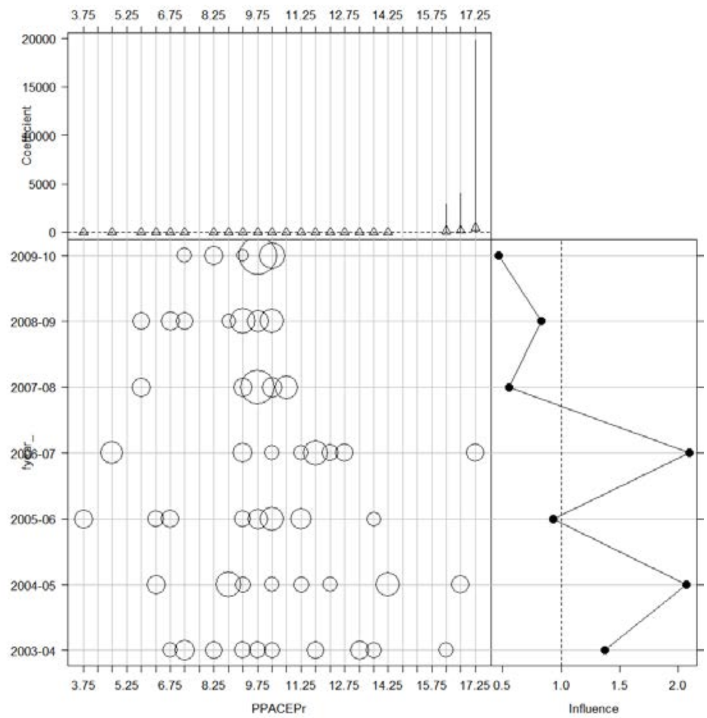


Figure 107: Coefficient-distribution-influence plot for "PPACEPr" (FLA_BT_MIX).

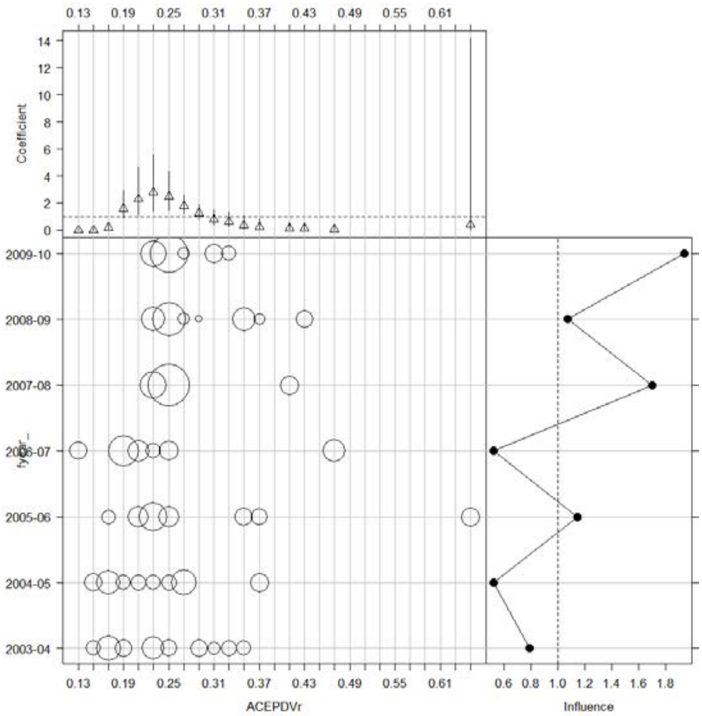


Figure 108: Coefficient-distribution-influence plot for "ACEPDVr" (FLA_BT_MIX).

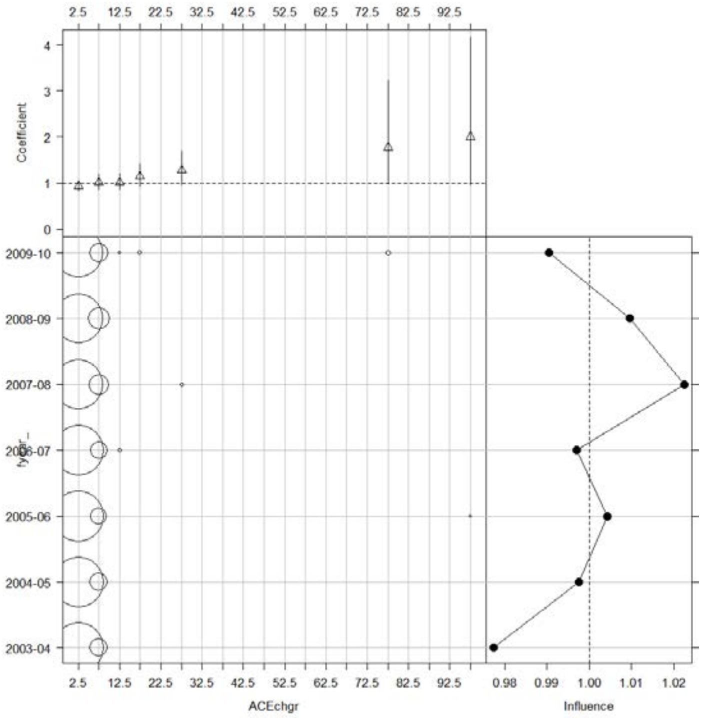


Figure 109: Coefficient-distribution-influence plot for "ACEchgr" (FLA_BT_MIX).

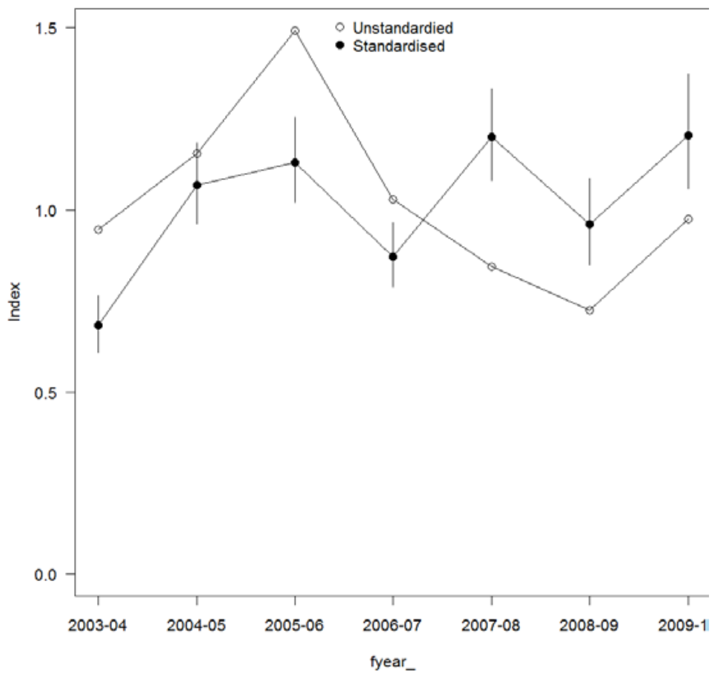


Figure 110: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (FLA_BT_MIX).

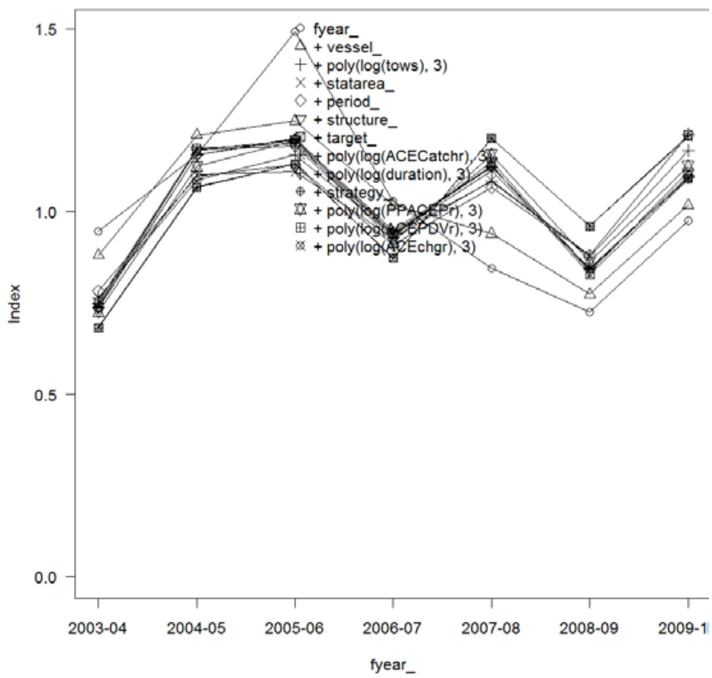


Figure 111: Annual influence for each term in the model (FLA_BT_MIX).

\

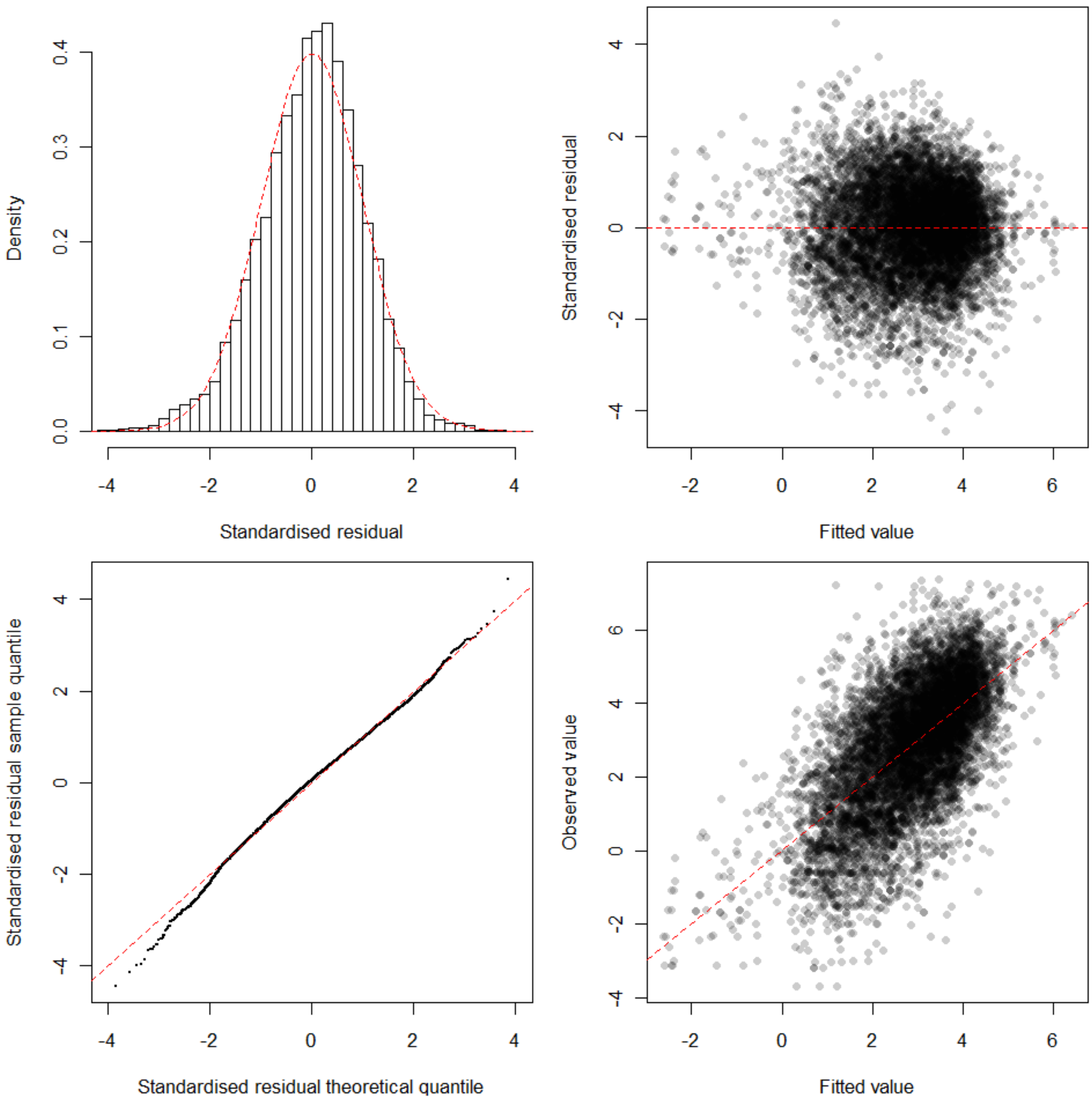


Figure 112: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (FLA_BT_MIX).

5.3.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-6.0397  -0.8600   0.0659   0.9014   6.0512

Coefficients: (1 not defined because of singularities)
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                        2.01326    0.32750   6.147 8.24e-10 ***
fyear_2004-05                      0.44749    0.06489   6.896 5.74e-12 ***
fyear_2005-06                      0.50421    0.06810   7.404 1.45e-13 ***
fyear_2006-07                      0.24474    0.06638   3.687 0.000228 ***
fyear_2007-08                      0.56421    0.09553   5.906 3.64e-09 ***
fyear_2008-09                      0.34118    0.10311   3.309 0.000941 ***
fyear_2009-10                      0.56727    0.10656   5.323 1.05e-07 ***
vessel_12                         -1.82202    0.19991  -9.114  < 2e-16 ***
vessel_15                         -0.71815    0.30775  -2.334 0.019645 *
vessel_17                         -1.52640    0.21093  -7.236 5.02e-13 ***
vessel_19                          0.03034    0.40880   0.074 0.940844
vessel_20                         -0.39750    0.34833  -1.141 0.253839
vessel_21                         -0.19224    0.34212  -0.562 0.574194
vessel_22                         -1.63966    0.20093  -8.160 3.83e-16 ***
vessel_24                         -0.74802    0.42081  -1.778 0.075510 .
vessel_29                         -3.21150    0.32658  -9.834  < 2e-16 ***
vessel_32                         -1.10641    0.23400  -4.728 2.30e-06 ***
vessel_34                          0.78421    0.19861   3.949 7.93e-05 ***
vessel_40                          0.32645    0.21381   1.527 0.126847
vessel_42                         -2.51148    0.40005  -6.278 3.61e-10 ***
vessel_44                          0.35833    0.19918   1.799 0.072059 .
vessel_46                         -0.47824    0.31652  -1.511 0.130843
vessel_60                         -0.47508    0.20768  -2.288 0.022187 *
vessel_61                         -0.30644    0.22356  -1.371 0.170503
vessel_68                          0.79249    0.19707   4.021 5.84e-05 ***
vessel_80                          0.63145    0.19751   3.197 0.001394 **
vessel_83                         -1.13445    0.32850  -3.453 0.000556 ***
vessel_86                         -1.10333    0.21204  -5.203 2.00e-07 ***
vessel_90                         -1.16848    0.19641  -5.949 2.80e-09 ***
vessel_95                         -0.83220    1.38979  -0.599 0.549323
vessel_97                         -1.52557    0.28718  -5.312 1.11e-07 ***
vessel_99                          1.08205    0.47796   2.264 0.023608 *
vessel_100                         0.54636    0.19678   2.777 0.005506 **
vessel_101                        -0.95681    0.21293  -4.494 7.10e-06 ***
vessel_103                        -0.11162    0.24872  -0.449 0.653610
vessel_104                        -2.85187    0.41133  -6.933 4.42e-12 ***
vessel_105                        -0.78289    0.19746  -3.965 7.41e-05 ***
vessel_106                        -1.15096    0.26191  -4.394 1.12e-05 ***
vessel_108                         0.11262    0.22944   0.491 0.623559
vessel_110                        -0.85027    0.22480  -3.782 0.000156 ***
vessel_111                        -0.77644    0.24804  -3.130 0.001753 **
vessel_114                        -1.40029    0.18966  -7.383 1.70e-13 ***
vessel_116                        -0.09356    0.23478  -0.398 0.690278
vessel_119                        -0.91692    0.19795  -4.632 3.67e-06 ***
vessel_120                         0.17359    0.23768   0.730 0.465190
vessel_121                        -1.05983    0.28407  -3.731 0.000192 ***
vessel_128                        -2.33619    0.33028  -7.073 1.63e-12 ***
vessel_129                         0.20840    0.19791   1.053 0.292379
vessel_131                        -2.20190    0.30859  -7.135 1.05e-12 ***
vessel_133                        -0.13230    0.19095  -0.693 0.488427
vessel_139                         0.43378    0.20534   2.113 0.034669 *
vessel_142                        -1.76456    0.26673  -6.616 3.93e-11 ***
vessel_144                        -1.32905    0.19749  -6.730 1.81e-11 ***
vessel_147                        -1.52051    0.24547  -6.194 6.14e-10 ***
vessel_148                        -0.57068    0.22951  -2.487 0.012918 *
poly(log(tows), 3)1               36.53245    4.02157   9.084  < 2e-16 ***
poly(log(tows), 3)2                6.41026    2.06434   3.105 0.001908 **
poly(log(tows), 3)3               -2.37541    1.43886  -1.651 0.098798 .
Coefficients: (1 not defined because of singularities)
                                  Estimate Std. Error t value Pr(>|t|)
statarea_12                       -0.99524    0.21504  -4.628 3.75e-06 ***
statarea_13                        0.63488    0.21608   2.938 0.003310 **
statarea_14                        0.46491    0.21962   2.117 0.034301 *
statarea_15                        0.78386    0.24847   3.155 0.001612 **
statarea_16                        2.95246    0.30349   9.729  < 2e-16 ***
statarea_37                        0.51129    0.35929   1.423 0.154759
statarea_39                        2.80221    0.29511   9.495  < 2e-16 ***
```

(Cont…)

```
statarea_40                          0.45127    0.27663   1.631 0.102863
statarea_41                          1.50995    0.24556   6.149 8.16e-10 ***
period_2                             0.26652    0.16336   1.632 0.102818
period_3                            -0.06315    0.16188  -0.390 0.696453
period_4                            -0.29483    0.16654  -1.770 0.076713 .
period_5                            -0.29479    0.17032  -1.731 0.083521 .
period_6                            -0.34226    0.17037  -2.009 0.044580 *
period_7                            -0.09800    0.17053  -0.575 0.565499
period_8                             0.04363    0.17207   0.254 0.799830
period_9                            -0.02508    0.17525  -0.143 0.886219
period_10                            0.08186    0.17284   0.474 0.635766
period_11                            0.40621    0.17090   2.377 0.017479 *
period_12                            0.41136    0.17099   2.406 0.016161 *
structure_opportunistic              0.50149    0.08023   6.251 4.29e-10 ***
structure_vertically integrated      0.34861    0.06142   5.676 1.43e-08 ***
target_SNA                          -0.34963    0.09689  -3.608 0.000310 ***
target_TRE                          -0.51713    0.11155  -4.636 3.61e-06 ***
poly(log(ACECatchr), 3)1             9.12562   11.30258   0.807 0.419463
poly(log(ACECatchr), 3)2           -11.60451    6.82026  -1.701 0.088891 .
poly(log(ACECatchr), 3)3             6.57650    2.34936   2.799 0.005134 **
poly(log(duration), 3)1             13.38983    4.11460   3.254 0.001142 **
poly(log(duration), 3)2             -0.73457    1.90134  -0.386 0.699252
poly(log(duration), 3)3             -0.23914    1.79429  -0.133 0.893976
strategy_opportunistic              -0.01694    0.05825  -0.291 0.771269
strategy_vertically integrated      -0.12501    0.04512  -2.770 0.005611 **
poly(log(PPACEPr), 3)1              -1.71319    1.82844  -0.937 0.348800
poly(log(PPACEPr), 3)2             103.65213   29.55447   3.507 0.000455 ***
poly(log(PPACEPr), 3)3              95.37413   41.42475   2.302 0.021340 *
poly(log(ACEPDVr), 3)1                    NA         NA      NA       NA
poly(log(ACEPDVr), 3)2            -100.42393   30.02153  -3.345 0.000826 ***
poly(log(ACEPDVr), 3)3              90.36237   40.95782   2.206 0.027395 *
poly(log(ACEchgr), 3)1             -13.10246   12.46860  -1.051 0.293365
poly(log(ACEchgr), 3)2               9.75001    6.53118   1.493 0.135517
poly(log(ACEchgr), 3)3               1.35341    1.70432   0.794 0.427157
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 1.854958)

    Null deviance: 25771  on 8389  degrees of freedom
Residual deviance: 15381  on 8292  degrees of freedom
AIC: 29093

Number of Fisher Scoring iterations: 2

R-squared: 40.32%
adjusted R-squared: 39.62%
AIC: 29093
Dispersion parameter for Gamma family taken to be 1.855
    Null deviance: 25771  on 8389  degrees of freedom
Residual deviance: 15381  on 8292  degrees of freedom
```

5.4 GUR_BT_MIX

5.4.1 Summary of results

The model shows some influence of those ratios involving ACE prices, port prices and deemed value and capturing the change in the permit holder's ACE holdings between periods but no influence of the strategy and structure index variables (Table 27 and Table 28).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + vessel_ + poly(log(duration), 3) + period_ + target_ + poly(log(tows), 3) + statarea_ + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3)

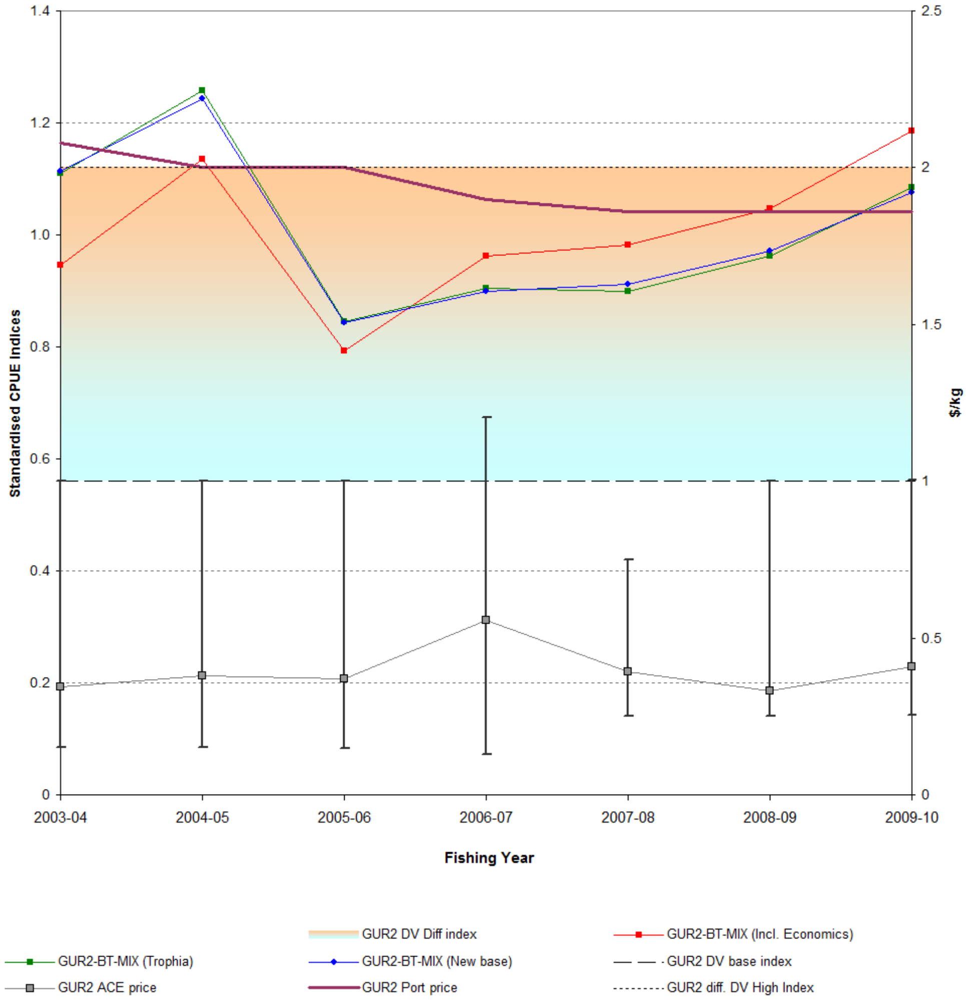


Figure 113: Comparison of GUR_BT_MIX Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.4.2 Data Subset

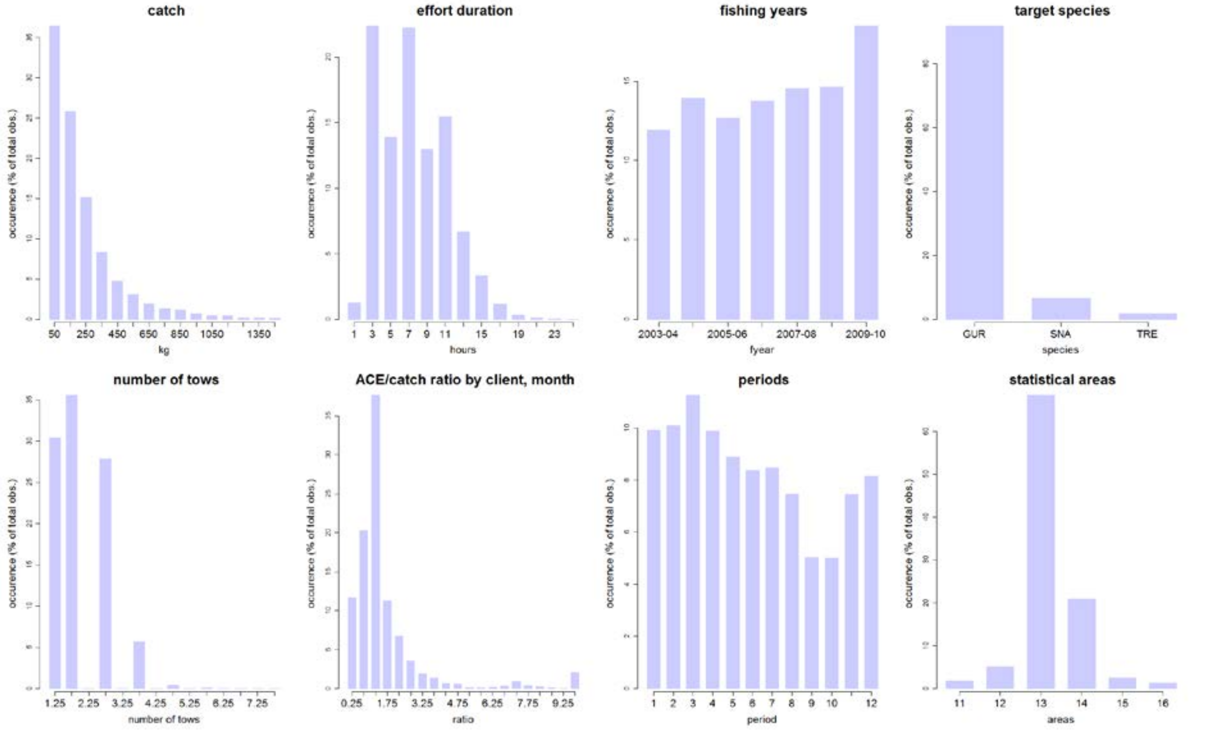


Figure 114: Histograms of Catch-Effort data for all strata included in the “GUR_BT_MIX” CPUE model.

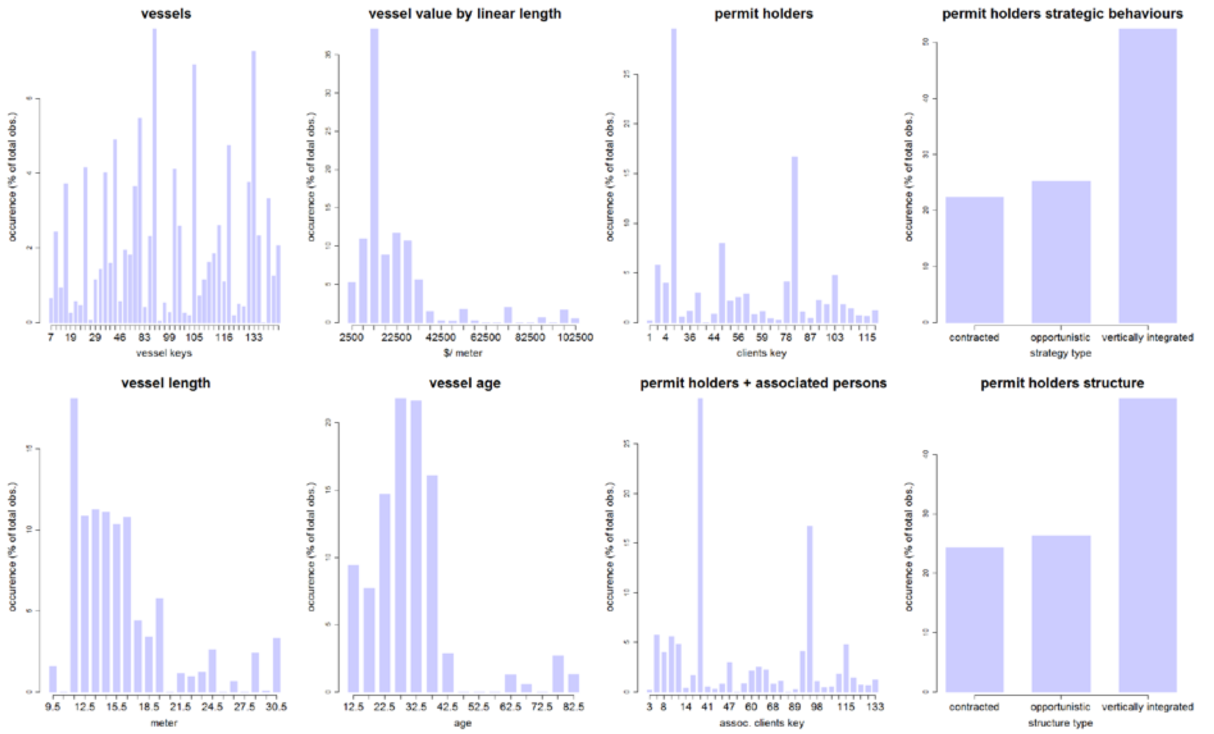


Figure 115: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “GUR_BT_MIX” CPUE model.

5.4.3 Stepwise selection of model terms

Table 27: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (GUR_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	12,066	148,792	0	
fyear_	6	-	11564	11,873	148,588	1.60	*
+ vessel_	45	3,437	11519	8,436	144,184	30.08	*
+ poly(log(duration), 3)	3	2,720	11516	5,716	139,247	52.63	*
+ period_	11	141	11505	5,574	138,957	53.80	*
+ target_	2	96	11503	5,478	138,743	54.60	*
+ poly(log(tows), 3)	3	89	11500	5,389	138,546	55.33	*
+ statarea_	5	61	11495	5,328	138,414	55.84	*
+ poly(log(PPACEPr), 3)	3	9	11492	5,320	138,401	55.91	
+ poly(log(ACECatchr), 3)	3	7	11489	5,313	138,390	55.97	
+ poly(log(ACEPDVr), 3)	3	5	11486	5,307	138,383	56.01	

acceptance threshold: 0.1%
based on the translog model

5.4.4 Influence of model terms on annual CPUE indices

Table 28: Summary of the influence of each term in the standardisation model (GUR_BT_MIX).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	193	1.60%	148,588	-	-
vessel_	45	3437	28.49%	144,184	8.95%	0.05
poly(log(duration), 3)	3	2720	22.55%	139,247	8.42%	-0.03
period_	11	141	1.17%	138,957	0.46%	0.00
target_	2	96	0.80%	138,743	0.83%	0.00
poly(log(tows), 3)	3	89	0.73%	138,546	5.44%	-0.02
statarea_	5	61	0.51%	138,414	0.68%	0.00
poly(log(PPACEPr), 3)	3	9	0.07%	138,401	0.93%	0.00
poly(log(ACECatchr), 3)	3	7	0.06%	138,390	0.22%	0.00

based on the translog model

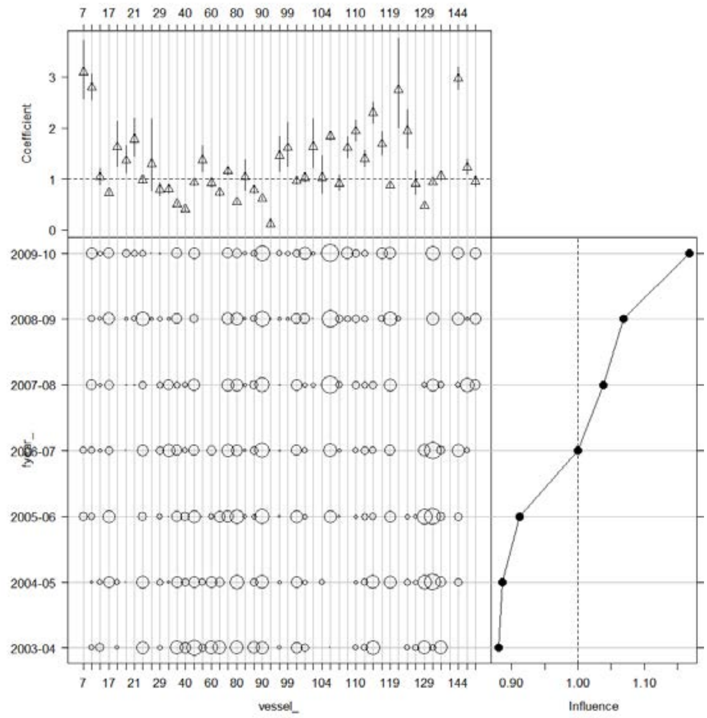


Figure 116: Coefficient-distribution-influence plot for "vessel" (GUR_BT_MIX).

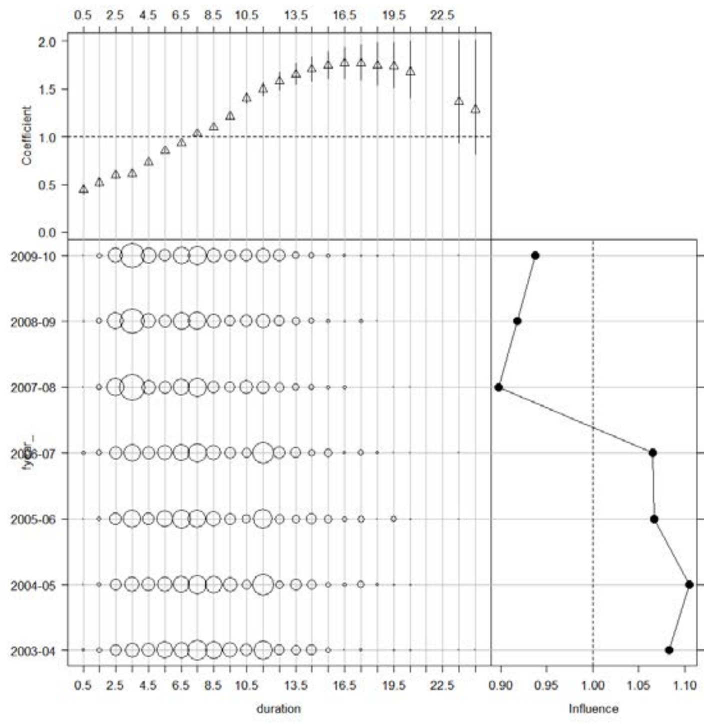


Figure 117: Coefficient-distribution-influence plot for "duration" (GUR_BT_MIX).

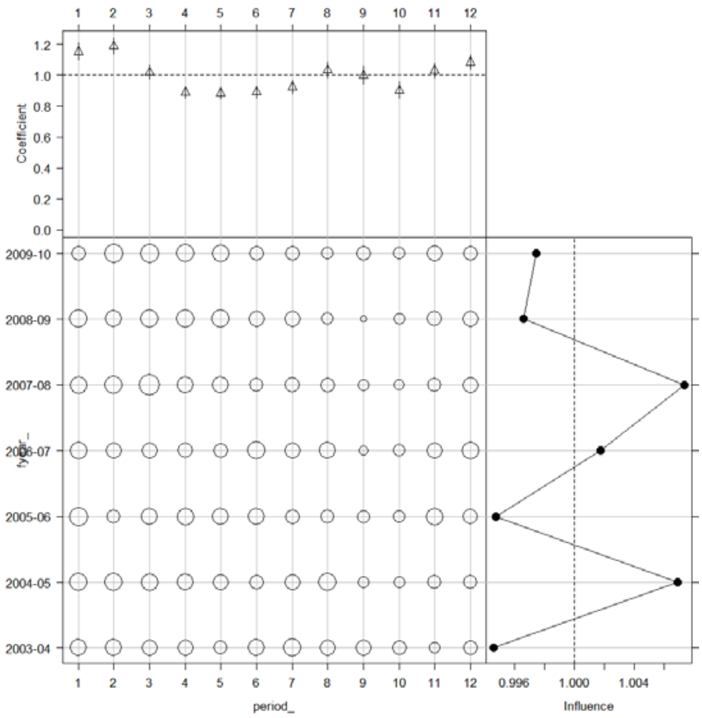


Figure 118: Coefficient-distribution-influence plot for “period” (GUR_BT_MIX).

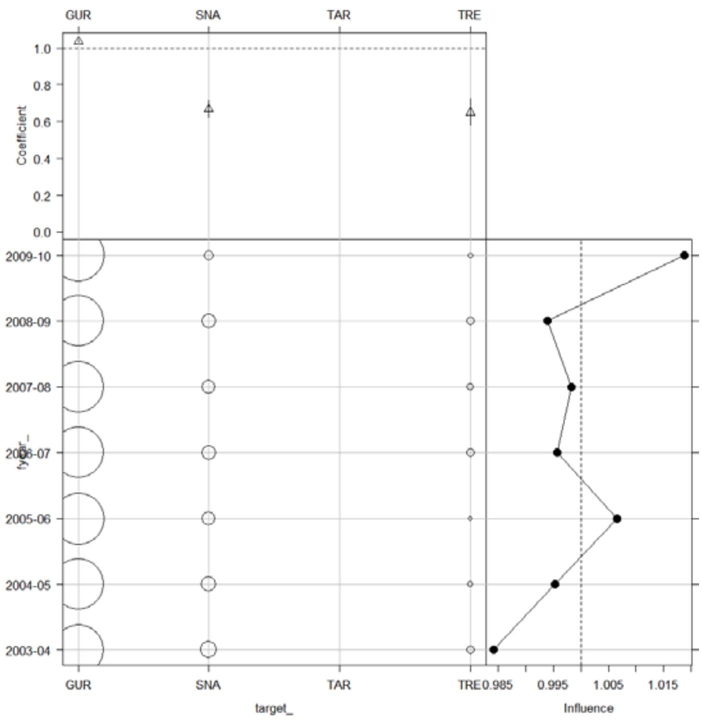


Figure 119: Coefficient-distribution-influence plot for “target” (GUR_BT_MIX).

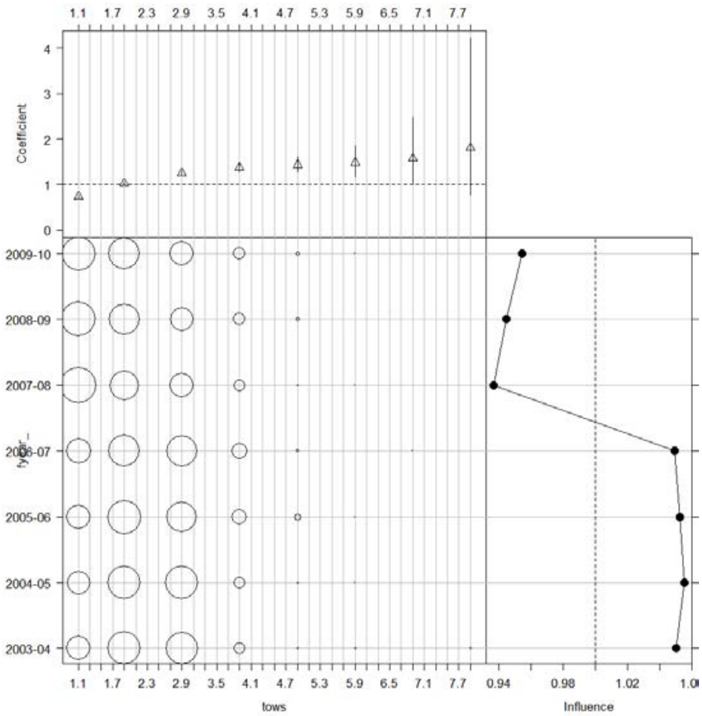


Figure 120: Coefficient-distribution-influence plot for "tows" (GUR_BT_MIX).

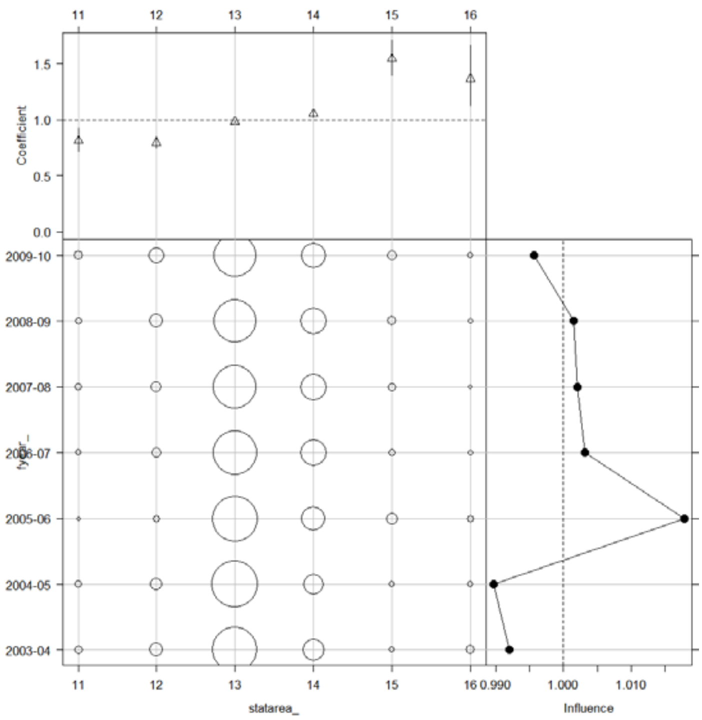


Figure 121: Coefficient-distribution-influence plot for "statarea" (GUR_BT_MIX).

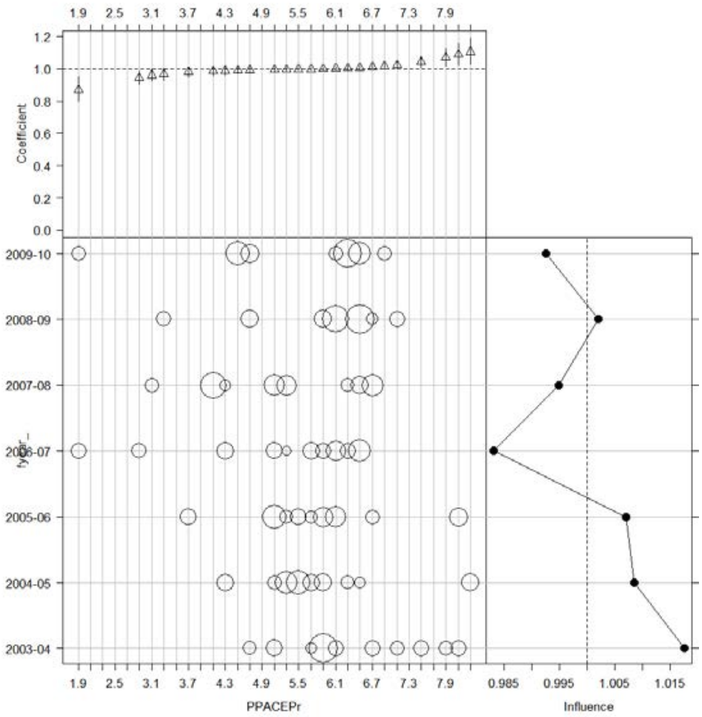


Figure 122: Coefficient-distribution-influence plot for "PPACEPr" (GUR_BT_MIX).

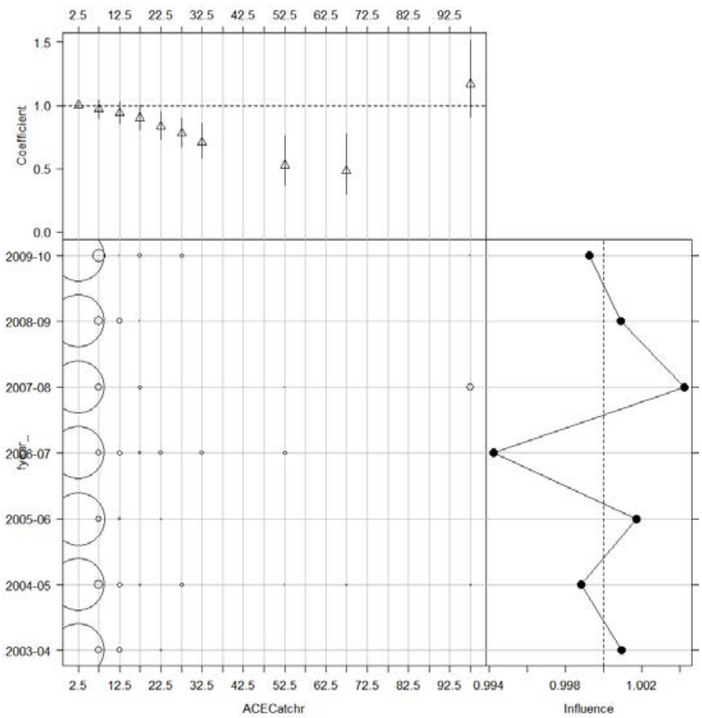


Figure 123: Coefficient-distribution-influence plot for "ACECatchr" (GUR_BT_MIX).

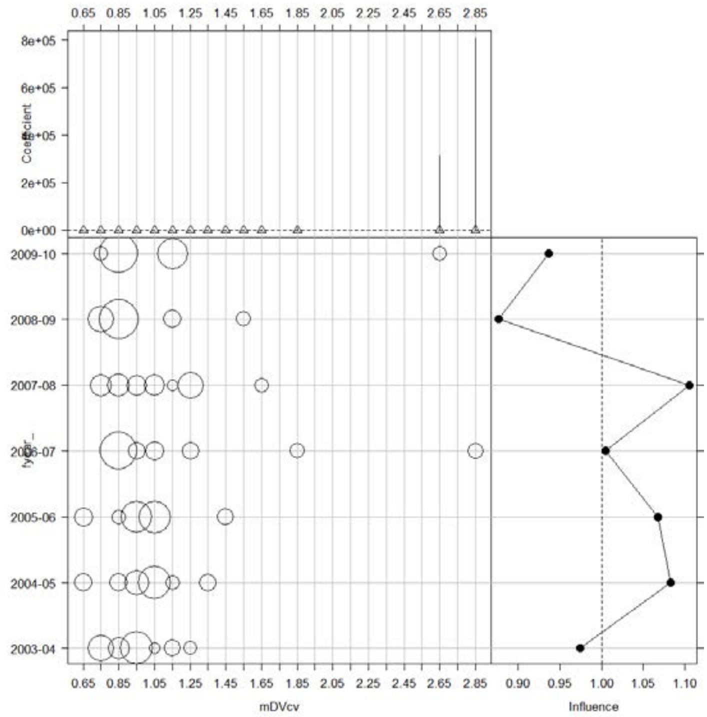


Figure 124: Coefficient-distribution-influence plot for "mDVcv" (GUR_BT_MIX).

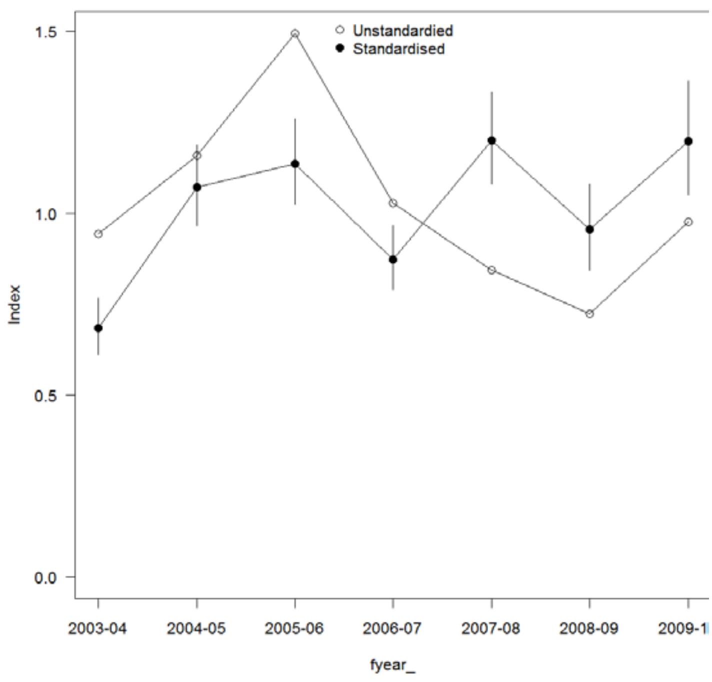


Figure 125: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (GUR_BT_MIX).

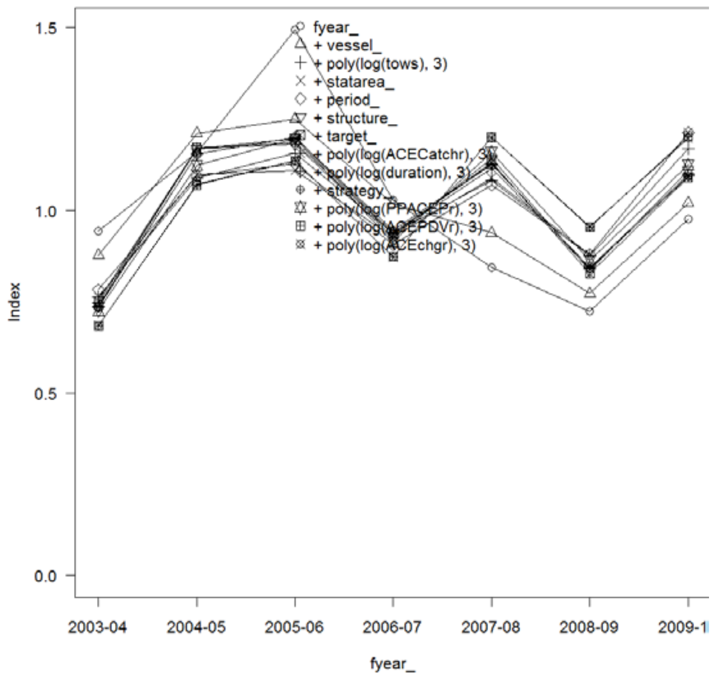


Figure 126: Annual influence for each term in the model (GUR_BT_MIX).

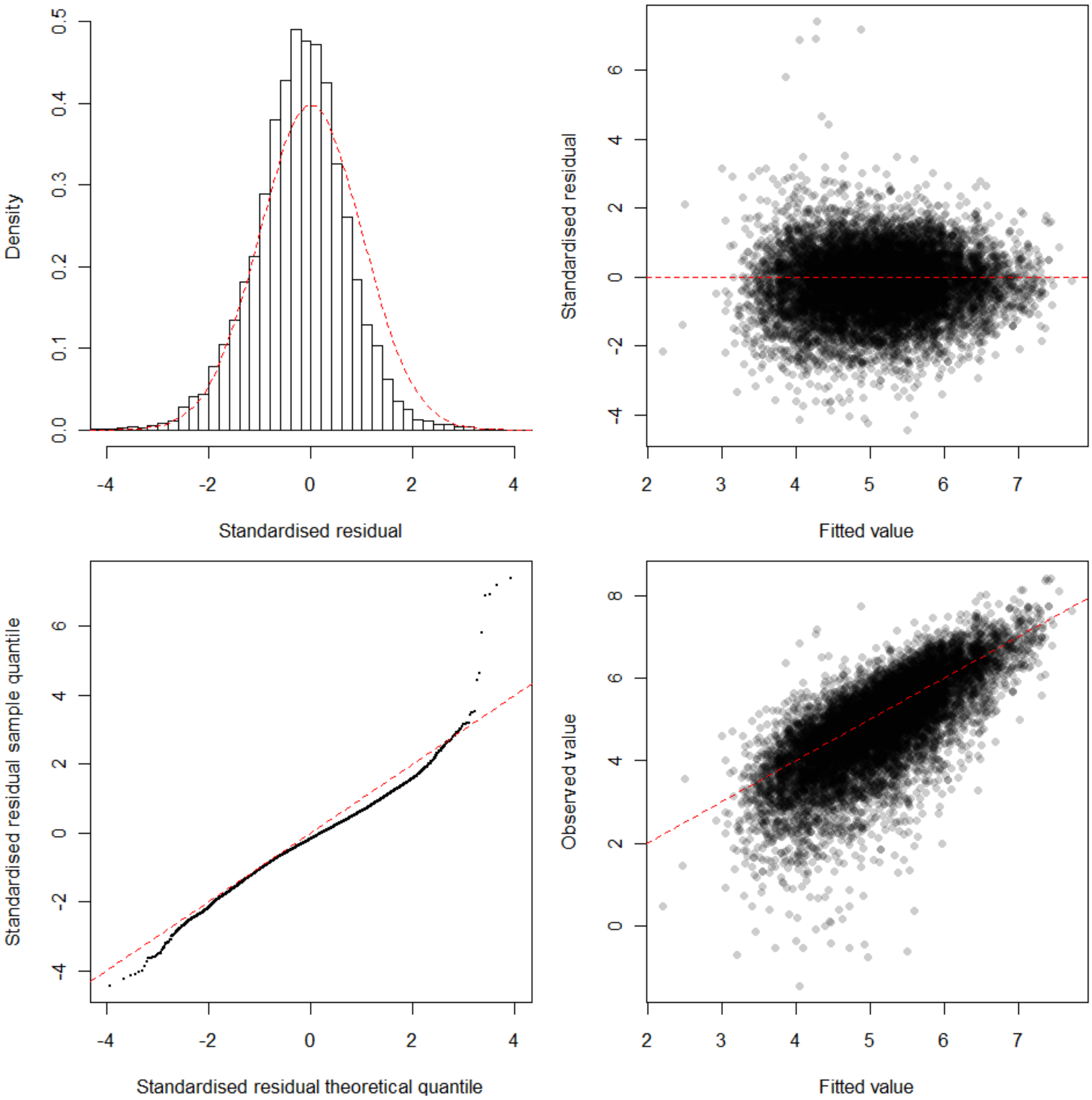


Figure 127: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (GUR_BT_MIX).

5.4.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.2032  -0.5329  -0.1280   0.2595   5.3388

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)          6.319608   0.119432  52.914  < 2e-16 ***
fyear_2004-05        0.088941   0.027639   3.218 0.001294 **
fyear_2005-06       -0.266180   0.028900  -9.210  < 2e-16 ***
fyear_2006-07       -0.159911   0.029737  -5.378 7.70e-08 ***
fyear_2007-08       -0.164162   0.030494  -5.383 7.45e-08 ***
fyear_2008-09       -0.111003   0.030091  -3.689 0.000226 ***
fyear_2009-10        0.008017   0.029576   0.271 0.786350
vessel_12           -0.103398   0.099349  -1.041 0.298008
vessel_15           -1.096212   0.122248  -8.967  < 2e-16 ***
vessel_17           -1.439730   0.099906 -14.411  < 2e-16 ***
vessel_19           -0.644650   0.164767  -3.912 9.19e-05 ***
vessel_20           -0.821531   0.133894  -6.136 8.76e-10 ***
vessel_21           -0.551179   0.140399  -3.926 8.69e-05 ***
vessel_22           -1.146928   0.098662 -11.625  < 2e-16 ***
vessel_24           -0.870026   0.271768  -3.201 0.001372 **
vessel_29           -1.363091   0.124087 -10.985  < 2e-16 ***
vessel_32           -1.350637   0.109288 -12.359  < 2e-16 ***
vessel_34           -1.794385   0.100535 -17.848  < 2e-16 ***
vessel_40           -2.024488   0.108278 -18.697  < 2e-16 ***
vessel_44           -1.204064   0.098702 -12.199  < 2e-16 ***
vessel_46           -0.814940   0.132654  -6.143 8.35e-10 ***
vessel_60           -1.205564   0.106356 -11.335  < 2e-16 ***
vessel_61           -1.433538   0.106584 -13.450  < 2e-16 ***
vessel_68           -0.990069   0.099605  -9.940  < 2e-16 ***
vessel_80           -1.729946   0.098199 -17.617  < 2e-16 ***
vessel_83           -1.096637   0.156590  -7.003 2.64e-12 ***
vessel_86           -1.368605   0.104867 -13.051  < 2e-16 ***
vessel_90           -1.618340   0.096490 -16.772  < 2e-16 ***
vessel_95           -3.299190   0.374698  -8.805  < 2e-16 ***
vessel_97           -0.755039   0.140418  -5.377 7.72e-08 ***
vessel_99           -0.650878   0.163567  -3.979 6.96e-05 ***
vessel_100          -1.166791   0.099362 -11.743  < 2e-16 ***
vessel_101          -1.102937   0.103040 -10.704  < 2e-16 ***
vessel_103          -0.638755   0.164236  -3.889 0.000101 ***
vessel_104          -1.101458   0.198242  -5.556 2.82e-08 ***
vessel_105          -0.518996   0.096865  -5.358 8.58e-08 ***
vessel_106          -1.223846   0.123843  -9.882  < 2e-16 ***
vessel_108          -0.654431   0.110830  -5.905 3.63e-09 ***
vessel_110          -0.468596   0.108967  -4.300 1.72e-05 ***
vessel_111          -0.795842   0.110185  -7.223 5.41e-13 ***
vessel_114          -0.298873   0.098749  -3.027 0.002479 **
vessel_116          -0.605725   0.115446  -5.247 1.57e-07 ***
vessel_119          -1.262564   0.098460 -12.823  < 2e-16 ***
vessel_120          -0.120684   0.177900  -0.678 0.497546
vessel_121          -0.465548   0.134824  -3.453 0.000556 ***
vessel_128          -1.227410   0.149035  -8.236  < 2e-16 ***
vessel_129          -1.868727   0.099583 -18.765  < 2e-16 ***
vessel_133          -1.189166   0.096572 -12.314  < 2e-16 ***
vessel_139          -1.071643   0.103252 -10.379  < 2e-16 ***
vessel_144          -0.040916   0.098912  -0.414 0.679130
vessel_147          -0.926098   0.110988  -8.344  < 2e-16 ***
vessel_148          -1.177356   0.108550 -10.846  < 2e-16 ***
poly(duration, 3)1  35.786355   2.100320  17.039  < 2e-16 ***
poly(duration, 3)2  -8.715059   1.130891  -7.706 1.40e-14 ***
poly(duration, 3)3  -0.446192   0.807533  -0.553 0.580591
period_2             0.030202   0.035616   0.848 0.396465
period_3            -0.122447   0.035201  -3.478 0.000506 ***
period_4            -0.259612   0.033894  -7.660 2.02e-14 ***
Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
period_5            -0.265668   0.034693  -7.658 2.05e-14 ***
period_6            -0.258052   0.034960  -7.381 1.68e-13 ***
period_7            -0.221023   0.035019  -6.311 2.87e-10 ***
period_8            -0.108832   0.034702  -3.136 0.001716 **
period_9            -0.142340   0.039378  -3.615 0.000302 ***
period_10           -0.244490   0.039262  -6.227 4.91e-10 ***
period_11           -0.111626   0.035671  -3.129 0.001757 **
```

