IN PROCEEDINGS CONDUCTED BY

THE REVIEW PANEL ESTABLISHED UNDER ARTICLE 17 OF THE CONVENTION ON THE CONSERVATION AND MANAGEMENT OF HIGH SEAS FISHERY RESOURCES IN THE SOUTH PACIFIC OCEAN

with regards to

THE OBJECTION BY THE REPUBLIC OF ECUADOR TO A DECISION OF THE COMMISSION OF THE SOUTH PACIFIC REGIONAL FISHERIES MANAGEMENT ORGANISATION

MEMORANDUM OF AUSTRALIA

Supporting Materials

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17 May 2018

Appendix of Australian Supporting Material

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CMM 01-2017[1]

Conservation and Management Measure for *Trachurus murphyi*

The Commission of the South Pacific Regional Fisheries Management Organisation;

NOTING that the *Trachurus murphyi* stock remains at very low levels;

CONCERNED in particular with the low levels of the current biomass, historically high fishing mortality, the need to maintain low fishing mortality, and the high degree of associated uncertainties;

TAKING INTO ACCOUNT the outcomes of the stock assessment carried out on 29 September to 3 October of 2016 and the advice of the Scientific Committee;

BEARING IN MIND the commitment to apply the precautionary approach and take decisions based on the best scientific and technical information available as set out in Article 3 of the Convention;

RECOGNISING that a primary function of the Commission is to adopt Conservation and Management Measures (CMMs) to achieve the objective of the Convention, including, as appropriate, CMMs for particular fish stocks;

AFFIRMING its commitment to rebuilding the stock of *Trachurus murphyi* and ensuring its long term conservation and sustainable management in accordance with the objective of the Convention;

RECOGNISING the need for effective monitoring and control and surveillance of fishing for *Trachurus murphyi* in the implementation of this measure pending the establishment of monitoring, control and surveillance measures pursuant to Article 27 of the Convention;

RECALLING Articles 4(2), 20(3), 20(4) and 21(2) of the Convention;

RECALLING also Article 21(1) of the Convention;

ADOPTS the following CMM in accordance with Articles 8 and 21 of the Convention:

GENERAL PROVISIONS

1. This CMM applies to fisheries for *Trachurus murphyi* undertaken by vessels flagged to Members and Cooperating Non-Contracting Parties (CNCPs) included on the Commission Record of Vessels (CMM 05-2016) in the Convention Area and, in accordance with Article 20(4)(a)(iii) and with the express consent of Chile, to fisheries for *Trachurus murphyi* undertaken by Chile in areas under its national jurisdiction.
2. Only fishing vessels duly authorized pursuant to Article 25 of the Convention and in accordance with CMM 05-2016 (Record of Vessels) that are flagged to Members and Cooperating Non-Contracting Parties (CNCPs) shall participate in the fishery for *Trachurus murphyi* in the Convention Area.
3. This CMM is not to be considered a precedent for future allocation decisions.

EFFORT MANAGEMENT

4. Relevant Members and CNCPs shall limit the total gross tonnage (GT)[2] of vessels flying their flag and participating in the fishing activities described in Article 1, (1)(g)(i) and (ii) of the Convention in respect of the *Trachurus murphyi* fisheries in the Convention Area to the total tonnage of their flagged vessels

[1] CMM 01-2017 (*T. murphyi*) supersedes CMM 4.01 (*T. murphyi*) and previously 3.01, 2.01 and 1.01.
[2]In the event that GT is not available, Members and CNCPs shall utilise Gross Registered Tonnage (GRT) for the purposes of this CMM.

that were engaged in such fishing activities in 2007 or 2008 or 2009 in the Convention Area and as set out in Table 1 of CMM 1.01 (*Trachurus murphyi*; 2013). Such Members and CNCPs may substitute their vessels as long as the total level of GT for each Member and CNCP does not exceed the level recorded in that Table.

CATCH MANAGEMENT

5. In 2017 the total catch of *Trachurus murphyi* in the area to which this CMM applies in accordance with paragraph 1 shall be limited to 443 000 tonnes. Members and CNCPs are to share in this total catch in the tonnages set out in Table 1 of this CMM.

6. Catches will be attributed to the Flag State whose vessels have undertaken the fishing activities described in Article 1 (1)(g)(i) and (ii) of the Convention.

7. In the event that a Member or CNCP reaches 70% of its catch limit set out in Table 1, the Executive Secretary shall inform that Member or CNCP of that fact, with a copy to all other Members and CNCPs. That Member or CNCP shall close the fishery for its flagged vessels when the total catch of its flagged vessels is equivalent to 100% of its catch limit. Such Member or CNCP shall notify promptly the Executive Secretary of the date of the closure.

8. The provisions of this CMM are without prejudice to the right of Members and CNCPs to adopt measures limiting vessels flying their flag and fishing for *Trachurus murphyi* in the Convention Area to catches less than the limits set out in Table 1. In any such case, Members and CNCPs shall notify the Executive Secretary of the measures, when practicable, within 1 month of adoption. Upon receipt, the Executive Secretary shall circulate such measures to all Members and CNCPs without delay.

9. By 31 December each year a Member or CNCP may transfer to another Member or CNCP all or part of its entitlement to catch up to the limit set out in Table 1, without prejudice to future agreements on the allocation of fishing opportunities, subject to the approval of the receiving Member or CNCP. When receiving fishing entitlement by transfer, a Member or CNCP may either allocate it on the basis of domestic legislation or endorse arrangements between owners participating in the transfer. Before the transferred fishing takes place, the transferring Member or CNCP shall notify the transfer to the Executive Secretary for circulation to Members and CNCPs without delay.

10. Members and CNCPs agree, having regard to the advice of the Scientific Committee, that catches of *Trachurus murphyi* in 2017 throughout the range of the stock should not exceed 493 000 tonnes.

DATA COLLECTION AND REPORTING

11. Members and CNCPs participating in the *Trachurus murphyi* fishery shall report in an electronic format the monthly catches of their flagged vessels to the Secretariat within 20 days of the end of the month, in accordance with CMM 02-2017 (Data Standards) and using templates prepared by the Secretariat and available on the SPRFMO website.

12. The Executive Secretary shall circulate monthly catches, aggregated by flag State, to all Members and CNCPs on a monthly basis.