(Cont…)

```
period_12           -0.061851   0.034429  -1.797 0.072440 .
target_SNA          -0.439491   0.037720 -11.651  < 2e-16 ***
target_TRE          -0.468570   0.056206  -8.337  < 2e-16 ***
poly(tows, 3)1      22.997881   2.022399  11.372  < 2e-16 ***
poly(tows, 3)2      -6.039926   1.099932  -5.491 4.08e-08 ***
poly(tows, 3)3       1.716989   0.844338   2.034 0.042022 *
statarea_12         -0.020998   0.063677  -0.330 0.741592
statarea_13          0.190191   0.066022   2.881 0.003975 **
statarea_14          0.261418   0.068079   3.840 0.000124 ***
statarea_15          0.641552   0.084202   7.619 2.75e-14 ***
statarea_16          0.519805   0.119208   4.360 1.31e-05 ***
poly(PPACEPr, 3)1    2.937966   0.839989   3.498 0.000471 ***
poly(PPACEPr, 3)2   -0.095948   0.809018  -0.119 0.905596
poly(PPACEPr, 3)3    1.594479   0.833547   1.913 0.055788 .
poly(ACECatchr, 3)1 -0.393899   0.889199  -0.443 0.657787
poly(ACECatchr, 3)2  2.389245   0.867761   2.753 0.005908 **
poly(ACECatchr, 3)3  2.053491   0.837104   2.453 0.014178 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Gamma family taken to be 0.5222165)

    Null deviance: 12065.7  on 11570  degrees of freedom
Residual deviance:  5312.6  on 11489  degrees of freedom
AIC: 138390

Number of Fisher Scoring iterations: 8

R-squared: 55.97%
adjusted R-squared: 55.66%
AIC: 138389
Dispersion parameter for Gamma family taken to be 0.5222
    Null deviance: 12065  on 11570  degrees of freedom
Residual deviance: 5312  on 11489  degrees of freedom
```

5.5 GUR_BT_TAR

5.5.1 Summary of results

The model shows some influence of the strategy and structure index variables and all the ratios involving ACE prices, port prices and deemed value and capturing the change in the permit holder's ACE holdings between periods (Table 29 and Table 30)
The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + vessel_ + poly(log(duration), 3) + statarea_ + period_ + poly(log(tows), 3) + poly(log(ACEchgr), 3) + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + strategy_ + structure_

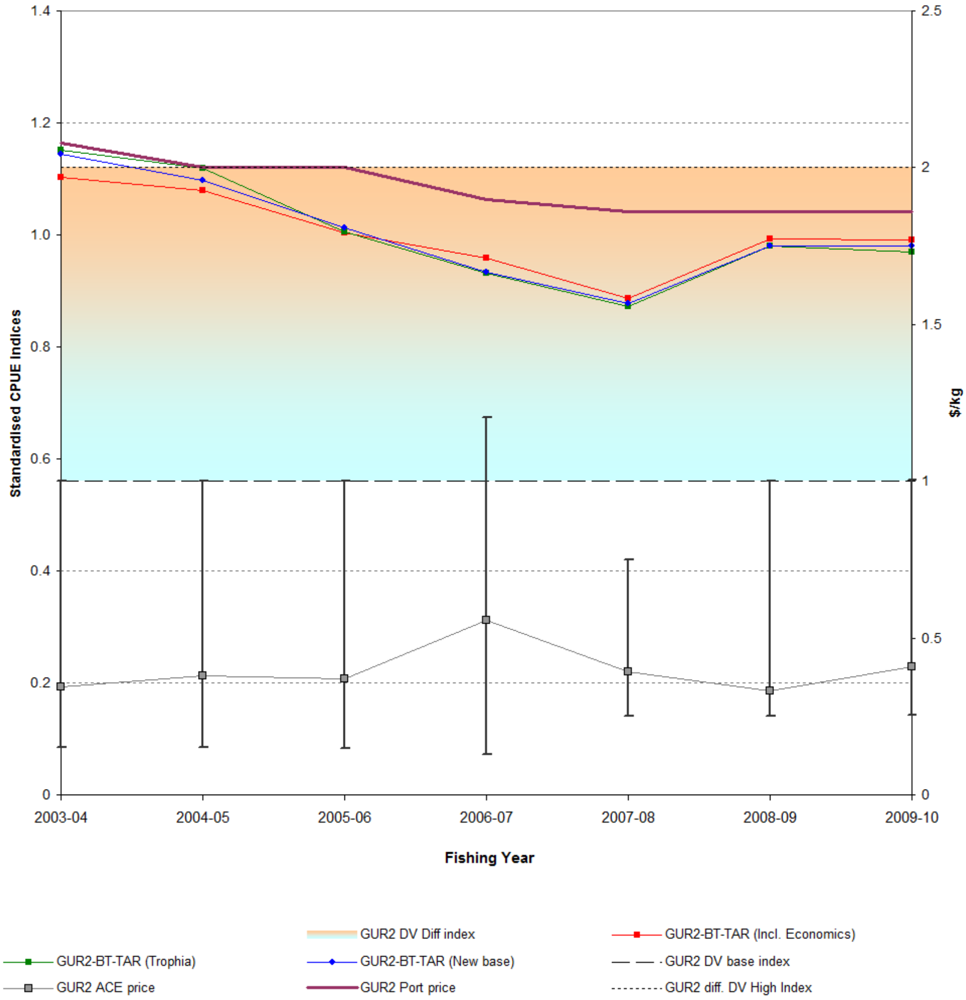


Figure 128: Comparison of GUR_BT_TAR Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.5.2 Data Subset

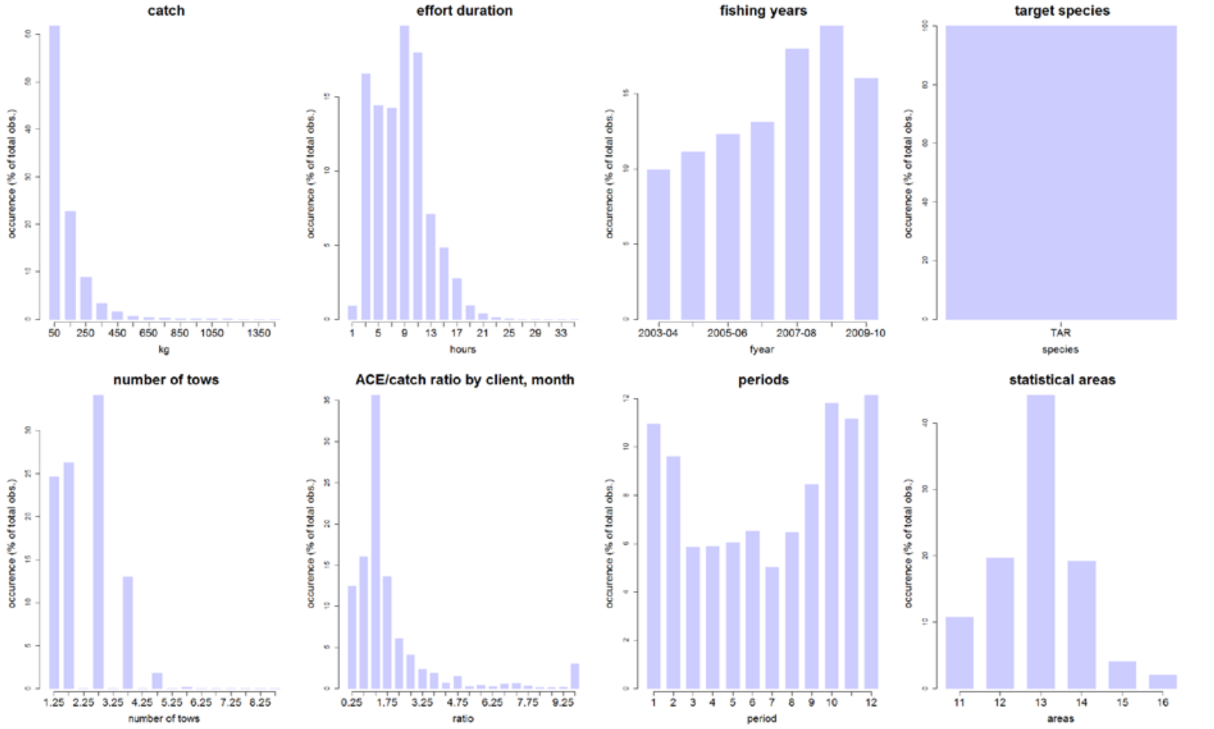


Figure 129: Histograms of Catch-Effort data for all strata included in the “GUR_BT_TAR” CPUE model.

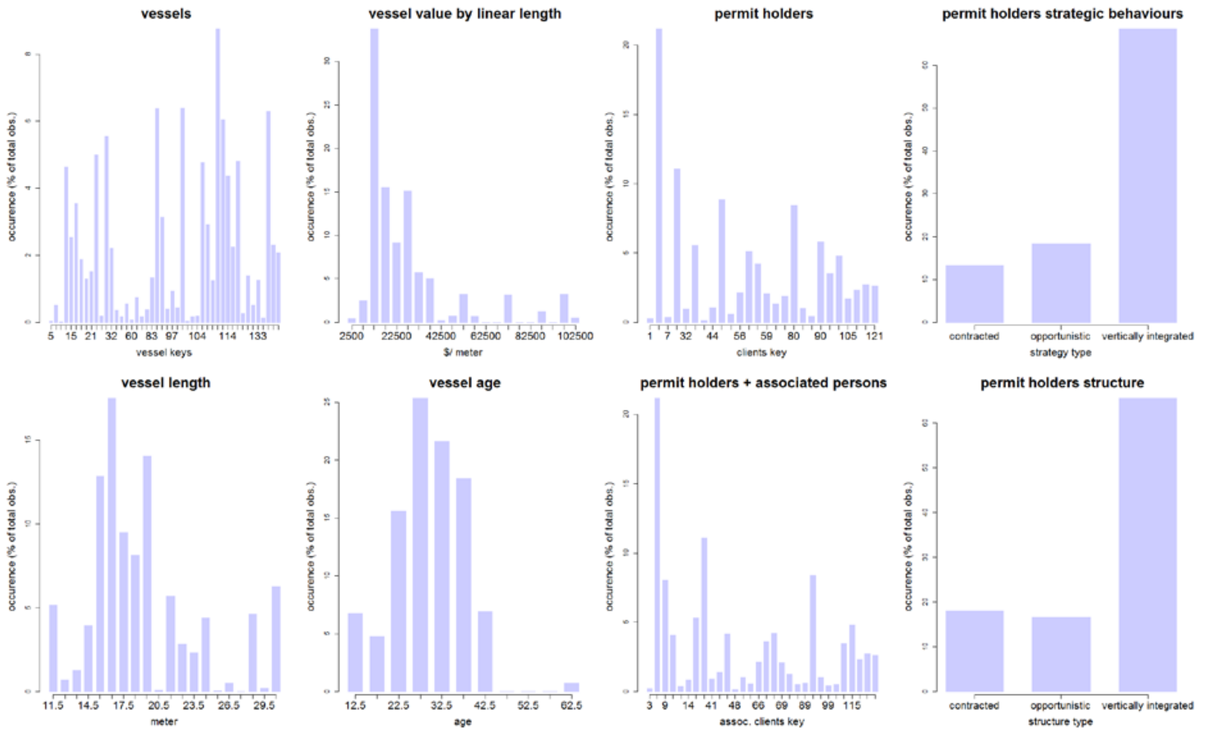


Figure 130: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “GUR_BT_TAR” CPUE model.

5.5.3 Stepwise selection of model terms

Table 29: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (GUR_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	12,958	115,922	0	
fyear_	6	-	10128	12,662	115,655	2.29	*
+ vessel_	45	1,892	10083	10,769	113,818	16.89	*
+ poly(log(duration), 3)	3	1,633	10080	9,137	111,905	29.49	*
+ statarea_	5	376	10075	8,760	111,429	32.40	*
+ period_	11	231	10064	8,529	111,144	34.18	*
+ poly(log(tows), 3)	3	43	10061	8,486	111,092	34.51	*
+ poly(log(ACEchgr), 3)	3	14	10058	8,472	111,079	34.62	*
+ poly(log(PPACEPr), 3)	3	11	10055	8,461	111,069	34.71	
+ poly(log(ACECatchr), 3)	3	10	10052	8,450	111,061	34.79	
+ strategy_	2	4	10050	8,447	111,060	34.82	
+ structure_	2	5	10048	8,441	111,057	34.86	

acceptance threshold: 0.1%
based on the translog model

5.5.4 Influence of model terms on annual CPUE indices

Table 30: Summary of the influence of each term in the standardisation model (GUR_BT_TAR).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	297	2.29%	115,655	-	-
vessel_	45	1892	14.60%	113,818	4.36%	0.02
poly(log(duration), 3)	3	1633	12.60%	111,905	5.80%	-0.02
statarea_	5	376	2.91%	111,429	1.88%	-0.01
period_	11	231	1.78%	111,144	0.90%	0.00
poly(log(tows), 3)	3	43	0.33%	111,092	4.56%	-0.02
poly(log(ACEchgr), 3)	3	14	0.11%	111,079	0.34%	0.00
poly(log(PPACEPr), 3)	3	11	0.09%	111,069	1.08%	0.00
poly(log(ACECatchr), 3)	3	10	0.08%	111,061	0.13%	0.00
strategy_	2	4	0.03%	111,060	0.47%	0.00
structure_	2	5	0.04%	111,057	0.72%	0.00

based on the translog model

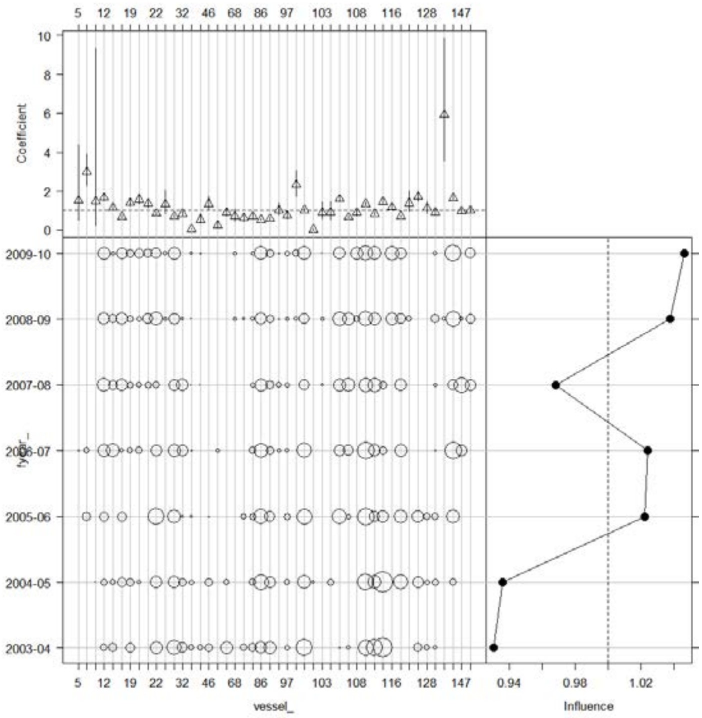


Figure 131: Coefficient-distribution-influence plot for "vessel" (GUR_BT_TAR).

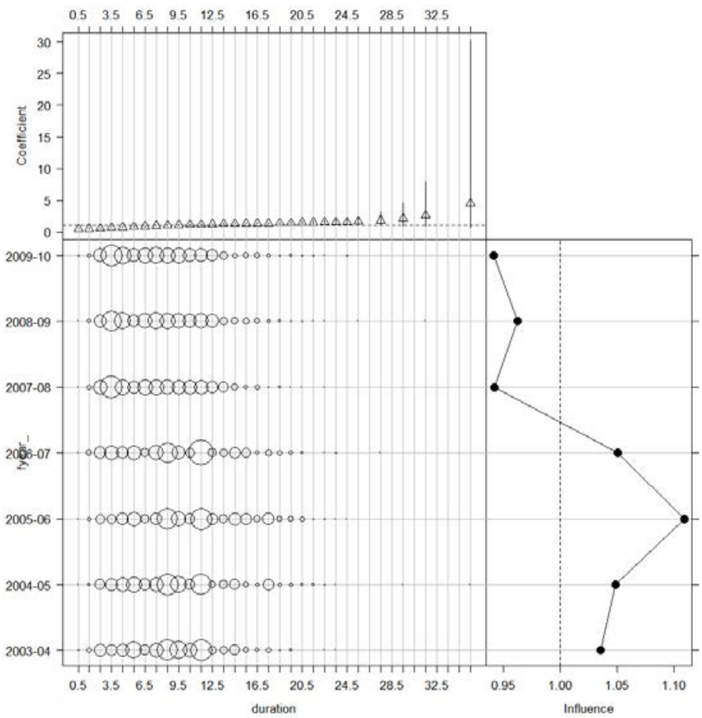


Figure 132: Coefficient-distribution-influence plot for "duration" (GUR_BT_TAR).

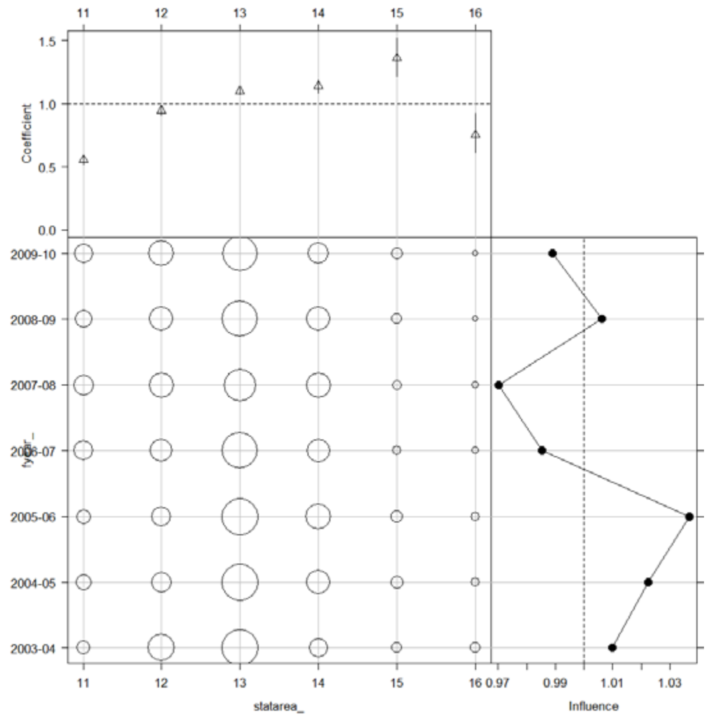


Figure 133: Coefficient-distribution-influence plot for "statarea" (GUR_BT_TAR).

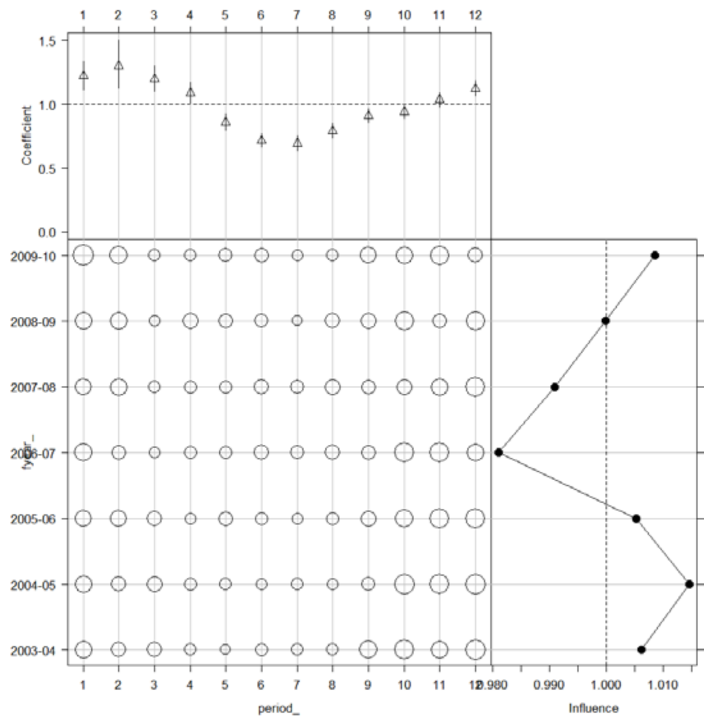


Figure 134: Coefficient-distribution-influence plot for "period" (GUR_BT_TAR).

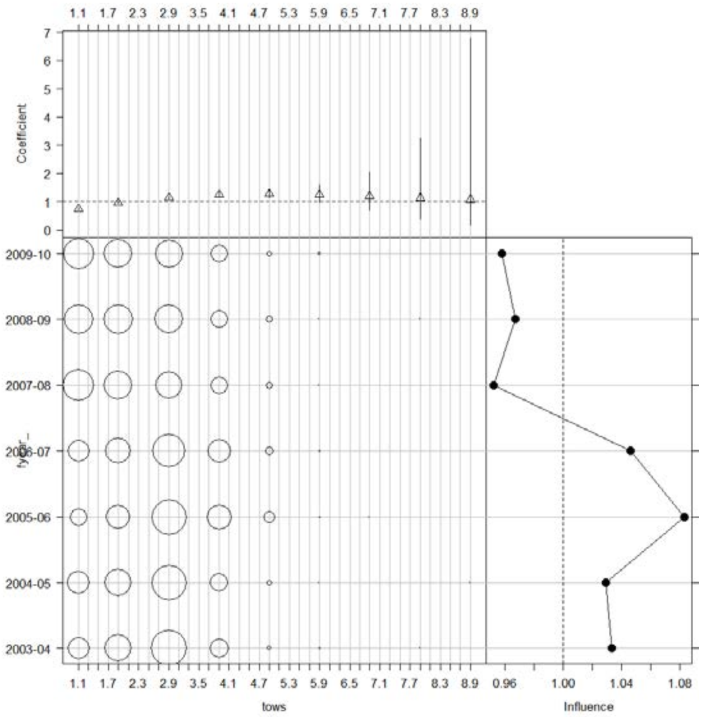


Figure 135: Coefficient-distribution-influence plot for "tows" (GUR_BT_TAR).

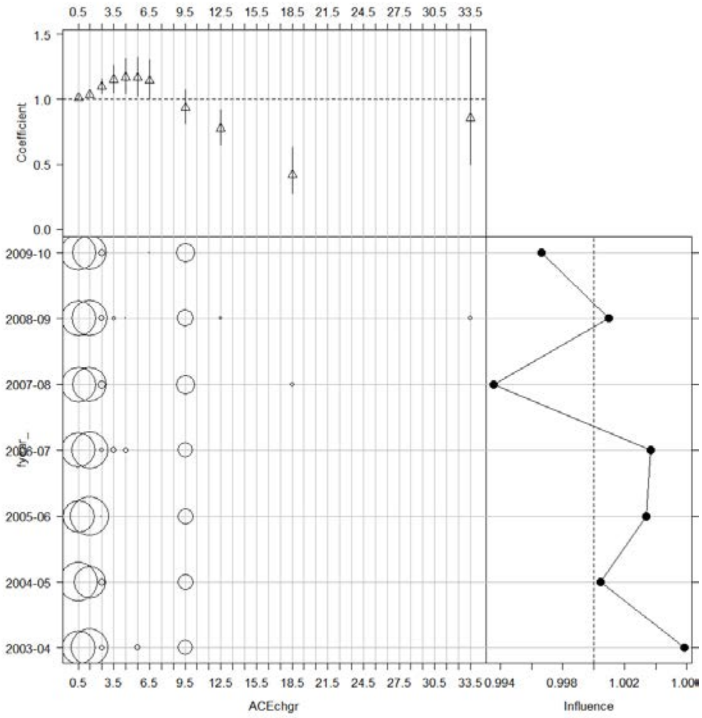


Figure 136: Coefficient-distribution-influence plot for "ACEchgr" (GUR_BT_TAR).

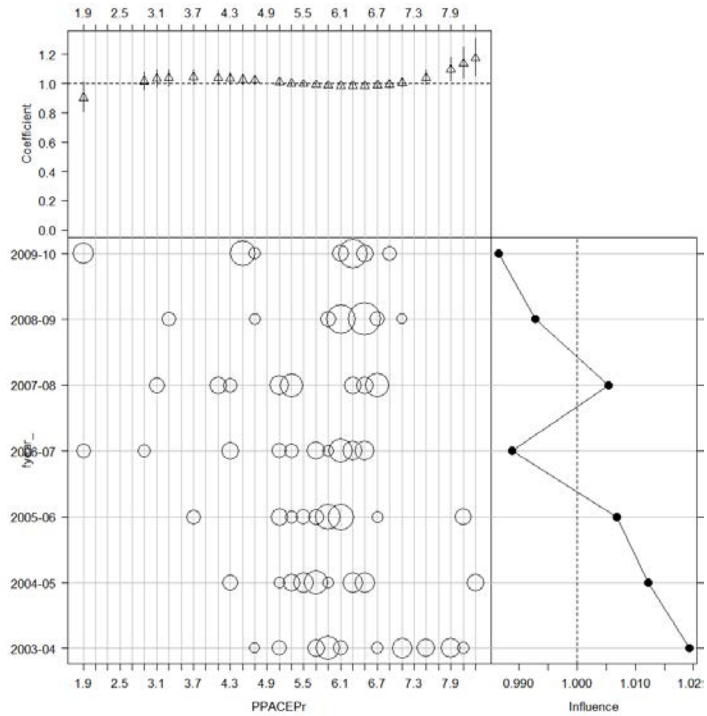


Figure 137: Coefficient-distribution-influence plot for "PPACEPr" (GUR_BT_TAR).

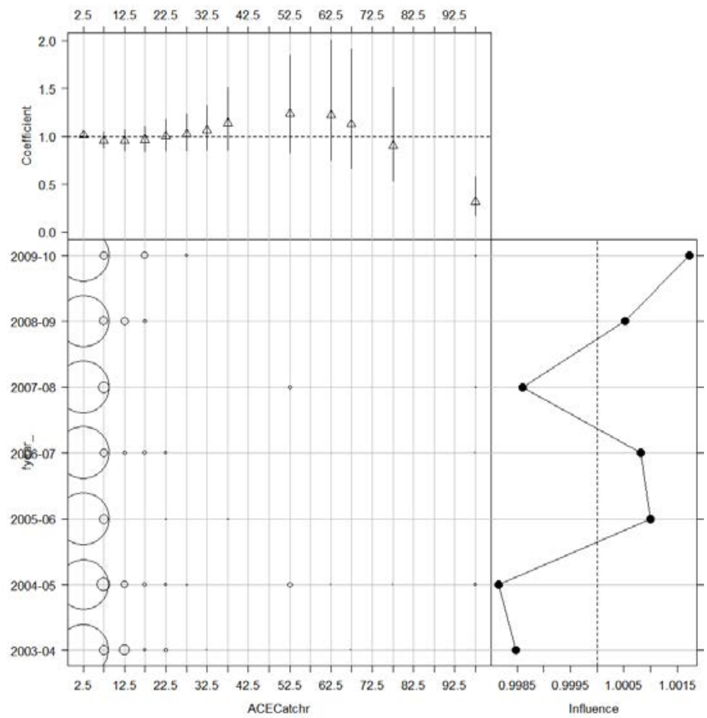


Figure 138: Coefficient-distribution-influence plot for "ACECatchr" (GUR_BT_TAR).

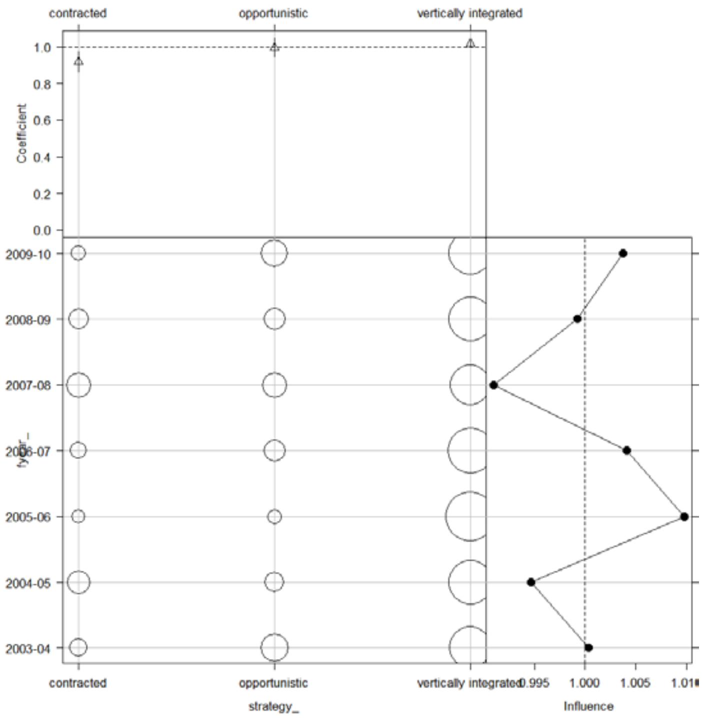


Figure 139: Coefficient-distribution-influence plot for "strategy" (GUR_BT_TAR).

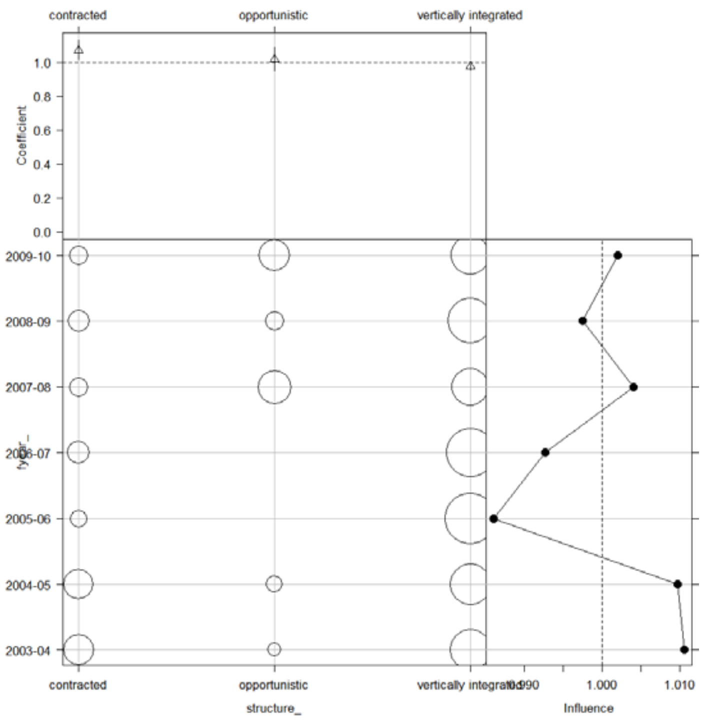


Figure 140: Coefficient-distribution-influence plot for "structure" (GUR_BT_TAR).

Figure 141: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (GUR_BT_TAR).

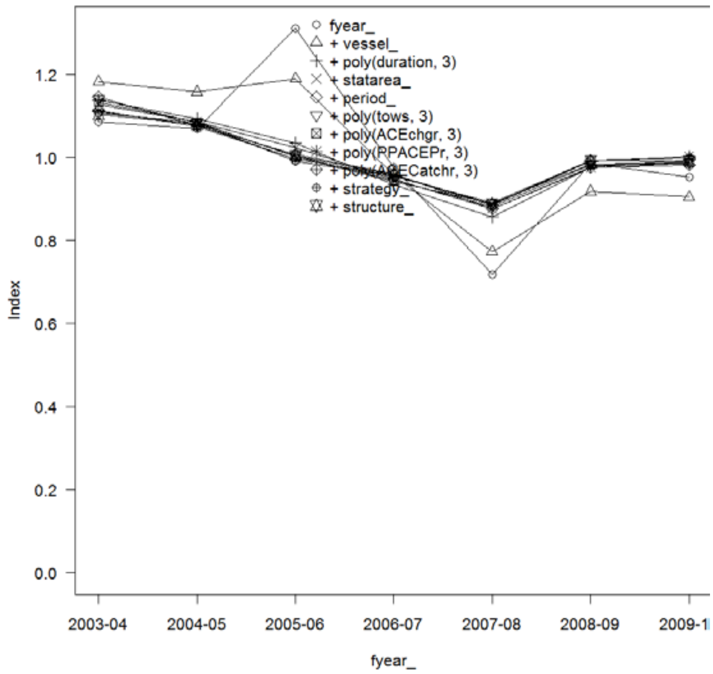


Figure 142: Annual influence for each term in the model (GUR_BT_TAR).

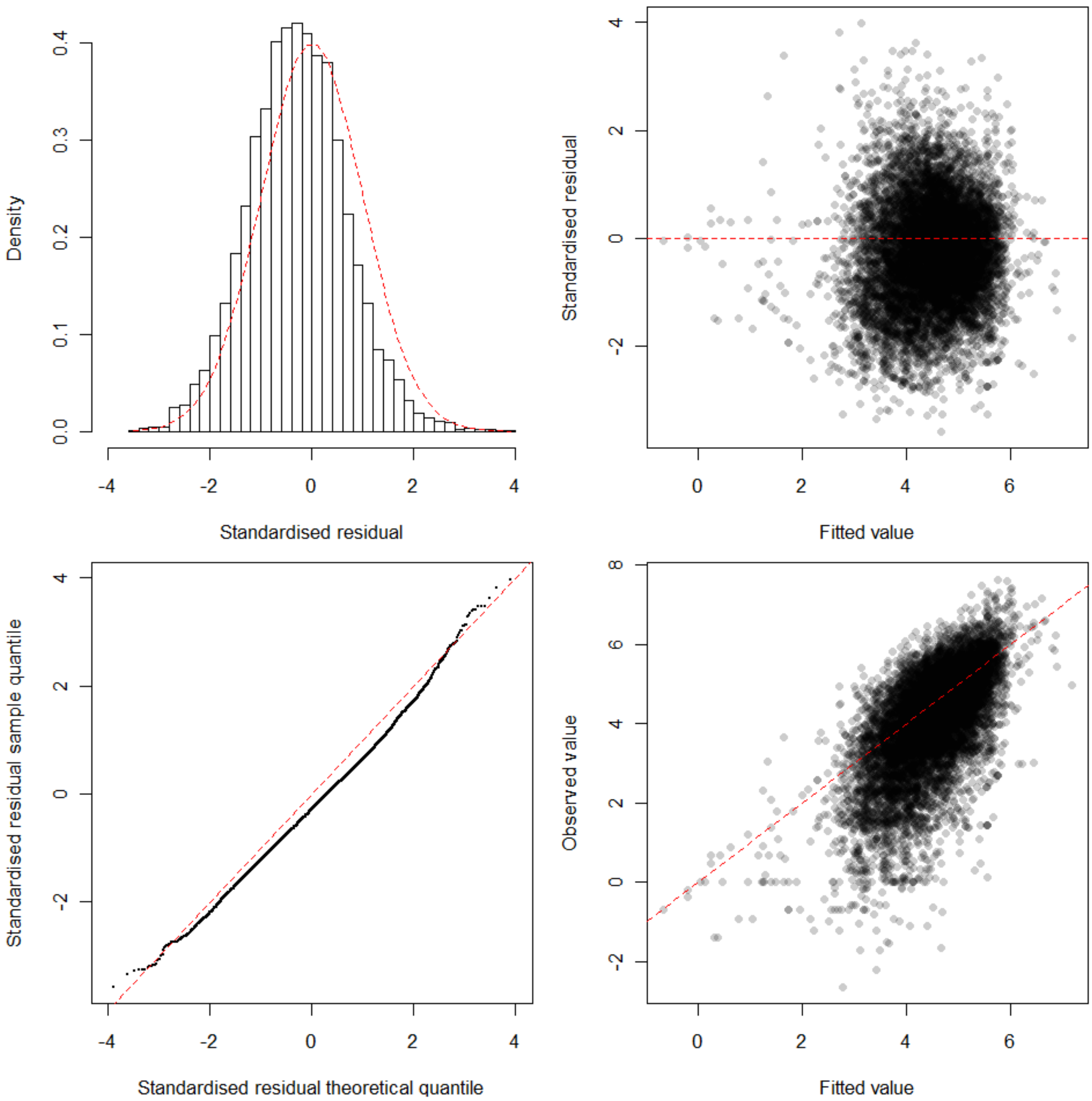


Figure 143: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (GUR_BT_TAR).

5.5.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.2606  -0.8396  -0.2620   0.3029   3.6064

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                      4.60228    0.54008   8.521  < 2e-16 ***
fyear_2004-05                   -0.02216    0.04211  -0.526 0.598793
fyear_2005-06                   -0.09446    0.04322  -2.186 0.028866 *
fyear_2006-07                   -0.14045    0.04341  -3.235 0.001219 **
fyear_2007-08                   -0.21808    0.04287  -5.086 3.72e-07 ***
fyear_2008-09                   -0.10651    0.04055  -2.626 0.008644 **
fyear_2009-10                   -0.10740    0.04365  -2.460 0.013902 *
vessel_7                         0.68303    0.55127   1.239 0.215374
vessel_10                       -0.01453    1.06395  -0.014 0.989102
vessel_12                        0.10379    0.53592   0.194 0.846443
vessel_15                       -0.27344    0.53662  -0.510 0.610364
vessel_17                       -0.77879    0.53635  -1.452 0.146527
vessel_19                       -0.06861    0.53866  -0.127 0.898650
vessel_20                        0.04636    0.54000   0.086 0.931583
vessel_21                       -0.10047    0.53919  -0.186 0.852179
vessel_22                       -0.57547    0.53534  -1.075 0.282416
vessel_24                       -0.12590    0.57412  -0.219 0.826425
vessel_29                       -0.77052    0.53547  -1.439 0.150191
vessel_32                       -0.58020    0.53732  -1.080 0.280253
vessel_42                       -3.33708    0.56969  -5.858 4.84e-09 ***
vessel_44                       -1.04568    0.57915  -1.806 0.071021 .
vessel_46                       -0.11760    0.54786  -0.215 0.830040
vessel_60                       -1.87125    0.64093  -2.920 0.003513 **
vessel_61                       -0.52442    0.54498  -0.962 0.335936
vessel_68                       -0.77081    0.57961  -1.330 0.183593
vessel_80                       -0.86483    0.55501  -1.558 0.119214
vessel_83                       -0.75196    0.54446  -1.381 0.167272
vessel_86                       -1.05537    0.53569  -1.970 0.048853 *
vessel_90                       -0.95726    0.53659  -1.784 0.074460 .
vessel_95                       -0.39041    0.55346  -0.705 0.480586
vessel_97                       -0.69600    0.54677  -1.273 0.203072
vessel_99                        0.43090    0.55136   0.782 0.434512
vessel_101                      -0.38298    0.53483  -0.716 0.473959
vessel_102                      -3.85049    0.75664  -5.089 3.67e-07 ***
vessel_103                      -0.52235    0.58128  -0.899 0.368883
vessel_104                      -0.51327    0.58613  -0.876 0.381216
vessel_105                       0.06147    0.53593   0.115 0.908688
vessel_106                      -0.80948    0.53654  -1.509 0.131406
vessel_108                      -0.52577    0.54074  -0.972 0.330918
vessel_110                      -0.11209    0.53513  -0.209 0.834089
vessel_111                      -0.58204    0.53552  -1.087 0.277120
vessel_114                      -0.03513    0.53656  -0.065 0.947803
vessel_116                      -0.24606    0.53781  -0.458 0.647312
vessel_119                      -0.73980    0.53545  -1.382 0.167107
vessel_120                      -0.08407    0.56501  -0.149 0.881717
vessel_121                       0.12657    0.53953   0.235 0.814525
vessel_128                      -0.29306    0.55007  -0.533 0.594206
vessel_133                      -0.49026    0.54024  -0.907 0.364165
vessel_142                       1.36911    0.59184   2.313 0.020725 *
vessel_144                       0.09346    0.53498   0.175 0.861316
vessel_147                      -0.43456    0.53793  -0.808 0.419204
vessel_148                      -0.39626    0.53866  -0.736 0.461966
poly(duration, 3)1              23.29818    2.52463   9.228  < 2e-16 ***
poly(duration, 3)2              -7.00342    1.42330  -4.921 8.77e-07 ***
poly(duration, 3)3               3.25740    1.39201   2.340 0.019300 *
statarea_12                      0.53532    0.03646  14.683  < 2e-16 ***
statarea_13                      0.68593    0.03776  18.166  < 2e-16 ***
statarea_14                      0.71997    0.04512  15.956  < 2e-16 ***
Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
statarea_15                      0.89841    0.06860  13.097  < 2e-16 ***
statarea_16                      0.30743    0.11087   2.773 0.005566 **
period_2                         0.06246    0.10328   0.605 0.545319
period_3                        -0.01998    0.07000  -0.285 0.775336
period_4                        -0.11560    0.06509  -1.776 0.075749 .
period_5                        -0.35331    0.06289  -5.618 1.99e-08 ***
period_6                        -0.53518    0.06091  -8.786  < 2e-16 ***
```

(Cont…)

```
period_7                           -0.56648    0.06374  -8.887  < 2e-16 ***
period_8                           -0.43480    0.05931  -7.332 2.45e-13 ***
period_9                           -0.29526    0.05648  -5.228 1.75e-07 ***
period_10                          -0.26006    0.05365  -4.848 1.27e-06 ***
period_11                          -0.16557    0.05523  -2.998 0.002725 **
period_12                          -0.08524    0.05275  -1.616 0.106172
poly(tows, 3)1                     18.23665    2.53587   7.191 6.87e-13 ***
poly(tows, 3)2                     -5.49843    1.37463  -4.000 6.38e-05 ***
poly(tows, 3)3                      0.89723    1.38021   0.650 0.515661
poly(ACEchgr, 3)1                  -2.51795    2.28661  -1.101 0.270849
poly(ACEchgr, 3)2                  -0.97470    1.32235  -0.737 0.461080
poly(ACEchgr, 3)3                   5.03297    1.35369   3.718 0.000202 ***
poly(PPACEPr, 3)1                   0.97008    1.06300   0.913 0.361483
poly(PPACEPr, 3)2                   0.56695    1.05088   0.540 0.589552
poly(PPACEPr, 3)3                   3.30841    1.02792   3.219 0.001293 **
poly(ACECatchr, 3)1                -2.39093    1.19148  -2.007 0.044809 *
poly(ACECatchr, 3)2                -1.78205    1.08969  -1.635 0.102002
poly(ACECatchr, 3)3                -2.69429    1.10555  -2.437 0.014824 *
strategy_opportunistic              0.08163    0.03663   2.228 0.025871 *
strategy_vertically integrated      0.10426    0.03674   2.838 0.004556 **
structure_opportunistic            -0.05141    0.04360  -1.179 0.238413
structure_vertically integrated -0.09179    0.03605  -2.546 0.010899 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Gamma family taken to be 0.8374447)

    Null deviance: 12958.3  on 10134  degrees of freedom
Residual deviance:  8441.3  on 10048  degrees of freedom
AIC: 111057

Number of Fisher Scoring iterations: 9

R-squared: 34.86%
adjusted R-squared: 34.3%
AIC: 111057
Dispersion parameter for Gamma family taken to be 0.8374
    Null deviance: 12958  on 10134  degrees of freedom
Residual deviance: 8441  on 10048  degrees of freedom
```

5.6 SNA_BT_MIX

5.6.1 Summary of results

The model shows some influence of the strategy and structure index variables and all the ratios involving ACE prices, port prices and deemed value and capturing the change in the permit holder's ACE holdings between periods (Table 31 and Table 32).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + statarea_ + vessel_ + target_ + poly(log(tows), 3) + period_ + poly(log(ACEchgr), 3) + poly(log(duration), 3) + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + strategy_ + structure_

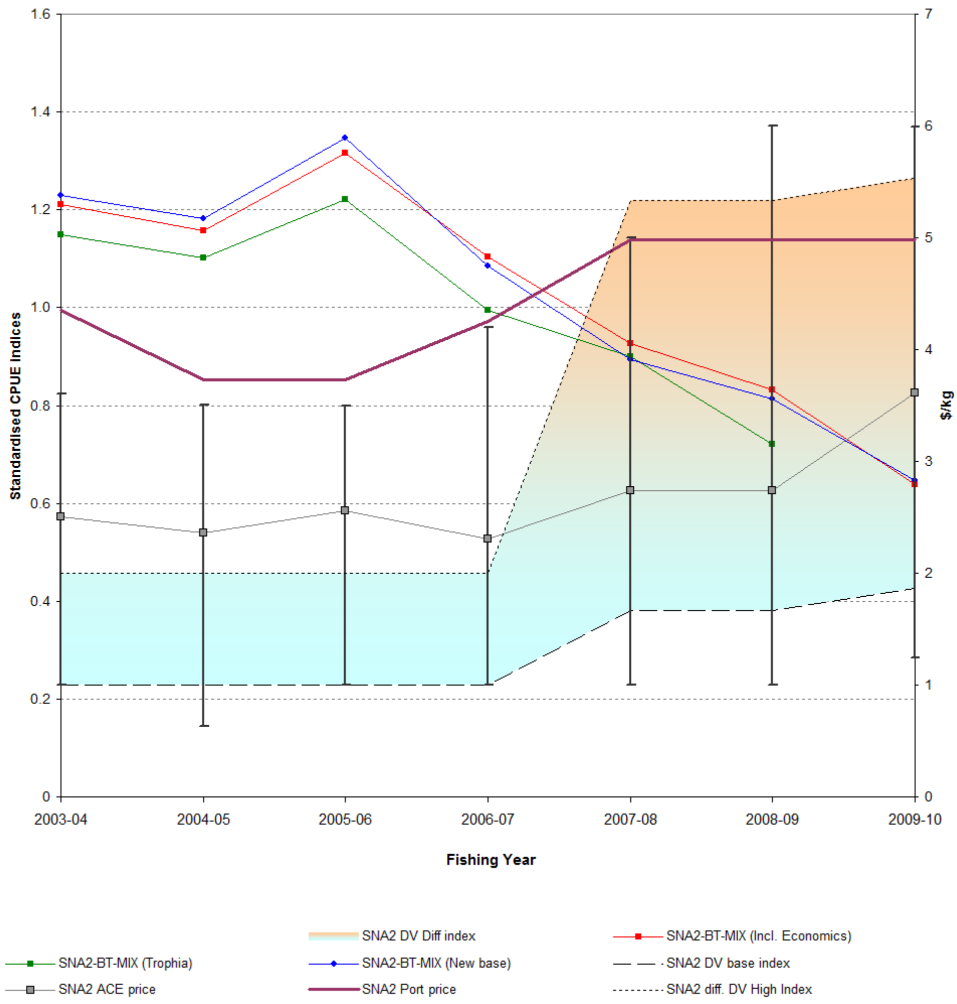


Figure 144: Comparison of SNA_BT_MIX Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.[1]

[1] There was no SNA 2 CPUE index estimate from Trophia in 2009–10.

5.6.2 Data Subset

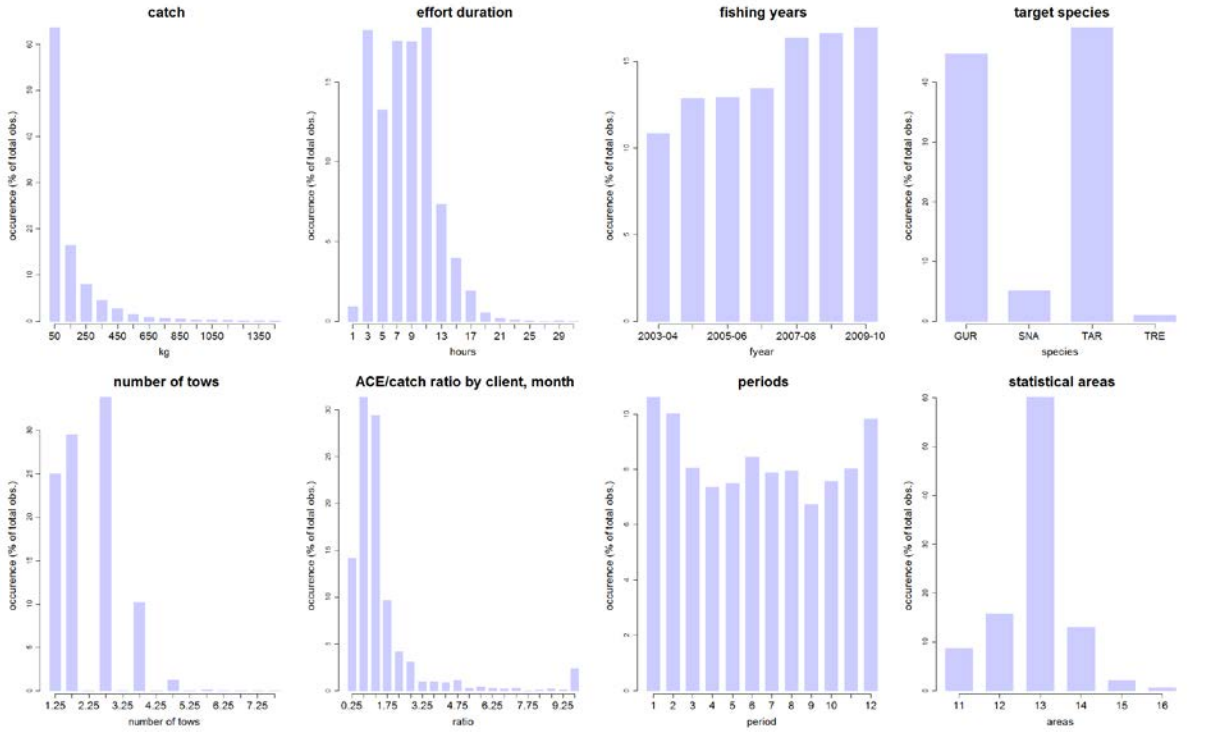


Figure 145: Histograms of Catch-Effort data for all strata included in the "SNA_BT_MIX" CPUE model.

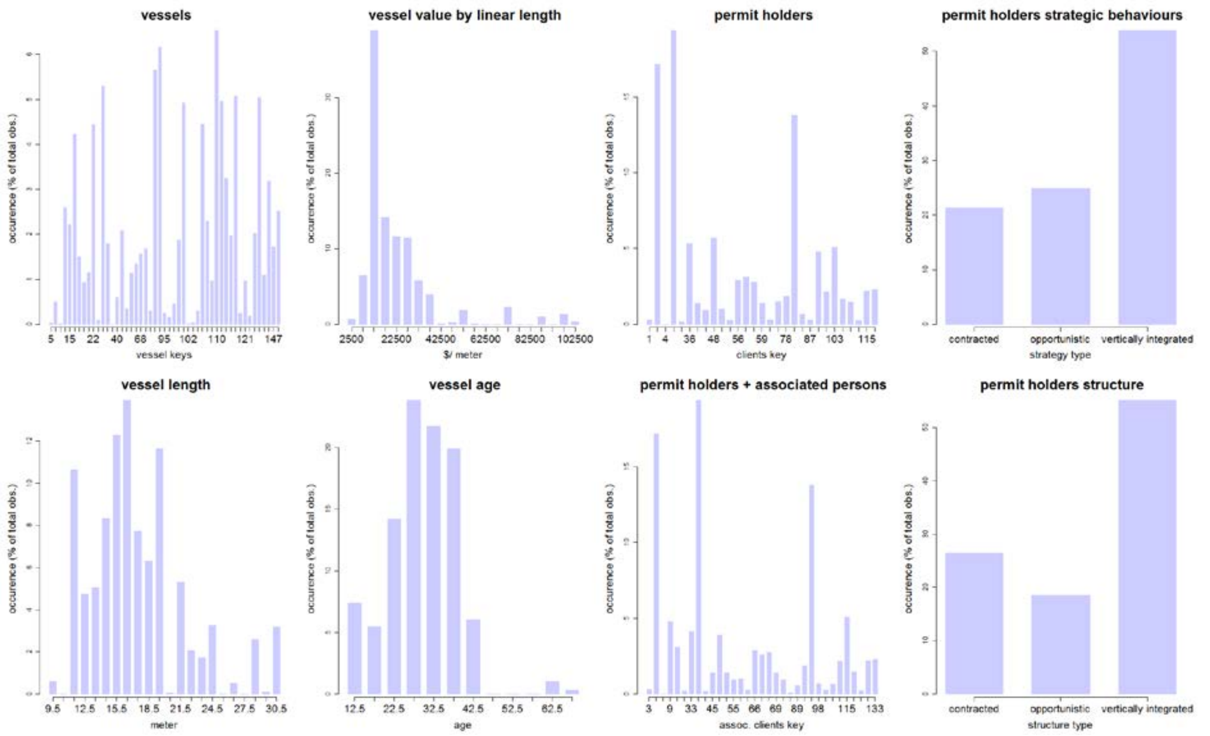


Figure 146: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the "SNA_BT_MIX" CPUE model.

5.6.3 Stepwise selection of model terms

Table 31: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (SNA_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	53,594	63,994	0	
fyear_	6	-	15745	52,928	63,809	1.24	*
+ statarea_	5	15,174	15740	37,755	58,498	29.55	*
+ vessel_	47	4,651	15693	33,104	56,521	38.23	*
+ target_	3	2,629	15690	30,475	55,224	43.14	*
+ poly(log(tows), 3)	3	2,134	15687	28,341	54,086	47.12	*
+ period_	11	995	15676	27,346	53,545	48.98	*
+ poly(log(ACEchgr), 3)	3	146	15673	27,200	53,467	49.25	*
+ poly(log(duration), 3)	3	92	15670	27,108	53,419	49.42	*
+ poly(log(ACEPDVr), 3)	3	49	15667	27,059	53,397	49.51	
+ poly(log(ACECatchr), 3)	3	29	15664	27,030	53,386	49.57	
+ strategy_	2	14	15662	27,016	53,382	49.59	
+ structure_	2	17	15660	26,999	53,376	49.62	
+ poly(log(PPACEPr), 3)	2	12	15658	26,987	53,373	49.65	

acceptance threshold: 0.1%
based on the translog model

5.6.4 Influence of model terms on annual CPUE indices

Table 32: Summary of the influence of each term in the standardisation model (SNA_BT_MIX).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	665	1.24%	63,809	-	-
statarea_	5	15174	28.31%	58,498	5.64%	0.01
vessel_	47	4651	8.68%	56,521	11.57%	0.06
target_	3	2629	4.91%	55,224	3.27%	-0.02
poly(log(tows), 3)	3	2134	3.98%	54,086	4.66%	-0.02
period_	11	995	1.86%	53,545	0.74%	0.00
poly(log(ACEchgr), 3)	3	146	0.27%	53,467	1.79%	0.01
poly(log(duration), 3)	3	92	0.17%	53,419	5.05%	-0.02
poly(log(PPACEPr), 3)	3	36	0.07%	53,405	1.80%	0.00
poly(log(ACECatchr), 3)	3	29	0.05%	53,394	0.69%	0.00
strategy_	2	16	0.03%	53,389	0.21%	0.00
structure_	2	18	0.03%	53,382	1.12%	0.00

based on the translog model

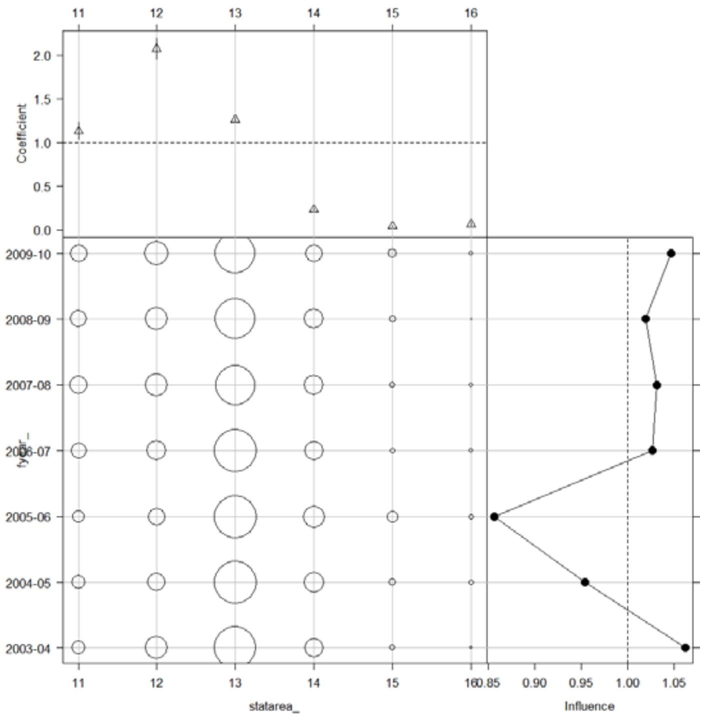


Figure 147: Coefficient-distribution-influence plot for "statarea" (SNA_BT_MIX).

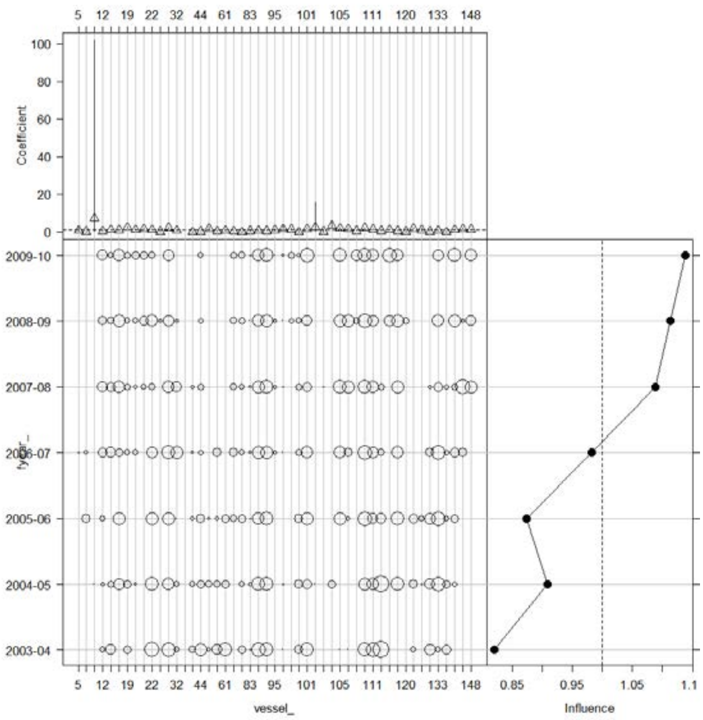


Figure 148: Coefficient-distribution-influence plot for "vessel" (SNA_BT_MIX).

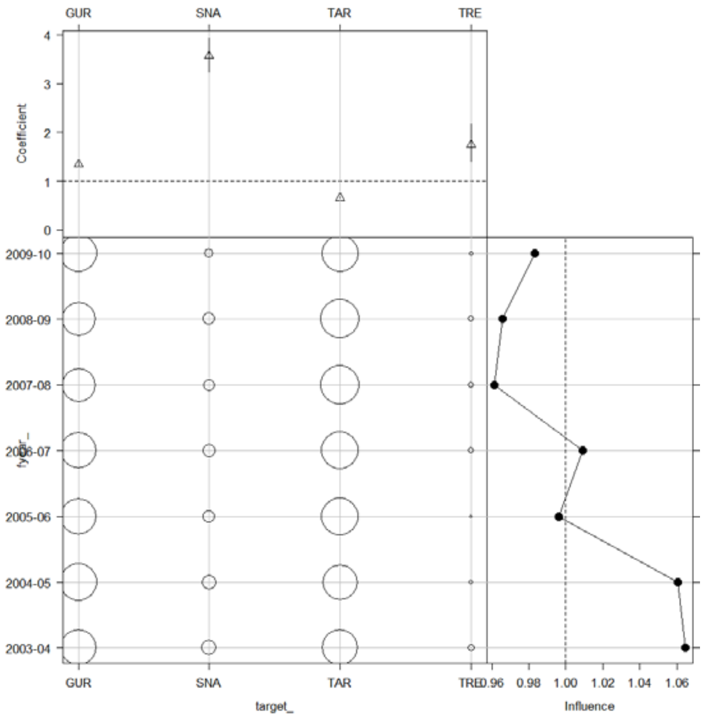


Figure 149: Coefficient-distribution-influence plot for "target" (SNA_BT_MIX).

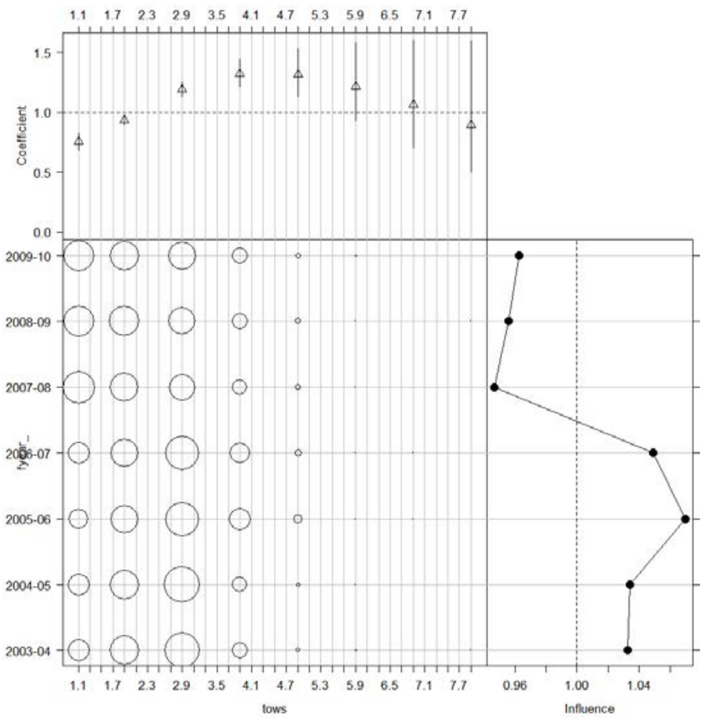


Figure 150: Coefficient-distribution-influence plot for "tows" (SNA_BT_MIX).

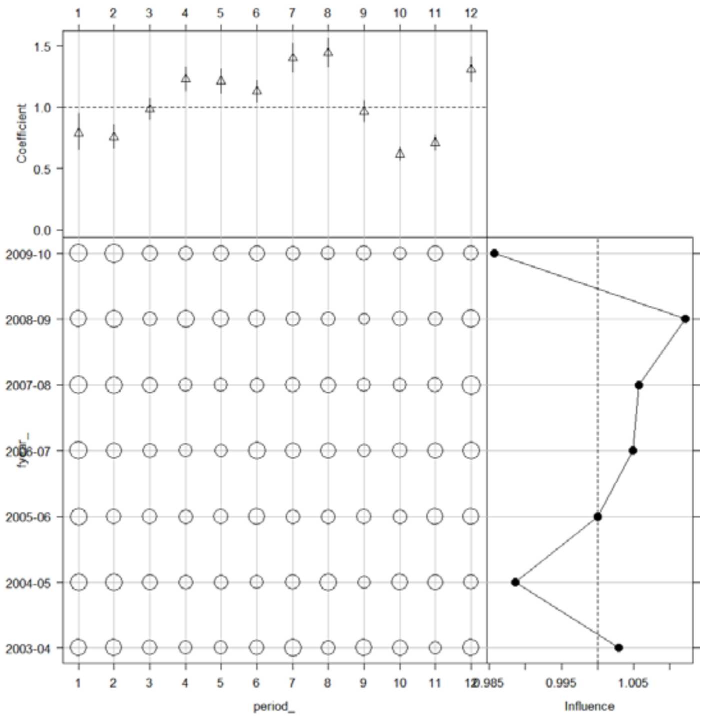


Figure 151: Coefficient-distribution-influence plot for “period” (SNA_BT_MIX).

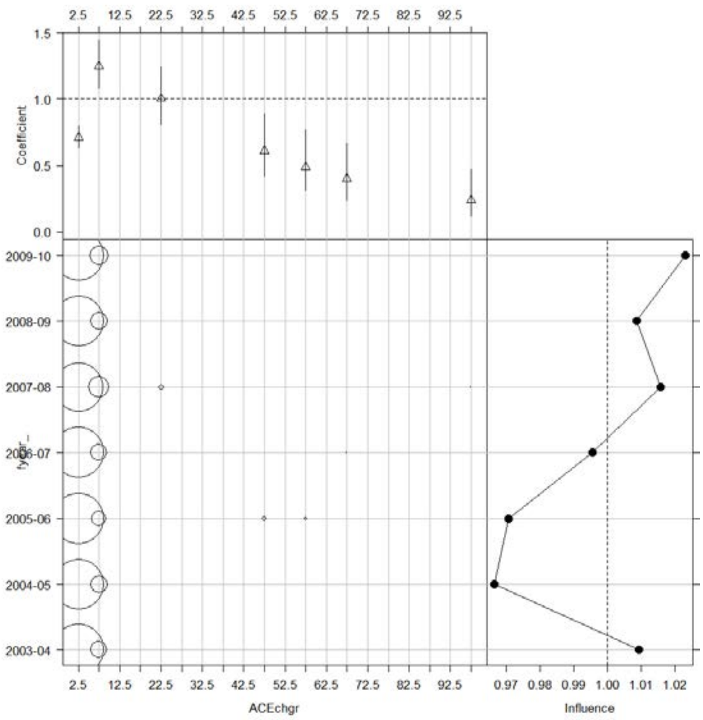


Figure 152: Coefficient-distribution-influence plot for “ACEchgr” (SNA_BT_MIX).

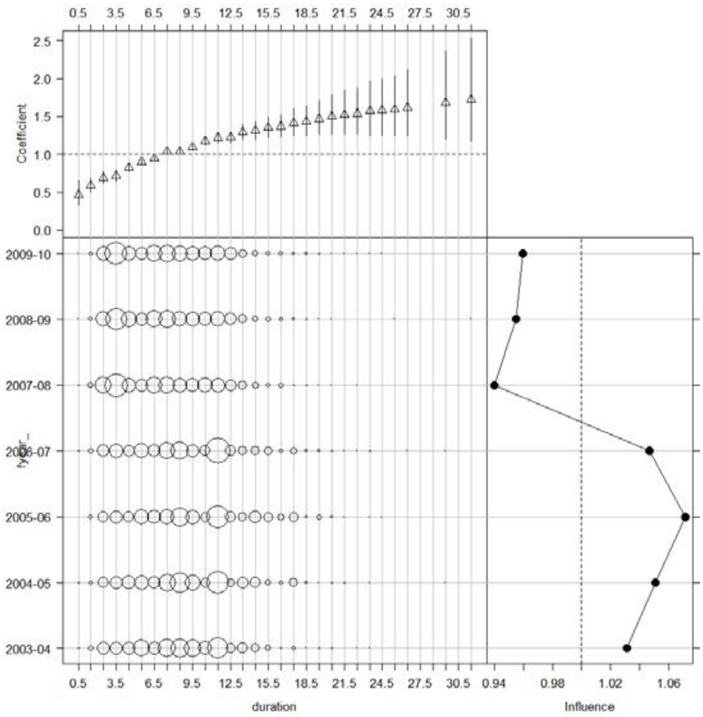


Figure 153: Coefficient-distribution-influence plot for "duration" (SNA_BT_MIX).

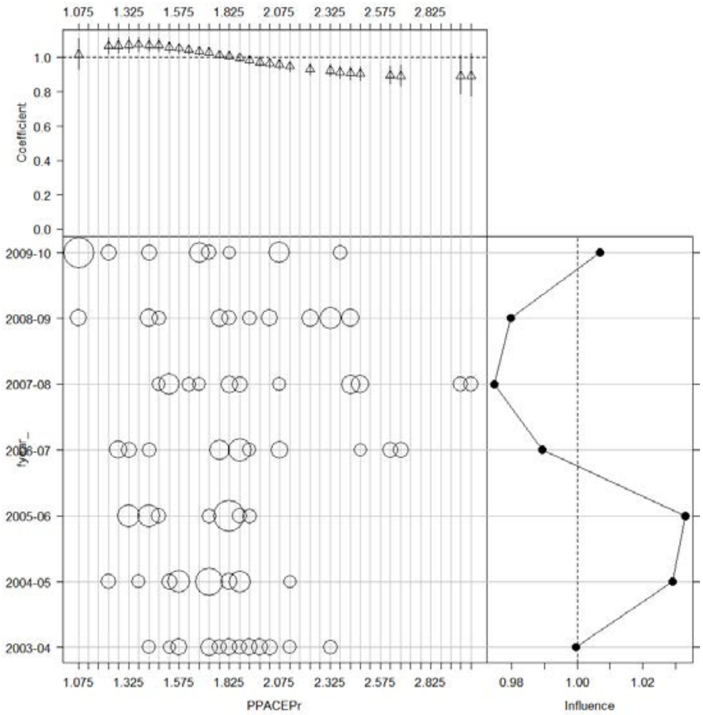


Figure 154: Coefficient-distribution-influence plot for "PPACEPr" (SNA_BT_MIX).

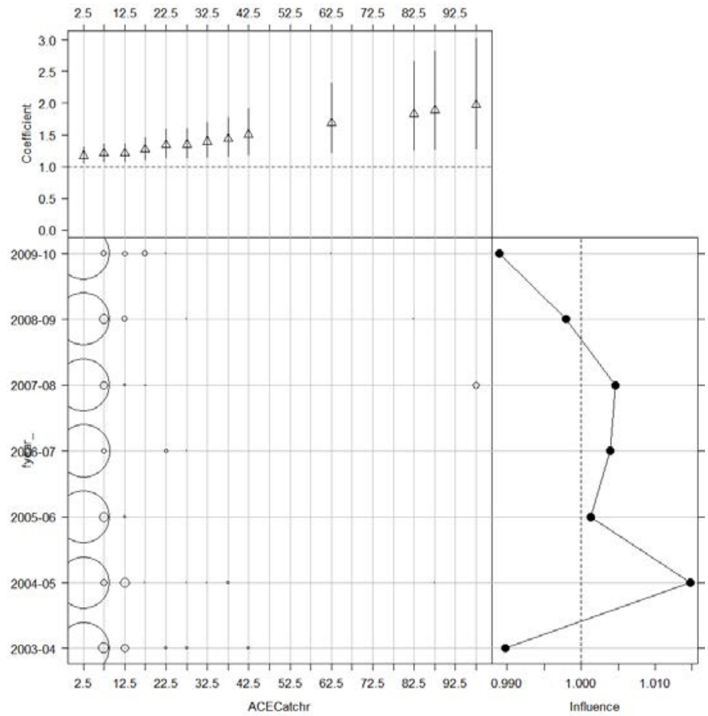


Figure 155: Coefficient-distribution-influence plot for "ACECatchr" (SNA_BT_MIX).

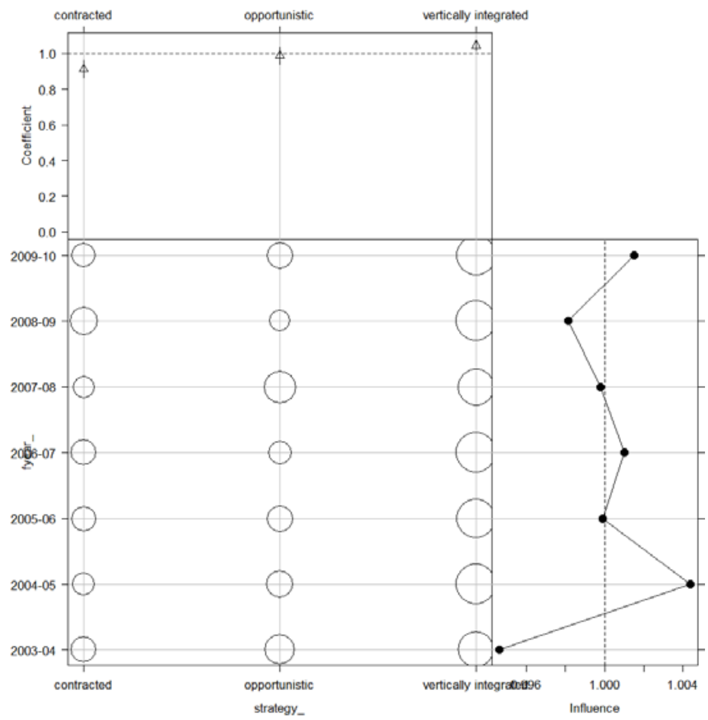


Figure 156: Coefficient-distribution-influence plot for "strategy" (SNA_BT_MIX).

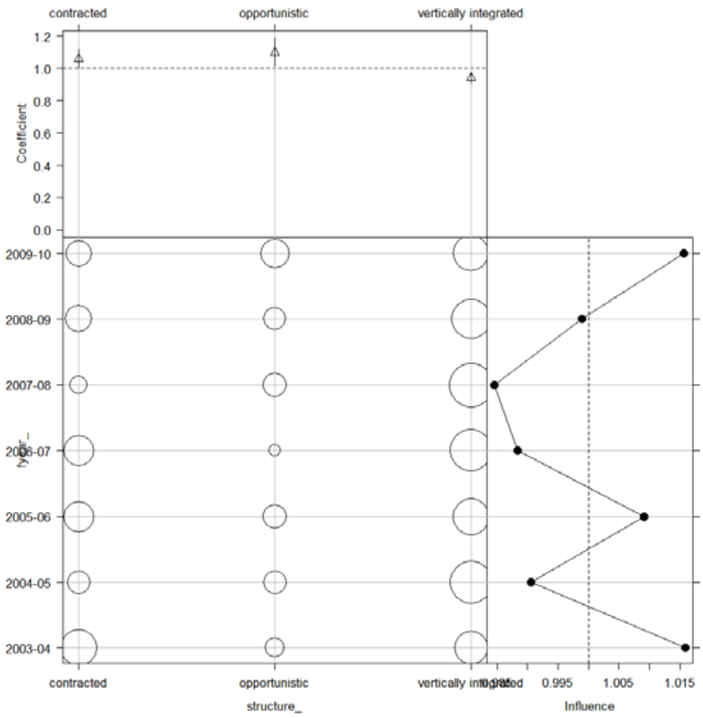


Figure 157: Coefficient-distribution-influence plot for "structure" (SNA_BT_MIX).

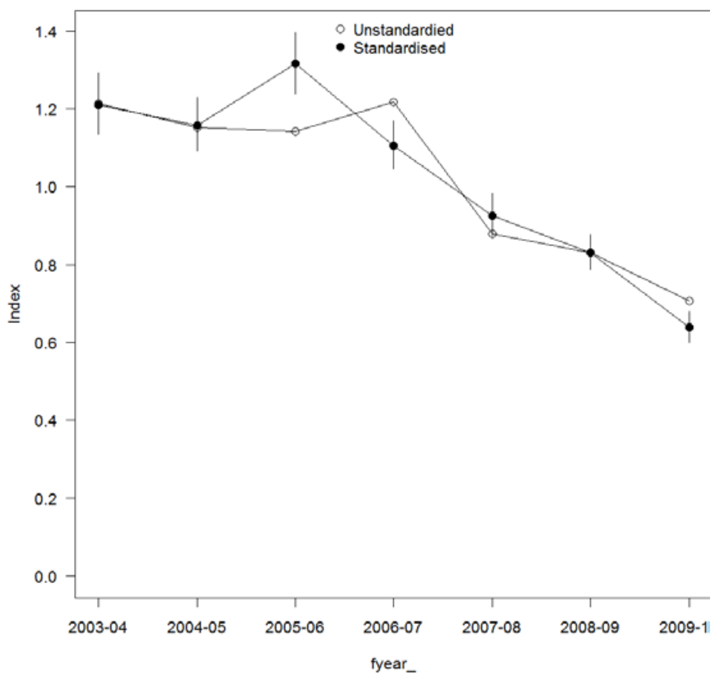


Figure 158: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (SNA_BT_MIX).

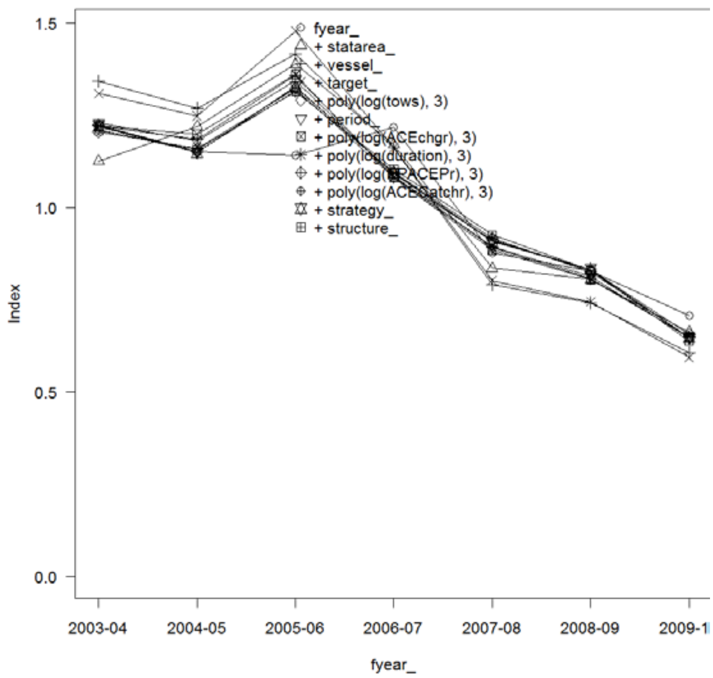


Figure 159: Annual influence for each term in the model (SNA_BT_MIX).

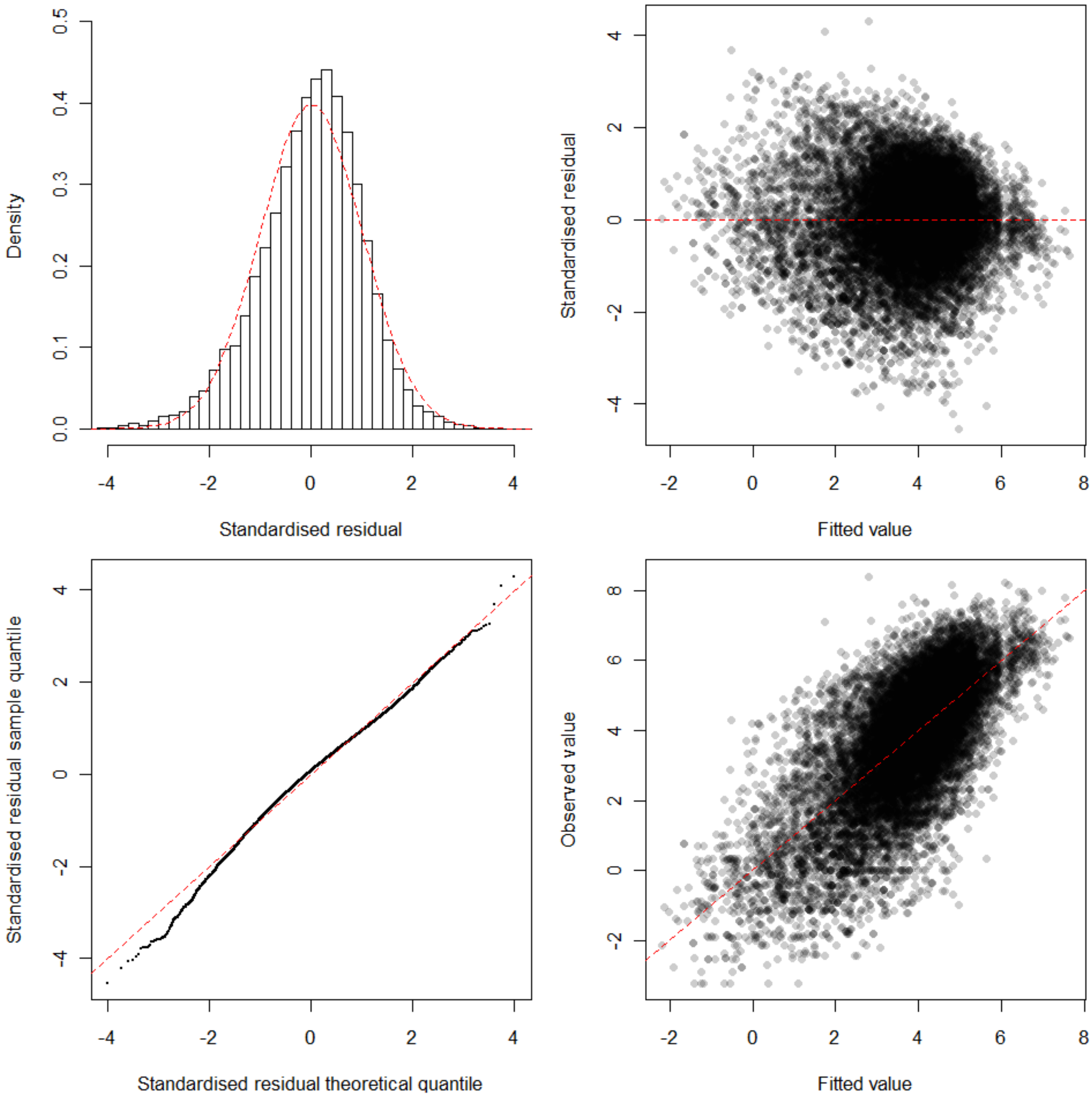


Figure 160: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (SNA_BT_MIX).

5.6.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-5.9501  -0.7836   0.0984   0.8726   5.6078

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                      3.852e+00  6.022e-01   6.396 1.64e-10 ***
fyear_2004-05                   -4.405e-02  4.621e-02  -0.953 0.340537
fyear_2005-06                    8.318e-02  4.675e-02   1.779 0.075217 .
fyear_2006-07                   -9.132e-02  4.652e-02  -1.963 0.049672 *
fyear_2007-08                   -2.675e-01  4.938e-02  -5.417 6.15e-08 ***
fyear_2008-09                   -3.755e-01  4.717e-02  -7.962 1.81e-15 ***
fyear_2009-10                   -6.395e-01  5.106e-02 -12.525  < 2e-16 ***
statarea_12                      6.070e-01  4.680e-02  12.969  < 2e-16 ***
statarea_13                      1.120e-01  4.897e-02   2.288 0.022166 *
statarea_14                     -1.564e+00  5.854e-02 -26.713  < 2e-16 ***
statarea_15                     -3.224e+00  1.008e-01 -31.989  < 2e-16 ***
statarea_16                     -2.836e+00  2.023e-01 -14.022  < 2e-16 ***
vessel_7                        -1.238e+00  6.152e-01  -2.012 0.044214 *
vessel_10                        2.254e+00  1.444e+00   1.561 0.118552
vessel_12                       -3.927e-01  5.954e-01  -0.659 0.509601
vessel_15                        4.105e-01  5.963e-01   0.688 0.491193
vessel_17                        3.500e-01  5.928e-01   0.590 0.554928
vessel_19                        1.152e+00  6.004e-01   1.918 0.055129 .
vessel_20                        4.996e-01  6.025e-01   0.829 0.407016
vessel_21                        7.417e-01  6.014e-01   1.233 0.217488
vessel_22                        4.705e-01  5.943e-01   0.792 0.428539
vessel_24                       -7.911e-01  6.942e-01  -1.140 0.254481
vessel_29                        1.083e+00  5.956e-01   1.818 0.069011 .
vessel_32                        1.857e-01  5.960e-01   0.312 0.755383
vessel_40                       -1.586e+00  6.082e-01  -2.608 0.009105 **
vessel_44                       -8.555e-01  5.952e-01  -1.437 0.150671
vessel_46                        8.735e-01  6.198e-01   1.409 0.158770
vessel_60                       -3.501e-01  6.015e-01  -0.582 0.560511
vessel_61                       -9.908e-04  5.981e-01  -0.002 0.998678
vessel_68                       -5.070e-01  5.971e-01  -0.849 0.395840
vessel_80                       -1.531e+00  5.964e-01  -2.567 0.010260 *
vessel_83                       -6.239e-02  6.506e-01  -0.096 0.923609
vessel_86                        6.212e-02  5.959e-01   0.104 0.916977
vessel_90                       -9.670e-02  5.921e-01  -0.163 0.870265
vessel_95                        3.334e-01  6.314e-01   0.528 0.597518
vessel_97                        7.599e-01  6.705e-01   1.133 0.257107
vessel_99                        6.870e-01  6.142e-01   1.119 0.263330
vessel_100                      -1.526e+00  5.991e-01  -2.548 0.010845 *
vessel_101                       8.098e-01  5.952e-01   1.360 0.173711
vessel_102                       1.174e+00  1.104e+00   1.064 0.287507
vessel_103                      -9.271e-01  8.393e-01  -1.105 0.269318
vessel_104                       1.506e+00  6.279e-01   2.398 0.016479 *
vessel_105                       9.696e-01  5.938e-01   1.633 0.102535
vessel_106                       7.144e-01  5.975e-01   1.196 0.231834
vessel_108                      -6.468e-02  6.012e-01  -0.108 0.914322
vessel_110                       1.060e+00  5.955e-01   1.779 0.075209 .
vessel_111                       6.446e-01  5.960e-01   1.081 0.279528
vessel_114                      -7.264e-02  5.954e-01  -0.122 0.902900
vessel_116                       5.640e-01  5.989e-01   0.942 0.346353
vessel_119                      -7.966e-02  5.948e-01  -0.134 0.893468
vessel_120                      -1.171e+00  6.343e-01  -1.846 0.064875 .
vessel_121                       8.974e-01  6.039e-01   1.486 0.137281
vessel_128                       3.482e-01  6.457e-01   0.539 0.589717
vessel_129                      -1.074e+00  5.968e-01  -1.800 0.071917 .
vessel_133                       1.230e-01  5.942e-01   0.207 0.836013
vessel_139                      -1.422e+00  6.012e-01  -2.365 0.018049 *
vessel_144                       5.792e-01  5.957e-01   0.972 0.330890
vessel_147                       7.288e-01  5.980e-01   1.219 0.222978
Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
vessel_148                       6.080e-01  5.975e-01   1.018 0.308866
target_SNA                       9.730e-01  5.532e-02  17.587  < 2e-16 ***
target_TAR                      -7.153e-01  2.907e-02 -24.606  < 2e-16 ***
target_TRE                       2.597e-01  1.096e-01   2.370 0.017822 *
poly(log(tows), 3)1              2.477e+01  3.808e+00   6.505 7.99e-11 ***
poly(log(tows), 3)2              1.855e+00  1.759e+00   1.055 0.291658
```

(Cont…)

```
poly(log(tows), 3)3             -4.120e+00  1.362e+00  -3.026 0.002485 **
period_2                        -4.278e-02  1.038e-01  -0.412 0.680180
period_3                         2.194e-01  1.073e-01   2.045 0.040864 *
period_4                         4.408e-01  1.116e-01   3.950 7.85e-05 ***
period_5                         4.283e-01  1.134e-01   3.775 0.000160 ***
period_6                         3.575e-01  1.136e-01   3.148 0.001647 **
period_7                         5.729e-01  1.141e-01   5.022 5.16e-07 ***
period_8                         6.023e-01  1.142e-01   5.276 1.34e-07 ***
period_9                         1.978e-01  1.159e-01   1.706 0.088070 .
period_10                       -2.441e-01  1.160e-01  -2.103 0.035445 *
period_11                       -1.083e-01  1.145e-01  -0.946 0.344010
period_12                        5.031e-01  1.136e-01   4.427 9.62e-06 ***
poly(log(ACEchgr), 3)1          -5.997e+01  1.682e+01  -3.566 0.000363 ***
poly(log(ACEchgr), 3)2           4.896e+01  8.240e+00   5.942 2.88e-09 ***
poly(log(ACEchgr), 3)3          -1.325e+01  1.649e+00  -8.039 9.71e-16 ***
poly(log(duration), 3)1          2.666e+01  3.801e+00   7.014 2.41e-12 ***
poly(log(duration), 3)2         -4.724e-02  1.659e+00  -0.028 0.977280
poly(log(duration), 3)3         -5.320e-01  1.613e+00  -0.330 0.741544
poly(log(PPACEPr), 3)1          -5.791e+00  1.660e+00  -3.490 0.000485 ***
poly(log(PPACEPr), 3)2          -3.106e+00  1.652e+00  -1.880 0.060179 .
poly(log(PPACEPr), 3)3           2.418e+00  1.643e+00   1.472 0.141051
poly(log(ACECatchr), 3)1         5.017e+01  1.707e+01   2.940 0.003287 **
poly(log(ACECatchr), 3)2        -1.599e+01  6.879e+00  -2.324 0.020113 *
poly(log(ACECatchr), 3)3         6.874e+00  2.513e+00   2.736 0.006229 **
strategy_opportunistic           8.097e-02  3.642e-02   2.223 0.026214 *
strategy_vertically integrated   1.363e-01  3.674e-02   3.711 0.000208 ***
structure_opportunistic          3.803e-02  4.764e-02   0.798 0.424760
structure_vertically integrated -1.146e-01  4.233e-02  -2.706 0.006815 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 1.72477)

    Null deviance: 53594  on 15751  degrees of freedom
Residual deviance: 27010  on 15660  degrees of freedom
AIC: 53382

Number of Fisher Scoring iterations: 2

R-squared: 49.6%
adjusted R-squared: 49.31%
AIC: 53382
Dispersion parameter for Gamma family taken to be 1.725
    Null deviance: 53593  on 15751  degrees of freedom
Residual deviance: 27009  on 15660  degrees of freedom
```

5.7 TAR_BT_TAR

5.7.1 Summary of results

The model shows some influence of the strategy index variable and all the ratios involving ACE prices, deemed value and capturing the change in the permit holder's ACE holdings between periods but no influence from the structure index variable neither any ratio involving the port price (Table 33 and Table 34).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + poly(log(tows), 3) + vessel_ + period_ + statarea_ + poly(log(duration), 3) + poly(log(mDVcv), 3) + poly(log(ACECatchr), 3) + strategy_ + poly(log(ACEchgr), 3)

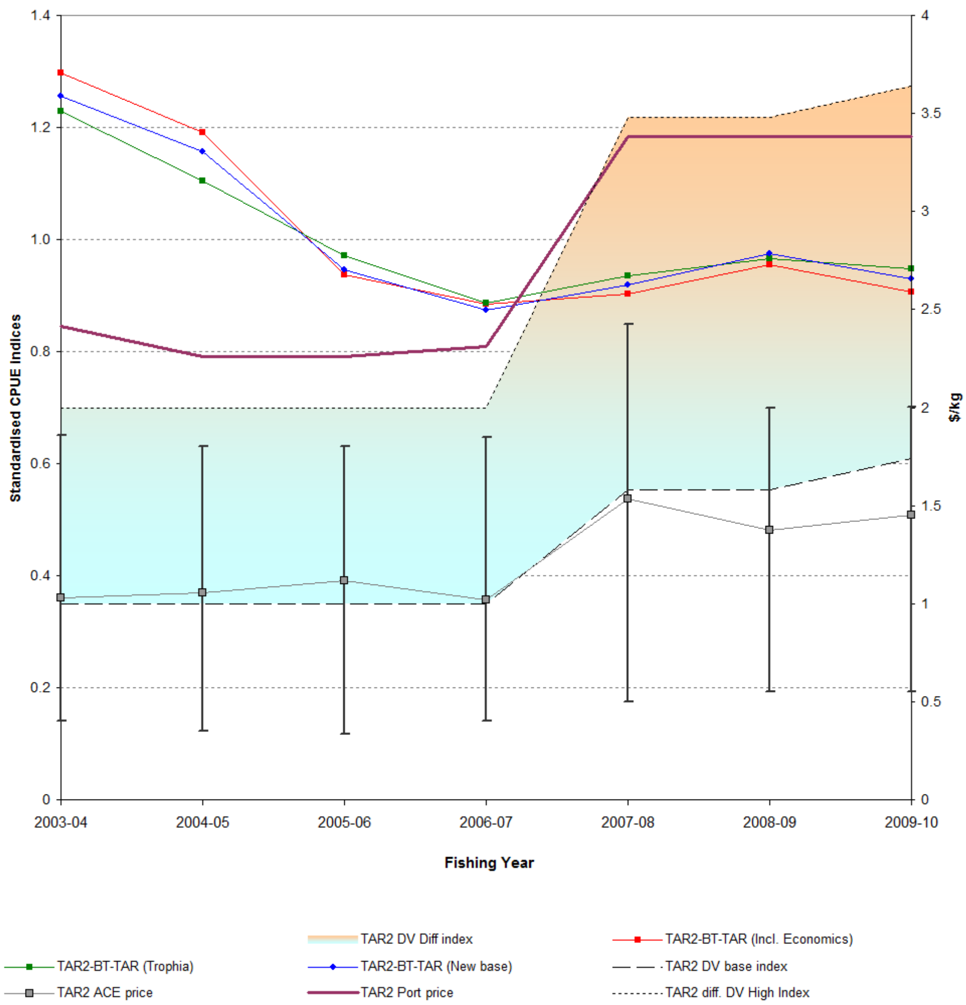


Figure 161: Comparison of TAR_BT_TAR Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.7.2 Data Subset

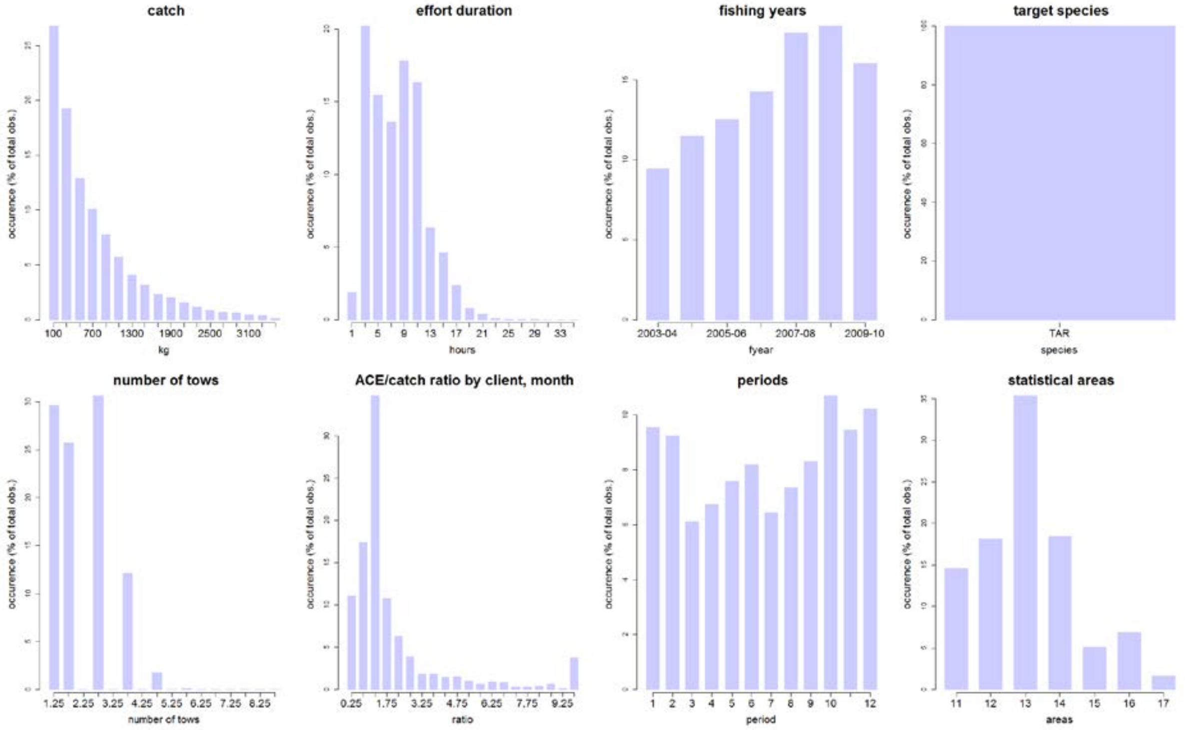


Figure 162: Histograms of Catch-Effort data for all strata included in the "TAR_BT_TAR" CPUE model.