13. Except as described in paragraph 11 above, each Member and CNCP participating in the *Trachurus murphyi* fishery shall collect, verify, and provide all required data to the Executive Secretary, in accordance with CMM 02-2017 (Data Standards) and the templates available on the SPRFMO website, including an annual catch report.

14. The Executive Secretary shall verify the annual catch reports submitted by Members and CNCPs against the submitted data (tow-by-tow in the case of trawlers, and set by set or trip by trip in the case of purse-seine fishing vessels). The Executive Secretary shall inform Members and CNCPs of the outcome of the verification exercise and any possible discrepancies encountered.

15. Members and CNCPs participating in the *Trachurus murphyi* fisheries shall implement a vessel

monitoring system (VMS) in accordance with CMM 02-2017 (Data Standards) and other relevant CMMs adopted by the Commission. These VMS data shall be provided to the Executive Secretary within 10 days of each quarter in the format prescribed by the SPRFMO Data Standards and using the templates on the SPRFMO website.

16. Each Member and CNCP participating in the *Trachurus murphyi* fishery shall provide the Executive Secretary a list of vessels[3] they have authorized to fish in the fishery in accordance with Article 25 of the Convention and CMM 05-2016 (Record of Vessels) and other relevant CMMs adopted by the Commission. They shall also notify the Executive Secretary of the vessels that are actively fishing or engaged in transhipment in the Convention Area within 20 days of the end of each month. The Executive Secretary shall maintain lists of the vessels so notified and will make them available on the SPRFMO website.

17. The Executive Secretary shall report annually to the Commission on the list of vessels having actively fished or been engaged in transhipment in the Convention Area during the previous year using data provided under CMM 02-2017 (Data Standards).

18. In order to facilitate the work of the Scientific Committee, Members and CNCPs shall provide their annual national reports, in accordance with the existing guidelines for such reports, in advance of the 2017 Scientific Committee meeting. Members and CNCPs shall also provide observer data for the 2017 fishing season to the Scientific Committee to the maximum extent possible. The reports shall be submitted to the Executive Secretary at least one month before the 2017 Scientific Committee meeting in order to ensure that the Scientific Committee has an adequate opportunity to consider the reports in its deliberations.

19. In accordance with Article 24(2) of the Convention, all Members and CNCPs participating in the *Trachurus murphyi* fishery shall provide a report describing their implementation of this CMM in accordance with the timelines specified in CMM 10-2017 (Compliance Monitoring Scheme). On the basis of submissions received the CTC shall develop a template to facilitate future reporting. The implementation reports will be made available on the SPRFMO website.

20. The information collected under paragraphs 11, 13 and 18, and any stock assessments and research in respect of *Trachurus murphyi* fisheries shall be submitted for review to the Scientific Committee. The Scientific Committee will conduct the necessary analysis and assessment, in accordance with its Workplan (2017) agreed by the Commission, in order to provide updated advice on stock status and recovery.

21. Contracting Parties and CNCPs, as port States, shall, subject to their national laws, facilitate access to their ports on a case-by-case basis to reefer vessels, supply vessels and vessels fishing for *Trachurus murphyi* in accordance with this CMM. Contracting Parties and CNCPs shall implement measures to verify catches of *Trachurus murphyi* caught in the Convention Area that are landed or transhipped in its ports. When taking such measures, a Contracting Party or CNCP shall not discriminate in form or fact against fishing, reefer or supply vessels of any Member or CNCP. Nothing in this paragraph shall prejudice the rights, jurisdiction and duties of these Contracting Parties and CNCPs under international law. In particular, nothing in this paragraph shall be construed to affect:

    (a) the sovereignty of Contracting Parties and CNCPs over their internal, archipelagic and territorial waters or their sovereign rights over their continental shelf and in their exclusive economic zone;

    (b) the exercise by Contracting Parties and CNCPs of their sovereignty over ports in their territory in accordance with international law, including their right to deny entry thereto as well as adopt more stringent port State measures than those provided for in this CMM and other relevant CMMs adopted by the Commission.

22. Until the Commission adopts an Observer Programme in accordance with Article 28 of the Convention, all Members and CNCPs participating in the *Trachurus murphyi* fishery shall ensure a minimum of 10%

[3] Fishing vessels as defined in Article 1 (1)(h) of the Convention.

scientific observer coverage of trips for vessels flying their flag and ensure that such observers collect and report data as described in CMM 02-2017 (Data Standards). In the case of the flagged vessels of a Member or CNCP undertaking no more than 2 trips in total, the 10% observer coverage shall be calculated by reference to active fishing days for trawlers and sets for purse seine vessels.

COOPERATION IN RESPECT OF FISHERIES IN ADJACENT AREAS UNDER NATIONAL JURISDICTION

23. Members and CNCPs participating in *Trachurus murphyi* fisheries in areas under national jurisdiction adjacent to the area to which this CMM applies in accordance with paragraph 1, and Members and CNCPs participating in *Trachurus murphyi* fisheries in the area to which this CMM applies, shall cooperate in ensuring compatibility in the conservation and management of the fisheries. Members and CNCPs participating in *Trachurus murphyi* fisheries in areas under national jurisdiction adjacent to the area to which this CMM applies are invited to apply the measures set out in paragraphs 11-22, insofar as they are applicable, to vessels associated with the *Trachurus murphyi* fisheries in their areas under national jurisdiction. They are also requested to inform the Executive Secretary of the Conservation and Management Measures in effect for *Trachurus murphyi* in areas under their national jurisdiction.

SPECIAL REQUIREMENTS OF DEVELOPING STATES

24. In recognition of the special requirements of developing States, in particular small island developing States and territories and possessions in the region, Members and CNCPs are urged to provide financial, scientific and technical assistance, where available, to enhance the ability of those developing States and territories and possessions to implement this CMM.

REVIEW

25. This Measure shall be reviewed by the Commission in 2018. The review shall take into account the latest advice of the Scientific Committee and the CTC, and the extent to which this CMM, CMM 1.01 (*Trachurus murphyi*, 2013), CMM 2.01 (*Trachurus murphyi,* 2014), CMM 3.01 (*Trachurus murphyi*; 2015) and CMM 4.01 (*Trachurus murphyi,* 2016) as well as the Interim Measures for pelagic fisheries of 2007, as amended in 2009, 2011 and 2012, have been complied with.

26. Without prejudice to Members and CNCPs without an entitlement in Table 1 and the rights and obligations specified in Article 20 paragraph 4(c) of the Convention and having regard to paragraph 10, the percentages included in Table 2 will be used by the Commission as a basis for the allocation of Member and CNCPs' catch limits from 2018 to 2021 inclusive.

Table 1: Tonnages in 2017 fishery as referred to in paragraph 5.

Member / CNCP	Tonnage
Chile	317 300
China	31 294
Cook Islands	0
Cuba	1 100
Ecuador (HS)	1 179
European Union	30 115
Faroe Islands	5 466
Korea	7 321
Peru (HS)	10 000
Russian Federation	16 183
Vanuatu	23 042
Total	**443 000**

Table 2: Percentages[4] related to the catches referred to in paragraph 10.

Member / CNCP	%
Chile	64.5638
China	6.3477
Cook Islands	
Cuba	0.2231
Ecuador (HS)	0.2391
European Union	6.1086
Faroe Islands	1.1087
Korea	1.2822
Peru (HS)	2.0284
Russian Federation	3.2825
Vanuatu	4.6738

4 These percentages shall apply from 2018 to 2021 inclusive.

Scientific Committee

The Hague, Kingdom of the Netherlands
10-14 October 2016

REPORT OF THE 4th SCIENTIFIC COMMITTEE MEETING

1. Welcome & Introductions

The participants were welcomed to the meeting by Mr. Frans Vroegop, from the Department of Fisheries at the Ministry of Economic Affairs in Kingdom of the Netherlands. Dr James Ianelli, Chair of the Scientific Committee (SC), opened proceedings, and participants introduced themselves.

2. Administrative Arrangements

2.1 Adoption of Agenda

The Chair sought proposed changes to the Draft Agenda. Several presentations were added to the agenda with consent of the SC. The agenda is attached as Annex 1.

2.2 Meeting documents

Access to meeting documents (all electronic) was explained. The proposed meeting schedule (SC04-02) was accepted as well as updated versions for the document list (SC04-03_rev3) and Agenda items and related papers (SC04-04_rev4). The list of participants is attached as Annex 2. Late papers relevant to agenda items 3 – 6 were added to the list of meeting documents.

2.3 Nomination of rapporteurs

Rapporteurs were assigned and included: the Chairperson (agenda item 1 and 2), the Secretariat (agenda item 3 and others not specified), New Zealand and vice-chair (agenda item 4), Chile (agenda item 5), New Zealand (agenda item 6), Australia (agenda item 7 and 8), EU (agenda item 9) and the invited experts (agenda item 10).

3. Discussion of Annual Reports

Annual Reports were provided for this meeting by Australia, Chile, China (2), Colombia, European Union, Korea, New Zealand, Peru (2), Russian Federation, Chinese Taipei, United States of America, and Vanuatu (papers SC04-07 to 17 and 29 to 31). Participants made brief presentations of their reports and provided answers and explanations in response to questions. In addition, Observer Implementation reports were either contained within those annual reports (Peru, China, Australia, Chile, Korea) or as separate papers (the EU [SC04-32] and New Zealand [SC04-18])

The presentations of the annual reports were followed by discussions among representatives as summarised in Annex 4 below.

4. Commission Guidance and other intersessional activities

4.1. Commission SC Workplan

The workplan (COMM-04 Annex D) provides guidance to the SC. The items were reviewed and it was noted that most of the workplan will be addressed based on intersessional activities and work to be done during the week. The Chair shared the presentation shown to the 2016 Commission in order to provide an overview of how results from the SC are communicated to the Commission.

In addition, the SC noted that two intersessional web meetings had been conducted in July (SC04-05) and in September (SC04-28), and the SC expressed its support for those coordination meetings.

4.2. Secretariat SC related activities

Paper SC04-25_rev1 informed the SC about relevant meetings that the Secretariat had attended over the past year, in particular: a meeting of the Sustainable Ocean Initiative discussing biodiversity beyond national jurisdiction, a meeting by the CBD, a UN workshop addressing the impact of bottom fishing on VMEs and long-term sustainability of deep-sea fish stocks, last year's CCAMLR meeting, Our Oceans 2015 conference, and a data workshop with regional data managers. The Executive Secretary specifically noted a need to communicate important progress made by RFMOs to coastal states and regional seas programmes that operate in conjunction with UN and other programmes. The paper also summarized the various data releases that the Executive Secretary has authorised during the past year. It was noted that one of these data releases related to a dataset that was released to support a risk assessment of Southern hemisphere porbeagle sharks conducted as part of the FAO-implemented GEF Project in ABNJ.

The potential development and/or strengthening of collaboration among RFMOs was discussed. The SC Chair indicated that such collaborations were typically restricted by funding sources. Chile indicated support for collaborations development, however keeping in mind that we are a cost-effective organisation. The Secretariat reminded the SC that the Commission had directed the Secretariat to prepare advice and guidance on potential collaborations and asked for views from the SC. Reference was made to existing MoU's with ACAP and CCAMLR. François Gerlotto mentioned that there was ongoing collaboration between ICES and the SPRFMO acoustics working group.

4.3. Assessment Workshop

Jim Ianelli chaired a workshop of a sub-group of Member scientists that preceded the SC04 meeting. The purpose of the workshop was to provide more focus on the assessment model used for Jack Mackerel within SPRFMO. Recommendations from this group were implemented, including sensitivity runs, and continued in the regular SC meeting, also used to develop the basis for advice. Specific activities included evaluating the sample size of the data sources used in the assessment based on the SC-03 data workshop outcomes, evaluating new fisheries selectivity settings to reduce the number of parameters to be estimated in the assessment models, and evaluating whether rescaling natural mortality to reflect higher mortality at younger ages would result in better model fits. As with practice at previous SCs, the incremental addition of updated 2015 and new 2016 data was evaluated.

4.4. Fishery dependent acoustic Task Group

The proposal concerning "Fishing vessels as scientific platforms" was presented in 2015 as an initiative taken by IREA. A special issue was published by Fisheries Research (Volume 178, SPECIAL ISSUE: THE USE OF FISHING VESSELS AS SCIENTIFIC PLATFORMS, June 2016). It gathers 15 contributions and a biographical list can be found in SC04-INF01.