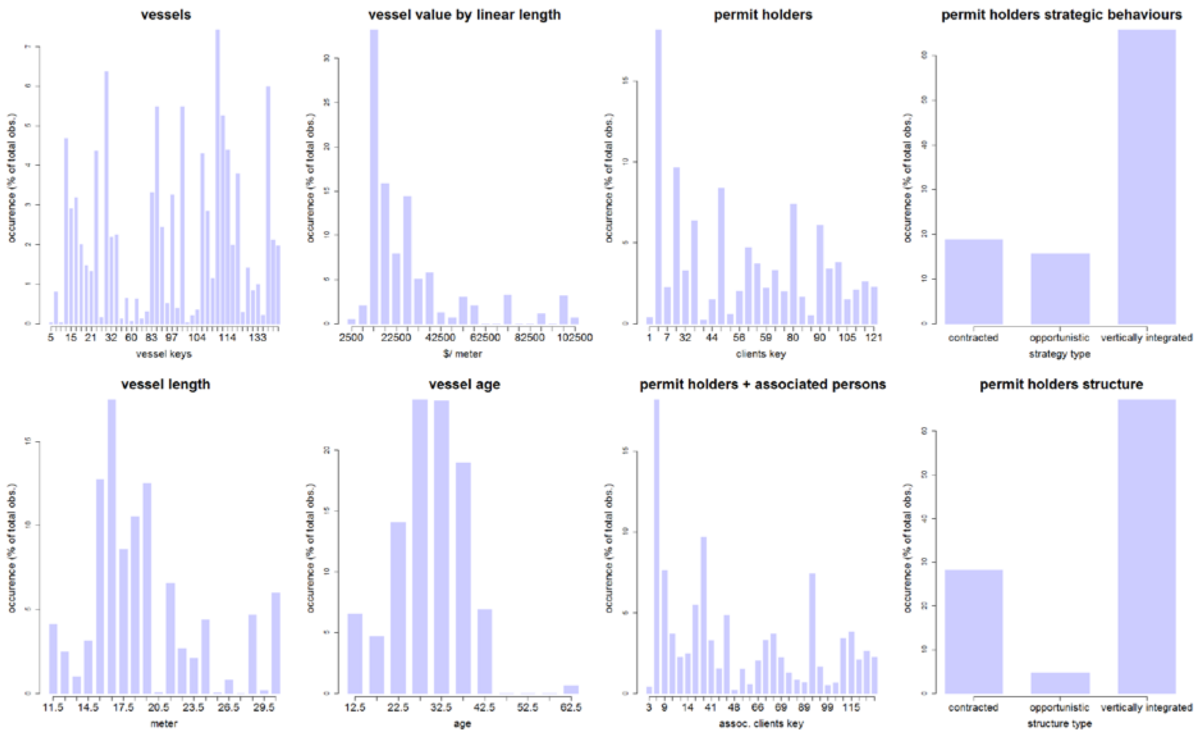


Figure 163: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the "TAR_BT_TAR" CPUE model.

5.7.3 Stepwise selection of model terms

Table 33: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TAR_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	18,008	210,610	0	
fyear_	6	-	13864	17,777	210,408	1.28	*
+ poly(tows, 3)	3	3,790	13861	13,987	206,513	22.33	*
+ vessel_	45	1,415	13816	12,572	204,904	30.19	*
+ period_	11	374	13805	12,198	204,449	32.26	*
+ statarea_	6	219	13799	11,979	204,175	33.48	*
+ poly(log(duration), 3)	3	120	13796	11,859	204,023	34.15	*
+ poly(log(mDVcv), 3)	3	9	13793	11,850	204,016	34.20	
+ poly(log(ACECatchr), 3)	3	8	13790	11,842	204,012	34.24	
+ strategy_	2	6	13788	11,836	204,008	34.27	
+ poly(log(ACEchgr), 3)	3	6	13785	11,831	204,007	34.30	

acceptance threshold: 0.1%
based on the translog model

5.7.4 Influence of model terms on annual CPUE indices

Table 34: Summary of the influence of each term in the standardisation model (TAR_BT_TAR).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	231	1.28%	210,408	-	-
poly(log(tows), 3)	3	3790	21.05%	206,513	8.07%	-0.03
vessel_	45	1415	7.86%	204,904	2.56%	0.01
period_	11	374	2.08%	204,449	1.03%	0.00
statarea_	6	219	1.22%	204,175	1.20%	0.00
poly(log(duration), 3)	3	120	0.67%	204,023	5.87%	-0.02
poly(log(mDVcv), 3)	3	9	0.05%	204,016	1.76%	0.01
poly(log(ACECatchr), 3)	3	8	0.04%	204,012	0.10%	0.00
strategy_	2	6	0.03%	204,008	0.11%	0.00
poly(log(ACEchgr), 3)	3	6	0.03%	204,007	0.10%	0.00

based on the translog model

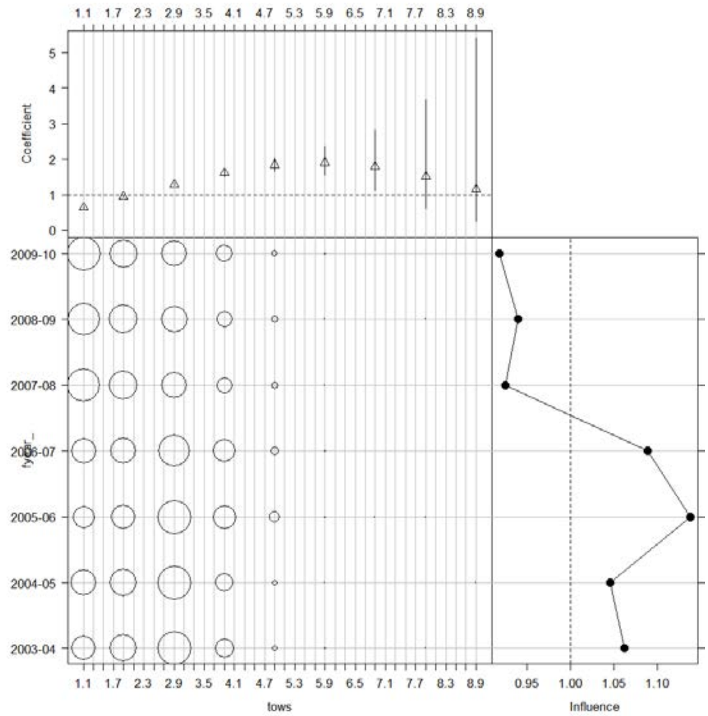


Figure 164: Coefficient-distribution-influence plot for "tows" (TAR_BT_TAR).

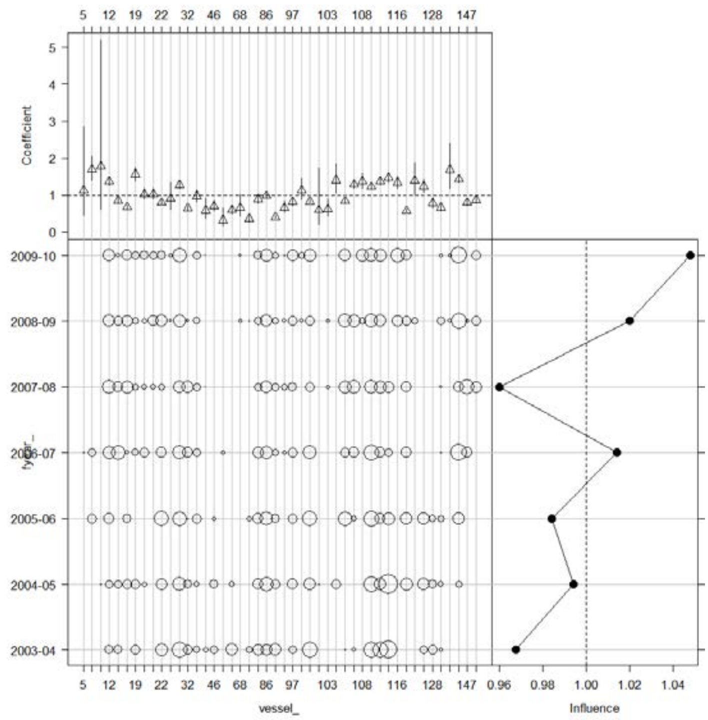


Figure 165: Coefficient-distribution-influence plot for "vessel" (TAR_BT_TAR).

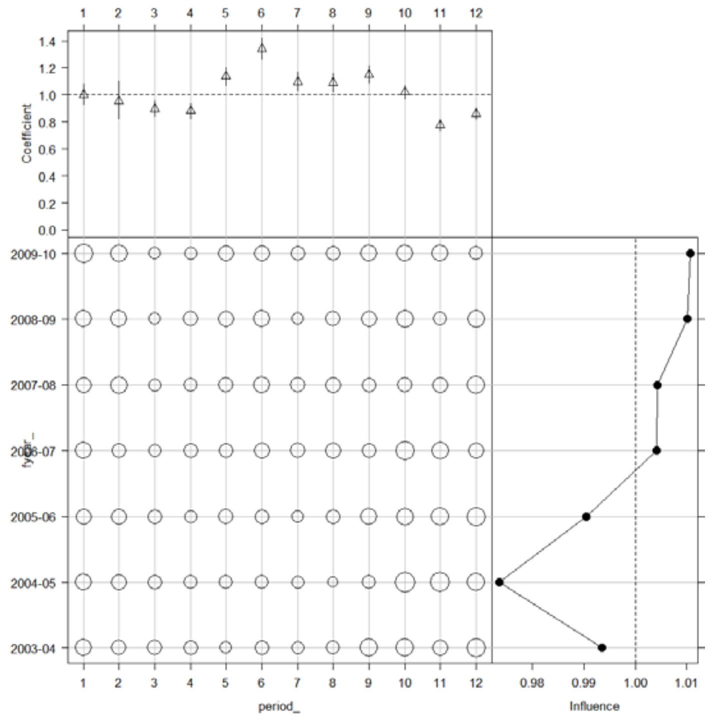


Figure 166: Coefficient-distribution-influence plot for "period" (TAR_BT_TAR).

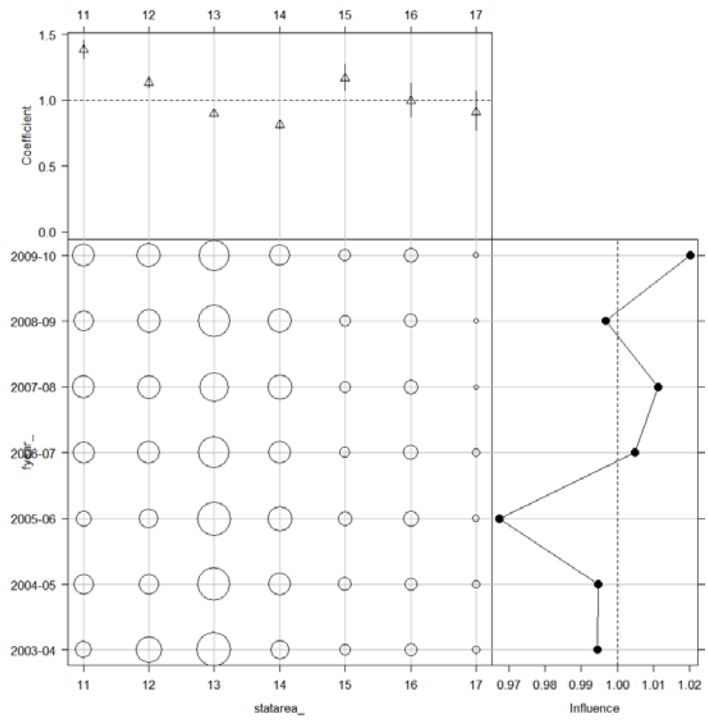


Figure 167: Coefficient-distribution-influence plot for "statarea" (TAR_BT_TAR).

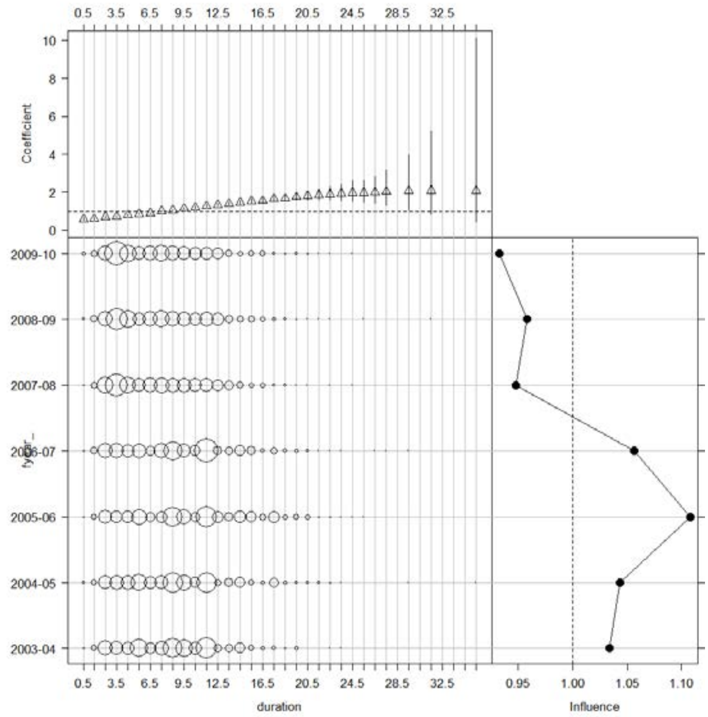


Figure 168: Coefficient-distribution-influence plot for "duration" (TAR_BT_TAR).

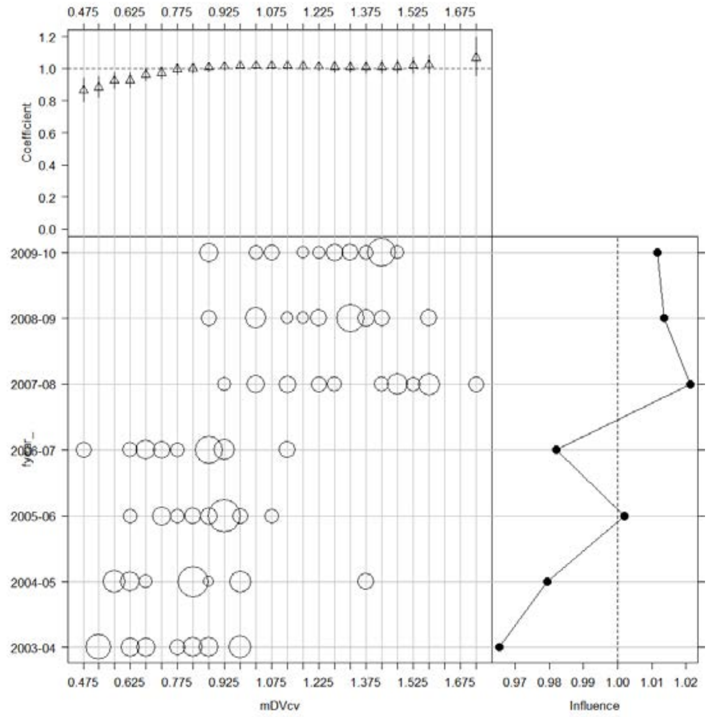


Figure 169: Coefficient-distribution-influence plot for "mDVcv" (TAR_BT_TAR).

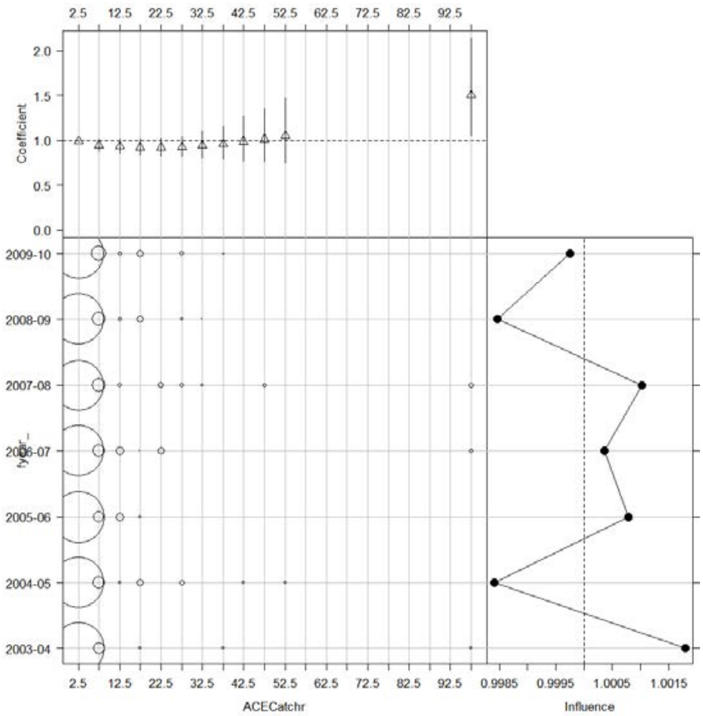


Figure 170: Coefficient-distribution-influence plot for "ACECatchr" (TAR_BT_TAR).

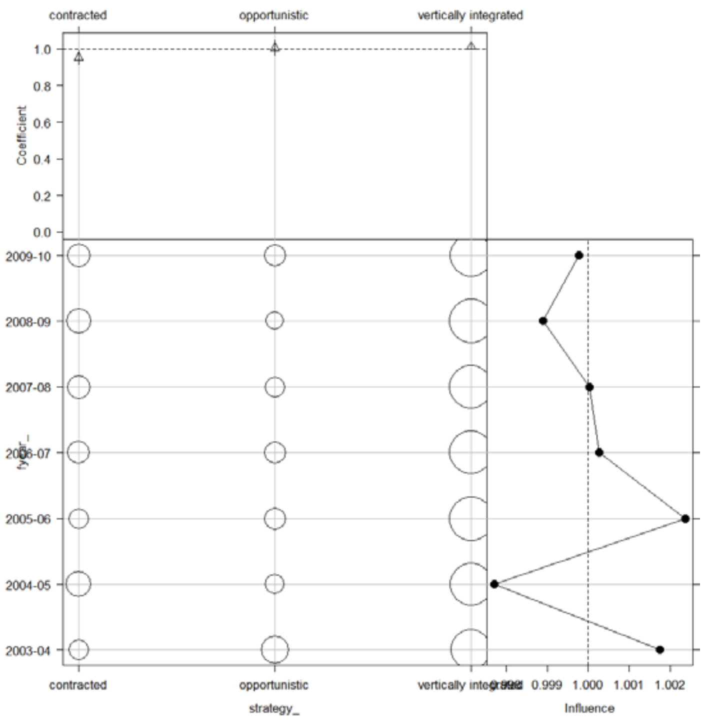


Figure 171: Coefficient-distribution-influence plot for "strategy" (TAR_BT_TAR).

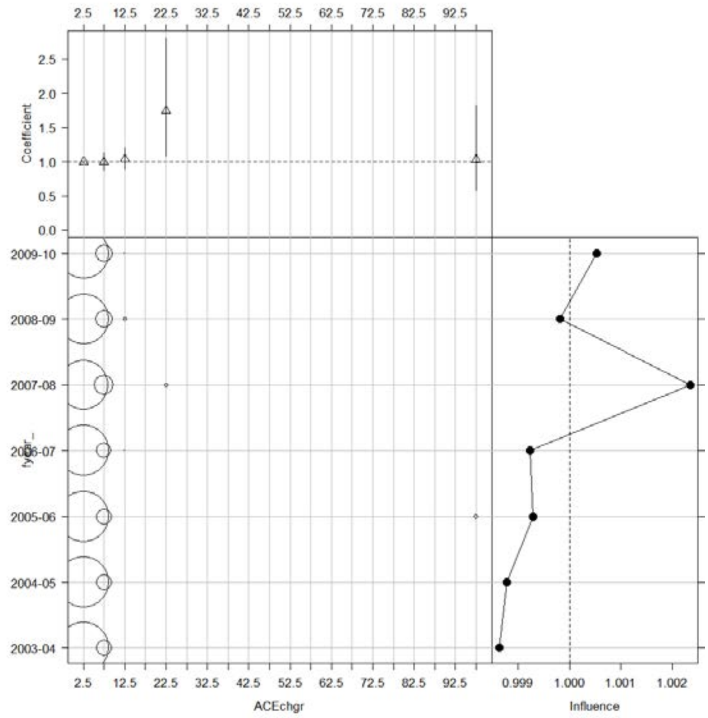


Figure 172: Coefficient-distribution-influence plot for "ACEchgr" (TAR_BT_TAR).

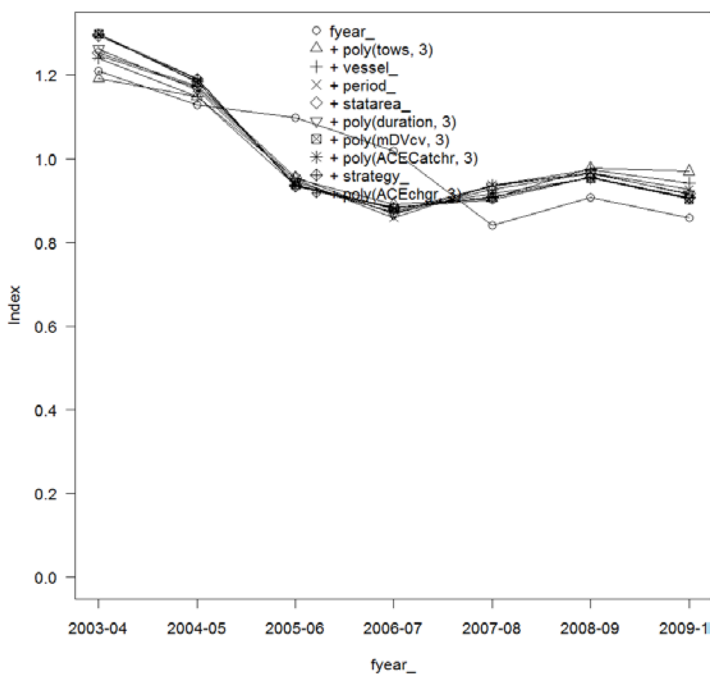


Figure 173: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TAR_BT_TAR).

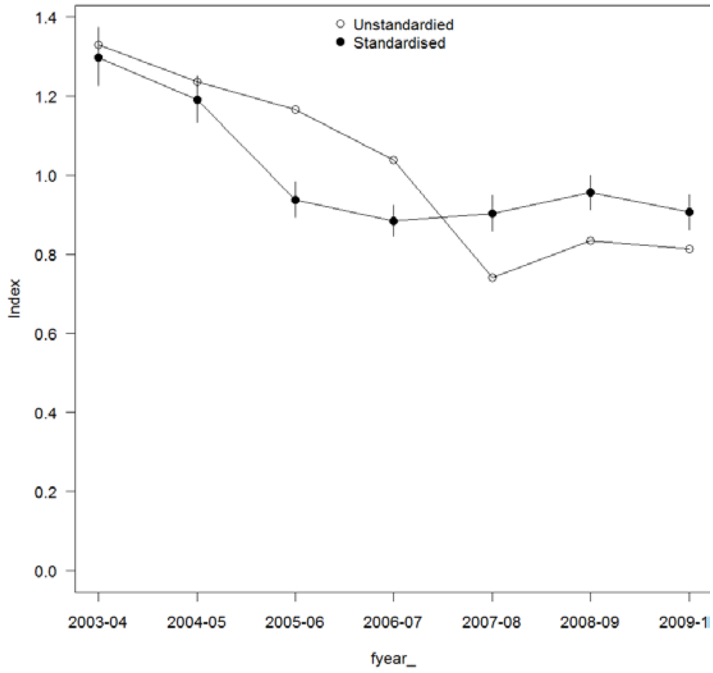


Figure 174: Annual influence for each term in the model (TAR_BT_TAR).

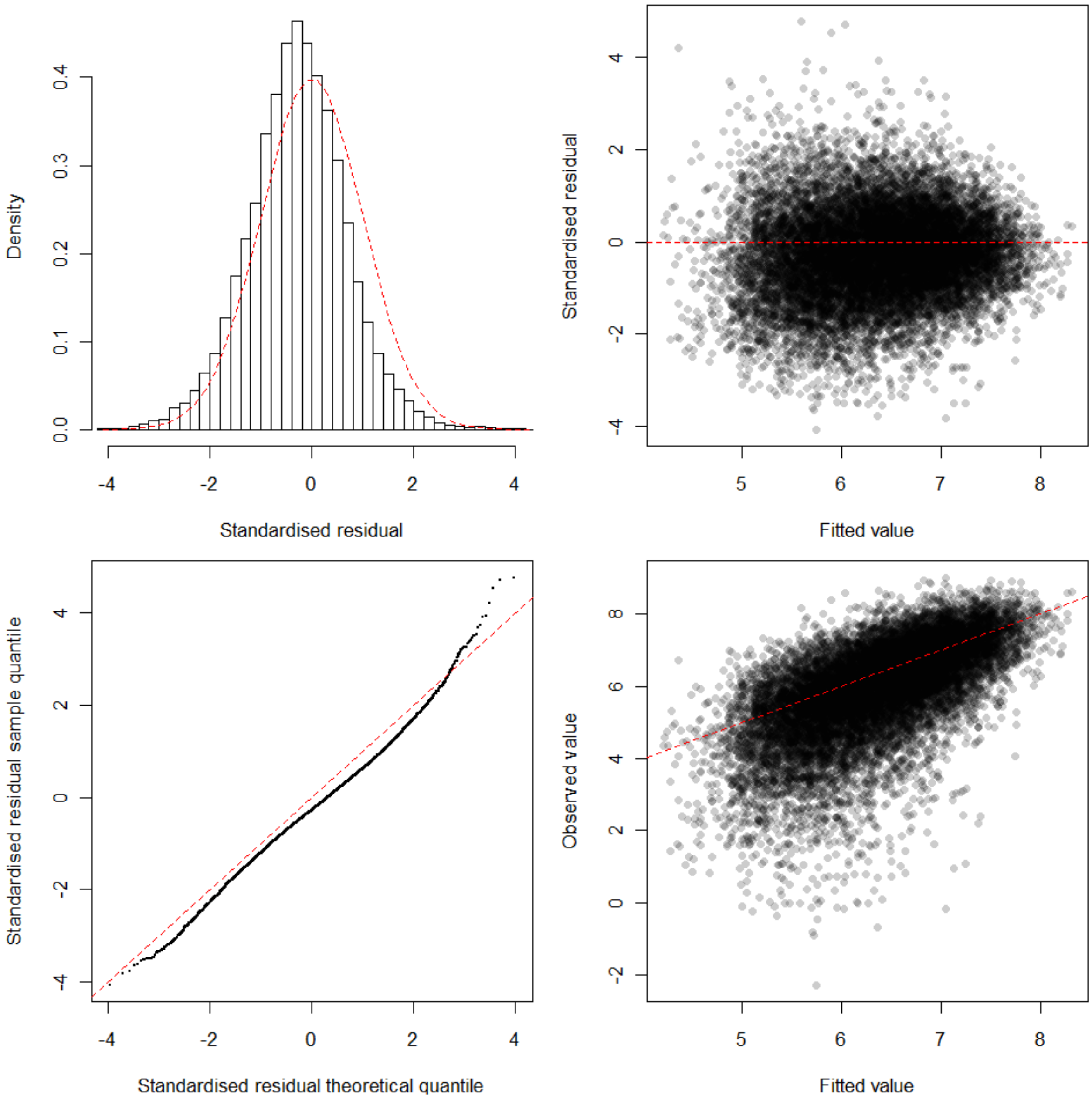


Figure 175: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TAR_BT_TAR).

5.7.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.7477  -0.8116  -0.2579   0.2956   4.3957

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                   7.046693   0.468227  15.050  < 2e-16 ***
fyear_2004-05                -0.085836   0.036125  -2.376 0.017512 *
fyear_2005-06                -0.325701   0.037333  -8.724  < 2e-16 ***
fyear_2006-07                -0.384079   0.035656 -10.772  < 2e-16 ***
fyear_2007-08                -0.362914   0.044743  -8.111 5.44e-16 ***
fyear_2008-09                -0.306442   0.043665  -7.018 2.35e-12 ***
fyear_2009-10                -0.359078   0.044302  -8.105 5.70e-16 ***
poly(tows, 3)1               39.403416   2.522801  15.619  < 2e-16 ***
poly(tows, 3)2               -7.169370   1.328853  -5.395 6.96e-08 ***
poly(tows, 3)3               -0.195907   1.275256  -0.154 0.877910
vessel_7                      0.408687   0.473942   0.862 0.388530
vessel_10                     0.455993   0.708890   0.643 0.520073
vessel_12                     0.195052   0.465994   0.419 0.675536
vessel_15                    -0.283549   0.466082  -0.608 0.542954
vessel_17                    -0.510281   0.466802  -1.093 0.274351
vessel_19                     0.325794   0.467973   0.696 0.486327
vessel_20                    -0.098453   0.468442  -0.210 0.833537
vessel_21                    -0.099789   0.469294  -0.213 0.831614
vessel_22                    -0.339681   0.465768  -0.729 0.465835
vessel_24                    -0.220120   0.506160  -0.435 0.663654
vessel_29                     0.124406   0.465497   0.267 0.789278
vessel_32                    -0.563170   0.467687  -1.204 0.228548
vessel_42                    -0.152078   0.473866  -0.321 0.748269
vessel_44                    -0.651499   0.516887  -1.260 0.207537
vessel_46                    -0.481201   0.474892  -1.013 0.310942
vessel_60                    -1.270182   0.590950  -2.149 0.031621 *
vessel_61                    -0.636722   0.475473  -1.339 0.180549
vessel_68                    -0.537067   0.514472  -1.044 0.296542
vessel_80                    -1.130415   0.486817  -2.322 0.020245 *
vessel_83                    -0.235373   0.470815  -0.500 0.617134
vessel_86                    -0.137058   0.466438  -0.294 0.768885
vessel_90                    -1.028981   0.467422  -2.201 0.027724 *
vessel_95                    -0.535839   0.477237  -1.123 0.261545
vessel_97                    -0.326462   0.470316  -0.694 0.487611
vessel_99                    -0.005843   0.480869  -0.012 0.990306
vessel_101                   -0.311473   0.465467  -0.669 0.503404
vessel_102                   -0.641731   0.708327  -0.906 0.364962
vessel_103                   -0.599965   0.498803  -1.203 0.229071
vessel_104                    0.218283   0.484458   0.451 0.652306
vessel_105                   -0.296901   0.466189  -0.637 0.524221
vessel_106                    0.135113   0.466722   0.289 0.772208
vessel_108                    0.193881   0.470602   0.412 0.680356
vessel_110                    0.084988   0.465932   0.182 0.855268
vessel_111                    0.197481   0.466264   0.424 0.671908
vessel_114                    0.263222   0.466472   0.564 0.572571
vessel_116                    0.170186   0.468251   0.363 0.716275
vessel_119                   -0.664661   0.466365  -1.425 0.154123
vessel_120                    0.205258   0.488539   0.420 0.674386
vessel_121                    0.089307   0.469746   0.190 0.849220
vessel_128                   -0.366273   0.474254  -0.772 0.439941
vessel_133                   -0.525191   0.471063  -1.115 0.264911
vessel_142                    0.400727   0.498583   0.804 0.421566
vessel_144                    0.236720   0.465501   0.509 0.611092
vessel_147                   -0.349519   0.467401  -0.748 0.454598
vessel_148                   -0.263527   0.468962  -0.562 0.574168
period_2                     -0.048624   0.097982  -0.496 0.619722
period_3                     -0.111435   0.054317  -2.052 0.040229 *
period_4                     -0.129446   0.050431  -2.567 0.010276 *
Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
period_5                      0.125994   0.047786   2.637 0.008383 **
period_6                      0.291223   0.046617   6.247 4.30e-10 ***
period_7                      0.089720   0.047635   1.884 0.059652 .
period_8                      0.083825   0.045772   1.831 0.067069 .
period_9                      0.135724   0.044131   3.076 0.002106 **
period_10                     0.017046   0.042024   0.406 0.685028
period_11                    -0.257197   0.045102  -5.703 1.20e-08 ***
```

(Cont…)

```
period_12                        -0.152624   0.041680  -3.662 0.000251 ***
statarea_12                      -0.197217   0.029368  -6.715 1.95e-11 ***
statarea_13                      -0.433091   0.031304 -13.835  < 2e-16 ***
statarea_14                      -0.529948   0.038301 -13.836  < 2e-16 ***
statarea_15                      -0.169551   0.055463  -3.057 0.002240 **
statarea_16                      -0.330440   0.076301  -4.331 1.50e-05 ***
statarea_17                      -0.420092   0.092163  -4.558 5.20e-06 ***
poly(duration, 3)1               29.954338   2.561411  11.694  < 2e-16 ***
poly(duration, 3)2               -4.603582   1.388372  -3.316 0.000916 ***
poly(duration, 3)3                0.341683   1.292723   0.264 0.791543
poly(mDVcv, 3)1                   2.750883   1.673232   1.644 0.100188
poly(mDVcv, 3)2                  -2.172491   1.105759  -1.965 0.049468 *
poly(mDVcv, 3)3                   2.082126   1.123414   1.853 0.063848 .
poly(ACECatchr, 3)1               0.902434   1.183175   0.763 0.445642
poly(ACECatchr, 3)2               3.040335   1.126012   2.700 0.006941 **
poly(ACECatchr, 3)3              -0.648371   1.073561  -0.604 0.545891
strategy_opportunistic            0.054695   0.029273   1.868 0.061719 .
strategy_vertically integrated    0.060416   0.024905   2.426 0.015283 *
poly(ACEchgr, 3)1                 0.091212   2.051293   0.044 0.964534
poly(ACEchgr, 3)2                 0.201049   2.021917   0.099 0.920794
poly(ACEchgr, 3)3                -2.420572   1.159604  -2.087 0.036869 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Gamma family taken to be 0.8536701)

    Null deviance: 18008  on 13870  degrees of freedom
Residual deviance: 11831  on 13785  degrees of freedom
AIC: 204007