Francois Gerlotto presented a report of the activities of the Fishery dependent acoustic Task Group (SC04-27). The document submitted in Port Vila on calibration of fishing vessel echo sounders was presented to the ICES WGFAST during its meeting in Vigo, Spain, April 2016. The document was positively analyzed and is now considered as a final version. The project on JM Target Strength (TS) studies was discussed in Vigo by scientists from the SPRFMO area (Australia, NZ, Chile, Peru, EU). They concluded that it was too soon to consider performing experiments at sea and recommended the preliminary step of studying the existing data. A workshop will be organized by IREA, IMARPE and SNP (Lima, 7-10 November, 2016), to produce a synthesis on the existing TS equations. The question of the huge flow of acoustic data from FVs was discussed in Vigo. There is a need for acoustic monitoring methods including choice of indicators, data collection, processing, management and storage. This question will be explored during the workshop in November and a proposal submitted to SPRFMO. Dr John Horne (Univ. Washington, Seattle) offered to provide his expertise in this field.

A report of Peruvian acoustic activities aboard FVs (SC04-26) was presented and covered calibration methods developed in Peru for single frequency digital echo sounders. These methods were applied and validated, and the acoustic data collected aboard fishing vessels analysed. Besides offering information for the assessment of several species of fish and squids, the acoustic data is useful to: get relative abundance indexes of macro zooplankton; detect the upper limit of minimum oxygen zone; detect internal waves and other physical structures; detect the vertical migration of fish and plankton; and calculate the volume of the pelagic habitat. The task group suggests that the SC recommend the design of joint synoptic surveys using data collected along the normal tracks of fishing vessels that are properly equipped and calibrated. The goal is to advance toward an Ecosystem-Based Approach to Fisheries Management.

4.5. Jack mackerel Age/Growth Task Team

SC04-JM04 was presented and covered the analysis of jack mackerel otolith microstructure. The age-size estimation showed a high growth rate in the first 200 days. This growth rate is higher than the one estimated for jack mackerel from Peru by Goicochea et al. (2013), who observed a mean size at 150 days of approximately 9.3 cm total length, compared to the 15 cm in FL, at the same age, estimated in the current study. Certain doubts arose regarding the interpretation of daily-rings which suggests the need to conduct a validation study for the periodicity of primary micro-increments in otoliths of juvenile and adult fish.

SC04-JM05 was presented on developing a protocol for age-determination of jack mackerel. An inter-calibration exercise and a scientific workshop was undertaken. The inter-calibration exercise included participants from the Netherlands, Ecuador, Russia and Chile, while just two countries attended the workshop (Ecuador and Chile). The workshop showed large differences between readers. The protocol contains procedures for reading including identifying checks indicating hatch date, annuli, and how to interpret otolith margins.

SC04-JM03 was presented in two parts. The first part examines the application of the two known criteria used for the analysis of the growth of microstructures in otoliths: the Individual Mark Reading (IMR) and the Group Band Reading (GBR). The first criterion (IMR) shows a great coincidence in the readings of microstructures in otoliths from northern Chile and central-southern Peru for the first year (365 rings, corresponding to a total length of 19.5 to 20.8 cm). The second criterion (GBR) was only applied in the analysis of otoliths from central-southern Peru and these readings indicate that at one year of age (365 rings read) jack mackerel would have reached a total length of 28.4 cm. These results, and especially those with the GBR criterion, suggest that at one year of age jack mackerel reaches a much larger total length than the 15.3 cm corresponding to the growth parameters currently in use. The second part of this study analyses the frequency in the formation of the growth rings after the first formed ring in otoliths from southern Peru. Two types of ring formation patterns were identified: one with the formation of quarterly rings (Pattern I) and the other with semi-annual rings (Pattern II). The occurrence of these quarterly type-I and biannual type-II growth rings in the otoliths of jack mackerel underlines the need to clearly distinguish and properly identify these two types of rings in the age determination process in order to avoid the overestimation or underestimation of the ages of jack mackerel. From these results it seems clear that the problems and uncertainties regarding the age determination of jack mackerel within the context of the SPRFMO are still not resolved and more in-depth analyses of the otolith microstructure and of the formation process of daily, seasonal and annual rings are needed.

The SC discussed the possibility of deriving an ageing error matrix based on precision evaluation information (inter-reader comparisons) presented in the Chilean paper. Chile indicated they will follow up on whether data can be made available.

The SC **agreed on the need to maintain age reading research as a high priority and to account for ageing error** in the jack mackerel assessment.

The SC recommended that activities such as jack mackerel age-determination workshops and age validation work continue to be pursued.

The SC noted the need to refine ageing protocols to be more descriptive/detailed (e.g., include specifics on sections preparation and other procedures to ensure standardisation) and to develop QAQC procedures such as ongoing training for age readers.

The SC noted that analysis and validation of juvenile growth is a key information gap. It was suggested that a tagging experiment may be more useful than experimental (laboratory) growth studies.

The SC noted potentially confounded differences in age reading versus differences in population structure between Peru and Chile (i.e., separate but related issues of age determination/growth estimation and stock discrimination) and there was a pressing need to resolve these.

5. Jack Mackerel Working Group

5.1. Report on Inter-Sessional assessment/research by Participants

Paper SC04-JM06 evaluated parsimony in the stock assessment model for Jack mackerel. The paper showed that the use of temporal blocks in selectivity reduces significantly both the number of parameters (parsimony) without a large loss in the fit goodness of the model and also the parameter correlation produced in large-scale models. It was concluded that the use of variable selectivity by year in the current assessment model was not justified. The age-compositions fitted substantially less well under this scenario and objectively evaluating selectivity blocks was difficult. The SC agreed to continue using time-varying selectivity in the assessment model for the fishing fleet age composition.

Cristian Canales also presented paper SC04-JM07 on weighting factors for likelihood components in the statistical assessment model. The results of reviewing the data weighting factors in the jack mackerel assessment model showed that, in general, the value of these sample sizes should be down-weighted. The SC appreciated results from this analysis and included these characteristics in models 1.4 and 1.8.

A late information paper was presented by Dr Sepúlveda on Biophysical modelling to assess population connectivity and inter-annual variability in the recruitment patterns of jack mackerel in the southeastern Pacific. An individual-based model (IBM) was coupled to a validated hydrodynamic model to simulate annual patterns in the early life history of jack mackerel for the period 1994-2014. The IBM configuration included realistic initial conditions related to the location and synchrony of spawning in three spawning grounds: coastal area off Peru, coastal area off northern Chile and oceanic area off central Chile. The proposed modelling scheme reasonably simulates the early life history of jack mackerel and can also be considered when evaluating the current stock structure hypotheses. The high dispersion range and spatial overlap of modelled recruitments support the hypothesis of a single panmictic population, which is consistent with the genetic evidence of jack mackerel in the southeastern Pacific.