Number of Fisher Scoring iterations: 7

R-squared: 34.3%
adjusted R-squared: 33.9%
AIC: 204007
Dispersion parameter for Gamma family taken to be 0.8537
    Null deviance: 18008  on 13870  degrees of freedom
Residual deviance: 11830  on 13785  degrees of freedom
```

5.8 TRE_BT_MIX

5.8.1 Summary of results

The model shows some influence of the strategy and structure index variables and all the ratios involving ACE prices, port prices and capturing the change in the permit holder's ACE holdings between periods but no influence of any ratio involving deemed value (Table 35 and Table 36).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + vessel_ + period_ + poly(log(tows), 3) + target_ + structure_ + poly(log(duration), 3) + poly(log(PPACEPr), 3) + statarea_ + strategy_ + poly(log(ACEchgr), 3) + poly(log(ACECatchr), 3)

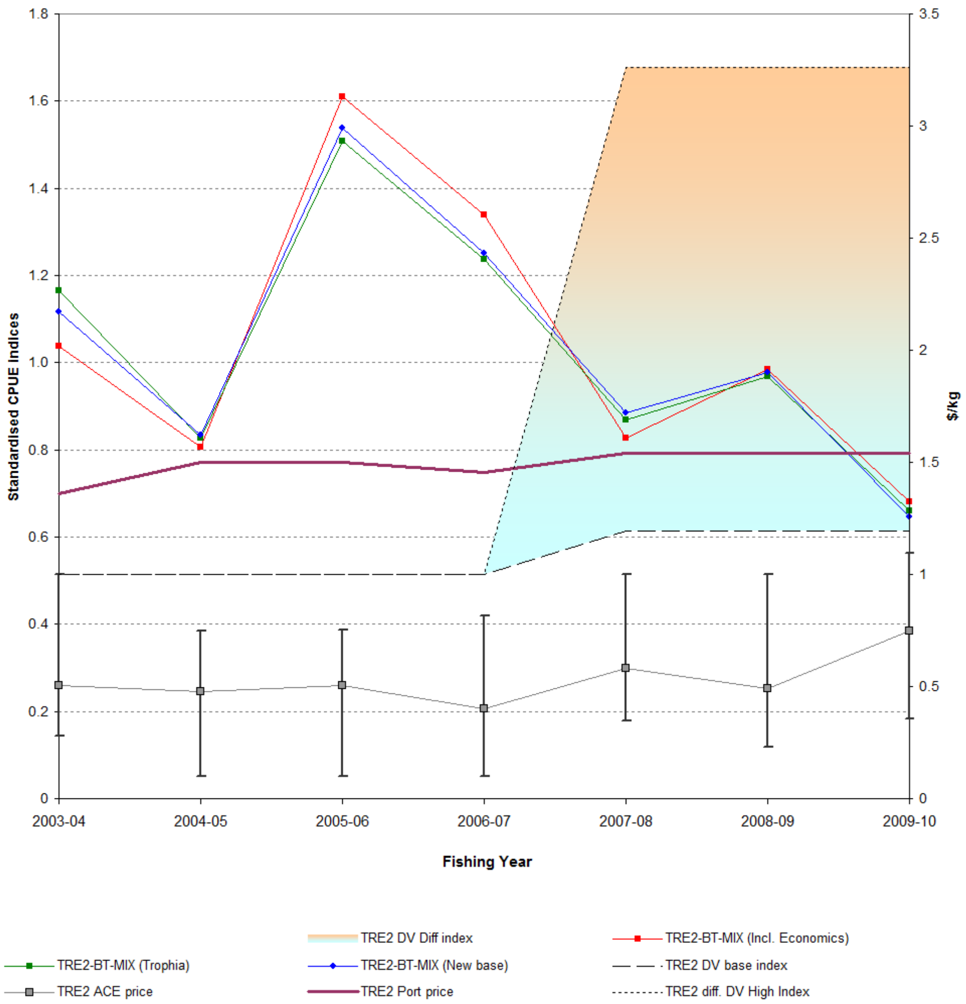


Figure 176: Comparison of TRE_BT_MIX Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.8.2 Data Subset

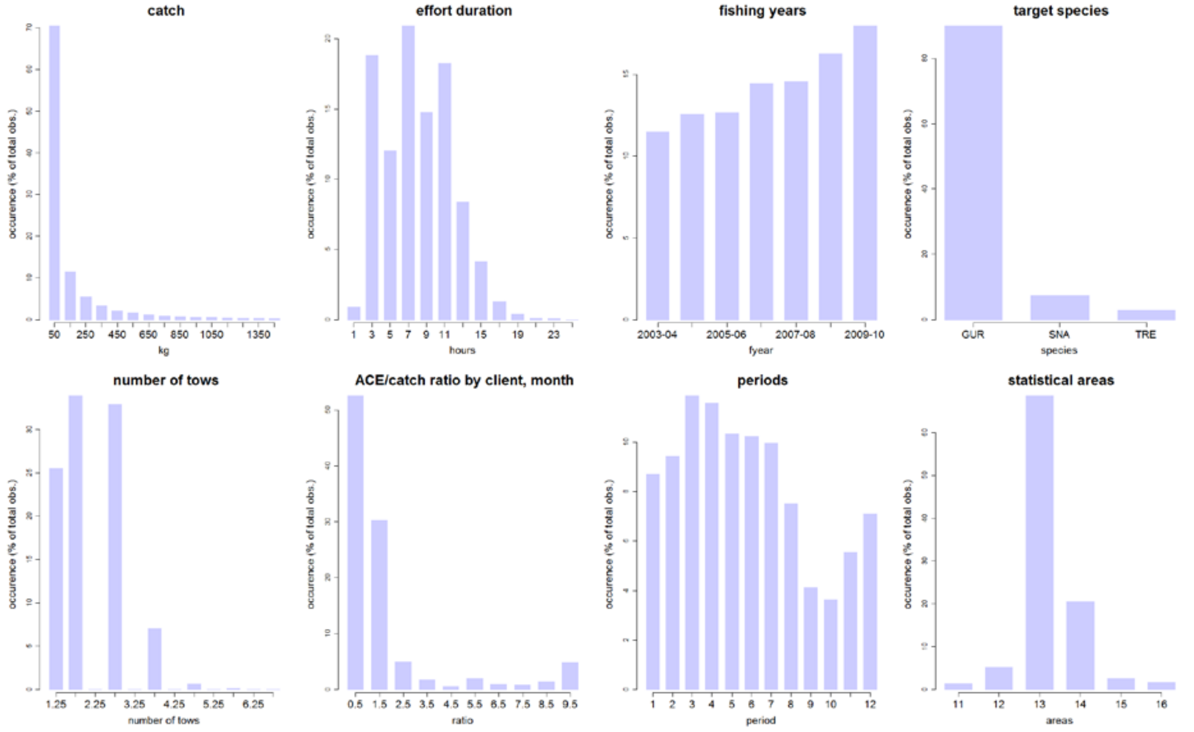


Figure 177: Histograms of Catch-Effort data for all strata included in the “TRE_BT_MIX” CPUE model.

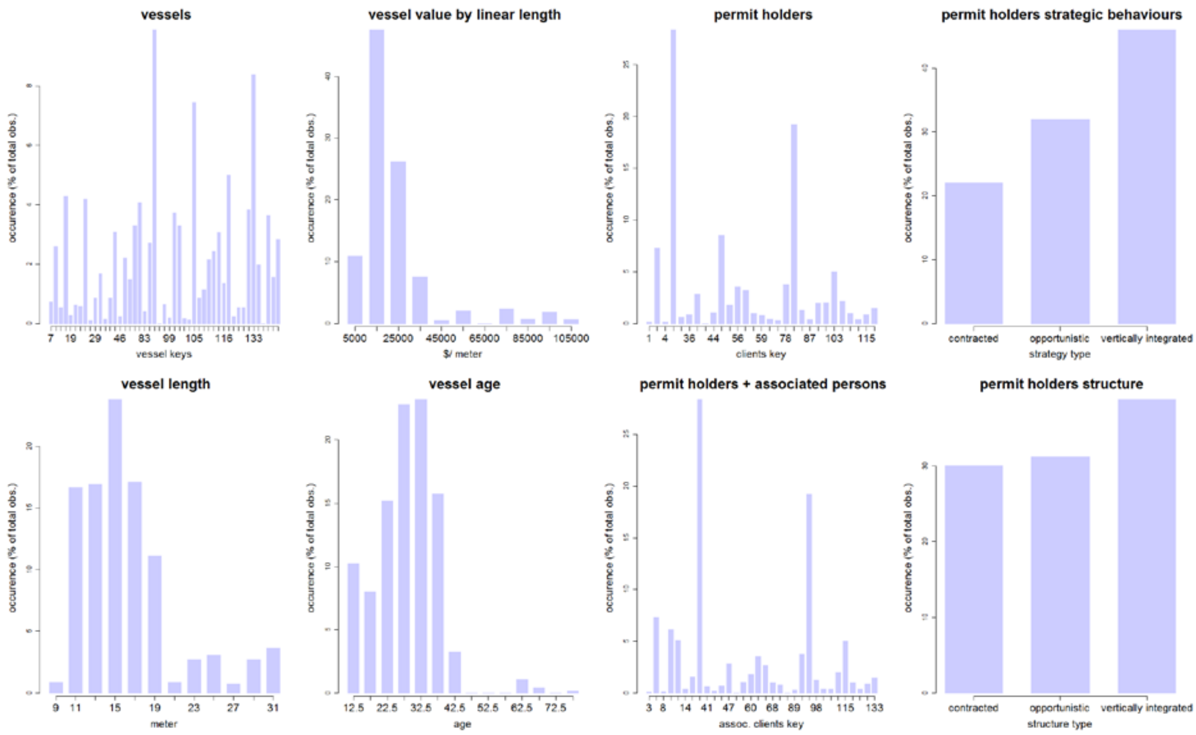


Figure 178: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “TRE_BT_MIX” CPUE model.

5.8.3 Stepwise selection of model terms

Table 35: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TRE_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	29,515	30,864	0	
fyear_	6	-	7276	28,957	30,737	1.89	*
+ vessel_	44	8,539	7232	20,417	28,280	30.82	*
+ period_	11	2,631	7221	17,786	27,297	39.74	*
+ poly(log(tows), 3)	3	1,406	7218	16,380	26,703	44.50	*
+ target_	2	421	7216	15,960	26,518	45.93	*
+ structure_	2	79	7214	15,881	26,486	46.19	*
+ poly(log(duration), 3)	3	57	7211	15,824	26,466	46.39	*
+ poly(log(PPACEPr), 3)	3	44	7208	15,780	26,452	46.53	*
+ statarea_	5	47	7203	15,733	26,440	46.69	*
+ strategy_	2	21	7201	15,712	26,434	46.77	
+ poly(log(ACEchgr), 3)	3	16	7198	15,696	26,433	46.82	
+ poly(log(ACECatchr), 3)	3	15	7195	15,682	26,432	46.87	

acceptance threshold: 0.1%
based on the translog model

5.8.4 Influence of model terms on annual CPUE indices

Table 36: Summary of the influence of each term in the standardisation model (TRE_BT_MIX).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	558	1.89%	30,737	-	-
vessel_	44	8539	28.93%	28,280	32.38%	0.17
period_	11	2631	8.92%	27,297	3.42%	0.01
poly(log(tows), 3)	3	1406	4.76%	26,703	6.35%	-0.02
target_	2	421	1.43%	26,518	1.71%	0.00
structure_	2	79	0.27%	26,486	2.87%	-0.01
poly(log(duration), 3)	3	57	0.19%	26,466	4.34%	-0.02
poly(log(PPACEPr), 3)	3	44	0.15%	26,452	2.85%	0.00
statarea_	5	47	0.16%	26,440	0.60%	0.00
strategy_	2	21	0.07%	26,434	0.89%	0.00
poly(log(ACEchgr), 3)	3	16	0.05%	26,433	1.41%	0.01
poly(log(ACECatchr), 3)	3	15	0.05%	26,432	1.52%	-0.01

based on the translog model

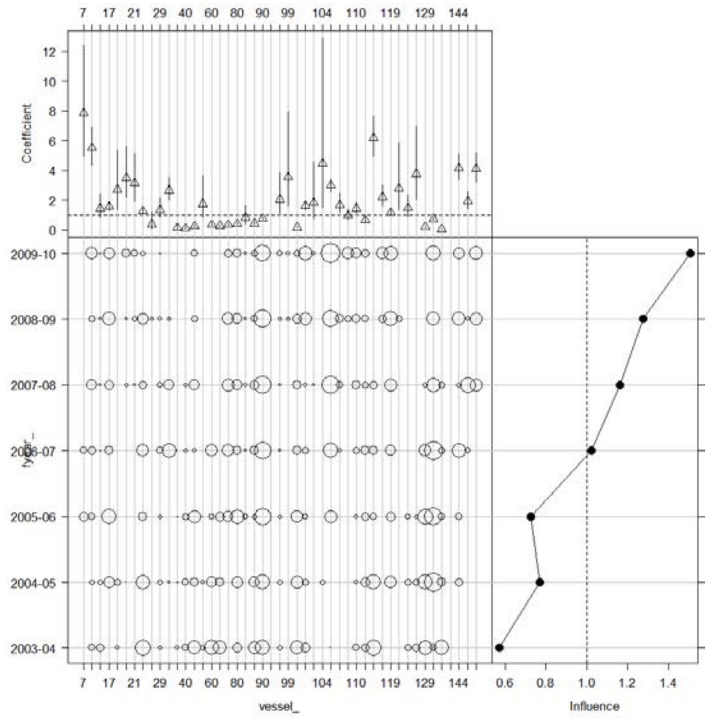


Figure 179: Coefficient-distribution-influence plot for "vessel" (TRE_BT_MIX).

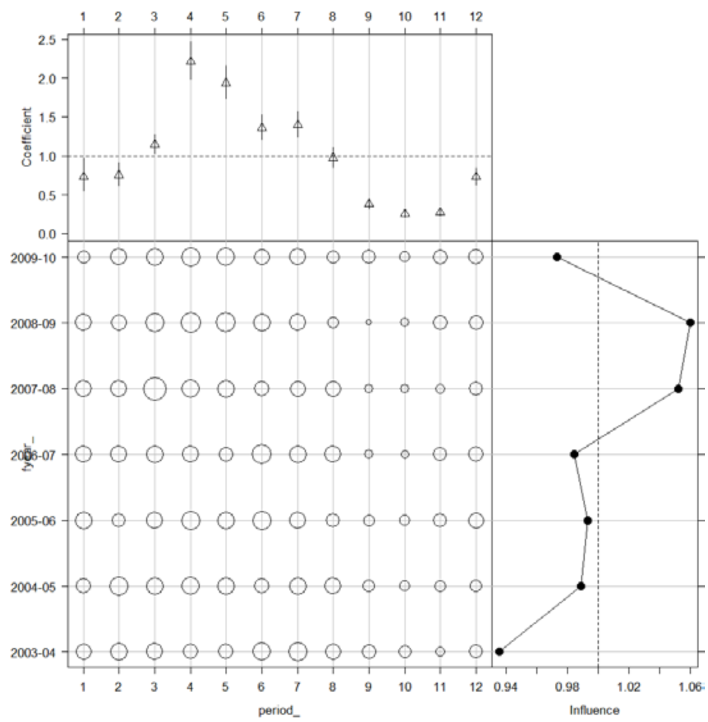


Figure 180: Coefficient-distribution-influence plot for "period" (TRE_BT_MIX).

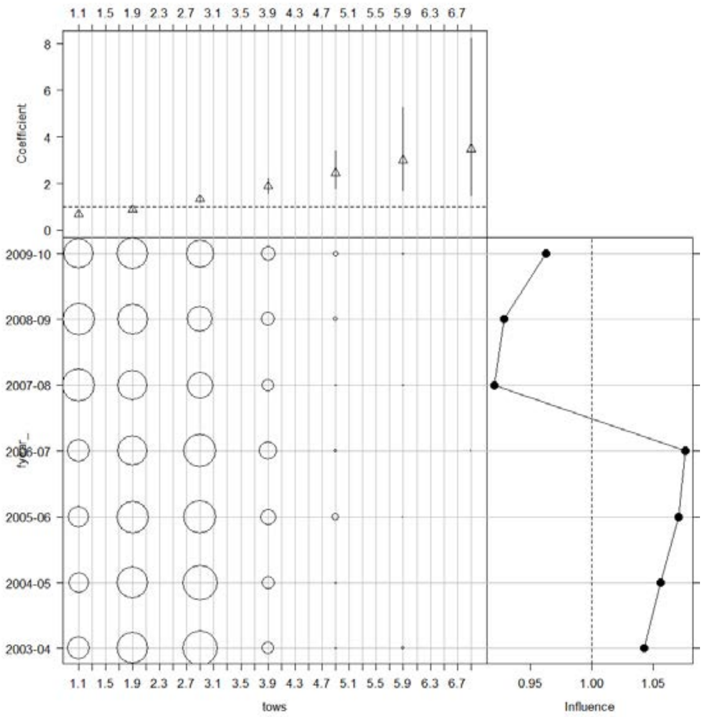


Figure 181: Coefficient-distribution-influence plot for “tows” (TRE_BT_MIX).

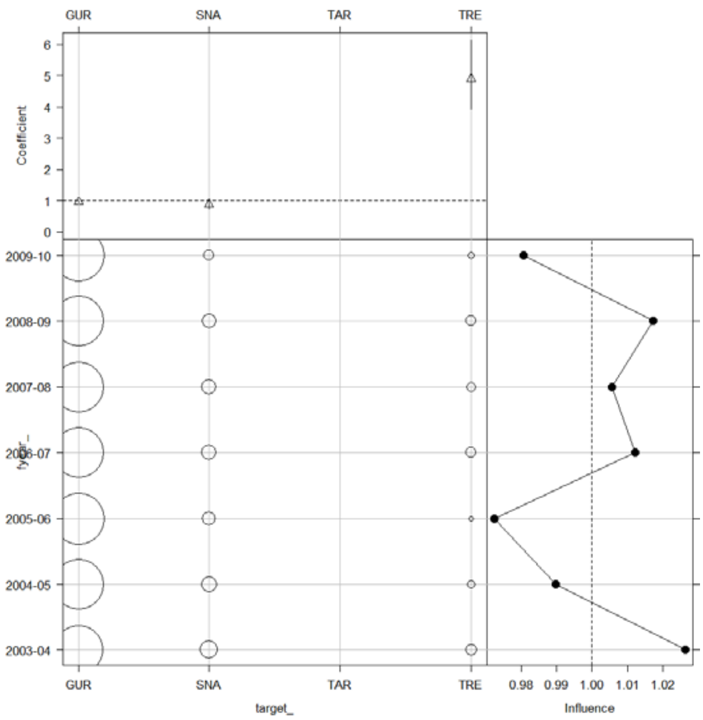


Figure 182: Coefficient-distribution-influence plot for “target” (TRE_BT_MIX).

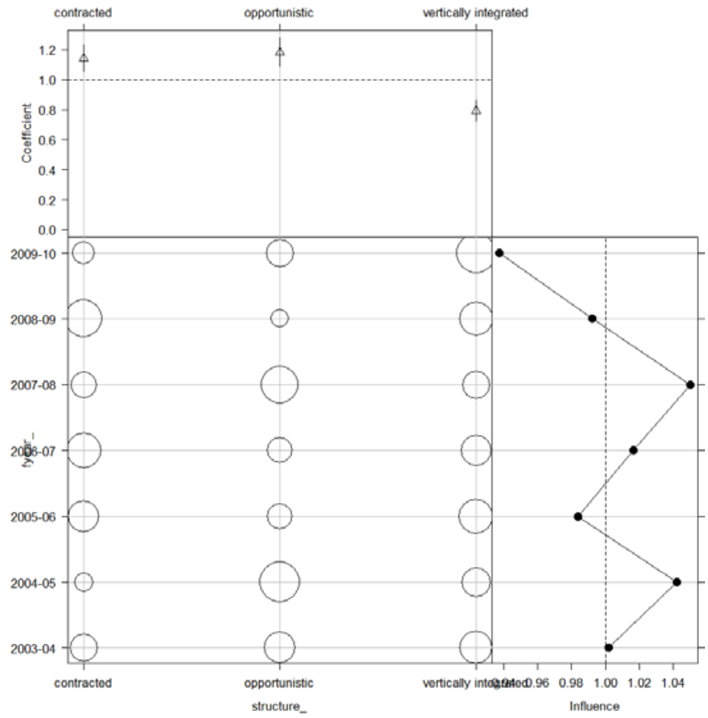


Figure 183: Coefficient-distribution-influence plot for "structure" (TRE_BT_MIX).

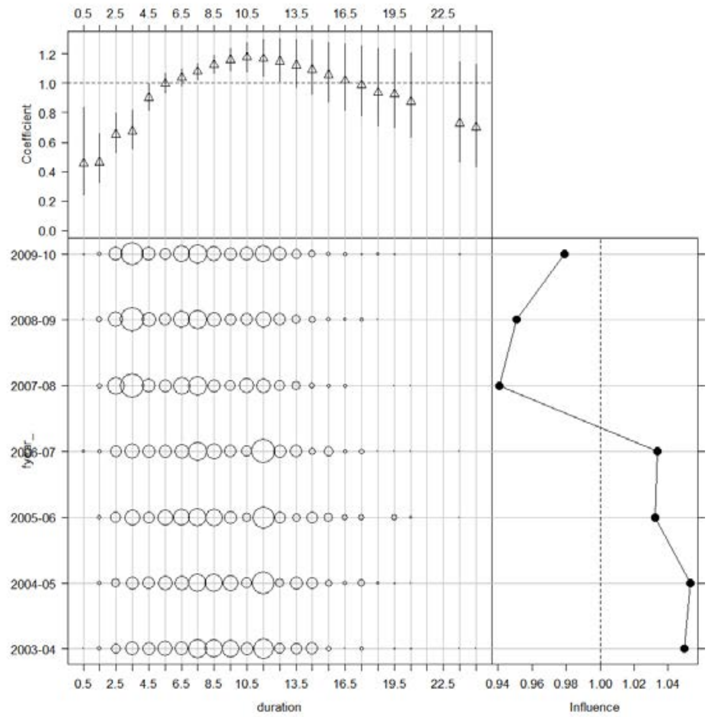


Figure 184: Coefficient-distribution-influence plot for "duration" (TRE_BT_MIX).

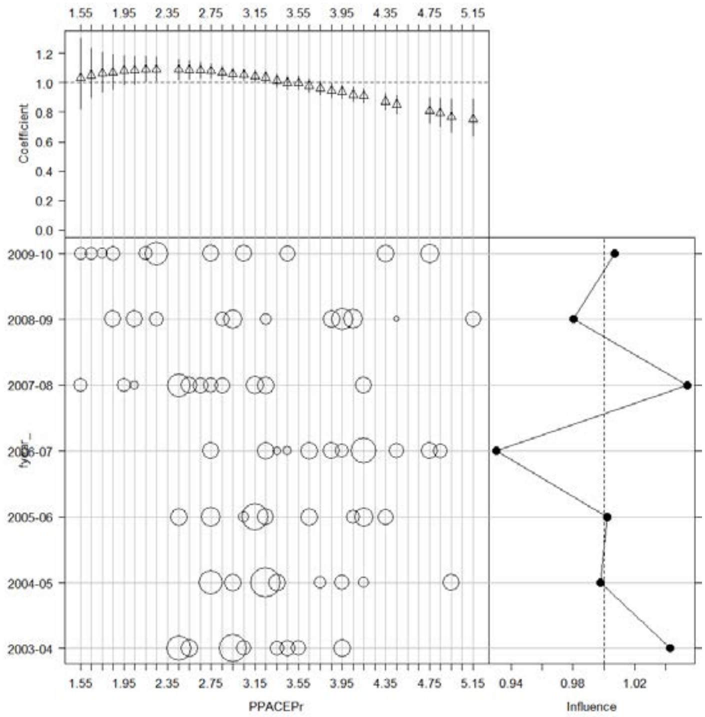


Figure 185: Coefficient-distribution-influence plot for "PPACEPr" (TRE_BT_MIX).

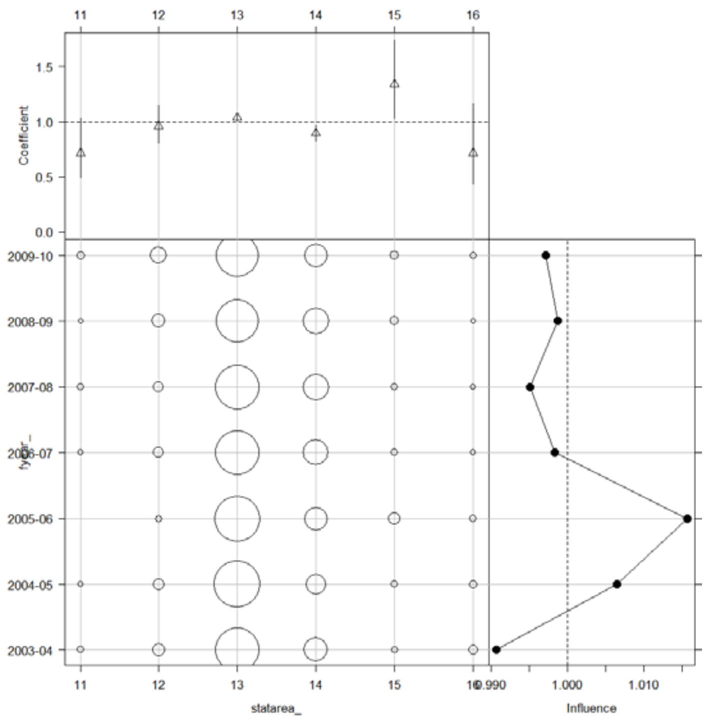


Figure 186: Coefficient-distribution-influence plot for "statarea" (TRE_BT_MIX).

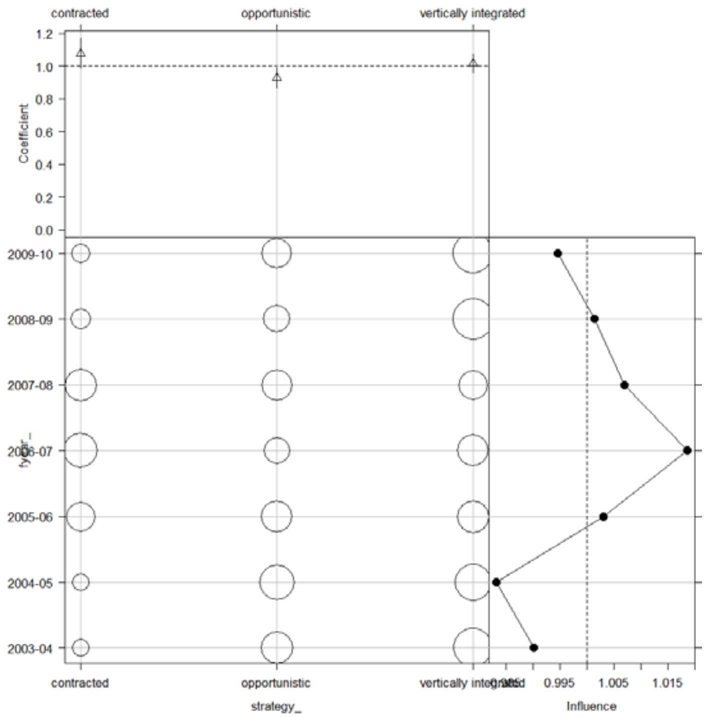


Figure 187: Coefficient-distribution-influence plot for “strategy” (TRE_BT_MIX).

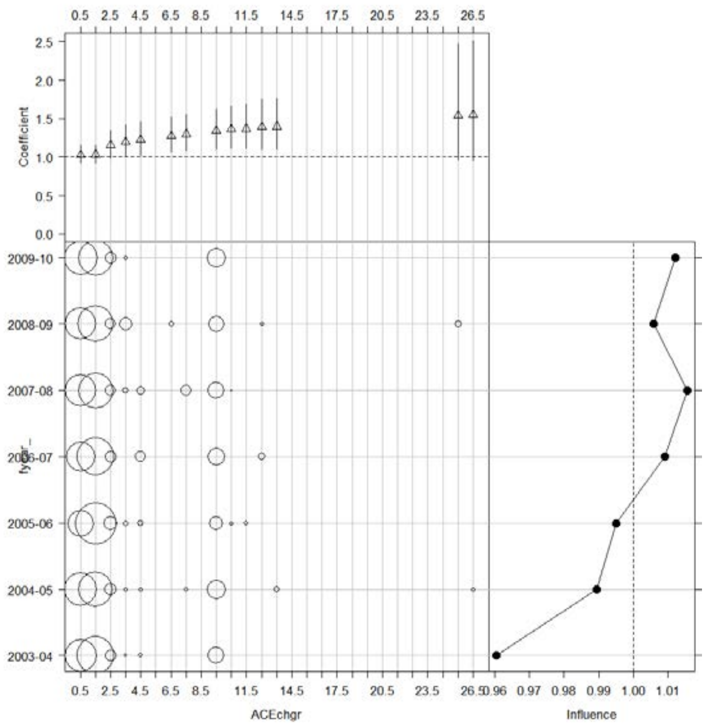


Figure 188: Coefficient-distribution-influence plot for “ACEchgr” (TRE_BT_MIX).

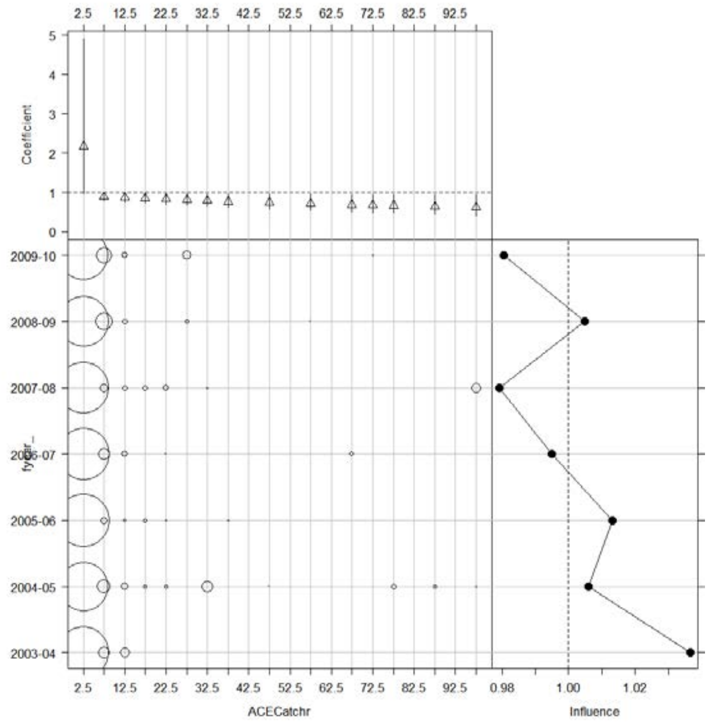


Figure 189: Coefficient-distribution-influence plot for “ACECatchr” (TRE_BT_MIX).

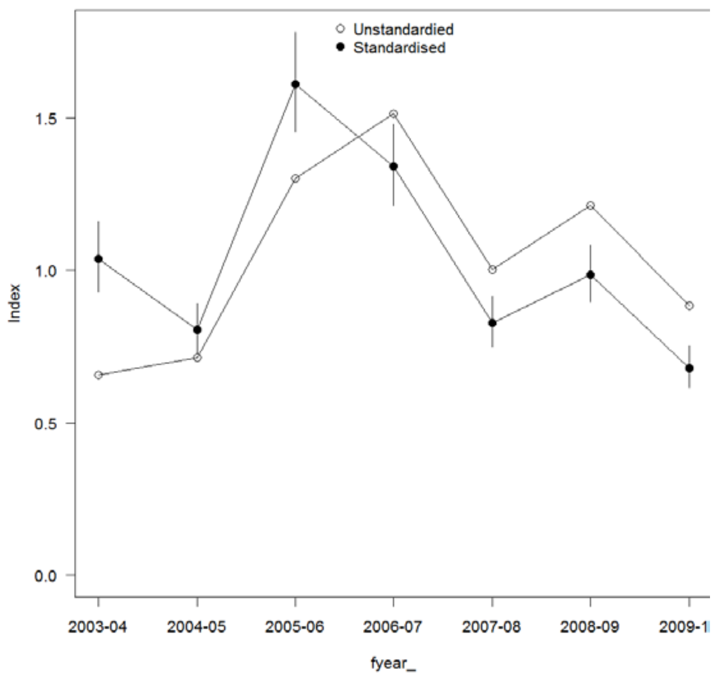


Figure 190: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TRE_BT_MIX).

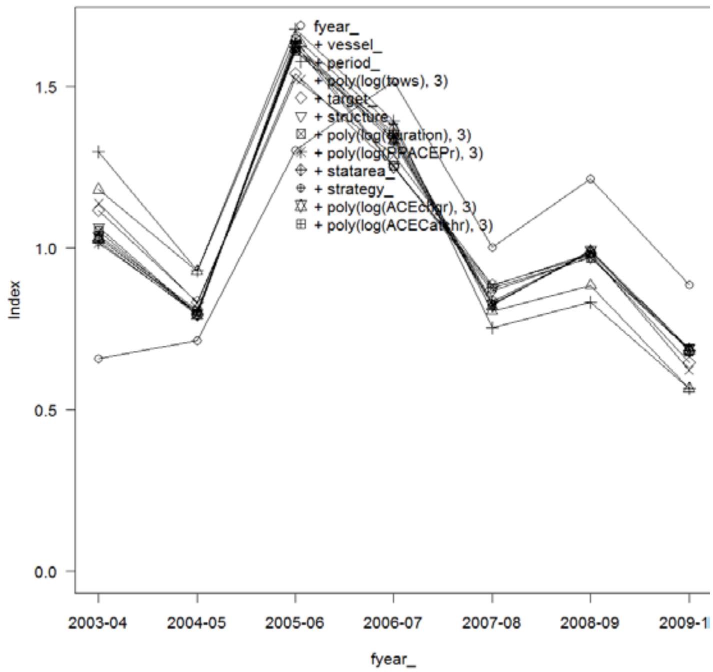


Figure 191: Annual influence for each term in the model (TRE_BT_MIX).

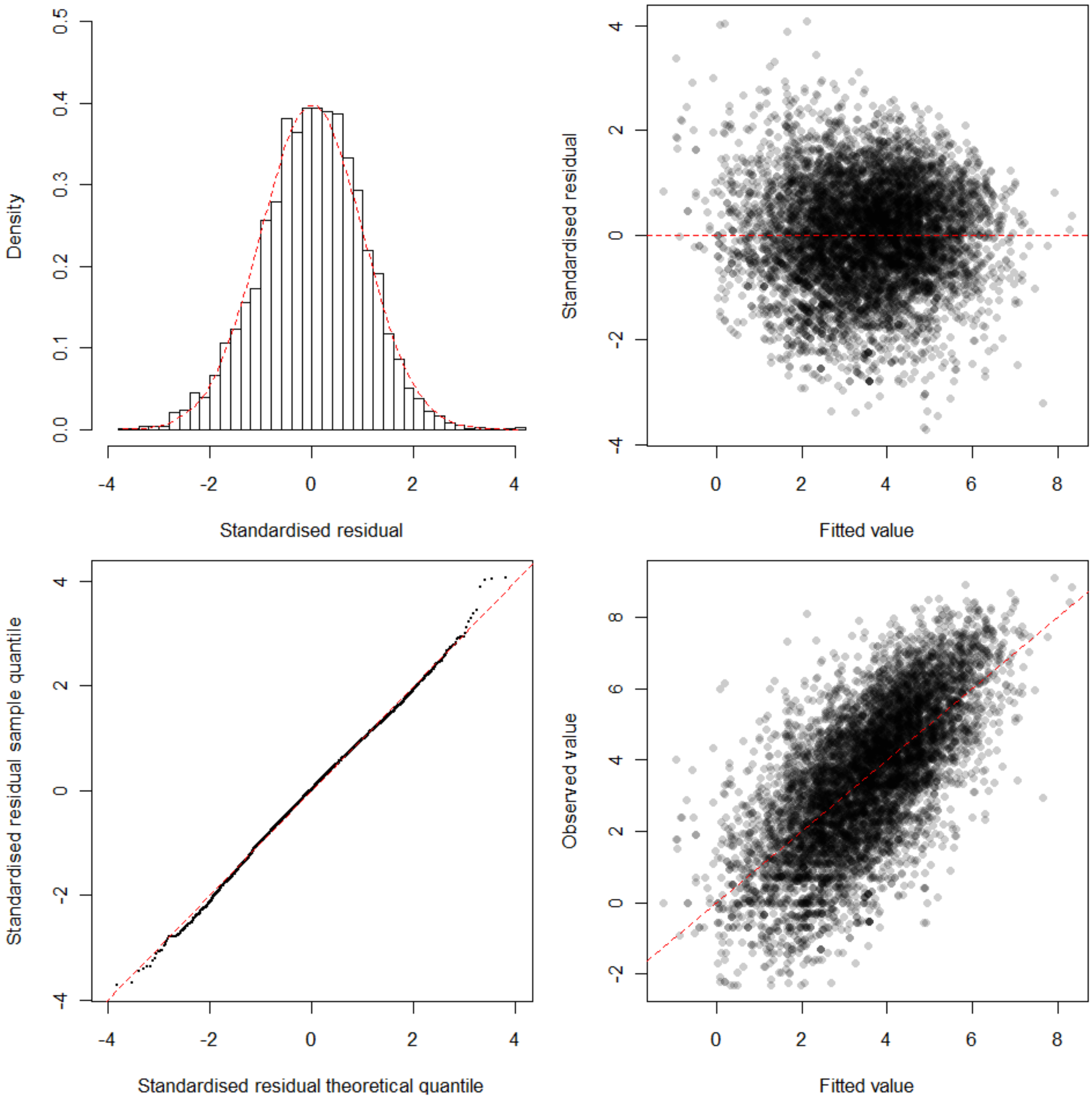


Figure 192: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TRE_BT_MIX).

5.8.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-5.4476  -0.9275   0.0350   0.9951   5.9702

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                       5.155955   0.348806  14.782  < 2e-16 ***
fyear_2004-05                    -0.253286   0.074916  -3.381 0.000726 ***
fyear_2005-06                     0.438063   0.081115   5.401 6.86e-08 ***
fyear_2006-07                     0.255122   0.081729   3.122 0.001806 **
fyear_2007-08                    -0.227984   0.082350  -2.768 0.005646 **
fyear_2008-09                    -0.052963   0.080814  -0.655 0.512251
fyear_2009-10                    -0.422207   0.085318  -4.949 7.64e-07 ***
vessel_12                        -0.351877   0.252438  -1.394 0.163387
vessel_15                        -1.689807   0.350921  -4.815 1.50e-06 ***
vessel_17                        -1.596312   0.253837  -6.289 3.39e-10 ***
vessel_19                        -1.061450   0.412146  -2.575 0.010032 *
vessel_20                        -0.807466   0.332273  -2.430 0.015118 *
vessel_21                        -0.909158   0.338243  -2.688 0.007207 **
vessel_22                        -1.821206   0.249096  -7.311 2.93e-13 ***
vessel_24                        -3.028584   0.605920  -4.998 5.92e-07 ***
vessel_29                        -1.757846   0.333170  -5.276 1.36e-07 ***
vessel_32                        -1.075433   0.274470  -3.918 9.00e-05 ***
vessel_34                        -3.898416   0.507358  -7.684 1.75e-14 ***
vessel_40                        -4.194153   0.301478 -13.912  < 2e-16 ***
vessel_44                        -3.386952   0.258959 -13.079  < 2e-16 ***
vessel_46                        -1.498280   0.432945  -3.461 0.000542 ***
vessel_60                        -3.046890   0.261257 -11.662  < 2e-16 ***
vessel_61                        -3.339064   0.279569 -11.944  < 2e-16 ***
vessel_68                        -3.097334   0.253137 -12.236  < 2e-16 ***
vessel_80                        -2.969908   0.254303 -11.679  < 2e-16 ***
vessel_83                        -2.271511   0.394403  -5.759 8.79e-09 ***
vessel_86                        -2.883942   0.263815 -10.932  < 2e-16 ***
vessel_90                        -2.323489   0.244816  -9.491  < 2e-16 ***
vessel_97                        -1.335779   0.358009  -3.731 0.000192 ***
vessel_99                        -0.790520   0.465002  -1.700 0.089168 .
vessel_100                       -3.722056   0.258169 -14.417  < 2e-16 ***
vessel_101                       -1.569373   0.254051  -6.177 6.87e-10 ***
vessel_103                       -1.456654   0.489812  -2.974 0.002950 **
vessel_104                       -0.564974   0.580050  -0.974 0.330085
vessel_105                       -0.964828   0.247121  -3.904 9.54e-05 ***
vessel_106                       -1.540531   0.302581  -5.091 3.65e-07 ***
vessel_108                       -2.074139   0.287205  -7.222 5.66e-13 ***
vessel_110                       -1.691875   0.268999  -6.290 3.37e-10 ***
vessel_111                       -2.455767   0.273591  -8.976  < 2e-16 ***
vessel_114                       -0.239641   0.245149  -0.978 0.328339
vessel_116                       -1.264764   0.281822  -4.488 7.31e-06 ***
vessel_119                       -1.886906   0.246468  -7.656 2.17e-14 ***
vessel_120                       -1.028118   0.420262  -2.446 0.014454 *
vessel_121                       -1.677989   0.336082  -4.993 6.09e-07 ***
vessel_128                       -0.729528   0.354115  -2.060 0.039421 *
vessel_129                       -3.660086   0.255055 -14.350  < 2e-16 ***
vessel_133                       -2.364398   0.244065  -9.688  < 2e-16 ***
vessel_139                       -4.766767   0.263914 -18.062  < 2e-16 ***
vessel_144                       -0.633666   0.250897  -2.526 0.011571 *
vessel_147                       -1.408231   0.279601  -5.037 4.85e-07 ***
vessel_148                       -0.648837   0.261782  -2.479 0.013215 *
period_2                          0.034269   0.166558   0.206 0.836995
period_3                          0.453570   0.161436   2.810 0.004974 **
period_4                          1.110059   0.167239   6.638 3.42e-11 ***
period_5                          0.974997   0.169225   5.762 8.68e-09 ***
period_6                          0.624103   0.171686   3.635 0.000280 ***
period_7                          0.649273   0.168209   3.860 0.000114 ***
period_8                          0.292452   0.172352   1.697 0.089771 .
Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
period_9                         -0.659570   0.181692  -3.630 0.000285 ***
period_10                        -1.049421   0.183018  -5.734 1.02e-08 ***
period_11                        -0.975179   0.176101  -5.538 3.17e-08 ***
period_12                        -0.001610   0.174078  -0.009 0.992623
poly(log(tows), 3)1              25.867492   4.500231   5.748 9.40e-09 ***
poly(log(tows), 3)2               8.810108   2.194024   4.016 5.99e-05 ***
poly(log(tows), 3)3              -1.621960   1.542156  -1.052 0.292950
```

(cont…)

```
target_SNA                        -0.088524   0.093921  -0.943 0.345949    
target_TRE                         1.629173   0.116283  14.010  < 2e-16 ***
structure_opportunistic            0.033177   0.056384   0.588 0.556278    
structure_vertically integrated   -0.366613   0.077672  -4.720 2.40e-06 ***
poly(log(duration), 3)1           15.390600   4.579485   3.361 0.000781 ***
poly(log(duration), 3)2           -6.498801   2.009700  -3.234 0.001227 ** 
poly(log(duration), 3)3           -4.556869   1.919605  -2.374 0.017629 *  
poly(log(PPACEPr), 3)1            -6.643502   1.882703  -3.529 0.000420 ***
poly(log(PPACEPr), 3)2            -4.412046   1.824924  -2.418 0.015645 *  
poly(log(PPACEPr), 3)3            -0.516223   1.598759  -0.323 0.746788    
statarea_12                        0.298242   0.185168   1.611 0.107299    
statarea_13                        0.375945   0.188604   1.993 0.046266 *  
statarea_14                        0.227385   0.193561   1.175 0.240135    
statarea_15                        0.630219   0.231096   2.727 0.006405 ** 
statarea_16                        0.001931   0.311991   0.006 0.995061    
strategy_opportunistic            -0.148360   0.056381  -2.631 0.008522 ** 
strategy_vertically integrated    -0.058458   0.063707  -0.918 0.358854    
poly(log(ACEchgr), 3)1            20.778504  11.640407   1.785 0.074298 .  
poly(log(ACEchgr), 3)2            -1.481485   5.729061  -0.259 0.795958    
poly(log(ACEchgr), 3)3             0.377305   1.717587   0.220 0.826133    
poly(log(ACECatchr), 3)1         -21.283414  10.409444  -2.045 0.040928 *  
poly(log(ACECatchr), 3)2           9.697737   6.926972   1.400 0.161557    
poly(log(ACECatchr), 3)3          -5.587654   3.162318  -1.767 0.077279 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 2.17952)

    Null deviance: 29515  on 7282  degrees of freedom
Residual deviance: 15682  on 7195  degrees of freedom
AIC: 26432

Number of Fisher Scoring iterations: 2

R-squared: 46.87%
adjusted R-squared: 46.23%
AIC: 26431
Dispersion parameter for Gamma family taken to be 2.18
    Null deviance: 29514  on 7282  degrees of freedom
Residual deviance: 15681  on 7195  degrees of freedom
```

5.9 TRE_BT_TAR

5.9.1 Summary of results

The model shows some influence of the strategy and structure index variables and all the ratios involving ACE prices, port prices and deemed value and capturing the change in the permit holder's ACE holdings between periods (Table 37 and Table 38).

The stepwise process led to the final translog function with the following functional form:

log(catch) ~ fyear_ + vessel_ + period_ + poly(log(duration), 3) + statarea_ + poly(log(PPACEPr), 3) + poly(log(ACECatchr), 3) + poly(log(ACEchgr), 3) + poly(log(tows), 3) + structure_ + strategy_

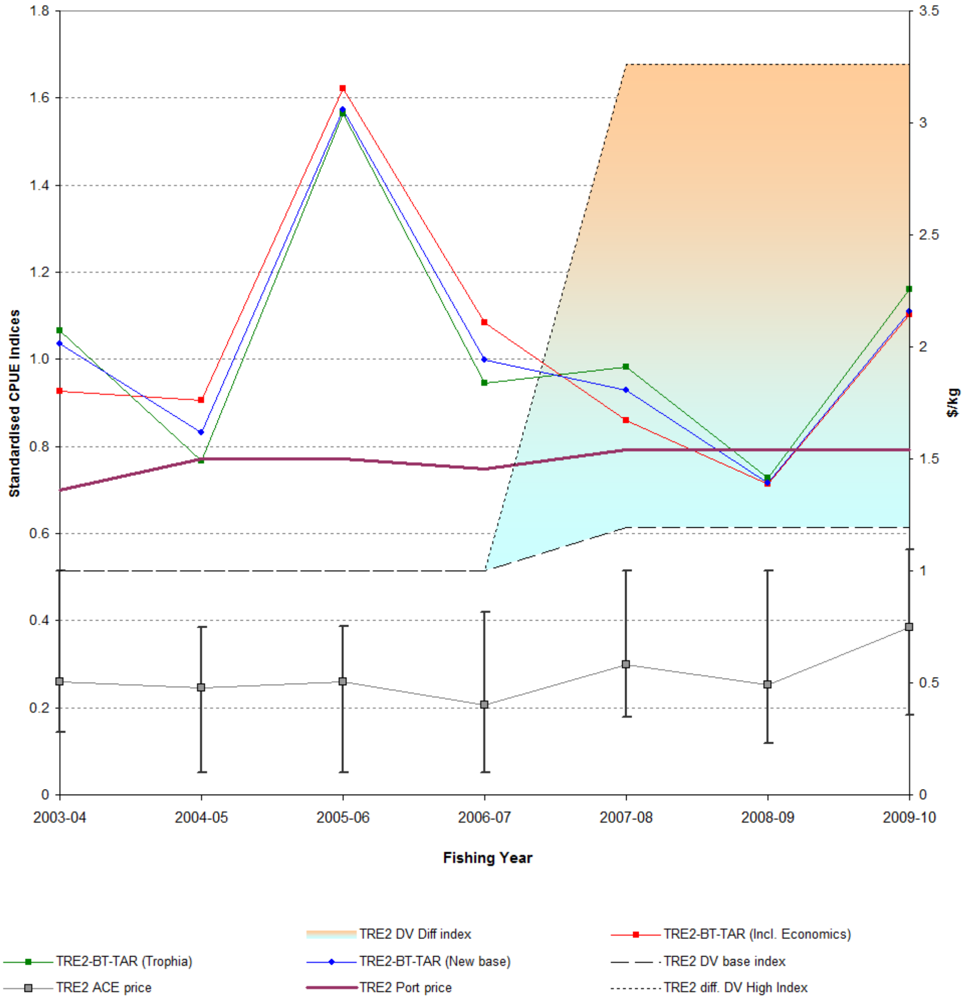


Figure 193: Comparison of TRE_BT_TAR Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.

5.9.2 Data Subset

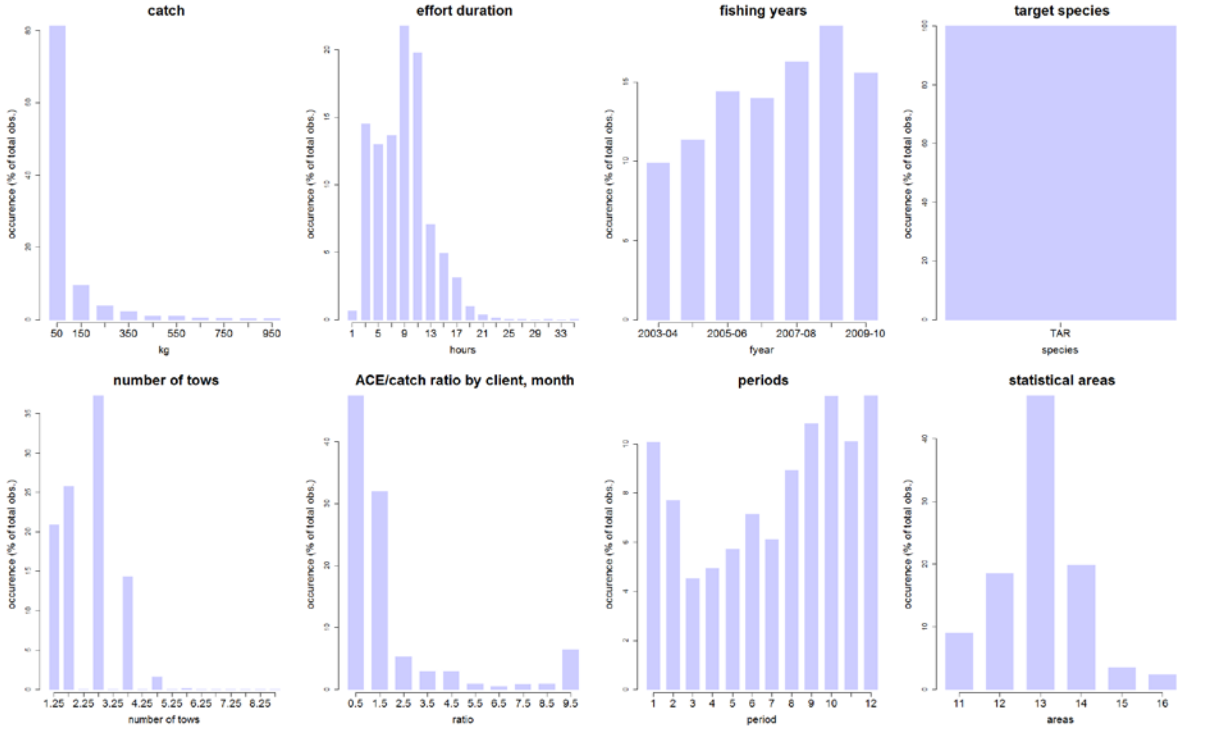


Figure 194: Histograms of Catch-Effort data for all strata included in the “TRE_BT_TAR” CPUE model.

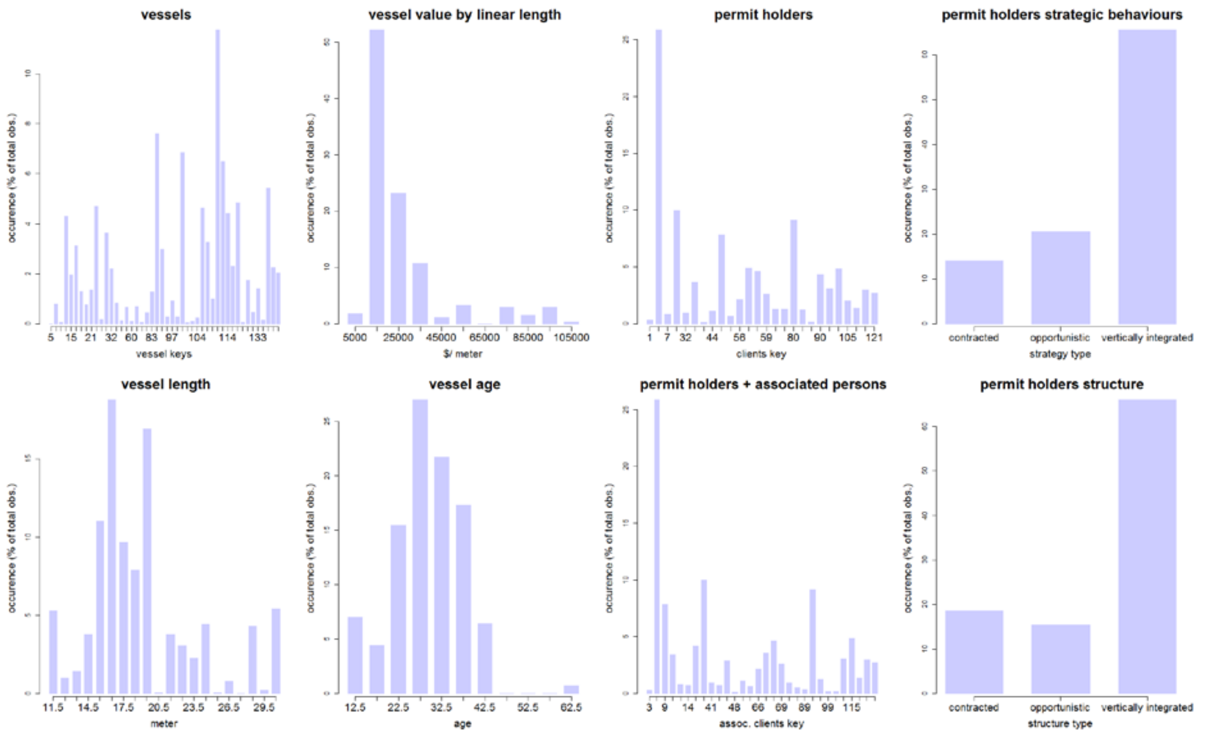


Figure 195: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “TRE_BT_TAR” CPUE model.

5.9.3 Stepwise selection of model terms

Table 37: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TRE_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level.

Term	Df	Deviance	Resid. Df	Resid. Dev	AIC	R-squared (%)	
-	-	-	-	22,694	25,650	0	
fyear_	6	-	6195	22,109	25,500	2.58	*
+ vessel_	44	4,167	6151	17,943	24,293	20.94	*
+ period_	11	2,238	6140	15,705	23,489	30.80	*
+ poly(log(duration), 3)	3	964	6137	14,741	23,102	35.05	*
+ statarea_	5	188	6132	14,553	23,032	35.87	*
+ poly(log(PPACEPr), 3)	3	122	6129	14,430	22,986	36.41	*
+ poly(log(ACECatchr), 3)	3	58	6126	14,373	22,967	36.67	*
+ poly(log(ACEchgr), 3)	3	59	6123	14,313	22,947	36.93	*
+ poly(log(tows), 3)	3	47	6120	14,266	22,933	37.14	*
+ structure_	2	36	6118	14,231	22,921	37.29	*
+ strategy_	2	15	6116	14,215	22,919	37.36	

acceptance threshold: 0.1%

based on the translog model

5.9.4 Influence of model terms on annual CPUE indices

Table 38: Summary of the influence of each term in the standardisation model (TRE_BT_TAR).

Term	Df	Deviance explained	Deviance explained (%)	AIC	Influence overall (%)	trend
Null	-	-	-	-	-	-
fyear_	6	585	2.58%	25,500	-	-
vessel_	44	4167	18.36%	24,293	9.51%	0.04
period_	11	2238	9.86%	23,489	6.74%	0.03
poly(log(duration), 3)	3	964	4.25%	23,102	3.96%	-0.01
statarea_	5	188	0.83%	23,032	1.84%	-0.01
poly(log(PPACEPr), 3)	3	122	0.54%	22,986	4.49%	0.00
poly(log(ACECatchr), 3)	3	58	0.25%	22,967	4.51%	0.01
poly(log(ACEchgr), 3)	3	59	0.26%	22,947	2.27%	0.00
poly(log(tows), 3)	3	47	0.21%	22,933	5.56%	-0.02
structure_	2	36	0.16%	22,921	2.24%	0.00
strategy_	2	15	0.07%	22,919	1.21%	0.00

based on the translog model

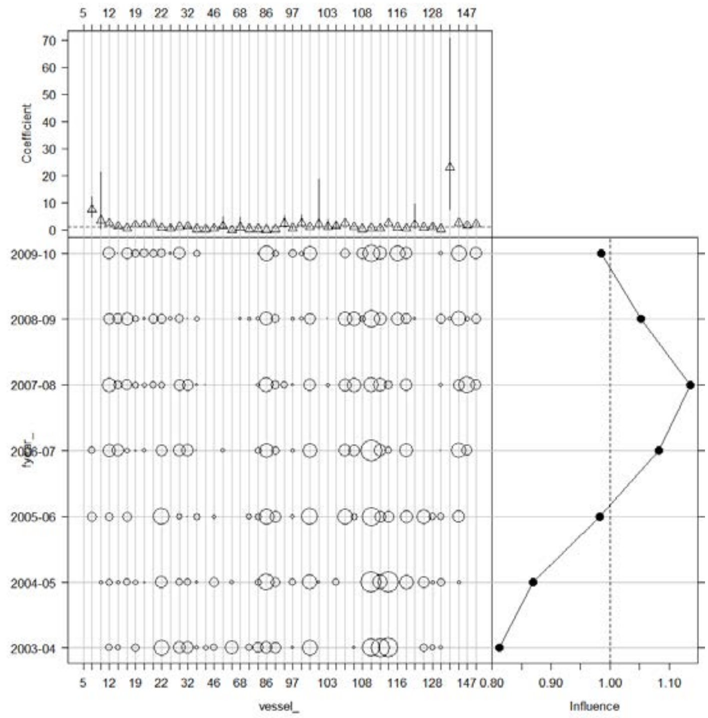


Figure 196: Coefficient-distribution-influence plot for "vessel" (TRE_BT_TAR).

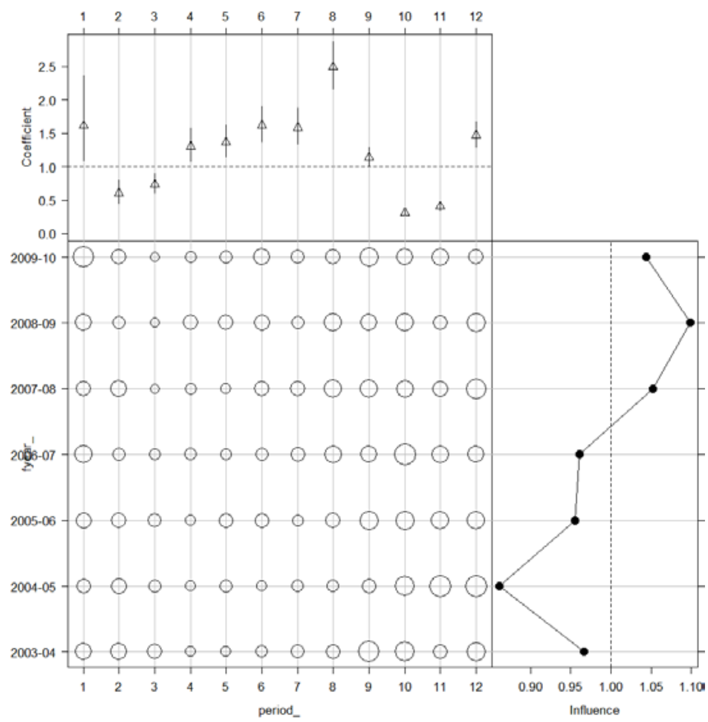


Figure 197: Coefficient-distribution-influence plot for "period" (TRE_BT_TAR).

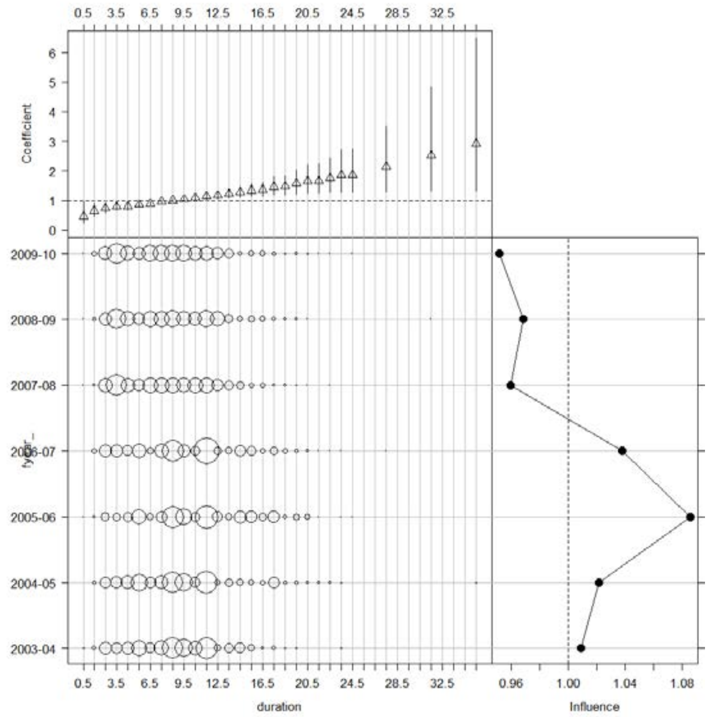


Figure 198: Coefficient-distribution-influence plot for "duration" (TRE_BT_TAR).

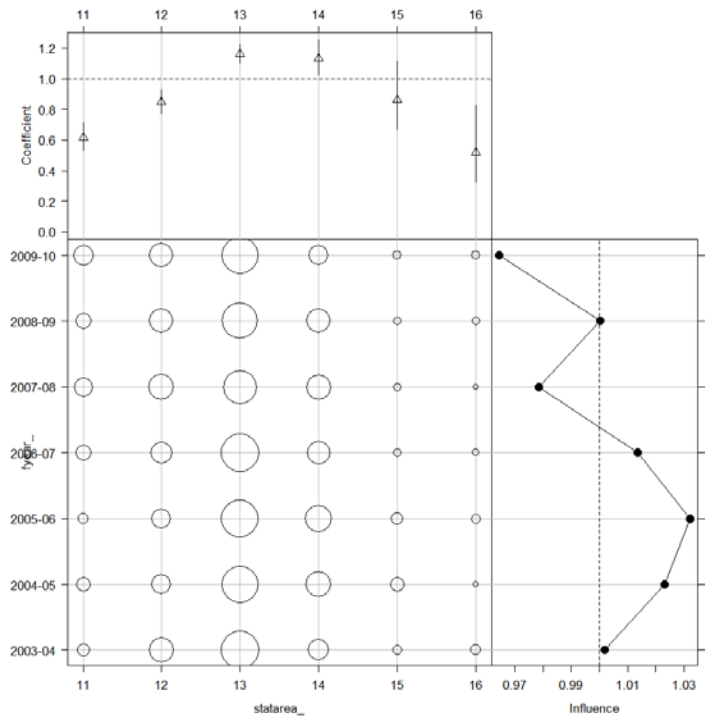


Figure 199: Coefficient-distribution-influence plot for "statarea" (TRE_BT_TAR).

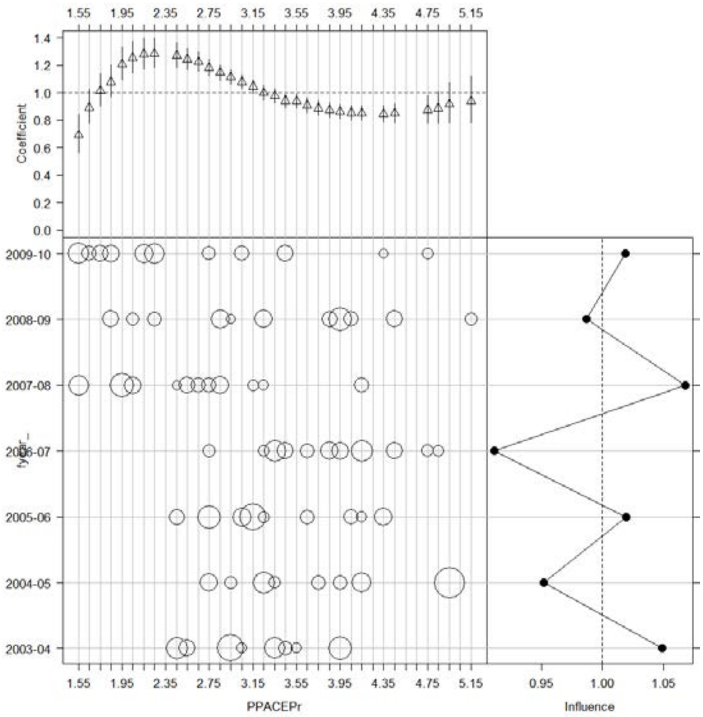


Figure 200: Coefficient-distribution-influence plot for "PPACEPr" (TRE_BT_TAR).

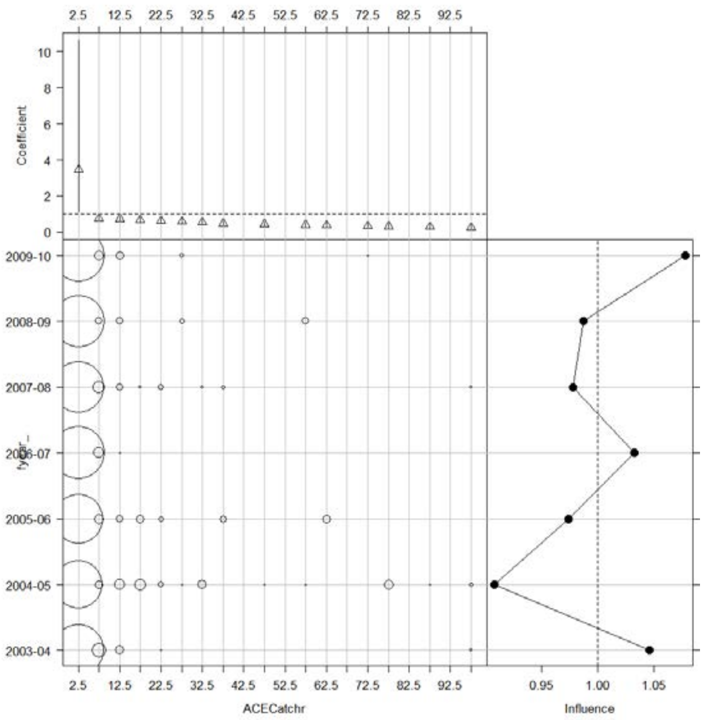


Figure 201: Coefficient-distribution-influence plot for "ACECatchr" (TRE_BT_TAR).

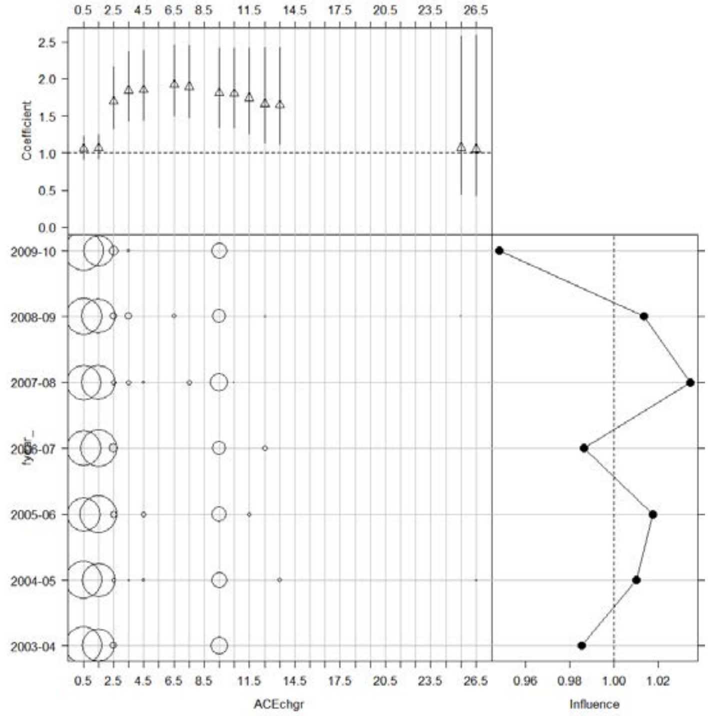


Figure 202: Coefficient-distribution-influence plot for "ACEchgr" (TRE_BT_TAR).

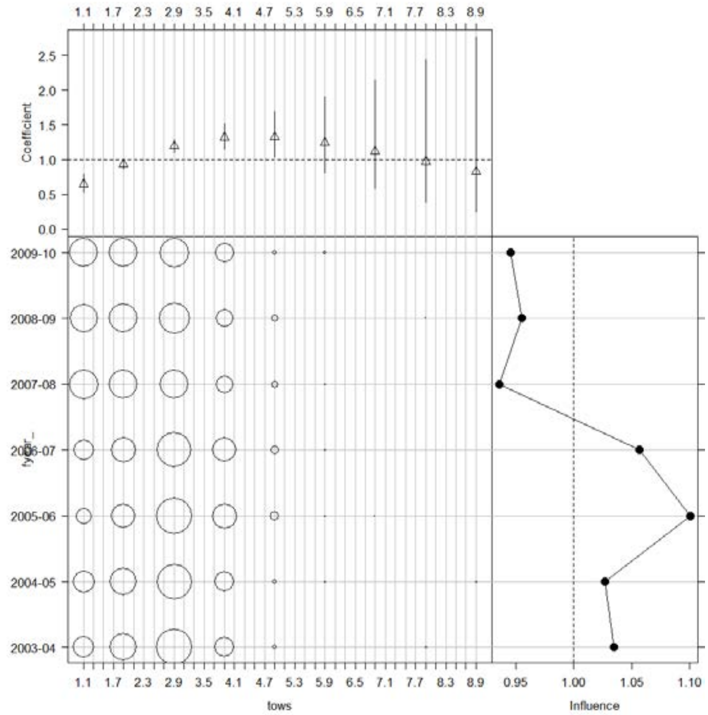


Figure 203: Coefficient-distribution-influence plot for "tows" (TRE_BT_TAR).

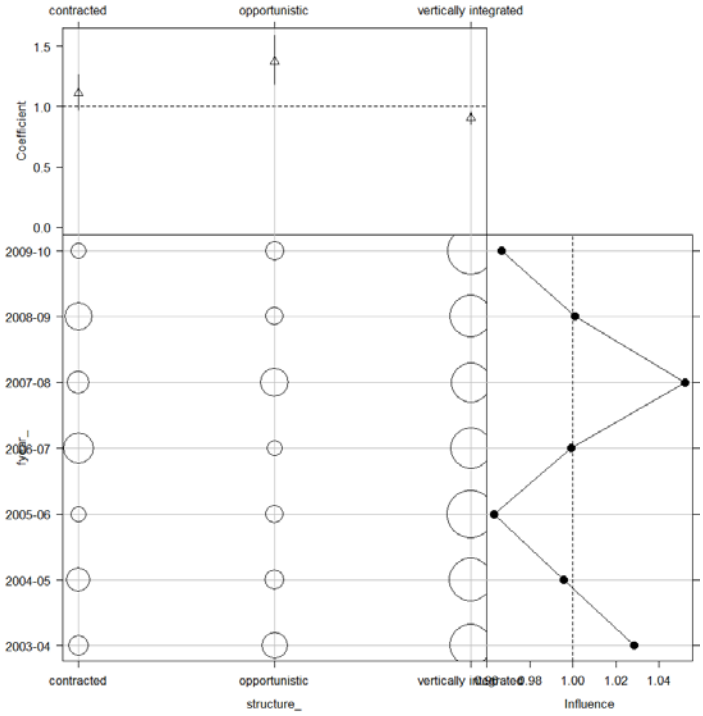


Figure 204: Coefficient-distribution-influence plot for "structure" (TRE_BT_TAR).

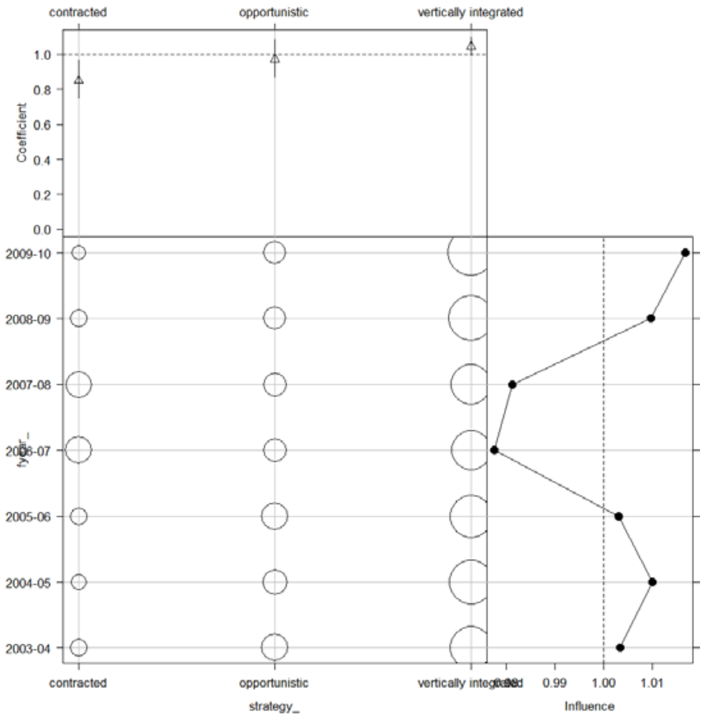


Figure 205: Coefficient-distribution-influence plot for "strategy" (TRE_BT_TAR).

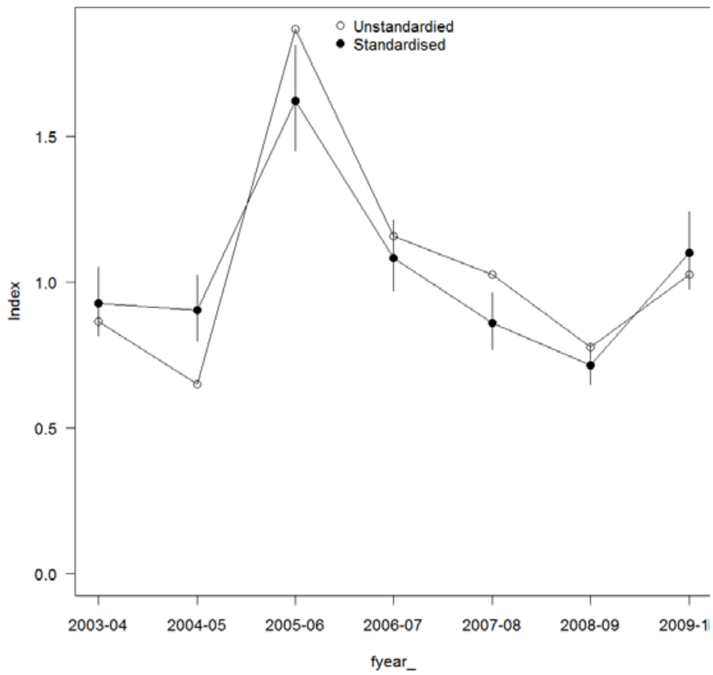


Figure 206: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TRE_BT_TAR).

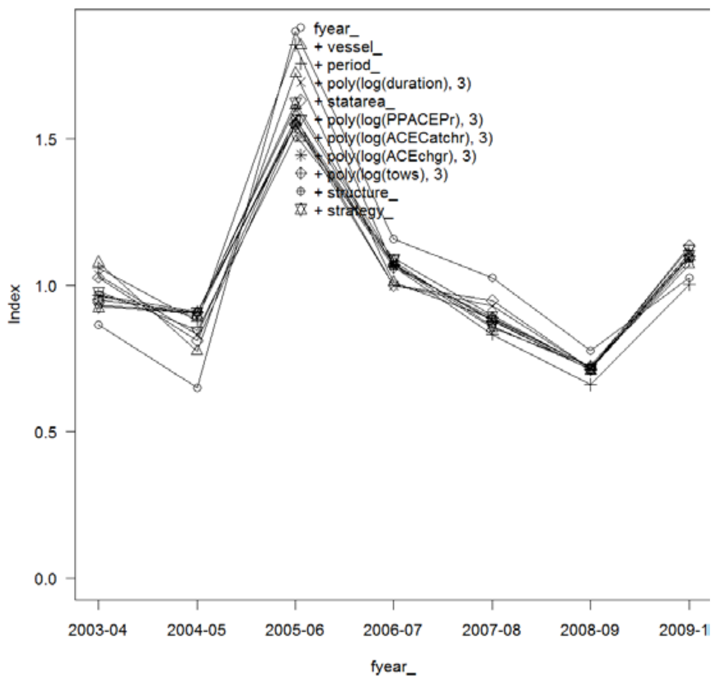


Figure 207: Annual influence for each term in the model (TRE_BT_TAR).

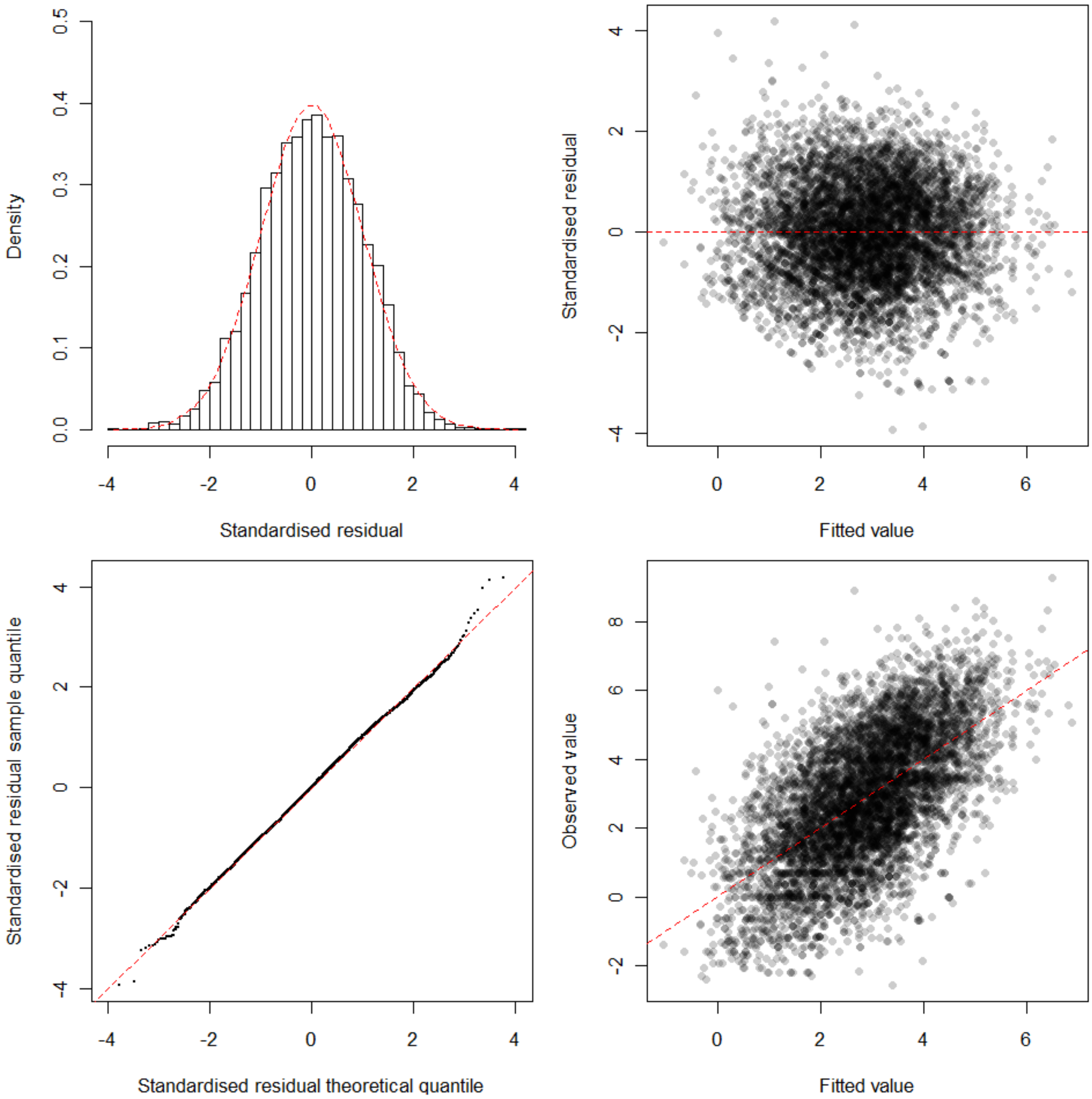


Figure 208: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TRE_BT_TAR).

5.9.5 Generalised Linear Model Regression parameters

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-5.9548  -1.0516   0.0066   1.0496   6.3536

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                       4.744512   0.346317  13.700  < 2e-16 ***
fyear_2004-05                    -0.024892   0.094547  -0.263 0.792349
fyear_2005-06                     0.559164   0.088537   6.316 2.88e-10 ***
fyear_2006-07                     0.155959   0.092206   1.691 0.090806 .
fyear_2007-08                    -0.074908   0.092593  -0.809 0.418546
fyear_2008-09                    -0.260917   0.088439  -2.950 0.003187 **
fyear_2009-10                     0.172632   0.097495   1.771 0.076665 .
vessel_10                        -0.753253   0.931999  -0.808 0.419000
vessel_12                        -1.106172   0.261739  -4.226 2.41e-05 ***
vessel_15                        -1.705622   0.288005  -5.922 3.35e-09 ***
vessel_17                        -2.340219   0.276875  -8.452  < 2e-16 ***
vessel_19                        -1.363518   0.306534  -4.448 8.81e-06 ***
vessel_20                        -1.367696   0.337395  -4.054 5.10e-05 ***
vessel_21                        -1.259175   0.303933  -4.143 3.48e-05 ***
vessel_22                        -2.154016   0.265940  -8.100 6.60e-16 ***
vessel_24                        -2.563248   0.523630  -4.895 1.01e-06 ***
vessel_29                        -1.797527   0.277029  -6.489 9.34e-11 ***
vessel_32                        -1.715398   0.282216  -6.078 1.29e-09 ***
vessel_42                        -2.864531   0.383389  -7.472 9.03e-14 ***
vessel_44                        -3.224417   0.636624  -5.065 4.21e-07 ***
vessel_46                        -2.398932   0.350274  -6.849 8.18e-12 ***
vessel_60                        -1.670280   0.680875  -2.453 0.014189 *
vessel_61                        -4.091390   0.353481 -11.575  < 2e-16 ***
vessel_68                        -2.010774   0.807263  -2.491 0.012770 *
vessel_80                        -2.769967   0.390292  -7.097 1.42e-12 ***
vessel_83                        -2.684347   0.316082  -8.493  < 2e-16 ***
vessel_86                        -3.460823   0.272555 -12.698  < 2e-16 ***
vessel_90                        -2.942821   0.275738 -10.673  < 2e-16 ***
vessel_95                        -1.128950   0.453294  -2.491 0.012781 *
vessel_97                        -2.247289   0.329495  -6.820 9.95e-12 ***
vessel_99                        -1.064959   0.450049  -2.366 0.017997 *
vessel_101                       -1.817318   0.258162  -7.039 2.14e-12 ***
vessel_102                       -1.266224   1.117919  -1.133 0.257401
vessel_103                       -1.927609   0.679385  -2.837 0.004565 **
vessel_104                       -1.638601   0.488073  -3.357 0.000792 ***
vessel_105                       -1.062931   0.263109  -4.040 5.41e-05 ***
vessel_106                       -1.819114   0.271396  -6.703 2.23e-11 ***
vessel_108                       -2.905165   0.324715  -8.947  < 2e-16 ***
vessel_110                       -2.303847   0.266688  -8.639  < 2e-16 ***
vessel_111                       -2.502640   0.271951  -9.203  < 2e-16 ***
vessel_114                       -1.073166   0.257148  -4.173 3.04e-05 ***
vessel_116                       -2.044993   0.283686  -7.209 6.33e-13 ***
vessel_119                       -2.541115   0.260362  -9.760  < 2e-16 ***
vessel_120                       -1.307151   0.805820  -1.622 0.104825
vessel_121                       -1.964963   0.290175  -6.772 1.39e-11 ***
vessel_128                       -1.863676   0.380932  -4.892 1.02e-06 ***
vessel_133                       -2.788229   0.299968  -9.295  < 2e-16 ***
vessel_142                        1.117555   0.595393   1.877 0.060565 .
vessel_144                       -1.032582   0.256067  -4.032 5.59e-05 ***
vessel_147                       -1.520643   0.288521  -5.270 1.41e-07 ***
vessel_148                       -1.282706   0.287672  -4.459 8.38e-06 ***
period_2                         -0.982359   0.221910  -4.427 9.73e-06 ***
period_3                         -0.782111   0.229269  -3.411 0.000651 ***
period_4                         -0.210368   0.235481  -0.893 0.371704
period_5                         -0.163476   0.234840  -0.696 0.486383
period_6                          0.003907   0.233804   0.017 0.986668
period_7                         -0.016044   0.232498  -0.069 0.944986
period_8                          0.435276   0.230315   1.890 0.058816 .
Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
period_9                         -0.347850   0.224986  -1.546 0.122134
period_10                        -1.637549   0.228208  -7.176 8.05e-13 ***
period_11                        -1.379123   0.224704  -6.138 8.91e-10 ***
period_12                        -0.088818   0.227122  -0.391 0.695768
poly(log(duration), 3)1          14.156192   4.429920   3.196 0.001403 **
poly(log(duration), 3)2           2.221262   1.976682   1.124 0.261171
poly(log(duration), 3)3           1.903535   1.871459   1.017 0.309127
```

(cont…)

```
statarea_12                        0.320244   0.082937   3.861 0.000114 ***
statarea_13                        0.636996   0.083773   7.604 3.31e-14 ***
statarea_14                        0.609928   0.099490   6.131 9.30e-10 ***
statarea_15                        0.338794   0.157880   2.146 0.031921 *
statarea_16                       -0.174173   0.255270  -0.682 0.495069
poly(log(PPACEPr), 3)1            -4.831246   2.196860  -2.199 0.027904 *
poly(log(PPACEPr), 3)2            -8.060626   1.917385  -4.204 2.66e-05 ***
poly(log(PPACEPr), 3)3             8.353541   1.705783   4.897 9.97e-07 ***
poly(log(ACECatchr), 3)1         -33.456786  13.172152  -2.540 0.011111 *
poly(log(ACECatchr), 3)2          10.296339   8.590442   1.199 0.230737
poly(log(ACECatchr), 3)3         -10.166771   3.477684  -2.923 0.003475 **
poly(log(ACEchgr), 3)1            35.408778  14.993330   2.362 0.018226 *
poly(log(ACEchgr), 3)2            -1.780103   7.131196  -0.250 0.802888
poly(log(ACEchgr), 3)3            -3.854365   1.799857  -2.141 0.032274 *
poly(log(tows), 3)1               19.957356   4.439994   4.495 7.09e-06 ***
poly(log(tows), 3)2               -1.508642   2.047324  -0.737 0.461221
poly(log(tows), 3)3               -2.192499   1.592714  -1.377 0.168692
structure_opportunistic            0.211811   0.080597   2.628 0.008609 **
structure_vertically integrated  -0.205435   0.090048  -2.281 0.022560 *
strategy_opportunistic             0.133569   0.074594   1.791 0.073405 .
strategy_vertically integrated     0.207238   0.082925   2.499 0.012476 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 2.324311)

    Null deviance: 22694  on 6201  degrees of freedom
Residual deviance: 14215  on 6116  degrees of freedom
AIC: 22919