5.2. Inter-Sessional Progress with the Stock Structure Research Programme

Francois Gerlotto presented a paper (SC04-JM02) which has been submitted to Fish and Fisheries discussing the stock structure of Jack mackerel under a new proposed metapopulation theory, which distinguishes territory bounded and environmental bounded habitats for sub-populations. In light of this theory he shows how stock structure over time for Jack mackerel might be explained.

5.3. Jack mackerel Stock assessments

The Commission advised the SC to execute a "benchmark' assessment in 2016 for which a two-day workshop was held prior to SC04. The data and assessment results for the models leading to advice are provided in Annex 7.

5.3.1. Updating of data sets for additional stock assessment runs

The Secretariat provided an updated historical catch data series to 2015 as well as an initial estimate of 2016 catches for use in the assessment (SC04-JM01 Annex 1). Changes to previous versions for this data series are explained in the paper and generally limited to the 2015 final figures as advised by Members and CNCPs. Paper SC04-JM01 also shows that generally previous estimates for total current catches have been within 10% of the final figures with Fleets 1 and 4 showing the highest variance.

2016 initial estimates were created by applying the mean observed difference, by fleet, between the provisional 2010-15 figures and the final 2010-15 figures, to the available 2016 monthly catches. Most initial estimates were accepted, but adjustments based on participant's knowledge were applied for China, the EU, Vanuatu and Korea. China adjusted its initial estimate downwards based upon this year's poor fishing conditions. The EU and Vanuatu fleets have finished fishing for the year and they were able to provide final estimates. Korea adjusted its initial estimate upwards based upon the entry of a second vessel into the fishery during September and one vessel is expected to continue fishing until the end of the year. In addition, Chile clarified that it has already caught 5,100 tonnes from international waters.

For the first time, standardized data templates were used to receive catch, age and length data from the fisheries and from the data used to derive indices. The templates proved useful as it allowed easy comparison of e.g. length-frequency data. Suggestions were made to improve the templates for next year's data compilation exercise.

Catch data were updated for all fleets including their age or length compositions. The Chinese CPUE index, Peruvian CPUE index, offshore / EU combined index, Russian CPUE index, Chilean CPUE index, and echo-abundance index from Peru were all updated.

All datasets were added in an incremental way to the dataset used for the assessment to allow testing the impact on stock perception following from each data addition. A complete list of the model configurations and access to the data tables can be found online (https://goo.gl/Gdc2c7) or in Annex 7 of this report.

5.3.2. Re-run of 2015 model configuration

Prior to simulation testing alternative model configurations, the final accepted model of 2015 (SC03) was used as a starting point for comparison. All alternatives tested were evaluated incrementally starting from the 2015 model configuration (but including updated data as described under 5.3.1).

5.3.3. Alternative model configurations

In the past several years the assessment model code has been enhanced to better evaluate model configurations. This includes approaches to evaluate how consistently the model performs when data years are successively excluded from the most recent period (so-called retrospective evaluation). Another capability added this year was the facility to profile over a model scale parameter in order to see which data components and model assumptions are most affecting estimates. Such plots are useful for evaluating among model structural assumptions.

Over 18 alternative model configurations were tested in the benchmark workshop and extending into the SC meeting. The complete list of the model configurations is published following the link as given under 5.3.1. A description of the configurations tested is provided below. Model 1.18 was used as the basis for the one-stock hypothesis. Models 1.18 (for the south) and 1.6 (for the north) were used for the two-stock hypothesis.

Model number	Model description
1.0	2015 base configurations with all data updated to 2016
1.1	As 1.0 but downweighting nominal CPUEs (EU and Russia)
1.2	As 1.0 but downweighting discontinued surveys (acoustic Peru, DEPM, acoustic Chile Central South)
1.3	As 1.0 but applying dataset uncertainty (through sample size of the multinomials and the CVs) set according to the estimated uncertainty of these datasets following from the 2015 data workshop
1.4	As 1.0 but applying dataset uncertainty (CVs) set according to numbers provided in SC04-JM07
1.5	As 1.0 but selectivity changes in the fisheries as set according to SC04-JM06
1.6	As 1.0 but selectivity changes in the fisheries as set according to SC01 settings
1.7	As 1.0 but downweighting catch-at-age
1.8	As 1.0 but rescaling sampling size using the Francis T1.8 method
1.9	As 1.0 but varying natural mortality between 0.05 and 0.5 in steps of 0.05
1.10	As 1.0 but implementing age-varying natural mortality following Lorenzen 1998, scaled to the maximum ages to be 0.23
1.11	As 1.0 but including a selectivity change in the Northern Chilean acoustic survey in 2015 and 2016 to reflect changes in availability due to El Nino
1.12	Combining 1.11 and 1.5
1.13	Combining 1.12 and 1.7
1.14	Combining 1.11 and 1.3
1.15	As 1.11 but including a change in the Northern Chilean acoustic in 2014, 2015 and 2016
1.16	As 1.11 but including the natural M following Lorenzen 1998 scaled to the mean of 0.23 (*unsuccessful*)
1.17	As 1.11 but including ageing-error
1.18	As 1.11, including time-varying selectivity in the fleets up to 2016
1.19	As 1.18 but including provisional age-error matrix
2.0	As 1.18, assuming steepness of 0.8 and recruitment regime from 1970-2013
2.1	As 1.18, assuming steepness of 0.8 and recruitment regime from 2000-2013
2.2	As 1.18, assuming steepness of 0.65 and recruitment regime from 1970-2013
2.3	As 1.18, assuming steepness of 0.65 and recruitment regime from 2000-2013

The Jack mackerel working group scrutinized model fits under each of these model configuration and discussed the implications of the changes in configuration. Using likelihood profiles, likelihood tables and diagnostic plots, the SC agreed on a final model for the combined stock. The proposed model configuration for the two-stock model as suggested by Peru was accepted as well.