Number of Fisher Scoring iterations: 2

R-squared: 37.36%
adjusted R-squared: 36.49%
AIC: 22918
Dispersion parameter for Gamma family taken to be 2.324
    Null deviance: 22694  on 6201  degrees of freedom
Residual deviance: 14215  on 6116  degrees of freedom
```

6. SUMMARY AND RECOMMENDATIONS

In this paper, the explanatory power of selected economic variables that might confound the CPUE-abundance relationship was tested. To do so, first the fishing permit holders' strategic behaviour and their structure over time were characterised. Secondly, a few indicators were selected based on their relevance in the context of this analysis. Various ratios involving ACE prices, surveyed port prices, deemed value and relative changes in catch and ACE between periods over time were also included. This was a first attempt to introduce such concepts to the Stock Assessment Methods Working Group (SAMWG). For each segment and despite the shorter time frame, this study replicates the general trends shown in the previous CPUE analysis conducted by Trophia using the more "traditional" approach.

The results suggest that in each of the eight segments analysed, it was possible to identify relationships between CPUE and one or more of the economic variables included in the model. One or more economic variables were selected in every stepwise process run on each segment, thus supporting somewhat the relevance of using such an approach. However, in no instance did the addition of the economic variables result in a significant change to the final standardised CPUE indices. Although the economic variables may not have contributed significantly, at least part of the reason may be the poor quality of the economic data. This highlights the importance of extending this work and the need to improve the quality and collection of useful economic information.

Another suggestion for future work is to narrow the data to the core fishing permit holders instead of the core vessels. If economic behaviour on the water is highly influenced by the fishing permit holders, the models should reflect this.

Furthermore it would be useful to generate a proxy that measures any comparative advantage between vessel/ year to reflect other differences such as skipper / crew skill, level of sophistication of electronics/ fish finders on board, gear settings, etc. In other words, it may be possible to improve the model by including some measure of skipper's skill and any other measures of comparative advantages not accounted for by the vessel's physical characteristics and the permit holder's strategic behaviour and structure. To test this assumption, one could use an approach similar to that in Lallemand (2009) where a variable representing "skill" was derived from the regression's residual means and was tested for statistical significance before determining the most likely fishing operation's skill level. In other words, the residuals derived from the regression can be used to approximate the individuals' skill level associated with their catch, often referred to as the "skipper effect". Because the generalized linear model should in essence capture the effects that can be attributed to strategic behaviour, structure, vessel, effort, seasonal and geographic characteristics as well as biomass through the year effect, the residuals should be white noise. However, the magnitude of the residuals can be tested for each vessel to see whether there is any consistency in the catch level in a given year and between years throughout the whole period. To test this hypothesis, the residuals associated with a specific vessel could be examined to determine whether they are consistently and statistically either below, equal to or above the mean residuals of the whole sample. The results can then be used to identify, for each vessel, patterns that may be associated with skill level.

Finally further work could be conducted to identify associations of registered clients. The analysis only took into account the information on included persons provided by FishServe to make an educated guess about the type of relationships between clients. However there are other "undeclared" types of association not necessarily identified here. One kind of association that comes to mind describes a company's subsidiary in charge of quota management for the mother company. Identifying those associations along with those from the "included persons rule" declaration would improve estimation of the strategy and structure indices of the fishing permit holders. Nonetheless, by systematically analysing the source of ACE acquired by the fishing permit holder, the most obvious relationships should have been taken into account[2].

[2] Although without refined information on registered clients' connection to others, a fishing permit holder's strategy may have been incorrectly labelled "contracted" when it should have been identified as "vertically integrated".

7. ACKNOWLEDGMENT

This work was funded by the New Zealand Ministry of Primary Industries -Fisheries (MPI) under project number SSP 2011-03. Thanks to Dr. Pamela Mace (MPI) and Dr. Marc Griffiths (MPI) for supporting this project and for their helpful suggestions early on. A special mention goes to Nokome Bentley (Trophia) whose encouragement and advice was crucial in completing this work. I am very grateful to Craig Loveridge and other staff from RDM-MPI for their diligence in providing the comprehensive and often complex data extracts required for this project. Last but not least, I'd like to thank Dr. Kevin Sullivan (MPI), Marianne Vignaux (MPI) who reviewed this work, Tom McClurgh (Toroa Strategy), Paul Starr (Starrfish), Terese Kendrick (Trophia), Chris Francis (NIWA) and Wayne Lowther (FishServe) for their useful comments.

8. REFERENCES

Bentley, N.; Kendrick, T. H.; Starr, P. J.; Breen, P.A. (2012). Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardizations. *ICES Journal of Marine Science, 69:* 84–88.

FishServe Register Extracts Database (2001–2011).

FishServe's Blue Book (2001–2011)

Kendrick, T.H.; Bentley, N. (2010a). Fishery characterisation and Catch-Per-Unit-Effort indices for snapper in SNA 2; 1989–90 to 2008–09. March 2010. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2010b). Fishery characterisation and Catch-Per-Unit-Effort indices for snapper in SNA 2; 1989–90 to 2008–09 (BT.MIX). Draft Research Progress Report for Specific Objective 1 of project SNA2009-01 - SNA 2 Stock assessment. March 2010. . (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011a). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for flatfish (FLA 2) from bottom trawling targetting flatfish (BT.FLA). 28 June 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011b). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for flatfish (FLA 2) from bottom trawling targetting gurnard, snapper or trevally (BT.GUR|SNA|TRE). 28 June 2011. . (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011c). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for red gurnard (GUR 2) from bottom trawling targetting gurnard, snapper or trevally (BT.GUR|SNA|TRE). 14 April 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011d). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for red gurnard (GUR 2) from bottom trawling targetting tarakihi (BT.TAR). 14 April 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011e). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for tarakihi (TAR 2) from bottom trawling targetting tarakihi (BT.TAR). 14 April 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011f). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for trevally (TRE 2) from bottom trawling targetting gurnard, snapper or trevally (BT.GUR|SNA|TRE). 14 April 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Kendrick, T.H.; Bentley, N. (2011g). Draft report to the Northern Inshore Stock Assessment Working Group (NINS WG). CPUE for trevally (TRE 2) from bottom trawling targetting tarakihi (BT.TAR). 14 April 2011. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Lallemand, P. (2009). Forecasting Fishing Vessels' Costs And Earnings. A Synthetic Approach Applied to the Trawl Fleet of The United States' Northeast Regions. Verlag Dr. Muller Aktiengesellschaft & Co. 428 p.

Ministry of Fisheries. Annual Prices survey and deemed values (2001–2011)

Reserve Bank of New Zealand website: long term deposit rates and Government 10 years bonds.

Starr, P.J. (2007). Procedure for merging MFish landing and effort data. Version 2.0. Report submitted to the Ministry of Fisheries Adaptive Management Programme Working Group in March 2007 AMP-WG-07/04. 17 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

9. LIST OF TABLES

Table 1: Proportion of permit holders who own quota by Fishstock and fishing year. 22
Table 2: Risk and Growth Free Quota value ($/t) by Fishstock and fishing year calculated from the Present Value of observed annual ACE returns discounted at the risk-free rate of 6%. 24
Table 3: Average Observed Quota value ($/t) by Fishstock and fishing year. 24
Table 4: Risk and Growth Free Quota value ($) by Fishstock and fishing year calculated by multiplying the risk and growth free quota value per tonne by the TACC. 25
Table 5: Observed Quota value ($) by Fishstock and fishing year calculated by multiplying the observed average quota value per tonne by the TACC. 25
Table 6: Annual ACE Holdings (t) by Fishstock and fishing year. 26
Table 7: Quantity of ACE (t) carried forward by Fishstock and fishing year. 26
Table 8: Quantity of ACE carried forward as a percent of TACC by Fishstock and fishing year. 26
Table 9: Average annual ACE Price ($/kg) at a glance by Fishstock and fishing year. 27
Table 10: Quantity of ACE Traded (t) by Fishstock and fishing year. 30
Table 11: Ratio between volume of ACE traded and available ACE by Fishstock and fishing year. 30
Table 12: Ratio between volume of ACE traded and TACC by Fishstock and fishing year. 30
Table 13 TACC (t) by Fishstock and fishing year. 61
Table 15. Comparison of catch and TACC in tonnes by Fishstock and fishing year. 62
Table 16: Estimated Forgone Revenue by Fishstock and fishing year. 65
Table 17: Operators' Over-Catch in tons (i.e. Catch-ACE) by Fishstock and fishing year. 67
Table 18: Estimated Deemed Value paid by Fishstock and fishing year. 66
Table 19: Number of Operators paying Deemed Value by Fishstock and fishing year. 66
Table 20: Surveyed Port Prices by Fishstock and fishing year. 66
Table 21: Comparative data scope used in the two models: traditional approach and the method incorporating economics. 82
Table 22: Summary of the regression models used in the traditional CPUE analysis compared with the CPUE analysis incorporating economics. 85
Table 23: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (FLA_BT_FLA). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 89
Table 24: Summary of the influence of each term in the standardisation model (FLA_BT_FLA). 89
Table 25: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (FLA_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 99
Table 26: Summary of the influence of each term in the standardisation model (FLA_BT_MIX). 99
Table 27: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (GUR_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 112
Table 28: Summary of the influence of each term in the standardisation model (GUR_BT_MIX). 112
Table 29: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (GUR_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 124
Table 30: Summary of the influence of each term in the standardisation model (GUR_BT_TAR). 124
Table 31: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (SNA_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 136
Table 32: Summary of the influence of each term in the standardisation model (SNA_BT_MIX). 136
Table 33: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TAR_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 149
Table 34: Summary of the influence of each term in the standardisation model (TAR_BT_TAR). 149
Table 35: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TRE_BT_MIX). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level. 161
Table 36: Summary of the influence of each term in the standardisation model (TRE_BT_MIX). 161

Table 37: Summary of stepwise selection. Model terms are listed in order of acceptance to the model (TRE_BT_TAR). AIC: Akaike Information Criterion; *: Term considered significant at the threshold level....174
Table 38: Summary of the influence of each term in the standardisation model (TRE_BT_TAR). 174
Table 39: Deemed value rates ($/kg) by % Range catch over ACE, Fishstock and fishing year....198

10. LIST OF FIGURES

Figure 1: Fisheries Quota Management Area 2, Central-East. 2
Figure 2: Structure of Independent quota-owner permit holders. 8
Figure 3: Structure of contracted permit holders. 9
Figure 4: Structure of vertically integrated permit holders. 10
Figure 5: Structure of Opportunistic permit holders. 11
Figure 6: Diagram showing the relations linking the tables used to model CPUE. 13
Figure 7: Trends in the number of quota owners and concentration of quota by Fishstock and fishing year. .. 21
Figure 8: Trends in the number of quota owners and proportion of those who hold fishing permits by Fishstock and fishing year. 22
Figure 9: Calculated Underlying Discount Rate from observed Quota value and ACE price by Fishstock and fishing year. 25
Figure 10: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for FLA 2 (flatfish) between fishing years 2003–04 and 2009–10. 27
Figure 11: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for GUR 2 (red gurnard) between fishing years 2003–04 and 2009–10. 28
Figure 12: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for SNA 2 (snapper) between fishing years 2003–04 and 2009–10. 28
Figure 13: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for TAR 2 (tarakihi) between fishing years 2003–04 and 2009–10. 29
Figure 14: Monthly trends of high, low, average ACE price and annual deemed value and surveyed port prices for TRE 2 (trevally) between fishing years 2003–04 and 2009–10. 29
Figure 15: Trends in monthly catch, quantity and numbers of ACE traded for FLA 2 (flatfish) between 2003–04 and 2009–10. 31
Figure 16: Trends in monthly catch, quantity and numbers of ACE traded for GUR 2 (red gurnard) between 2003–04 and 2009–10. 31
Figure 17: Trends in monthly catch, quantity and numbers of ACE traded for SNA 2 (snapper) between 2003–04 and 2009–10. 32
Figure 18: Trends in monthly catch, quantity and numbers of ACE traded for TAR 2 (tarakihi) between 2003–04 and 2009–10. 32
Figure 19: Trends in monthly catch, quantity and numbers of ACE traded for TRE 2 (trevally) between 2003–04 and 2009–10. 33
Figure 20: Trends in the total number of permit holders and proportion with and without quota by Fishstock and fishing year. 34
Figure 21: Trends in the number of fishing permit holders and proportion with and without included person by Fishstock and fishing year. 35
Figure 22: Trends in the number of permit holders and their structure types by Fishstock and fishing year. 36
Figure 23: Trend in the number of vessels and proportion operated under a) quota owner FPH, b) ACE dependent FPH, c) both types of FPH by Fishstock and fishing year. 37
Figure 24: Trend in the number of vessels and the mixed strategies they are operated under by segment and fishing year. 38
Figure 25: Trends in total number of aggregated records by stratum in each vessel length range for FLA 2..... 39
Figure 26: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for FLA 2. 40
Figure 27: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for FLA 2. 40
Figure 28: Trends in total number of aggregated records by stratum in each vessel length range for GUR 2.... 41
Figure 29: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for GUR 2. 41
Figure 30: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for GUR 2. 42
Figure 31: Trends in total number of aggregated records by stratum in each vessel length range for SNA 2. ... 43
Figure 32: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for SNA 2. 43
Figure 33: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for SNA 2. 44

Figure 34: Trends in total number of aggregated records by stratum in each vessel length range for TAR 2. ... 45
Figure 35: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for TAR 2. ... 45
Figure 36: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for TAR 2. ... 46
Figure 37: Trends in total number of aggregated records by stratum in each vessel length range for TRE 2. ... 47
Figure 38: Trends in total duration (hours) of aggregated records by stratum in each vessel length range for TRE 2. ... 47
Figure 39: Trends in the average duration (hours) of aggregated records by stratum in each vessel length range for TRE 2. ... 48
Figure 40: Trends in observed strategic behaviour for all strata by segment and fishing year. ... 50
Figure 41: FLA 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10. ... 51
Figure 42: FLA 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10. ... 51
Figure 43: FLA 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10. ... 52
Figure 44: GUR 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10. ... 53
Figure 45: GUR 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10. ... 53
Figure 46: GUR 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10. ... 54
Figure 47: SNA 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10. ... 55
Figure 48: SNA 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10. ... 55
Figure 49: SNA 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10. ... 56
Figure 50: TAR 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10. ... 57
Figure 51: TAR 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10. ... 57
Figure 52: TAR 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10. ... 58
Figure 53: TRE 2's ACE price distribution from clients exhibiting "independent, opportunistic or ad hoc" strategic behaviour between fishing years 2003–04 and 2009–10. ... 59
Figure 54: TRE 2's ACE price distribution from clients exhibiting "contracted" strategic behaviour between fishing years 2003–04 and 2009–10. ... 59
Figure 55: TRE 2's ACE price distribution from clients exhibiting "vertically integrated" strategic behaviour between fishing years 2003–04 and 2009–10. ... 60
Figure 56: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for FLA 2 (flatfish) between fishing years 2003–04 and 2009–10. ... 62
Figure 57: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for GUR 2 (red gurnard) between fishing years 2003–04 and 2009–10. ... 63
Figure 58: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for SNA 2 (snapper) between fishing years 2003–04 and 2009–10. ... 63
Figure 59: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for TAR 2 (tarakihi) between fishing years 2003–04 and 2009–10. ... 64
Figure 60: Monthly trend in quantity and number of ACE trades, cumulative catch and TACC for TRE 2 (trevally) between fishing years 2003–04 and 2009–10. ... 64
Figure 61: Trend in total deemed value payment by Fishstock and fishing year. ... 65
Figure 62: Trend in FLA 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10. ... 67
Figure 63: Trend in GUR 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10. ... 68
Figure 64: Trend in SNA 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2008–09. ... 68
Figure 65: Trend in TAR 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10. ... 69

Figure 66: Trend in TRE 2 standardised CPUE indices compared with underlying discount rate between 2001–02 and 2009–10. 69
Figure 67: Trend in FLA 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.......... 70
Figure 68: Trend in GUR 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.......... 71
Figure 69: Trend in SNA 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.......... 72
Figure 70: Trend in TAR 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.......... 73
Figure 71: Trend in TRE 2 standardised CPUE indices compared with deemed value, ACE and port prices between 2001–02 and 2009–10.......... 74
Figure 72: Trend in FLA 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10. 75
Figure 73: Trend in GUR 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10. 75
Figure 74: Trend in SNA 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10. 76
Figure 75: Trend in TAR 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10. 76
Figure 76: Trend in TRE 2 standardised CPUE indices compared with deemed value paid between 2001–02 and 2009–10. 77
Figure 77: Trend in FLA 2 standardised CPUE indices compared with percentage difference in deemed value paid between 2001–02 and 2009–10. 78
Figure 78: Trend in GUR 2 standardised CPUE indices compared with percentage difference in deemed value paid between 2001–02 and 2009–10. 78
Figure 79: Trend in SNA 2 standardised CPUE indices compared with percentage difference in deemed value paid between 2001–02 and 2009–10. 79
Figure 80: Trend in TAR 2 standardised CPUE indices compared with percentage difference in deemed value paid between 2001–02 and 2009–10. 79
Figure 81: Trend in TRE 2 standardised CPUE indices compared with percentage difference in deemed value paid between 2001–02 and 2009–10. 80
Figure 82: Comparison of FLA_BT_FLA standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 87
Figure 83: Histograms of Catch-Effort data for all strata included in the “FLA_BT_FLA” CPUE model. 88
Figure 84: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “FLA_BT_FLA” CPUE model. 88
Figure 85: Coefficient-distribution-influence plot for “poly(duration, 3)” (FLA_BT_FLA). 90
Figure 86: Coefficient-distribution-influence plot for “vessel” (FLA_BT_FLA). 90
Figure 87: Coefficient-distribution-influence plot for “poly(tows, 3)” (FLA_BT_FLA). 91
Figure 88: Coefficient-distribution-influence plot for “period” (FLA_BT_FLA). 91
Figure 89: Coefficient-distribution-influence plot for “statsarea” (FLA_BT_FLA). 92
Figure 90: Coefficient-distribution-influence plot for “strategy” (FLA_BT_FLA). 92
Figure 91: Coefficient-distribution-influence plot for “ACEchgr” (FLA_BT_FLA). 93
Figure 92: Annual influence for each term in the model (FLA_BT_FLA). 93
Figure 93: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (FLA_BT_FLA). 94
Figure 94: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution.', Bottom left: quantile-quantile plot of standardised residuals.Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (FLA_BT_FLA). 95
Figure 95: Comparison of FLA_BT_MIX standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 97
Figure 96: Histograms of Catch-Effort data for all strata included in the “FLA_BT_MIX” CPUE model. 98
Figure 97: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “FLA_BT_MIX” CPUE model. 98
Figure 98: Coefficient-distribution-influence plot for “vessel ” (FLA_BT_MIX). 100
Figure 99: Coefficient-distribution-influence plot for “tows” (FLA_BT_MIX). 100
Figure 100: Coefficient-distribution-influence plot for “statarea” (FLA_BT_MIX). 101
Figure 101: Coefficient-distribution-influence plot for “period” (FLA_BT_MIX). 101

Figure 102: Coefficient-distribution-influence plot for “structure” (FLA_BT_MIX).......................................102
Figure 103: Coefficient-distribution-influence plot for “target” (FLA_BT_MIX). 102
Figure 104: Coefficient-distribution-influence plot for “ACECatchr” (FLA_BT_MIX). 103
Figure 105: Coefficient-distribution-influence plot for “duration” (FLA_BT_MIX). 103
Figure 106: Coefficient-distribution-influence plot for “strategy” (FLA_BT_MIX)..104
Figure 107: Coefficient-distribution-influence plot for “PPACEPr” (FLA_BT_MIX)....................................104
Figure 108: Coefficient-distribution-influence plot for “ACEPDVr” (FLA_BT_MIX). 105
Figure 109: Coefficient-distribution-influence plot for “ACEchgr” (FLA_BT_MIX). 105
Figure 110: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (FLA_BT_MIX)................................106
Figure 111: Annual influence for each term in the model (FLA_BT_MIX). 106
Figure 112: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (FLA_BT_MIX). 107
Figure 113: Comparison of GUR_BT_MIX Standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 110
Figure 114: Histograms of Catch-Effort data for all strata included in the “GUR_BT_MIX” CPUE model. 111
Figure 115: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “GUR_BT_MIX” CPUE model...111
Figure 116: Coefficient-distribution-influence plot for “vessel” (GUR_BT_MIX)..113
Figure 117: Coefficient-distribution-influence plot for “duration” (GUR_BT_MIX). 113
Figure 118: Coefficient-distribution-influence plot for “period” (GUR_BT_MIX). 114
Figure 119: Coefficient-distribution-influence plot for “target” (GUR_BT_MIX). 114
Figure 120: Coefficient-distribution-influence plot for “tows” (GUR_BT_MIX)..115
Figure 121: Coefficient-distribution-influence plot for “statarea” (GUR_BT_MIX). 115
Figure 122: Coefficient-distribution-influence plot for “PPACEPr” (GUR_BT_MIX)...................................116
Figure 123: Coefficient-distribution-influence plot for “ACECatchr” (GUR_BT_MIX). 116
Figure 124: Coefficient-distribution-influence plot for “mDVcv” (GUR_BT_MIX)..117
Figure 125: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (GUR_BT_MIX)...............................117
Figure 126: Annual influence for each term in the model (GUR_BT_MIX). 118
Figure 127: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (GUR_BT_MIX). 119
Figure 128: Comparison of GUR_BT_TAR Standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 122
Figure 129: Histograms of Catch-Effort data for all strata included in the “GUR_BT_TAR” CPUE model......123
Figure 130: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “GUR_BT_TAR” CPUE model...123
Figure 131: Coefficient-distribution-influence plot for “vessel” (GUR_BT_TAR). 125
Figure 132: Coefficient-distribution-influence plot for “duration” (GUR_BT_TAR). 125
Figure 133: Coefficient-distribution-influence plot for “statarea” (GUR_BT_TAR). 126
Figure 134: Coefficient-distribution-influence plot for “period” (GUR_BT_TAR). 126
Figure 135: Coefficient-distribution-influence plot for “tows” (GUR_BT_TAR)..127
Figure 136: Coefficient-distribution-influence plot for “ACEchgr” (GUR_BT_TAR). 127
Figure 137: Coefficient-distribution-influence plot for “PPACEPr” (GUR_BT_TAR). 128
Figure 138: Coefficient-distribution-influence plot for “ACECatchr” (GUR_BT_TAR). 128
Figure 139: Coefficient-distribution-influence plot for “strategy” (GUR_BT_TAR).......................................129
Figure 140: Coefficient-distribution-influence plot for “structure” (GUR_BT_TAR). 129