Models 1.1, 1.2, 1.3, 1.4, 1.7, 1.8 (which downweighted certain datasets) were considered useful to test the sensitivity to data. Models 1.5 and 1.6 were informative to evaluate the trade-off between the number of parameters to estimate and the goodness of fit, and discussions led to the conclusion that fit was appreciated over reducing the number of parameters to be estimated, except for the Northern area in the 2-stock model, where setting selectivity time-blocks was deemed necessary to stabilize the assessment (model 1.6). To estimate what value of natural mortality would best fit to the observations, models 1.9, 1.10 and 1.16 were evaluated, but they didn't indicate any new candidate for the natural mortality assumption. Subtle changes in selectivity pattern estimation in the fisheries and surveys were deemed necessary (models 1.11 and 1.18) to get a best fit to the input data. This exercise lead to the selection of three models (1.11, 1.14 and 1.18) as candidates for the basis of advice. Under model 1.14 the individual datasets were weighted based on results obtained from the data workshop. Given the subjective nature of the data workshop exercise, it was agreed that more work needs to be allocated to retrieve robust uncertainty estimates of each of the datasets used in the assessment. The difference between model 1.11 and 1.18 is subtle and only assumes different selectivity patterns in the last 2 years of the fisheries.

5.3.4. Projections

The SC evaluated the ability of the assessment model to estimate stock productivity (via the stock-recruitment "steepness" parameter). The approach developed at the meeting was to “profile” over alternative fixed values and examine the likelihood components. This evaluation showed that information available to estimate the steepness parameter was limited, especially for alternative model configurations. Models 2.0 – 2.3 were used to project the jack mackerel stock into the future. Results are given in Fig. 2 and are used to provide advice to the commission.

5.4. Advice to the Commission on jack mackerel stock status

The SC is tasked to give advice on the status of jack mackerel. Similar to last year, the group agreed to present a range of plausible model configurations in order to reflect real concerns over recruitment uncertainty and productivity. Advice on jack mackerel stock status at this meeting was based on stock assessments conducted using the Joint Jack Mackerel (JJM) statistical catch-at-age model as developed collaboratively by participants since 2010. The assessment approach has matured and advice has been relatively stable over the past four years.

Conditions for the jack mackerel stock in its entire distribution range in the southeast Pacific shows a continued recovery since the time-series low in 2010. Under the two-stock model the Northern unit shows stable and relatively low biomass over the past decade. Fishing mortality is estimated to be well below candidate F_{MSY} levels. Recruitment in the most recent years shows signs of stronger incoming year-classes although the information is highly uncertain and may be influenced by the recent strong El Niño.

The results are in line with previous assessments. Historical fishing mortality rates and patterns relative to the provisional biomass target is shown in Figure 1 (so-called Kobe plot). Projection results under the assumption of recent average recruitment at the levels estimated for the recent period (2000–2013) continue to indicate that if fishing mortality is maintained at or below 2016 levels the likelihood of spawning biomass increases are improved. This results in catches for 2017 on the order of 493 kt or lower. Longer term projections (fishing at or below intended 2016 levels; i.e., mortality that corresponds to 460 kt in 2016) indicate there is a high probability of increased spawning biomass. Near term spawning biomass is expected to increase from the 2016 estimate of 4.1 million t to 5.2 million t in 2017 (with approximate 90% confidence bounds of 4.0 – 6.6 million t).

> On the application of the adjusted rebuilding plan adopted by the 2nd Meeting of the Commission as proposed from SC02, **the Commission should aim to maintain 2017 catches for the entire jack mackerel range in the southeast Pacific at or below 493 kt.**

A two-page summary of the advice on Jack mackerel is provided in Annex 3. The Commission notes the following in their work-plan to the SC:

> *Conduct the stock assessment of Jack mackerel. Advice from these results should be based on application of the adjusted rebuilding plan adopted by the 2nd Meeting of the Commission as proposed from SC02.*

The results addressing these requested projections are given in Table 1 for short-term and longer-term projections. Models 2.0 and 2.2 assume long-term average recruitment conditions (assuming that the environment is conducive to a more normal recruitment productivity regime) while models 2.1 and 2.3 assume recent average recruitment conditions (assuming a lower productivity regime). Example population trajectories under the different fishing mortality rate multipliers and productivity scenarios are shown in Figure 2.

Table 1. Summary results for the short term catch and medium, long term predictions for models 2.0-2.3 for the single stock hypothesis and for summed values under the two stock hypothesis (bottom panel). Note that "B" in all cases represents thousands of t of spawning stock biomass and B_{MSY} is provisionally taken to be 5.5 million t of spawning biomass in all cases and the bottom panel is the result of north and south models combined. Reference F_{2016} refers to the fishing mortality assuming the full TAC will be taken in 2016 (TAC uptake estimated to be 92% in 2016).

Model 2.0, steepness=0.8, recruitment from 1970-2013

Reference F_{2016}	B_{2018}	$P(B_{2018} > B_{MSY})$	B_{2022}	$P(B_{2022} > B_{MSY})$	B_{2026}	$P(B_{2026} > B_{MSY})$	Catch 2017 (kt)	Catch 2018 (kt)
0.00	7047	94%	11940	100%	15945	100%	0	0
0.50	6713	89%	10312	100%	12546	100%	232	298
0.75	6555	86%	9619	99%	11247	100%	345	435
1.00	6351	81%	8792	98%	9807	99%	493	609
1.25	6255	79%	8430	97%	9215	98%	563	689

Model 2.1, steepness=0.8, recruitment from 2000-2013

Reference F_{2016}	B_{2018}	$P(B_{2018} > B_{MSY})$	B_{2022}	$P(B_{2022} > B_{MSY})$	B_{2026}	$P(B_{2026} > B_{MSY})$	Catch 2017 (kt)	Catch 2018 (kt)
0.00	6706	90%	9547	100%	10857	100%	0	0
0.50	6372	82%	8017	97%	8049	96%	232	299
0.75	6214	78%	7372	93%	7010	88%	345	437
1.00	6010	71%	6608	82%	5886	63%	493	612
1.25	5915	67%	6276	74%	5435	48%	564	692

Model 2.2, steepness=0.65, recruitment from 1970-2013

Reference F_{2016}	B_{2018}	$P(B_{2018} > B_{MSY})$	B_{2022}	$P(B_{2022} > B_{MSY})$	B_{2026}	$P(B_{2026} > B_{MSY})$	Catch 2017 (kt)	Catch 2018 (kt)
0.00	6845	92%	11387	100%	15421	100%	0	0
0.50	6512	86%	9763	99%	12014	100%	231	297
0.75	6355	82%	9071	98%	10704	99%	344	434
1.00	6151	76%	8244	96%	9244	97%	492	607
1.25	6057	72%	7882	94%	8641	96%	562	687

Model 2.3, steepness=0.65, recruitment from 2000-2013

Reference F_{2016}	B_{2018}	$P(B_{2018} > B_{MSY})$	B_{2022}	$P(B_{2022} > B_{MSY})$	B_{2026}	$P(B_{2026} > B_{MSY})$	Catch 2017 (kt)	Catch 2018 (kt)
0.00	6603	88%	9383	100%	10756	100%	0	0
0.50	6269	80%	7857	96%	7956	95%	232	299
0.75	6112	75%	7213	91%	6913	86%	344	436
1.00	5909	67%	6449	78%	5780	59%	493	611
1.25	5814	64%	6118	70%	5324	44%	563	691

Model 1.6 North (recruitment: 1970-1996 and 2001-2013) + 1.18 South (recruitment: 1970-2013), steepness=0.8

Reference F_{2016}*	B_{2018}	B_{2022}	B_{2026}	Catch 2017 (kt)	Catch 2018 (kt)
0.00	7302	12099	15921	0	0
0.50	6882	10084	12202	281	337
0.75	6686	9241	10767	415	489
1.00	6500	8490	9551	547	630
1.25	6322	7820	8516	675	761

*Average $F_{2014-2016}$ was used for the Northern stock

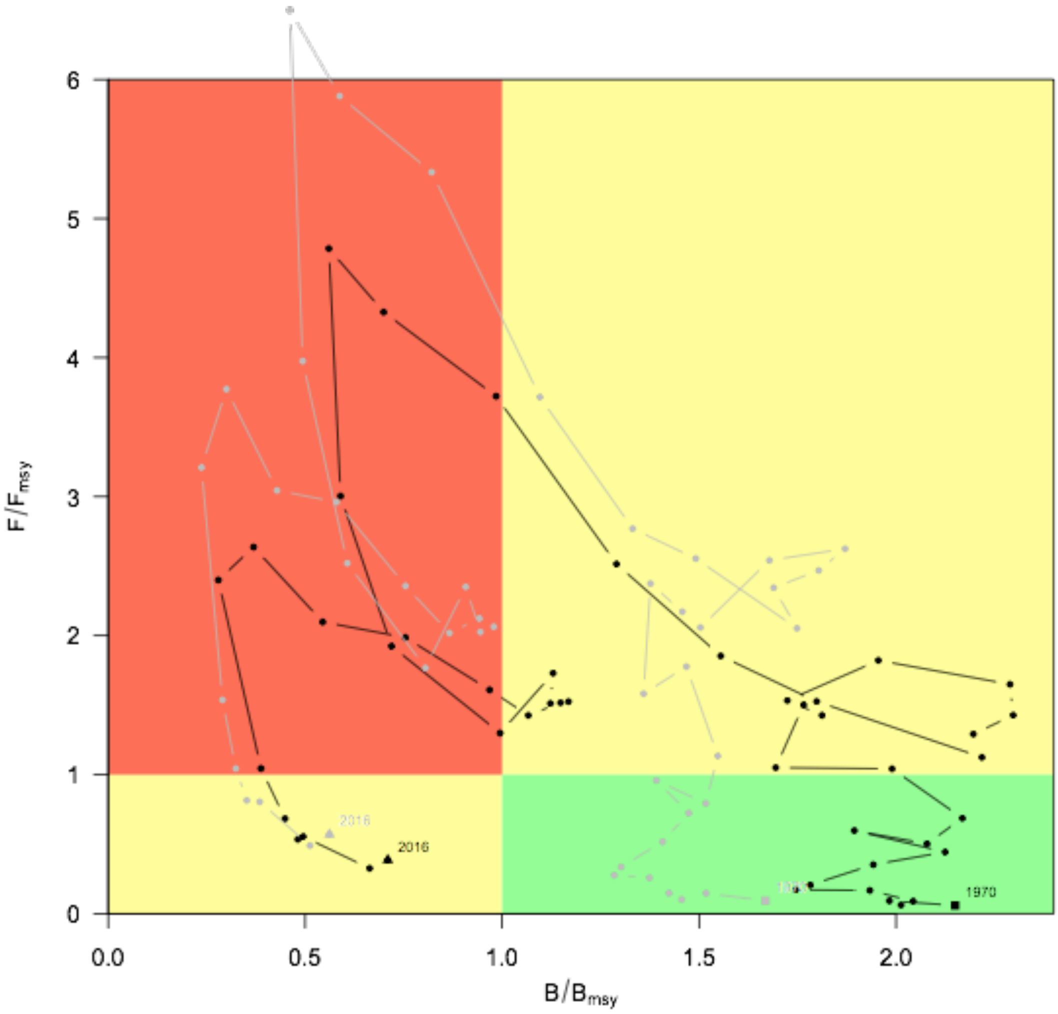

Figure 1. Phase plane (or "Kobe") plot of the estimated trajectory for jack mackerel under Model 2.2 (steepness = 0.65; grey line) compared with Model 2.0 (steepness = 0.8; higher productivity, black line) with reference points set to F_{MSY} and B_{MSY} estimated for the time series 1970-2013.