Figure 141: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (GUR_BT_TAR)................................130
Figure 142: Annual influence for each term in the model (GUR_BT_TAR). 130
Figure 143: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (GUR_BT_TAR). 131
Figure 144: Comparisonn of SNA_BT_MIX Standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 134

Figure 145: Histograms of Catch-Effort data for all strata included in the “SNA_BT_MIX” CPUE model. 135
Figure 146: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “SNA_BT_MIX” CPUE model. 135
Figure 147: Coefficient-distribution-influence plot for “statarea” (SNA_BT_MIX).....137
Figure 148: Coefficient-distribution-influence plot for “vessel” (SNA_BT_MIX).....137
Figure 149: Coefficient-distribution-influence plot for “target” (SNA_BT_MIX).....138
Figure 150: Coefficient-distribution-influence plot for “tows” (SNA_BT_MIX).....138
Figure 151: Coefficient-distribution-influence plot for “period” (SNA_BT_MIX).....139
Figure 152: Coefficient-distribution-influence plot for “ACEchgr” (SNA_BT_MIX).....139
Figure 153: Coefficient-distribution-influence plot for “duration” (SNA_BT_MIX).....140
Figure 154: Coefficient-distribution-influence plot for “PPACEPr” (SNA_BT_MIX).....140
Figure 155: Coefficient-distribution-influence plot for “ACECatchr” (SNA_BT_MIX).....141
Figure 156: Coefficient-distribution-influence plot for “strategy” (SNA_BT_MIX).....141
Figure 157: Coefficient-distribution-influence plot for “structure” (SNA_BT_MIX).....142
Figure 158: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (SNA_BT_MIX).....142
Figure 159: Annual influence for each term in the model (SNA_BT_MIX).....143
Figure 160: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (SNA_BT_MIX).....144
Figure 161: Comparison of TAR_BT_TAR Standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.....147
Figure 162: Histograms of Catch-Effort data for all strata included in the “TAR_BT_TAR” CPUE model. 148
Figure 163: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “TAR_BT_TAR” CPUE model. 148
Figure 164: Coefficient-distribution-influence plot for “tows” (TAR_BT_TAR).....150
Figure 165: Coefficient-distribution-influence plot for “vessel” (TAR_BT_TAR).....150
Figure 166: Coefficient-distribution-influence plot for “period” (TAR_BT_TAR).....151
Figure 167: Coefficient-distribution-influence plot for “statarea” (TAR_BT_TAR).....151
Figure 168: Coefficient-distribution-influence plot for “duration” (TAR_BT_TAR).....152
Figure 169: Coefficient-distribution-influence plot for “mDVcv” (TAR_BT_TAR).....152
Figure 170: Coefficient-distribution-influence plot for “ACECatchr” (TAR_BT_TAR).....153
Figure 171: Coefficient-distribution-influence plot for “strategy” (TAR_BT_TAR).....153
Figure 172: Coefficient-distribution-influence plot for “ACEchgr” (TAR_BT_TAR).....154
Figure 173: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TAR_BT_TAR).....154
Figure 174: Annual influence for each term in the model (TAR_BT_TAR).....155
Figure 175: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TAR_BT_TAR).....156
Figure 176: Comparison of TRE_BT_MIX Standardised CPUE indices: Trophia’s index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1.....159
Figure 177: Histograms of Catch-Effort data for all strata included in the “TRE_BT_MIX” CPUE model.....160
Figure 178: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the “TRE_BT_MIX” CPUE model.....160
Figure 179: Coefficient-distribution-influence plot for “vessel” (TRE_BT_MIX).....162
Figure 180: Coefficient-distribution-influence plot for “period” (TRE_BT_MIX).....162
Figure 181: Coefficient-distribution-influence plot for “tows” (TRE_BT_MIX).....163
Figure 182: Coefficient-distribution-influence plot for “target” (TRE_BT_MIX).....163
Figure 183: Coefficient-distribution-influence plot for “structure” (TRE_BT_MIX).....164
Figure 184: Coefficient-distribution-influence plot for “duration” (TRE_BT_MIX).....164
Figure 185: Coefficient-distribution-influence plot for “PPACEPr” (TRE_BT_MIX).....165
Figure 186: Coefficient-distribution-influence plot for “statarea” (TRE_BT_MIX).....165
Figure 187: Coefficient-distribution-influence plot for “strategy” (TRE_BT_MIX).....166
Figure 188: Coefficient-distribution-influence plot for “ACEchgr” (TRE_BT_MIX).....166
Figure 189: Coefficient-distribution-influence plot for “ACECatchr” (TRE_BT_MIX).....167
Figure 190: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TRE_BT_MIX).....167

Figure 191: Annual influence for each term in the model (TRE_BT_MIX). 168
Figure 192: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TRE_BT_MIX). 169
Figure 193: Comparison of TRE_BT_TAR Standardised CPUE indices: Trophia's index, New Base and CPUE Including Economics. The indices are normalised to an overall geometric mean of 1. 172
Figure 194: Histograms of Catch-Effort data for all strata included in the "TRE_BT_TAR" CPUE model.......173
Figure 195: Histograms of vessel characteristics, permit holders and their strategic behaviours and structure for all strata included in the "TRE_BT_TAR" CPUE model...173
Figure 196: Coefficient-distribution-influence plot for "vessel" (TRE_BT_TAR). 175
Figure 197: Coefficient-distribution-influence plot for "period" (TRE_BT_TAR)...175
Figure 198: Coefficient-distribution-influence plot for "duration" (TRE_BT_TAR).......................................176
Figure 199: Coefficient-distribution-influence plot for "statarea" (TRE_BT_TAR)..176
Figure 200: Coefficient-distribution-influence plot for "PPACEPr" (TRE_BT_TAR). 177
Figure 201: Coefficient-distribution-influence plot for "ACECatchr" (TRE_BT_TAR)..................................177
Figure 202: Coefficient-distribution-influence plot for "ACEchgr" (TRE_BT_TAR). 178
Figure 203: Coefficient-distribution-influence plot for "tows" (TRE_BT_TAR). 178
Figure 204: Coefficient-distribution-influence plot for "structure" (TRE_BT_TAR). 179
Figure 205: Coefficient-distribution-influence plot for "strategy" (TRE_BT_TAR). 179
Figure 206: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort. (TRE_BT_TAR). 180
Figure 207: Annual influence for each term in the model (TRE_BT_TAR). 180
Figure 208: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values. (TRE_BT_TAR). 181
Figure 209: Trend in FLA 2 over catch as a % of catch between the fishing years 2001–02 and 2009–10. 199
Figure 210: Trend in GUR 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10...200
Figure 211: Trend in SNA 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10...201
Figure 212: Trend in TAR 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10...201
Figure 213: Trend in TRE 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10. 202
Figure 214: Annual high, low, average Quota Prices for FLA 2 (flatfish) fishing years 2001–02 to 2010–11. ..203
Figure 215: Annual Quantity of Quota traded and transferred Quotas for FLA 2 (flatfish) fishing years 2001–02 to 2010–11. 203
Figure 216: Annual trend in Quota quantity traded versus average Quota price for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11...204
Figure 217: Annual high, low, average Quota Prices for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11...205
Figure 218: Annual Quantity of Quota traded and transferred Quotas for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11...205
Figure 219: Annual trend in Quota quantity traded versus average Quota price for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11. 206
Figure 220: Annual high, low, average Quota Prices for SNA 2 (snapper) fishing years 2001–02 to 2010–11..207
Figure 221: Annual Quantity of Quota traded and transferred Quotas for SNA 2 (snapper) for fishing years 2001–02 to 2010–11...207
Figure 222: Annual trend in Quota quantity traded versus average Quota price for SNA 2 (snapper) for fishing years 2001–02 to 2010–11. 208
Figure 223: Annual high, low, average Quota Prices for TAR 2 (tarakihi) fishing years 2001–02 to 2010–11..209
Figure 224: Annual Quantity of Quota traded and transferred Quotas for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11...209
Figure 225: Annual trend in Quota quantity traded versus average Quota price for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11. 210
Figure 226: Annual high, low, average Quota Prices for TRE 2 (trevally) fishing years 2001–02 to 2010–11. .211
Figure 227: Annual Quantity of Quota traded and transferred Quotas for TRE 2 (trevally) for fishing years 2001–02 to 2010–11...211

Figure 228: Annual trend in Quota quantity traded versus average Quota price for TRE 2 (trevally) for fishing years 2001–02 to 2010–11. 212
Figure 229: Annual high, low, average ACE Prices for FLA 2 (flatfish) fishing years 2001–02 to 2010–11. 213
Figure 230: Annual Quantity of ACE traded and transferred ACE for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11. 213
Figure 231: Annual trend of quantity of ACE traded versus average ACE price for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11. 214
Figure 232: Annual high, low, average ACE Prices for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11....215
Figure 233: Annual Quantity of ACE traded and transferred ACE for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11....215
Figure 234: Annual trend of quantity of ACE traded versus average ACE price for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11. 216
Figure 235: Annual high, low, average ACE Prices for SNA 2 (snapper) for fishing years 2001–02 to 2010–11. 217
Figure 236: Annual Quantity of ACE traded and transferred ACE for SNA 2 (snapper) for fishing years 2001–02 to 2010–11....217
Figure 237: Annual trend of quantity of ACE traded versus average ACE price for SNA 2 (snapper) for fishing years 2001–02 to 2010–11. 218
Figure 238: Annual high, low, average ACE Prices for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11. 219
Figure 239: Annual Quantity of ACE traded and transferred ACE for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11....219
Figure 240: Annual trend of quantity of ACE traded versus average ACE price for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11 220
Figure 241: Annual high, low, average ACE Prices for TRE 2 (trevally) for fishing years 2001–02 to 2010–11. 221
Figure 242: Annual Quantity of ACE traded and transferred ACE for TRE 2 (trevally) for fishing years 2001–02 to 2010–11....221
Figure 243: Annual trend of quantity of ACE traded versus average ACE price for TRE 2 (trevally) for fishing years 2001–02 to 2010–11. 222
Figure 244: Step 1: Import the Groomed, Reconciled Catch-Effort and Landings data (GRCEL) provided by the Ministry and aggregate by stratum then merge with information on core vessels into table "C-E data with core vessels info". 223
Figure 245: Step 2: Import the vessel specifications (VS) data provided by the Ministry and merge with GRCEL into table "VesselSpecandOpbyFYMonth". 223
Figure 246: Step3: Import data provided by the Ministry on ACE transfers, Catch-ACE balancing, ACE and Quota Holdings (QAH). Merge data on associated person from FishServe, calculation on strategy and structure indexes with QAH, VS and GRCEL into new table (Rdata_ACEi). 224
Figure 247: Step4: merge "Rdata_ACEi" with info on deemed value rates, port price, price ratios, core associated clients into table "RData". 225

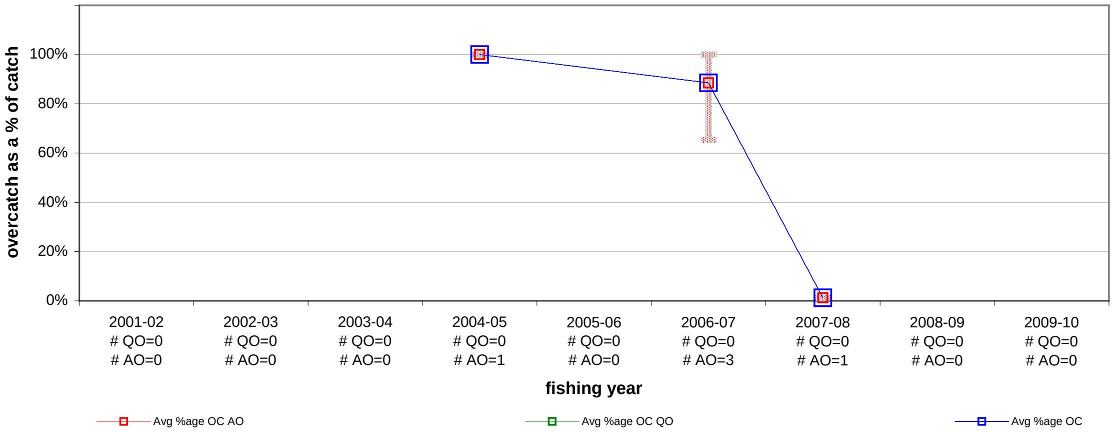
11. APPENDIX

Table 39: Deemed value rates ($/kg) by % Range catch over ACE, Fishstock and fishing year.

Fish Stock	Catch over ACE % range	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
FLA2	Interim	0.680	0.680	0.680	0.680	0.680	0.680	0.680
	[100,105[	1.360	1.360	1.360	1.360	1.360	1.360	1.360
	[105,110[	1.360	1.360	1.360	1.360	1.360	1.360	1.360
	[110,120[	1.360	1.360	1.360	1.360	1.360	1.360	1.360
	[120,125[	1.632	1.632	1.632	1.632	1.632	1.632	1.632
	[125,130[	1.632	1.632	1.632	1.632	1.632	1.632	1.632
	[130,140[	1.632	1.632	1.632	1.632	1.632	1.632	1.632
	[140,150[	1.904	1.904	1.904	1.904	1.904	1.904	1.904
	[150,160[	1.904	1.904	1.904	1.904	1.904	1.904	1.904
	[160,170[	2.176	2.176	2.176	2.176	2.176	2.176	2.176
	[170,180[	2.176	2.176	2.176	2.176	2.176	2.176	2.176
	[180,190[	2.176	2.176	2.176	2.176	2.448	2.448	2.448
	[190,200[	2.448	2.448	2.448	2.448	2.448	2.448	2.448
	[200,∞[	2.720	2.720	2.720	2.720	2.720	2.720	2.720
GUR2	Interim	0.620	0.620	0.620	0.620	0.620	0.620	0.620
	[100,105[	1.240	1.240	1.240	1.240	1.240	1.240	1.240
	[105,110[	1.240	1.240	1.240	1.240	1.240	1.240	1.240
	[110,120[	1.240	1.240	1.240	1.240	1.240	1.240	1.240
	[120,125[	1.488	1.488	1.488	1.488	1.488	1.488	1.488
	[125,130[	1.488	1.488	1.488	1.488	1.488	1.488	1.488
	[130,140[	1.488	1.488	1.488	1.488	1.488	1.488	1.488
	[140,150[	1.736	1.736	1.736	1.736	1.736	1.736	1.736
	[150,160[	1.736	1.736	1.736	1.736	1.736	1.736	1.736
	[160,170[	1.984	1.984	1.984	1.984	1.984	1.984	1.984
	[170,180[	1.984	1.984	1.984	1.984	1.984	1.984	1.984
	[180,190[	1.984	1.984	1.984	1.984	2.232	2.232	2.232
	[190,200[	2.232	2.232	2.232	2.232	2.232	2.232	2.232
	[200,∞[	2.480	2.480	2.480	2.480	2.480	2.480	2.480
SNA2	Interim	1.500	1.500	1.500	1.500	4.000	4.000	4.600
	[100,105[	3.000	3.000	3.000	3.000	5.000	5.000	5.600
	[105,110[	3.000	3.000	3.000	3.000	5.000	5.000	5.600
	[110,120[	3.000	3.000	3.000	3.000	9.000	9.000	9.600
	[120,125[	3.600	3.600	3.600	3.600	10.000	10.000	10.600
	[125,130[	3.600	3.600	3.600	3.600	10.000	10.000	10.600
	[130,140[	3.600	3.600	3.600	3.600	11.000	11.000	11.600
	[140,150[	4.200	4.200	4.200	4.200	12.000	12.000	12.600
	[150,160[	4.200	4.200	4.200	4.200	13.000	13.000	13.600
	[160,170[	4.800	4.800	4.800	4.800	14.000	14.000	14.600
	[170,180[	4.800	4.800	4.800	4.800	15.000	15.000	15.600
	[180,190[	4.800	4.800	4.800	4.800	16.000	16.000	16.600
	[190,200[	5.400	5.400	5.400	5.400	16.000	16.000	16.600
	[200,∞[	6.000	6.000	6.000	6.000	16.000	16.000	16.600
TAR2	Interim	0.790	0.790	0.790	0.790	1.250	1.250	1.380
	[100,105[	1.580	1.580	1.580	1.580	2.500	2.500	2.750
	[105,110[	1.580	1.580	1.580	1.580	2.500	2.500	2.750
	[110,120[	1.580	1.580	1.580	1.580	4.000	4.000	4.250
	[120,125[	1.896	1.896	1.896	1.896	5.500	5.500	5.750
	[125,130[	1.896	1.896	1.896	1.896	5.500	5.500	5.750
	[130,140[	1.896	1.896	1.896	1.896	5.500	5.500	5.750
	[140,150[	2.212	2.212	2.212	2.212	5.500	5.500	5.750
	[150,160[	2.212	2.212	2.212	2.212	5.500	5.500	5.750
	[160,170[	2.528	2.528	2.528	2.528	5.500	5.500	5.750
	[170,180[	2.528	2.528	2.528	2.528	5.500	5.500	5.750
	[180,190[	2.528	2.528	2.528	2.528	5.500	5.500	5.750
	[190,200[	2.844	2.844	2.844	2.844	5.500	5.500	5.750
	[200,∞[	3.160	3.160	3.160	3.160	5.500	5.500	5.750
TRE2	Interim	0.460	0.460	0.460	0.460	0.550	0.550	0.550
	[100,105[	0.920	0.920	0.920	0.920	1.100	1.100	1.100
	[105,110[	0.920	0.920	0.920	0.920	1.100	1.100	1.100
	[110,120[	0.920	0.920	0.920	0.920	2.000	2.000	2.000
	[120,125[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[125,130[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[130,140[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[140,150[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[150,160[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[160,170[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[170,180[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[180,190[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[190,200[	0.920	0.920	0.920	0.920	3.000	3.000	3.000
	[200,∞[	0.920	0.920	0.920	0.920	3.000	3.000	3.000

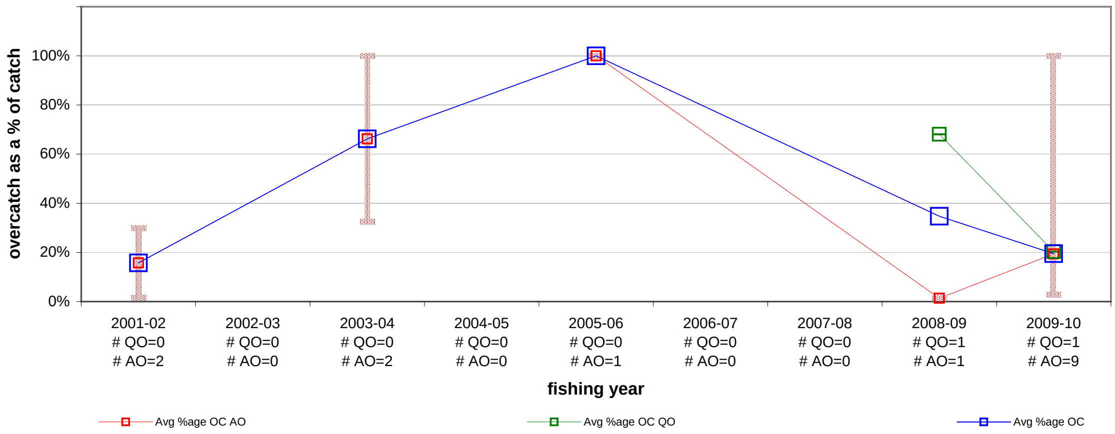
The following figures show for each of the five stocks the trend in overcatch between 2001 and 2010. To facilitate the comparison between years, the overcatch (OC) is expressed as a percentage of total catch for that year: that is, if the overcatch is 10% this means that 10% of the total catch came from overcatching (i.e. catch above the quantity of ACE held after balancing at the end of the fishing year). For each fishing year, the average amount overcaught (Avg OC) as well as the minimum (Min OC) and maximum (Max OC) are reported.

Also, trends are shown for both fishing permit holders who do not own quota (AO) and Quota-owner fishing permit holders (QO) separately as well as combined. For each year, below the year label the number of AO (# AO) and QO (# QO) who overcaught are shown. The summary table below each graph shows the actual range and total overcatch by type of fishing permit holder expressed in kilograms (Avg, Min, Max and Tot OC for QO and AO) and overall (Avg, Min, Max and Tot OC).



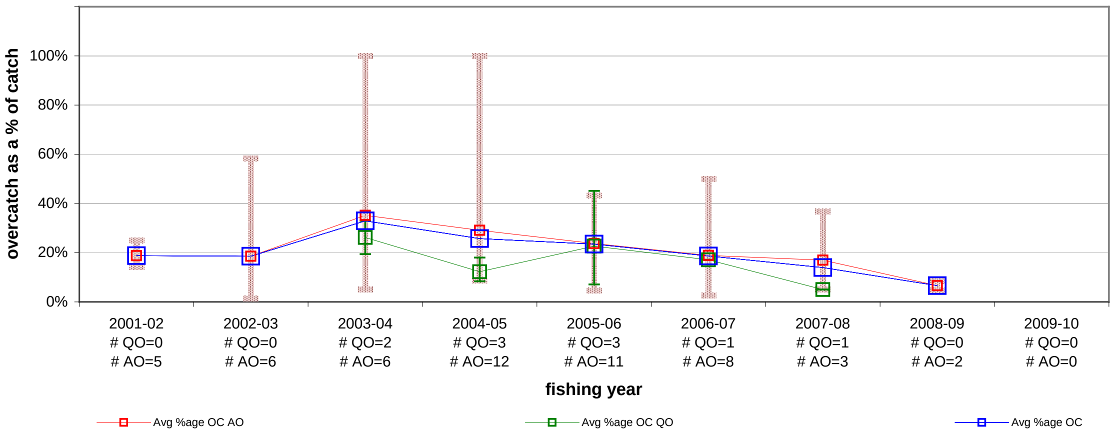
	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Min OC QO									
Avg OC QO									
Max OC QO									
Min OC AO				139 kg		95 kg	56 kg		
Avg OC AO				139 kg		262 kg	56 kg		
Max OC AO				139 kg		517 kg	56 kg		
Min OC				139 kg		95 kg	56 kg		
Avg OC				139 kg		262 kg	56 kg		
Max OC				139 kg		517 kg	56 kg		
Tot OC QO				0 kg		0 kg	0 kg		
Tot OC AO				139 kg		787 kg	56 kg		
Tot OC				139 kg		787 kg	56 kg		
%age OC QO				0.00%		0.00%	0.00%		

Figure 209: Trend in FLA 2 over catch as a % of catch between the fishing years 2001–02 and 2009–10.



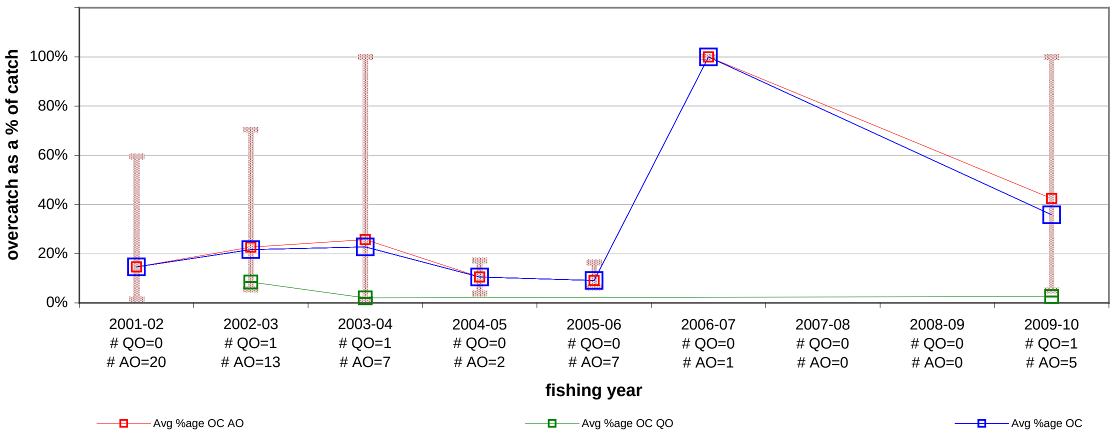
	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Min OC QO								145 kg	1,885 kg
Avg OC QO								145 kg	1,885 kg
Max OC QO								145 kg	1,885 kg
Min OC AO	66 kg		85 kg		425 kg			26 kg	251 kg
Avg OC AO	99 kg		465 kg		425 kg			26 kg	7,485 kg
Max OC AO	131 kg		844 kg		425 kg			26 kg	23,680 kg
Min OC	66 kg		85 kg		425 kg			26 kg	251 kg
Avg OC	99 kg		465 kg		425 kg			86 kg	6,925 kg
Max OC	131 kg		844 kg		425 kg			145 kg	23,680 kg
Tot OC QO	0 kg		0 kg		0 kg			145 kg	1,885 kg
Tot OC AO	197 kg		929 kg		425 kg			26 kg	67,361 kg
Tot OC	197 kg		929 kg		425 kg			171 kg	69,246 kg
%age OC QO	0.00%		0.00%		0.00%			84.80%	2.72%

Figure 210: Trend in GUR 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10.



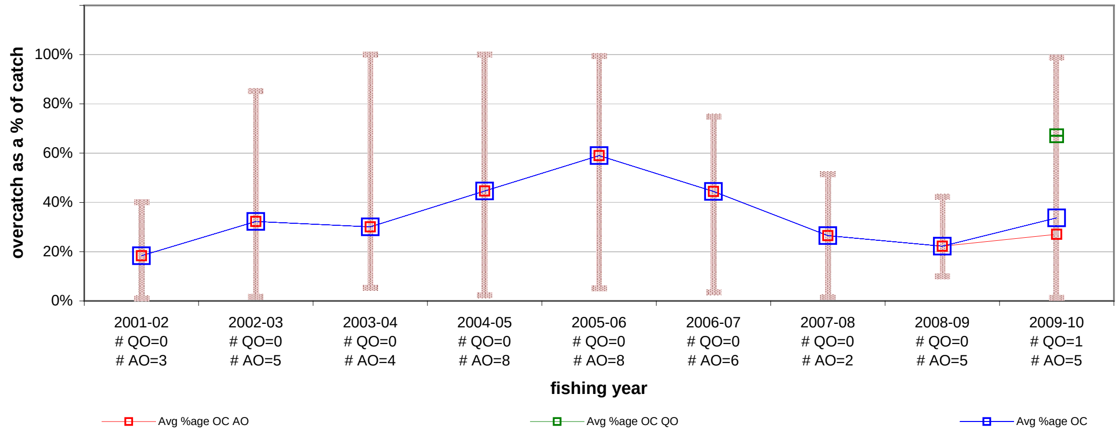
	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Min OC QO			520 kg	110 kg	828 kg	10,722 kg	2,706 kg		
Avg OC QO			6,487 kg	4,528 kg	3,822 kg	10,722 kg	2,706 kg		
Max OC QO			12,453 kg	10,801 kg	9,161 kg	10,722 kg	2,706 kg		
Min OC AO	642 kg	40 kg	174 kg	103 kg	100 kg	66 kg	73 kg	1,343 kg	
Avg OC AO	1,426 kg	2,849 kg	2,409 kg	4,985 kg	5,434 kg	1,604 kg	1,423 kg	1,959 kg	
Max OC AO	2,027 kg	9,888 kg	6,758 kg	13,800 kg	19,768 kg	5,485 kg	3,007 kg	2,574 kg	
Min OC	642 kg	40 kg	174 kg	103 kg	100 kg	66 kg	73 kg	1,343 kg	
Avg OC	1,426 kg	2,849 kg	3,429 kg	4,893 kg	5,089 kg	2,617 kg	1,744 kg	1,959 kg	
Max OC	2,027 kg	9,888 kg	12,453 kg	13,800 kg	19,768 kg	10,722 kg	3,007 kg	2,574 kg	
Tot OC QO	0 kg	0 kg	12,973 kg	13,583 kg	11,465 kg	10,722 kg	2,706 kg	0 kg	
Tot OC AO	7,130 kg	17,091 kg	14,456 kg	59,819 kg	59,776 kg	12,834 kg	4,268 kg	3,917 kg	
Tot OC	7,130 kg	17,091 kg	27,429 kg	73,402 kg	71,241 kg	23,556 kg	6,974 kg	3,917 kg	
%age OC QO	0.00%	0.00%	47.30%	18.50%	16.09%	45.52%	38.80%	0.00%	

Figure 211: Trend in SNA 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10.



	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Min OC QO		32,623 kg	7,247 kg						1,135 kg
Avg OC QO		32,623 kg	7,247 kg						1,135 kg
Max OC QO		32,623 kg	7,247 kg						1,135 kg
Min OC AO	43 kg	131 kg	311 kg	49 kg	5,449 kg	3,426 kg			63 kg
Avg OC AO	7,356 kg	7,433 kg	7,220 kg	69 kg	12,852 kg	3,426 kg			6,691 kg
Max OC AO	24,091 kg	21,433 kg	17,630 kg	88 kg	35,049 kg	3,426 kg			11,538 kg
Min OC	43 kg	131 kg	311 kg	49 kg	5,449 kg	3,426 kg			63 kg
Avg OC	7,356 kg	9,232 kg	7,223 kg	69 kg	12,852 kg	3,426 kg			5,765 kg
Max OC	24,091 kg	32,623 kg	17,630 kg	88 kg	35,049 kg	3,426 kg			11,538 kg
Tot OC QO	0 kg	32,623 kg	7,247 kg	0 kg	0 kg	0 kg			1,135 kg
Tot OC AO	147,123 kg	96,629 kg	50,539 kg	137 kg	89,963 kg	3,426 kg			33,457 kg
Tot OC	147,123 kg	129,252 kg	57,786 kg	137 kg	89,963 kg	3,426 kg			34,592 kg
%age OC QO	0.00%	25.24%	12.54%	0.00%	0.00%	0.00%			3.28%

Figure 212: Trend in TAR 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10.



	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Min OC QO									226 kg
Avg OC QO									226 kg
Max OC QO									226 kg
Min OC AO	210 kg	89 kg	396 kg	52 kg	34 kg	227 kg	67 kg	72 kg	264 kg
Avg OC AO	948 kg	5,780 kg	2,760 kg	9,971 kg	21,971 kg	21,006 kg	196 kg	9,251 kg	4,100 kg
Max OC AO	1,325 kg	21,446 kg	7,894 kg	45,774 kg	55,912 kg	59,073 kg	325 kg	23,186 kg	13,531 kg
Min OC	210 kg	89 kg	396 kg	52 kg	34 kg	227 kg	67 kg	72 kg	226 kg
Avg OC	948 kg	5,780 kg	2,760 kg	9,971 kg	21,971 kg	21,006 kg	196 kg	9,251 kg	3,454 kg
Max OC	1,325 kg	21,446 kg	7,894 kg	45,774 kg	55,912 kg	59,073 kg	325 kg	23,186 kg	13,531 kg
Tot OC QO	0 kg	0 kg	0 kg	0 kg	0 kg	0 kg	0 kg	0 kg	226 kg
Tot OC AO	2,844 kg	28,899 kg	11,041 kg	79,765 kg	175,768 kg	126,035 kg	392 kg	46,254 kg	20,498 kg
Tot OC	2,844 kg	28,899 kg	11,041 kg	79,765 kg	175,768 kg	126,035 kg	392 kg	46,254 kg	20,724 kg
%age OC QO	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.09%

Figure 213: Trend in TRE 2 overcatch as a percentage of catch between the fishing years 2001–02 and 2009–10.

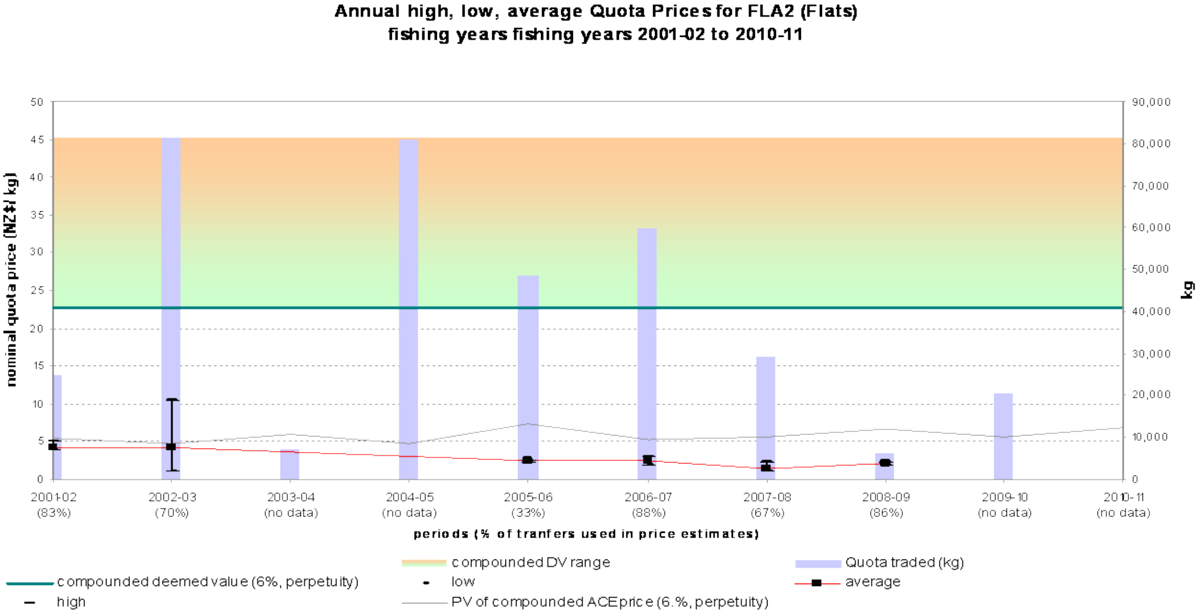


Figure 214: Annual high, low, average Quota Prices for FLA 2 (flatfish) fishing years 2001–02 to 2010–11.

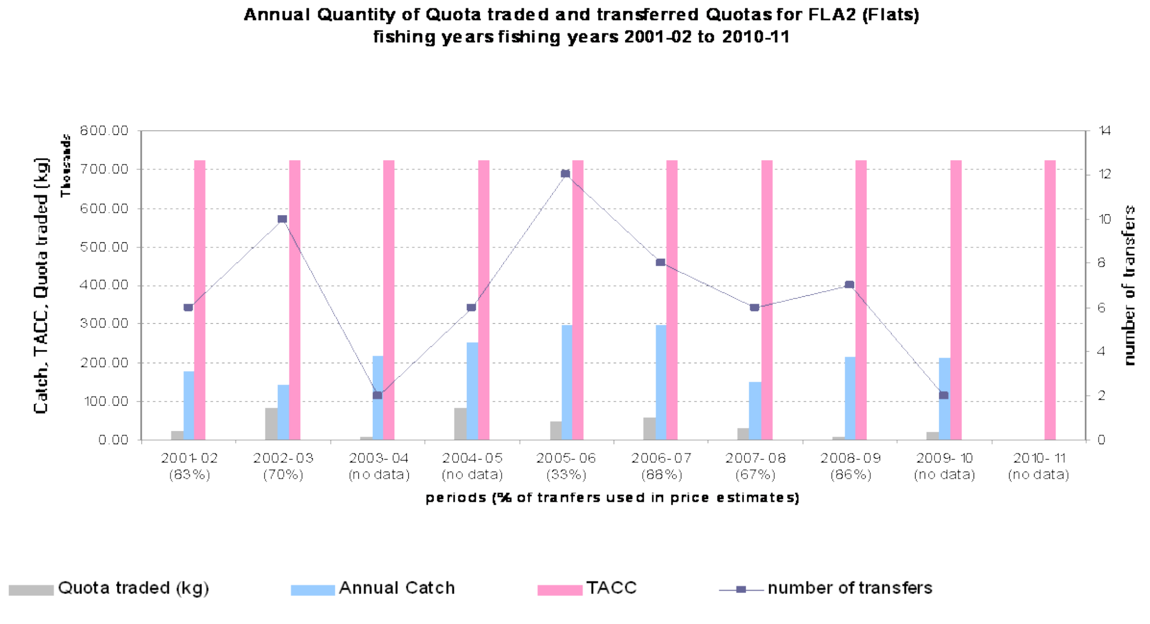


Figure 215: Annual Quantity of Quota traded and transferred Quotas for FLA 2 (flatfish) fishing years 2001–02 to 2010–11.

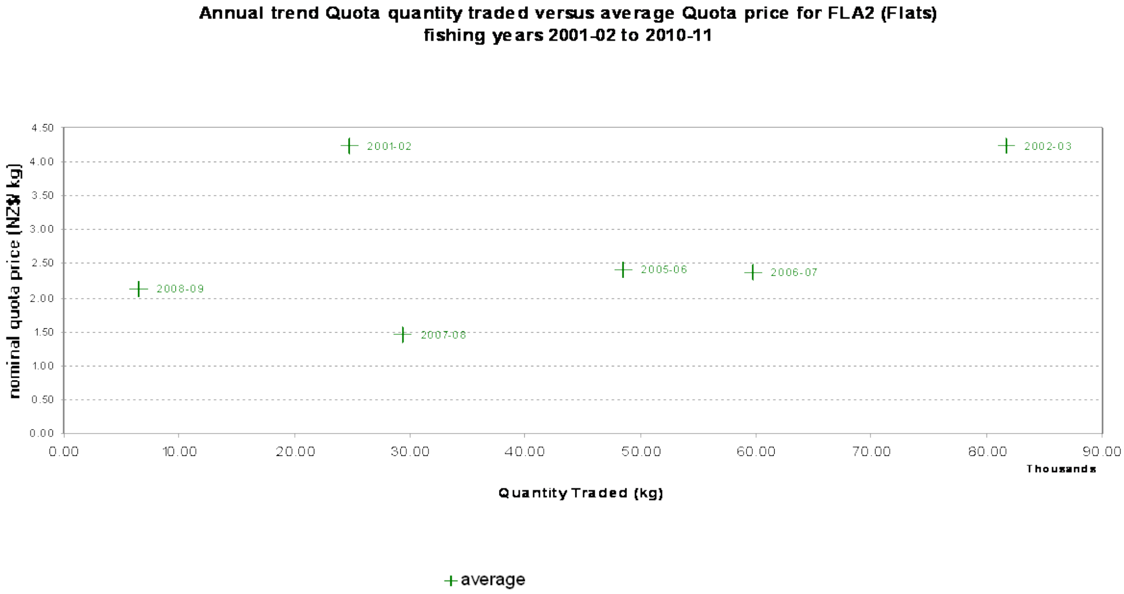


Figure 216: Annual trend in Quota quantity traded versus average Quota price for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11.

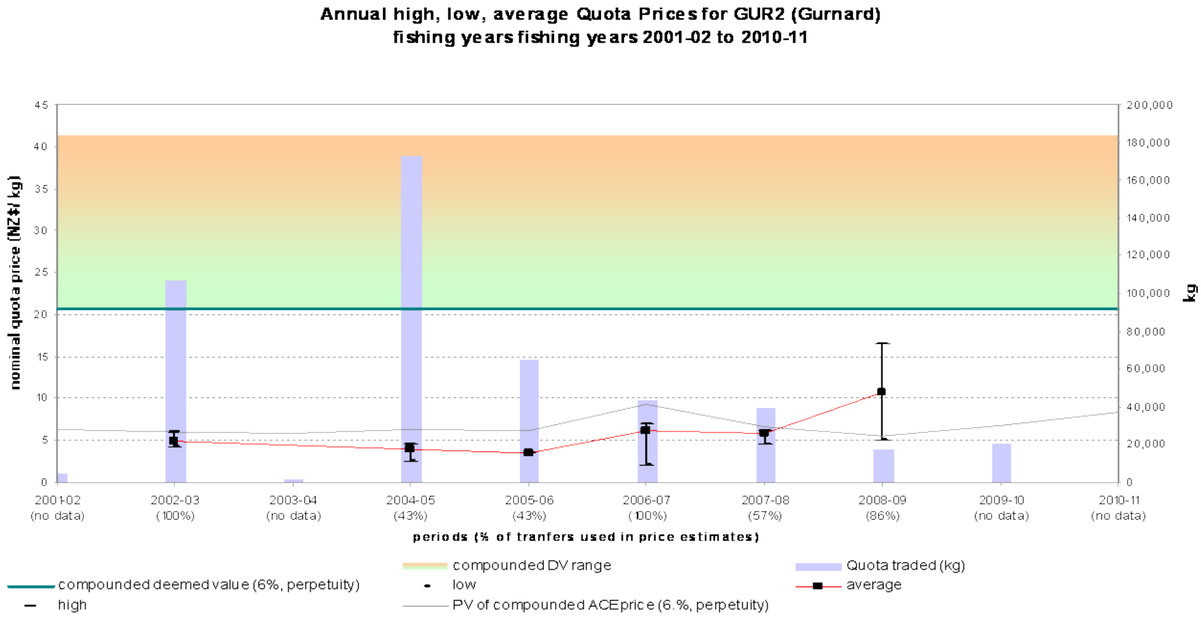


Figure 217: Annual high, low, average Quota Prices for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

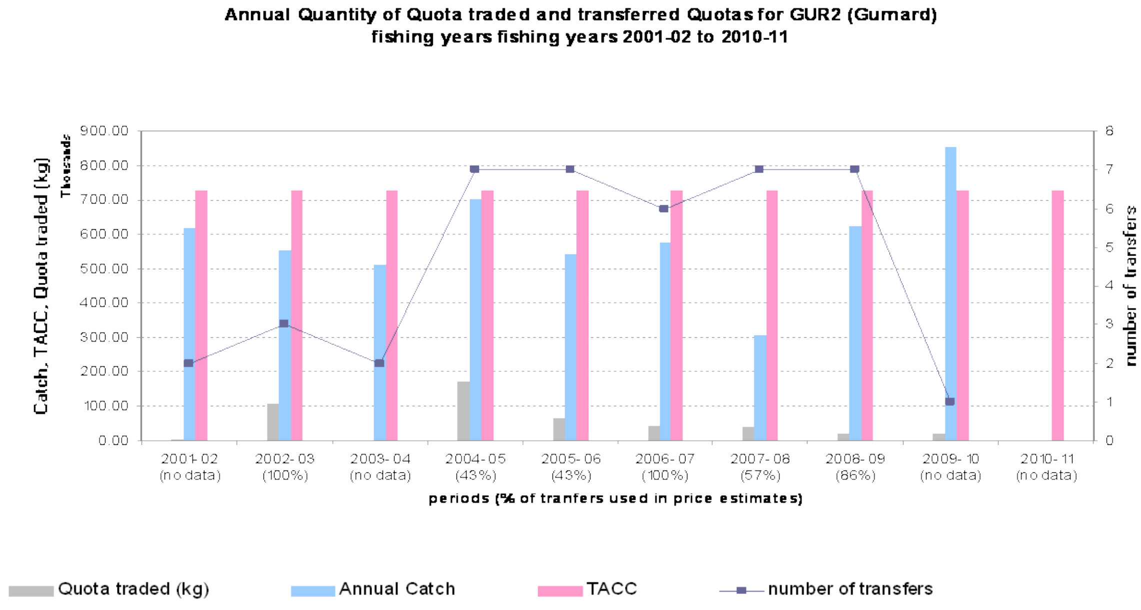


Figure 218: Annual Quantity of Quota traded and transferred Quotas for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

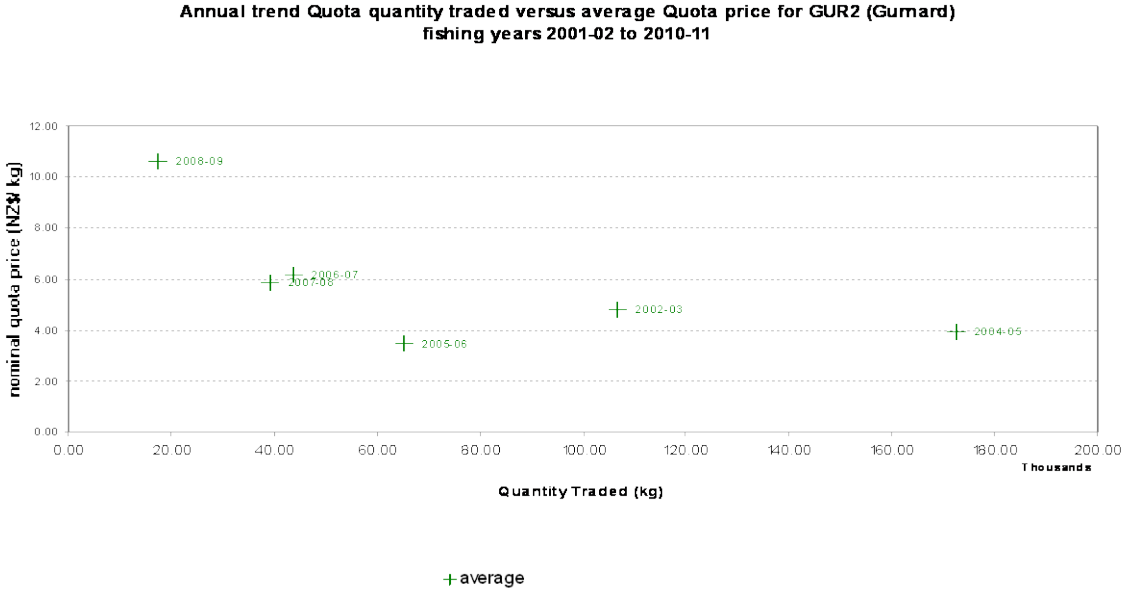


Figure 219: Annual trend in Quota quantity traded versus average Quota price for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

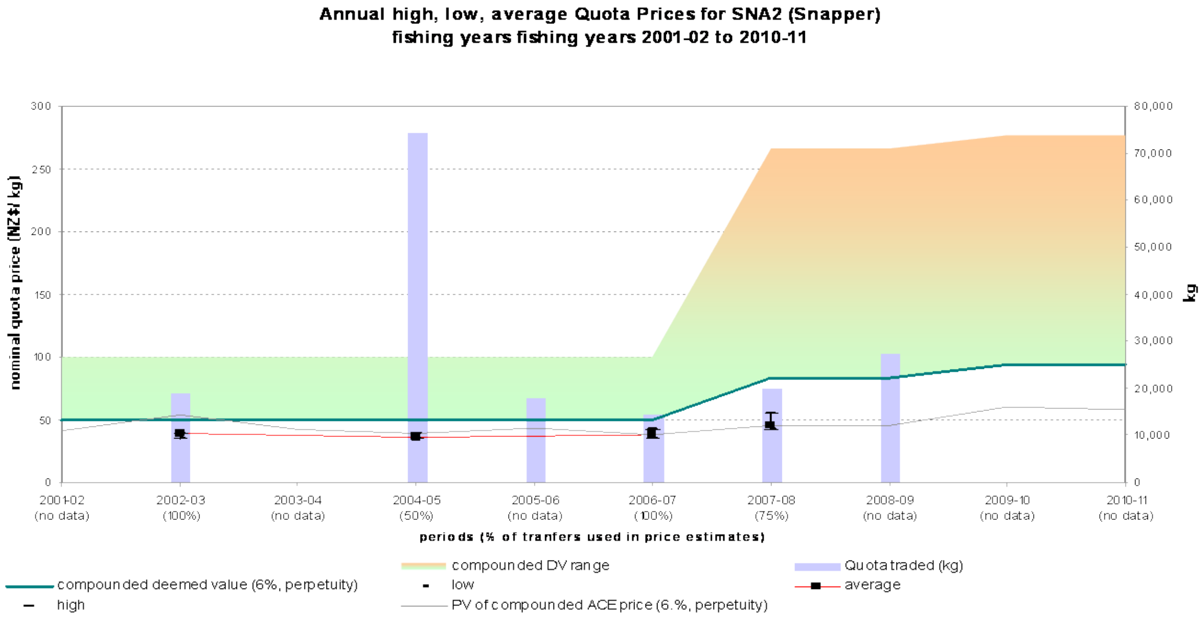


Figure 220: Annual high, low, average Quota Prices for SNA 2 (snapper) fishing years 2001–02 to 2010–11.

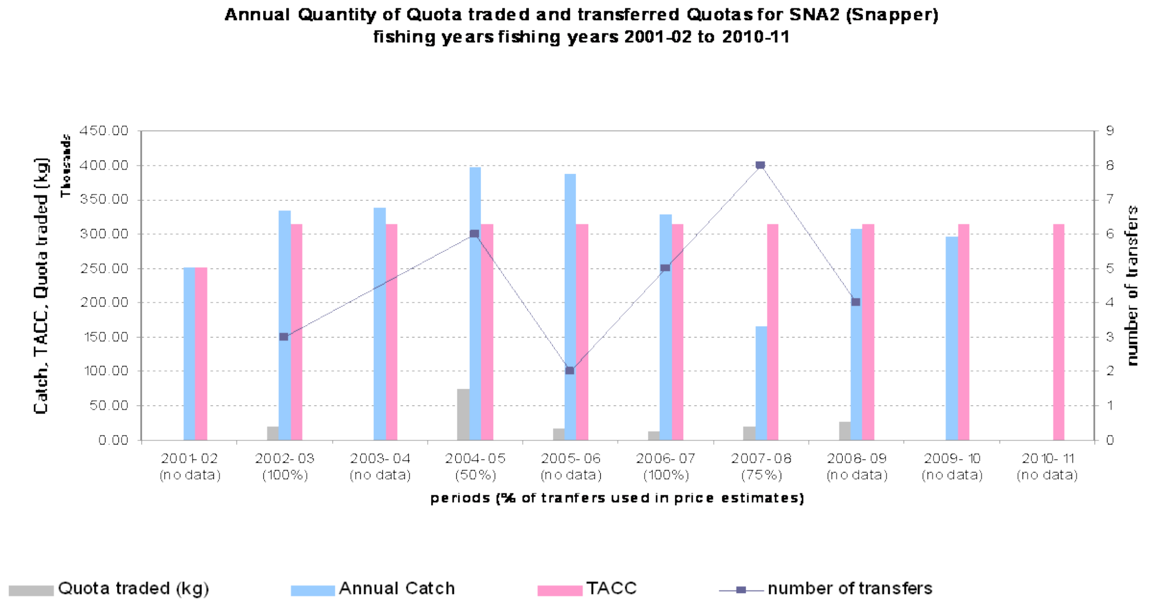


Figure 221: Annual Quantity of Quota traded and transferred Quotas for SNA 2 (snapper) for fishing years 2001–02 to 2010–11.

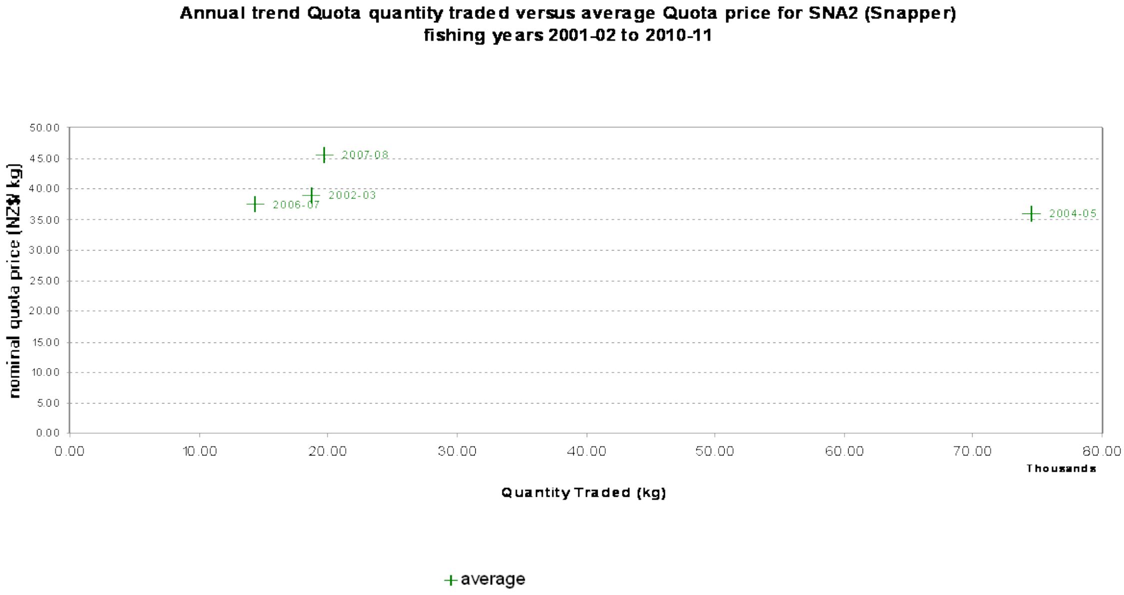


Figure 222: Annual trend in Quota quantity traded versus average Quota price for SNA 2 (snapper) for fishing years 2001–02 to 2010–11.

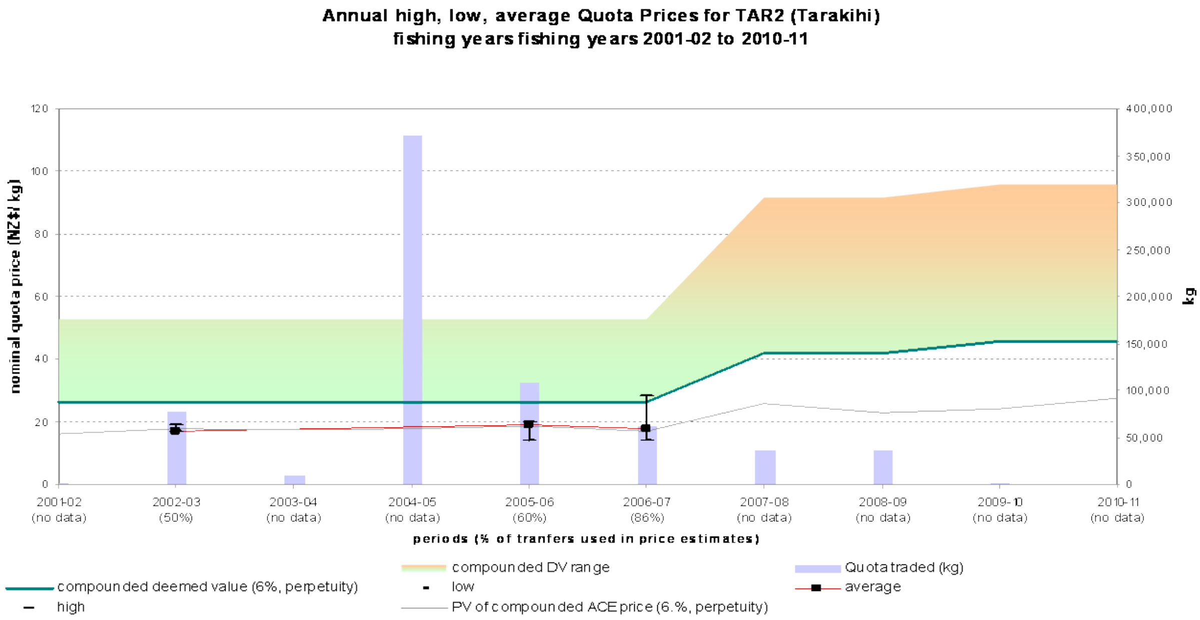


Figure 223: Annual high, low, average Quota Prices for TAR 2 (tarakihi) fishing years 2001–02 to 2010–11.

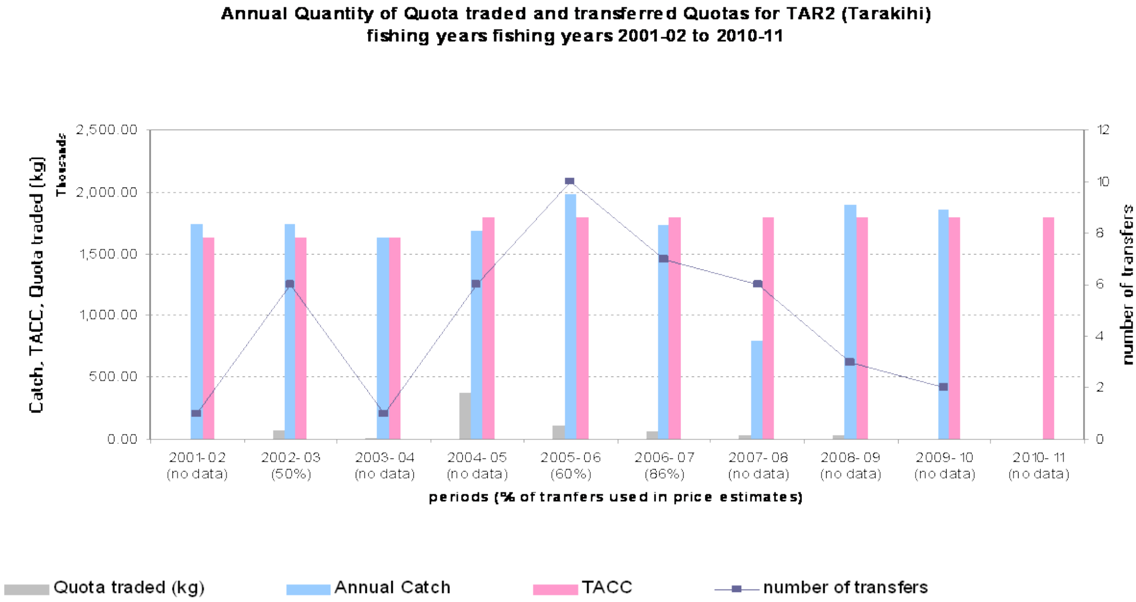


Figure 224: Annual Quantity of Quota traded and transferred Quotas for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11.

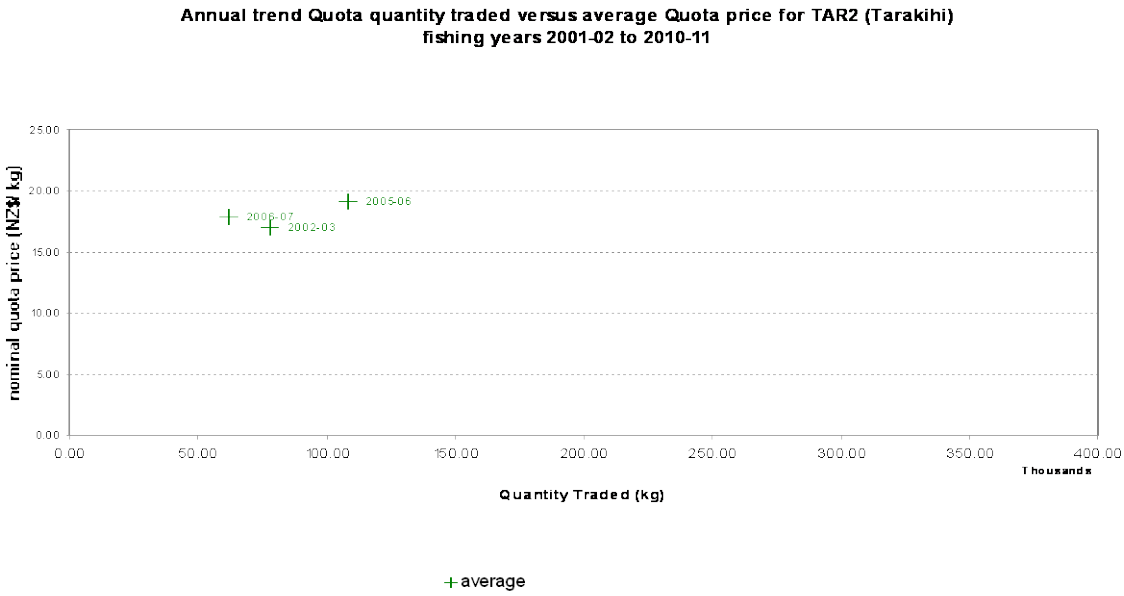


Figure 225: Annual trend in Quota quantity traded versus average Quota price for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11.

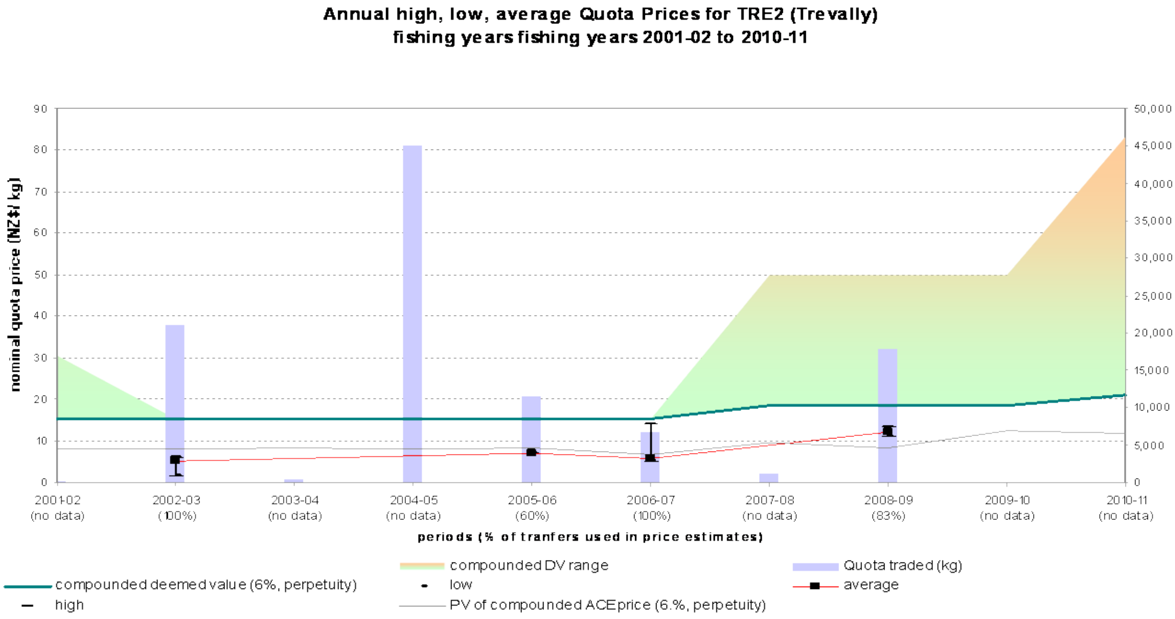


Figure 226: Annual high, low, average Quota Prices for TRE 2 (trevally) fishing years 2001–02 to 2010–11.

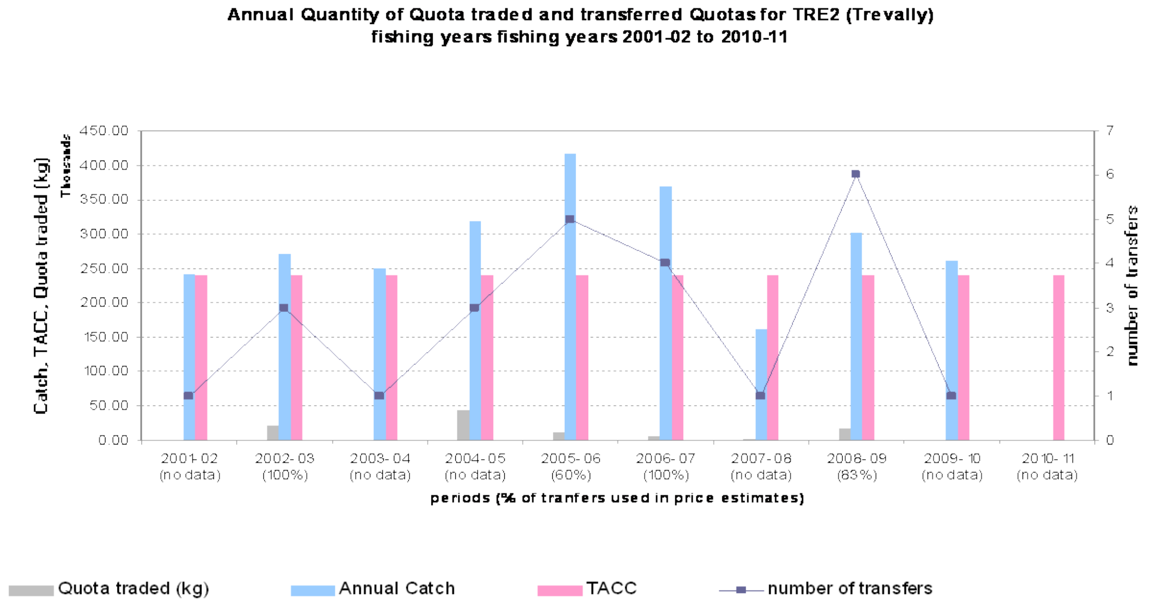


Figure 227: Annual Quantity of Quota traded and transferred Quotas for TRE 2 (trevally) for fishing years 2001–02 to 2010–11.

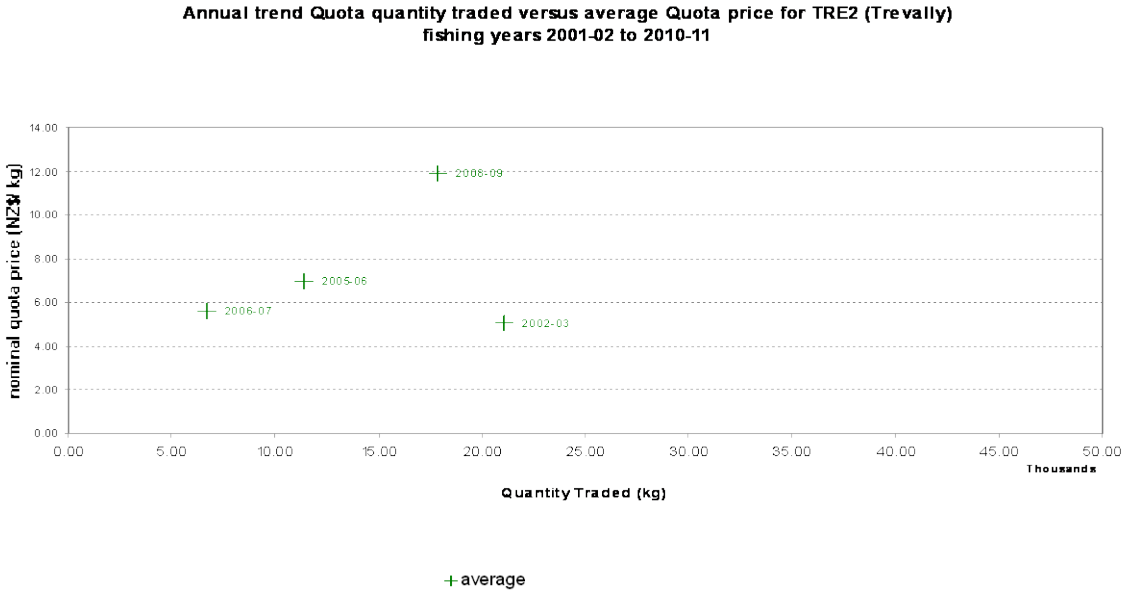


Figure 228: Annual trend in Quota quantity traded versus average Quota price for TRE 2 (trevally) for fishing years 2001–02 to 2010–11.

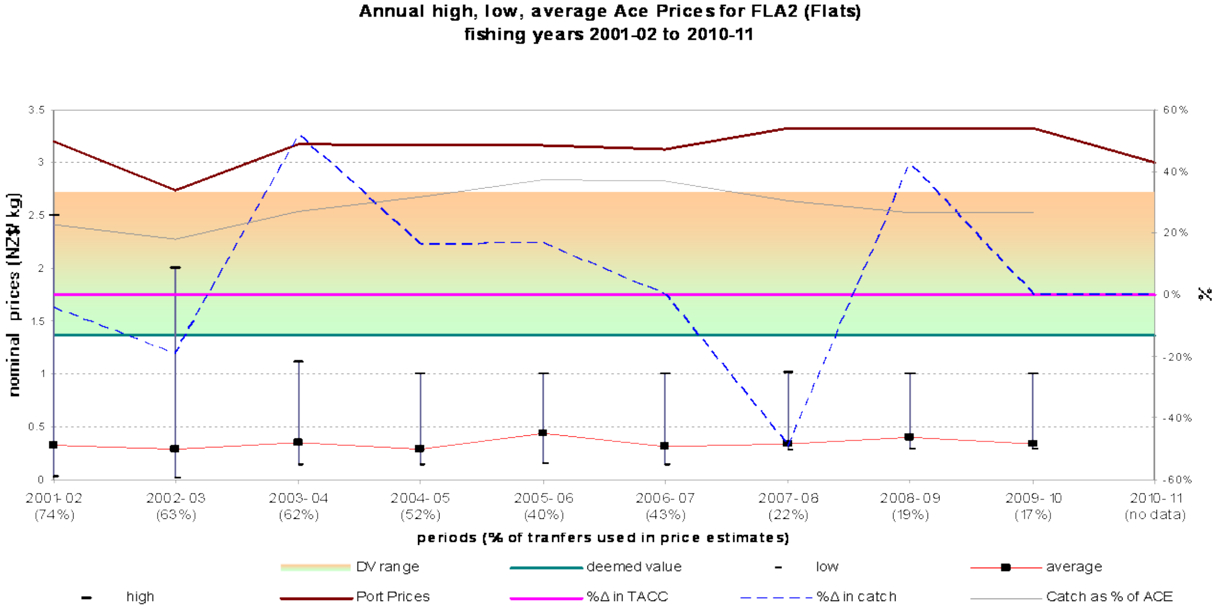


Figure 229: Annual high, low, average ACE Prices for FLA 2 (flatfish) fishing years 2001–02 to 2010–11.

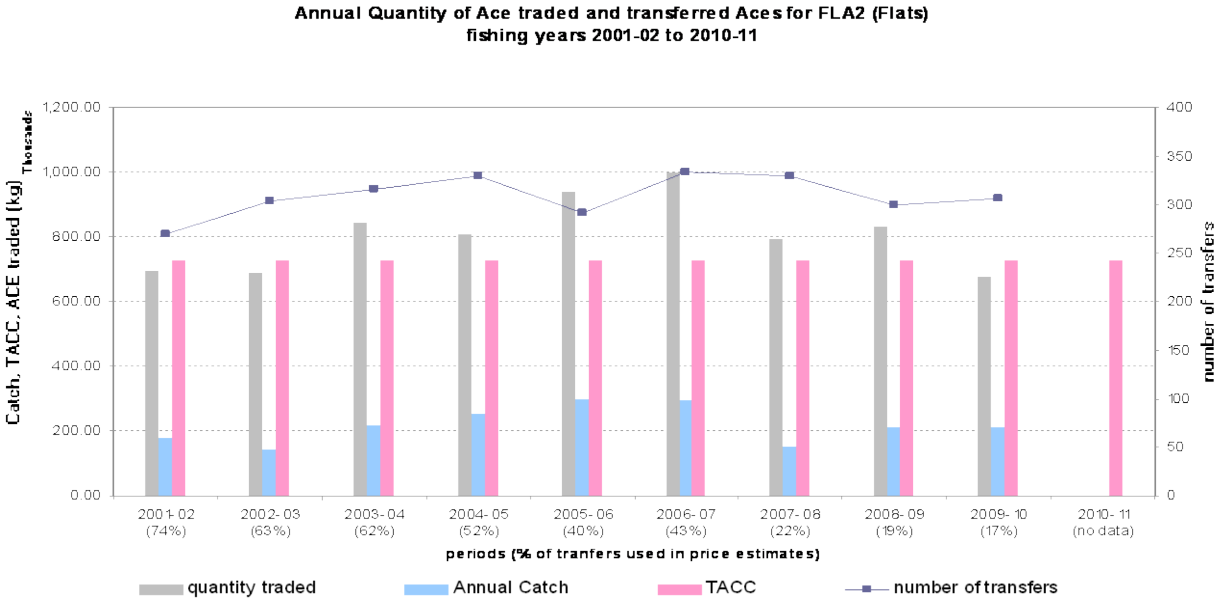


Figure 230: Annual Quantity of ACE traded and transferred ACE for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11.

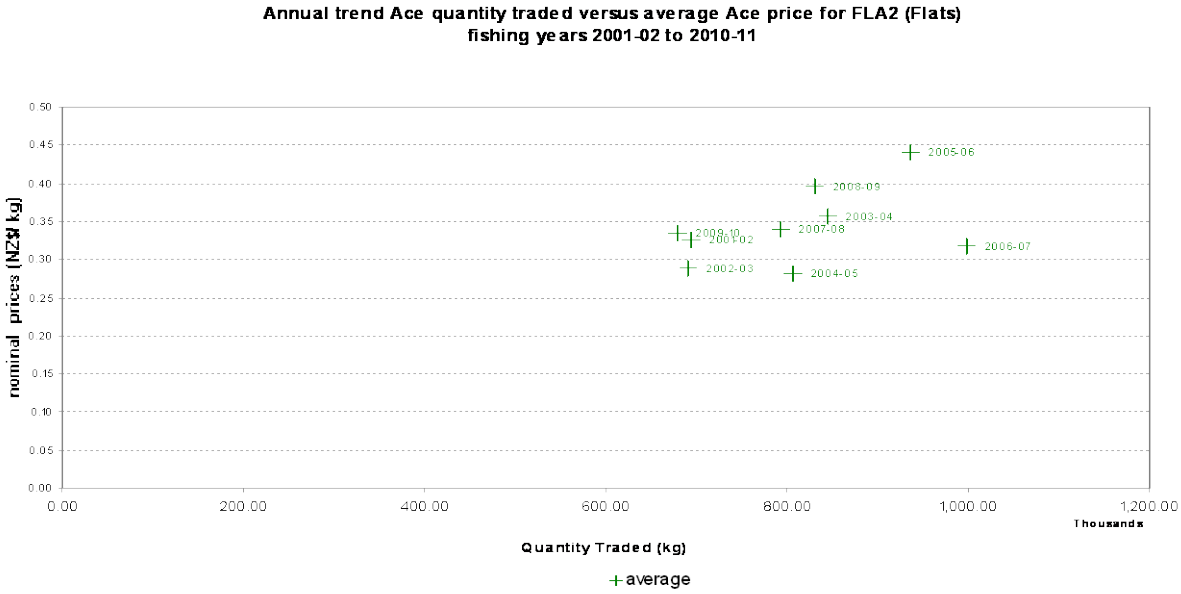


Figure 231: Annual trend of quantity of ACE traded versus average ACE price for FLA 2 (flatfish) for fishing years 2001–02 to 2010–11.

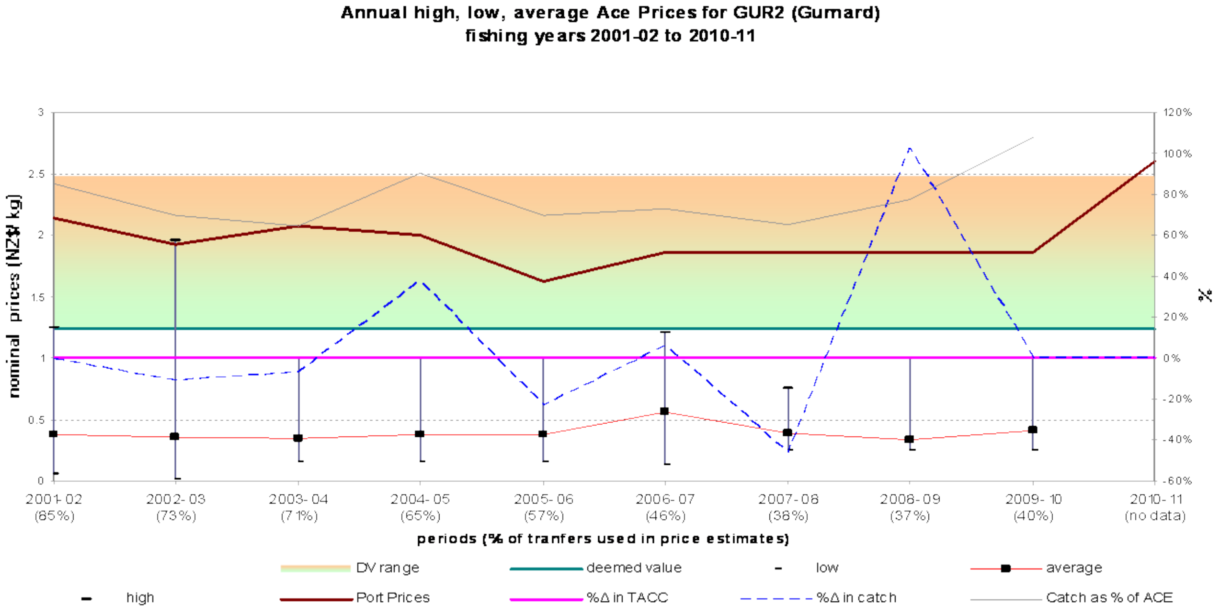


Figure 232: Annual high, low, average ACE Prices for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

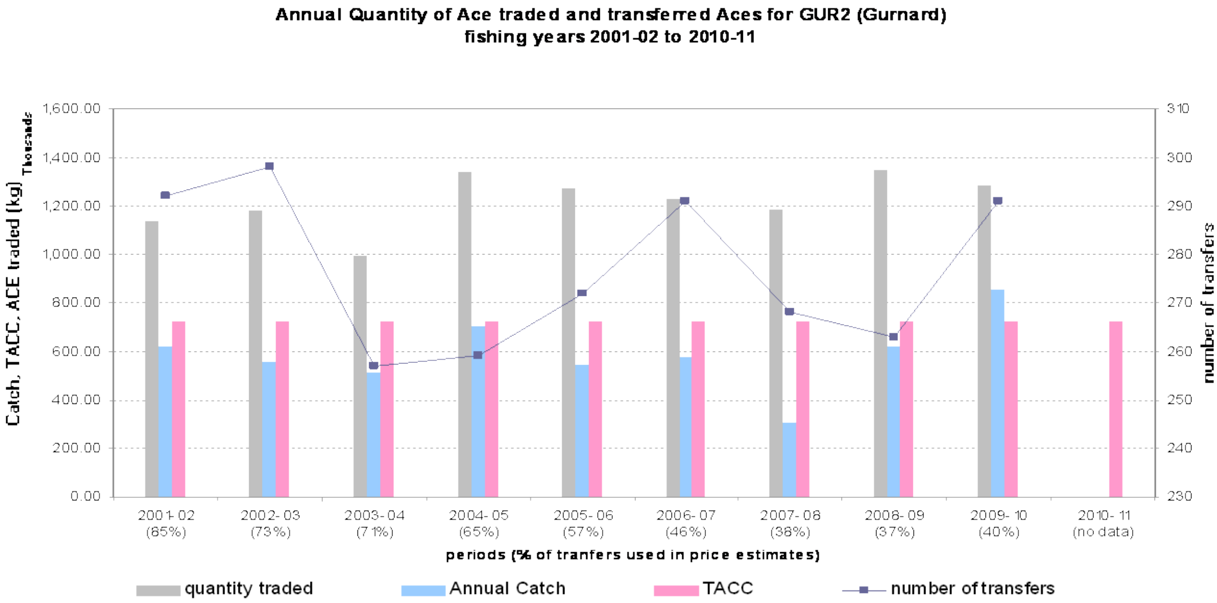


Figure 233: Annual Quantity of ACE traded and transferred ACE for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

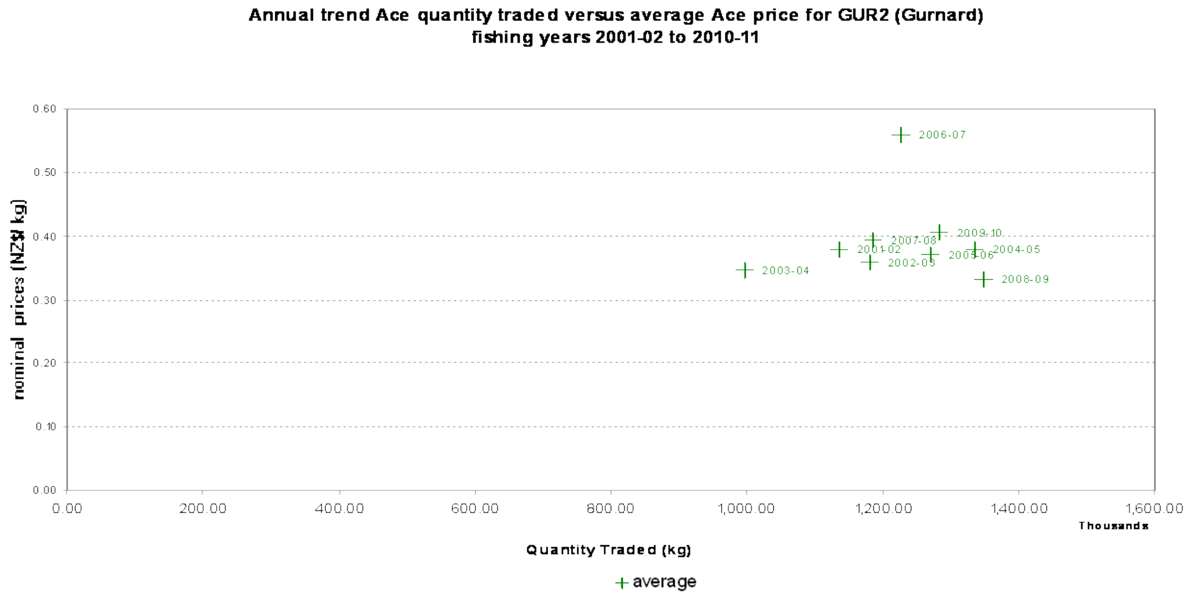


Figure 234: Annual trend of quantity of ACE traded versus average ACE price for GUR 2 (red gurnard) for fishing years 2001–02 to 2010–11.

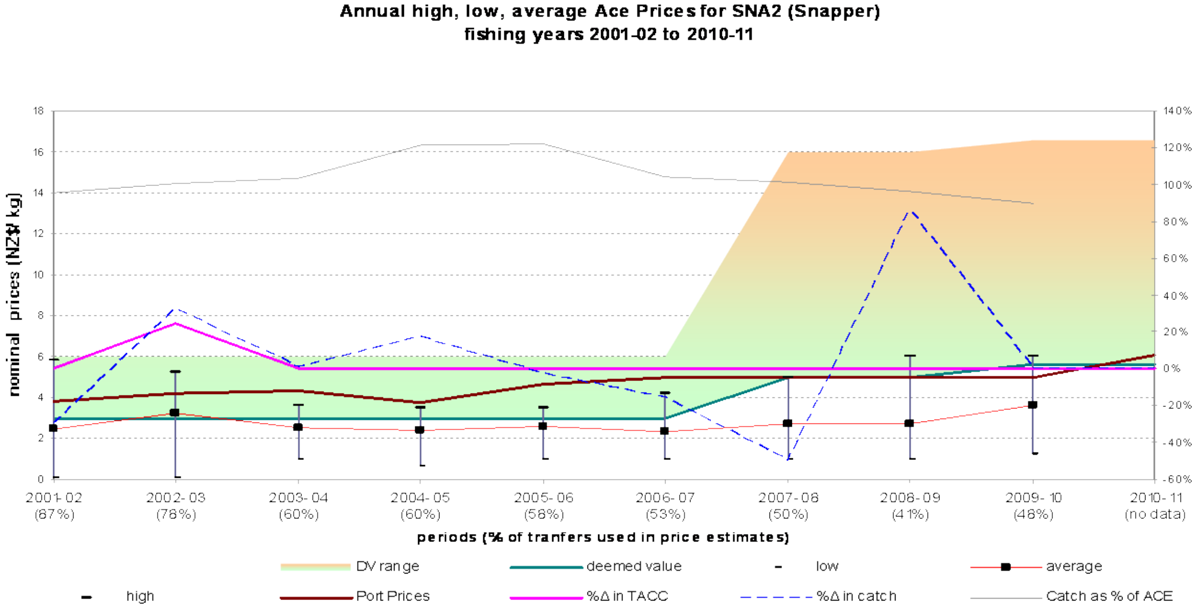


Figure 235: Annual high, low, average ACE Prices for SNA 2 (snapper) for fishing years 2001–02 to 2010–11.

Figure 236: Annual Quantity of ACE traded and transferred ACE for SNA 2 (snapper) for fishing years 2001–02 to 2010–11.

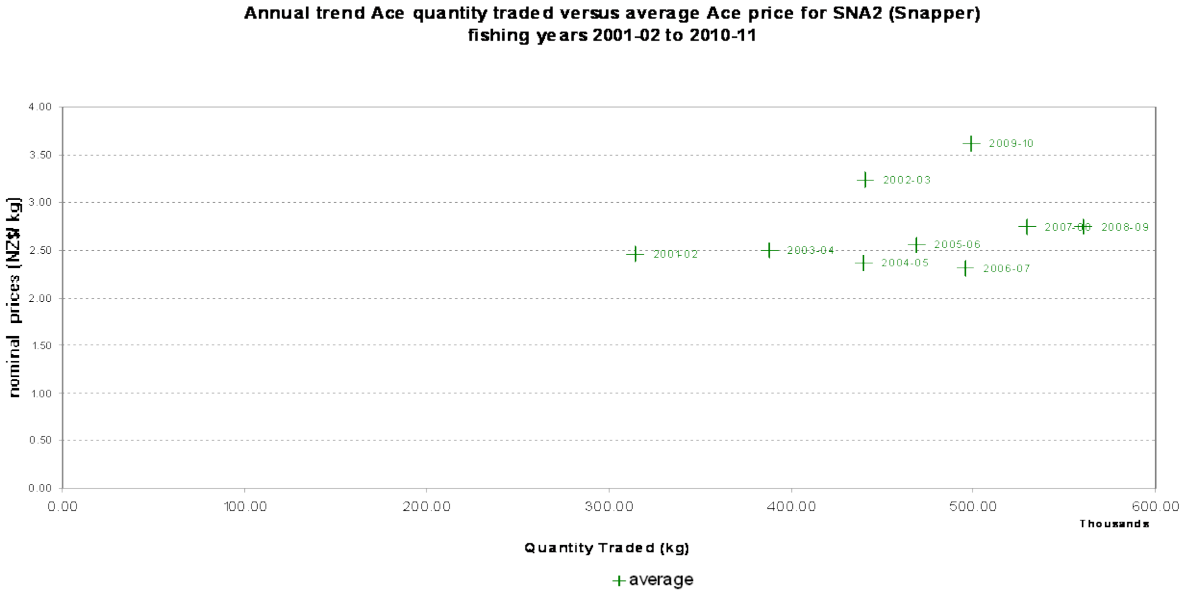


Figure 237: Annual trend of quantity of ACE traded versus average ACE price for SNA 2 (snapper) for fishing years 2001–02 to 2010–11.

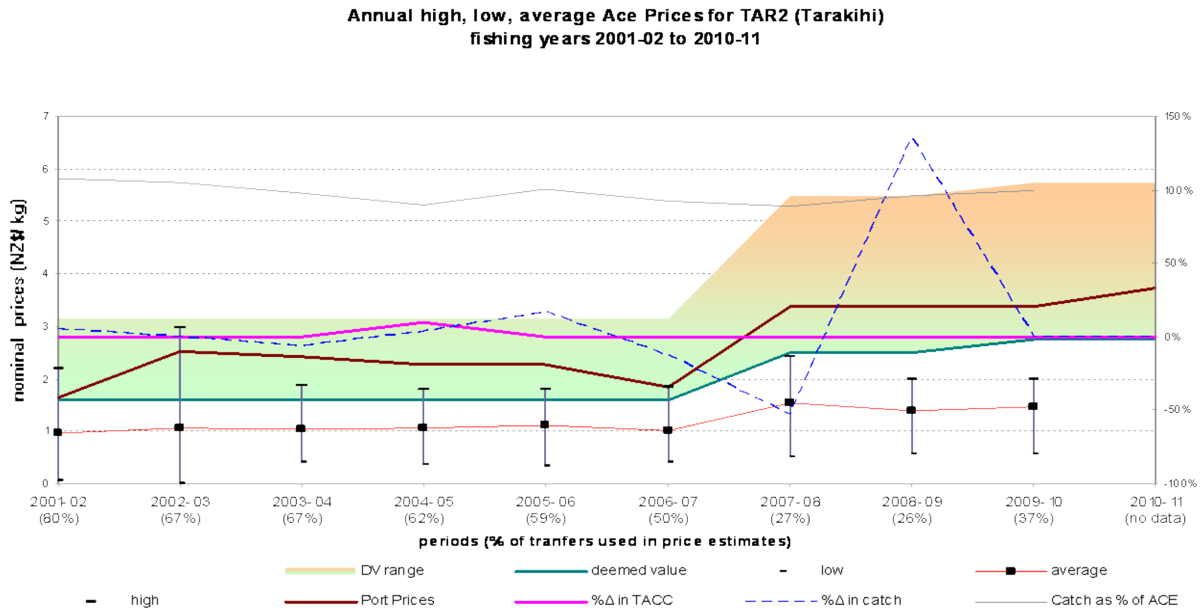


Figure 238: Annual high, low, average ACE Prices for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11.

Figure 239: Annual Quantity of ACE traded and transferred ACE for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11

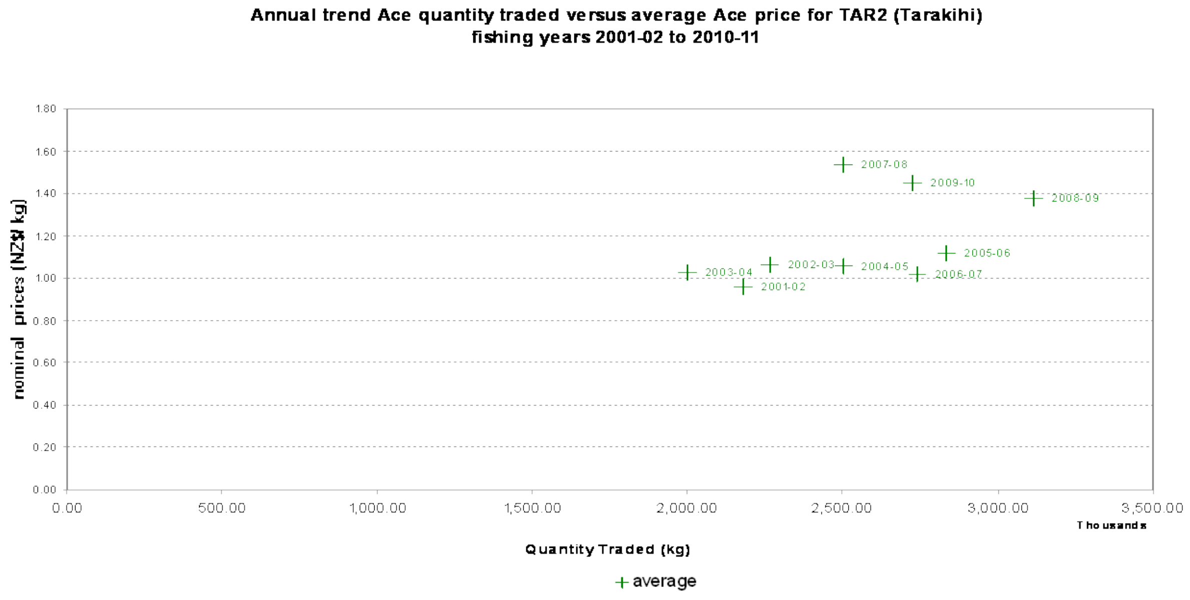


Figure 240: Annual trend of quantity of ACE traded versus average ACE price for TAR 2 (tarakihi) for fishing years 2001–02 to 2010–11

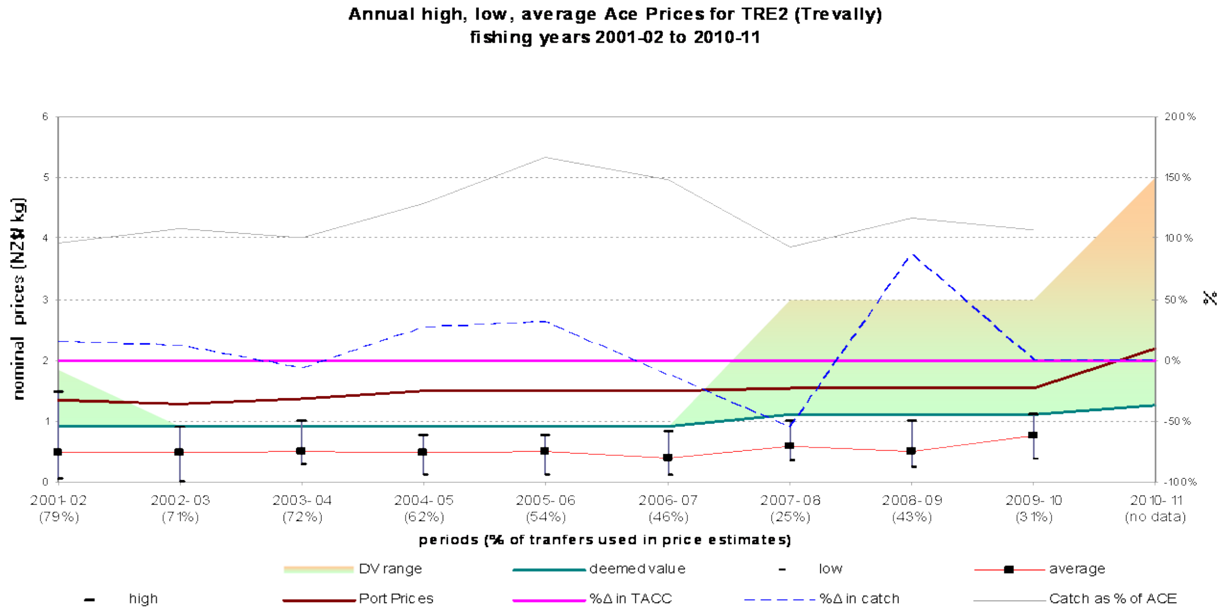


Figure 241: Annual high, low, average ACE Prices for TRE 2 (trevally) for fishing years 2001–02 to 2010–11.

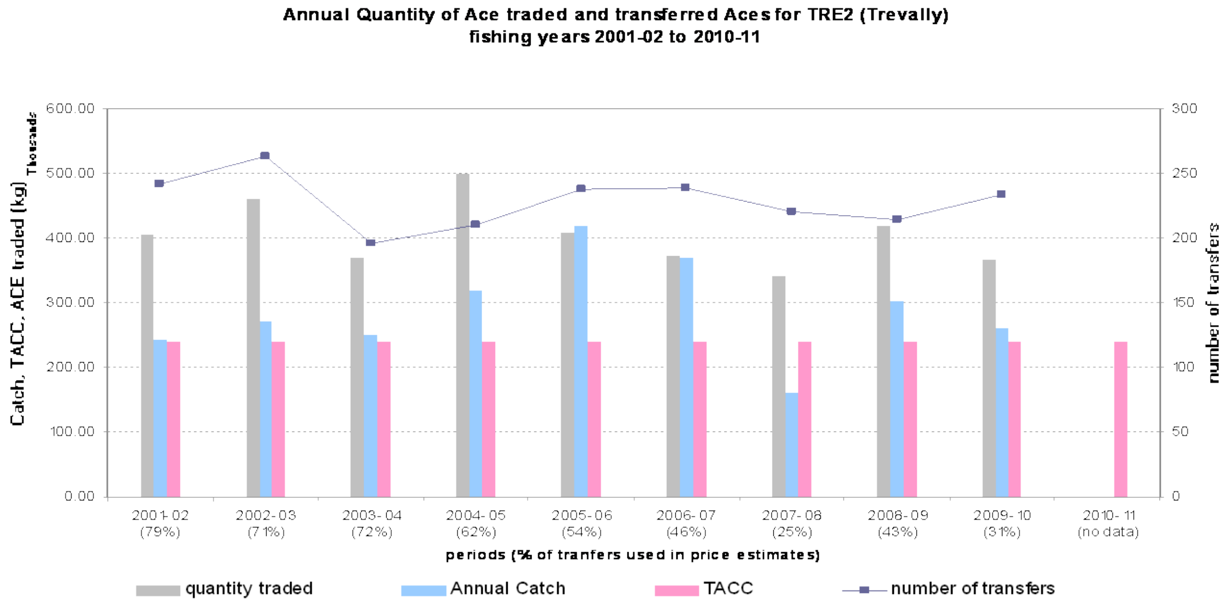


Figure 242: Annual Quantity of ACE traded and transferred ACE for TRE 2 (trevally) for fishing years 2001–02 to 2010–11.

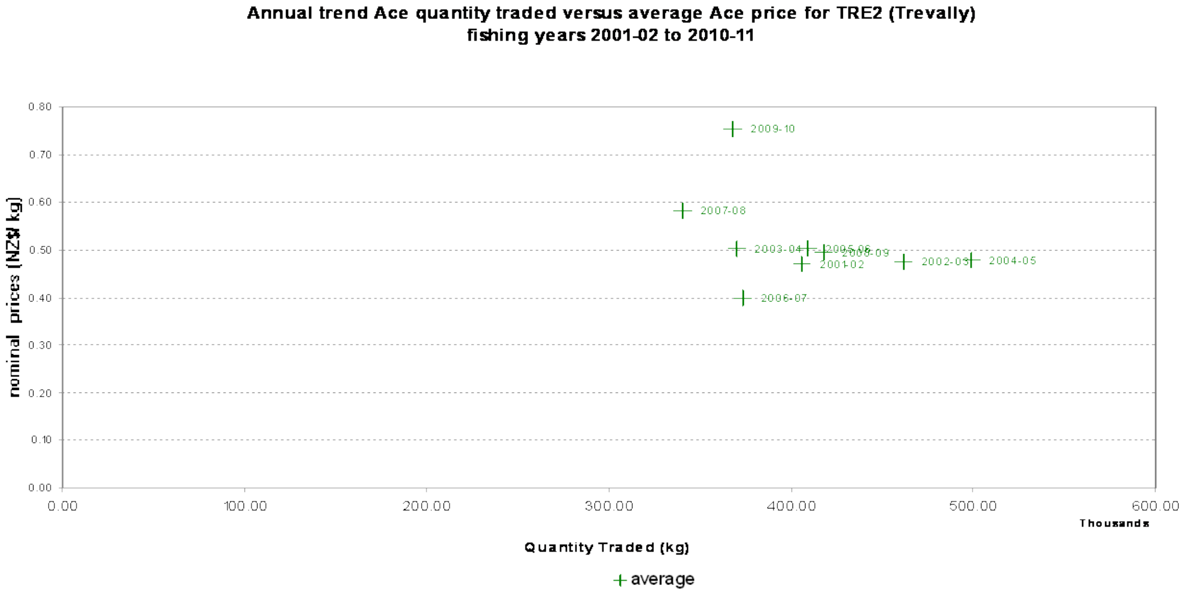


Figure 243: Annual trend of quantity of ACE traded versus average ACE price for TRE 2 (trevally) for fishing years 2001–02 to 2010–11.

The following diagrams show Steps 1 to 4 used to generate the data used to model CPUE for the eight segments.

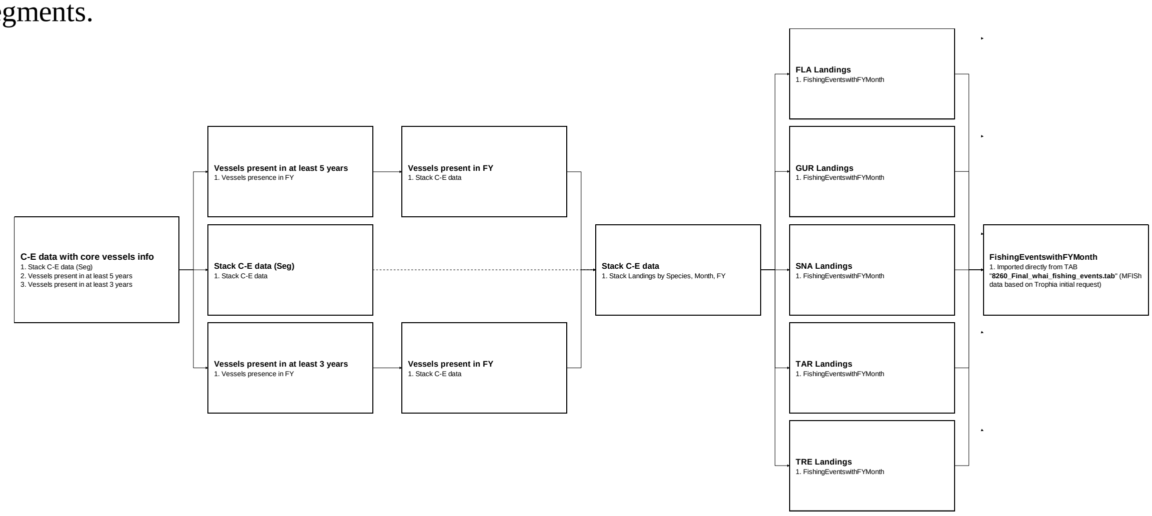


Figure 244: Step 1: Import the Groomed, Reconciled Catch-Effort and Landings data (GRCEL) provided by the Ministry and aggregate by stratum then merge with information on core vessels into table "C-E data with core vessels info".

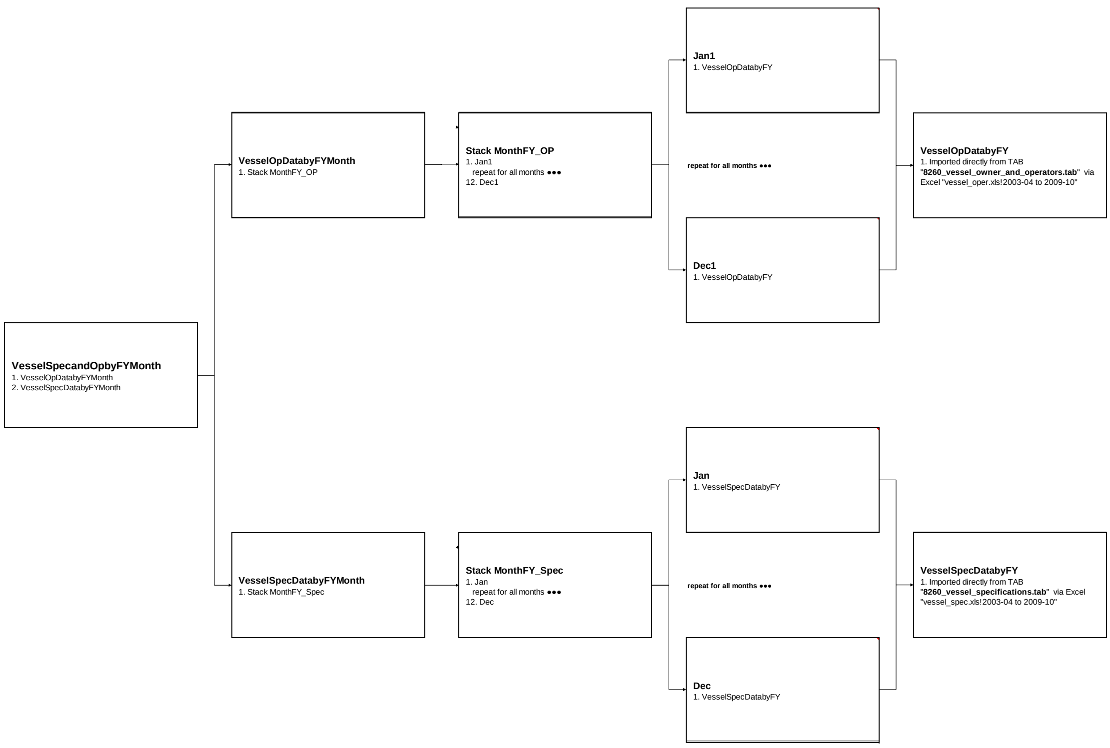


Figure 245: Step 2: Import the vessel specifications (VS) data provided by the Ministry and merge with GRCEL into table "VesselSpecandOpbyFYMonth".

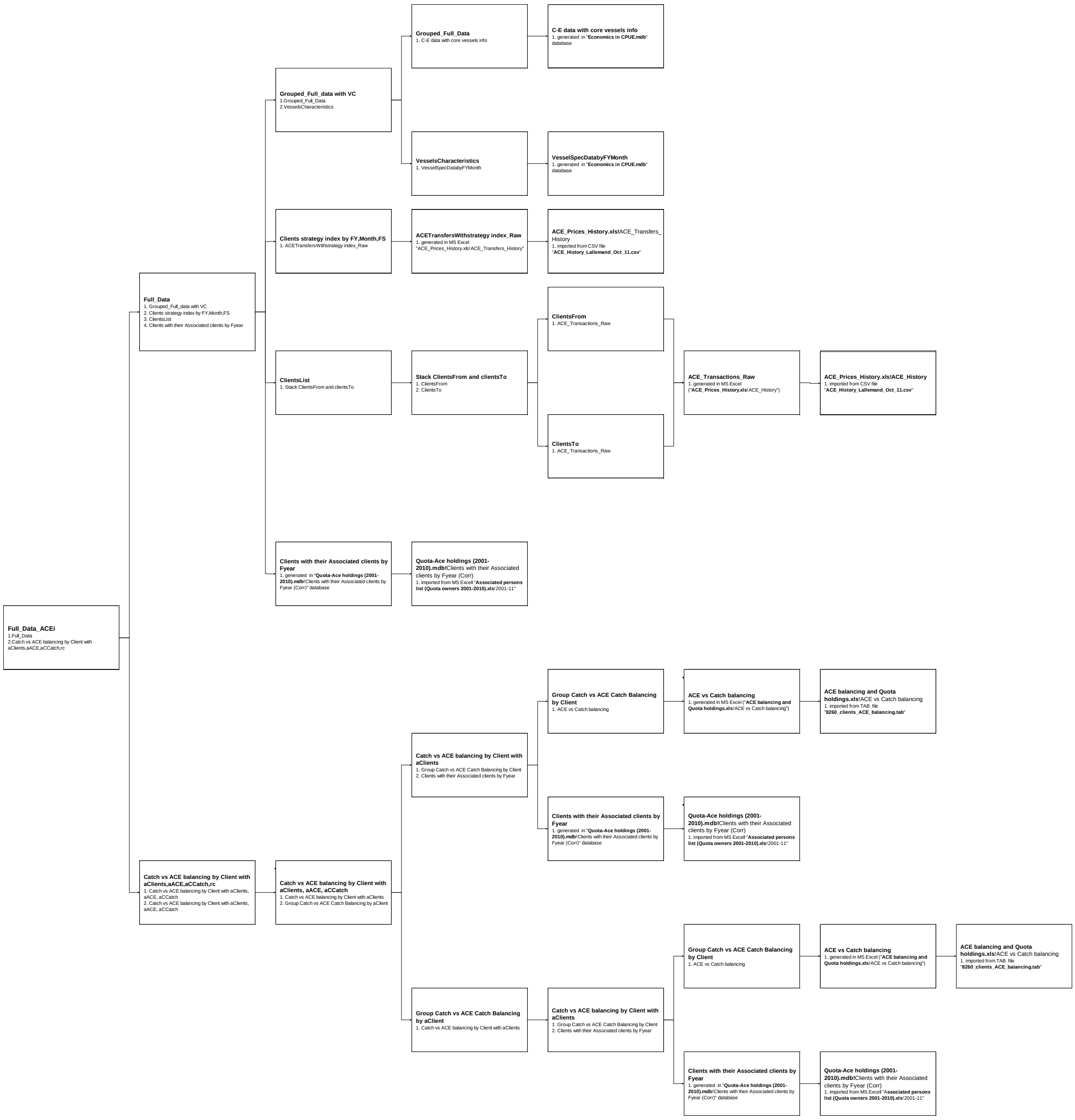


Figure 246: Step3: Import data provided by the Ministry on ACE transfers, Catch-ACE balancing, ACE and Quota Holdings (QAH). Merge data on associated person from FishServe, calculation on strategy and structure indices with QAH, VS and GRCEL into new table (Rdata_ACEi).

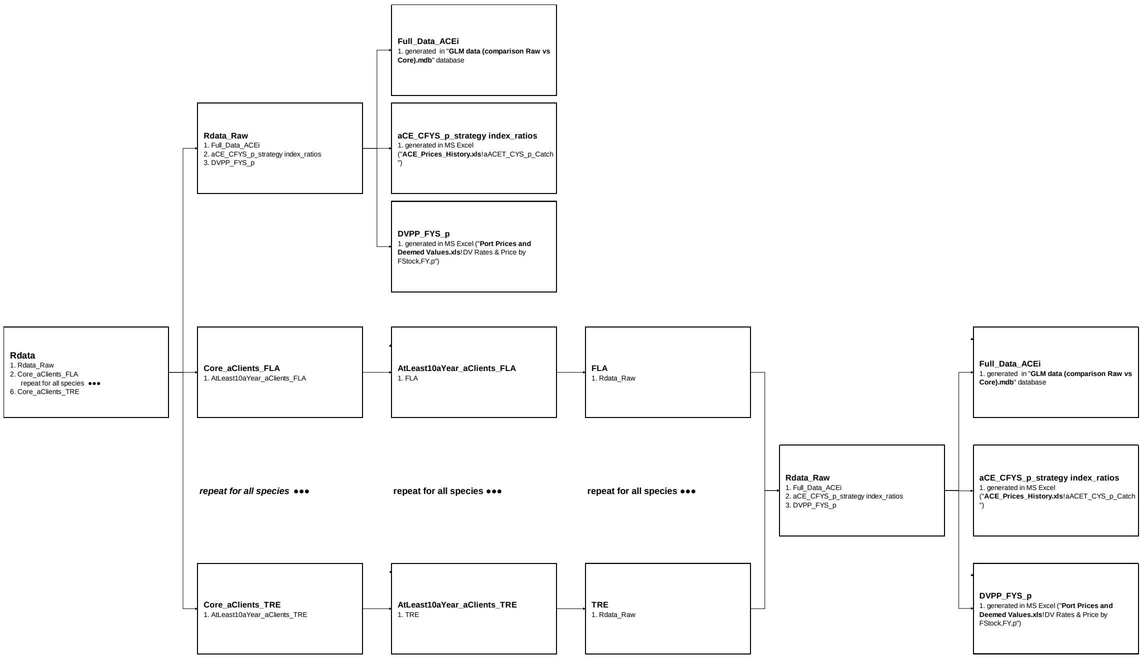


Figure 247: Step4: merge "Rdata_ACEi" with info on deemed value rates, port price, price ratios, core associated clients into table "RData".