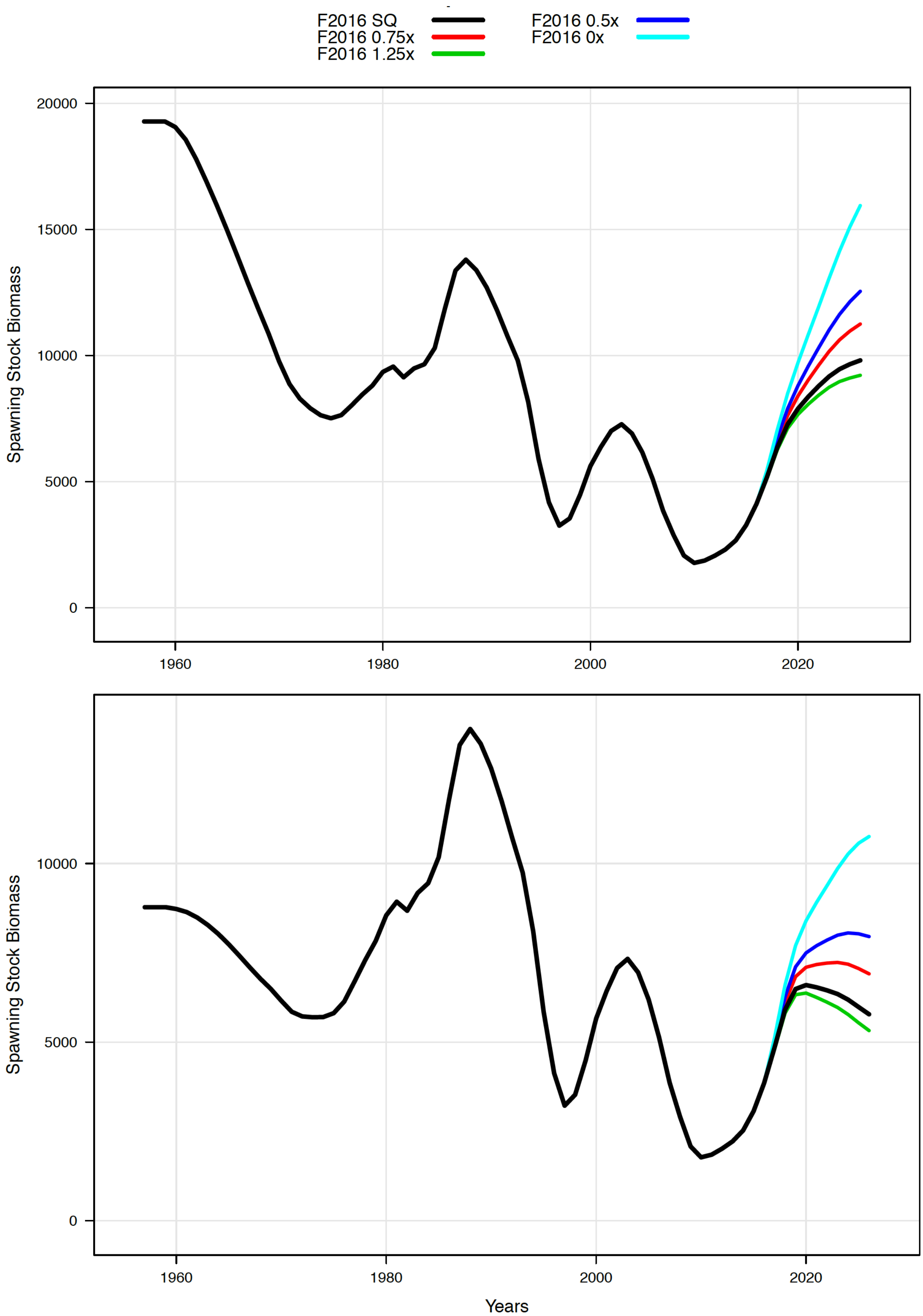

Figure 2. Projections of jack mackerel population trajectories for different multipliers of the reference 2016 fishing mortality rate under models 2.2 (recruitment from 1970-2013; top) and 2.3 (recruitment from 2000-2013; bottom). The provisional B_{MSY} is 5.5 million t.

5.5. *Other jack mackerel topics*

In 2015, a self-sampling protocol was initiated for the EU freezer-trawlers fishing in the SPRFMO area. SC04-INF04 provides a description of the fishing carried out by vessels belonging to members of the Pelagic Freezer-trawler Association (PFA) within the SPRFMO area during 2015 and 2016. The PFA self-sampling programme has been carried out during all trips from April to September. The self-sampling programme delivers information on spatial and temporal evolution of the fishery, species and length compositions, CPUE and ambient fishing conditions (temperature and depth). Ambient water temperature (at fishing depth) appears to have been higher in 2016 compared to 2015. A comparison between self-sampling data and observer data shows that there is generally a close correspondence between the two sources.

6. Deepwater Working Group

6.1. *Applications to fish outside the footprint or above reference period catch levels*

In paper SC04-DW02, New Zealand updated the Scientific Committee on the exploratory fishing for toothfish pursuant to CMM 4.14. Seven sets of integrated weight line were made in August 2016 in depths of 1000 to 2300 m. A total of 35 994 hooks were set, of which 30 424 were recovered (the rest were lost on broken lines). Substantial information was collected, but this has not yet been fully analysed. A total of 29 tonnes of toothfish was caught, all *Dissostichus mawsoni* (Antarctic toothfish), and mostly males with late-stage or spent gonads. A total of 104 toothfish were tagged using standard CCAMLR tags. There was little fish bycatch, mainly of rattails. An average of 0.48 kg of VME material was recovered from each set. Relatively few birds attended the vessel (there were 88 sightings, mostly of Cape, snow, or Antarctic petrels. Standard CCAMLR mitigation was used throughout (meeting or exceeding SPRFMO requirements) and no seabirds were killed or injured. No marine mammals, reptiles, or other species of concern were observed. It is anticipated that the second exploratory fishing trip will occur in 2017 and a more comprehensive analysis of the two trips will be considered by New Zealand's domestic working groups and, depending on timing, submitted to SC-05. Data and information will be shared with CCAMLR, consistent with the MoU between the two organizations, and should contribute to the understanding of the distribution, dynamics and status of stocks of Antarctic toothfish in both SPRFMO and CCAMLR areas. The SC:

- **noted** the completion of the first trip of the 2-year exploratory fishing programme approved under CMM 4.14;
- **noted** that substantial information was collected;
- **noted** that the catch of 29 tonnes greenweight was under the 30 tonne annual limit;
- **noted** the tag and release of 104 Antarctic toothfish (*Dissostichus mawsoni*);
- **noted** that this paper has been provided to the CCAMLR working groups to facilitate cooperation between the two organisations consistent with the MoU;
- **affirmed** its suggestion made at SC3 that the full data and analyses from the trip should be shared with CCAMLR;
- **agreed** that closer collaboration with CCAMLR, especially with respect to tagging of toothfish (as per CCAMLR's request - paper SC04-DW01) would be mutually beneficial;

The Secretariat presented paper SC04-DW01. The SPRFMO Scientific Committee supported increasing collaboration between CCAMLR and SPRFMO especially considering the likelihood of shared toothfish stocks.

The SC agreed that a tagging programme for toothfish was a priority for that fishery and that it should be implemented and managed in close cooperation with CCAMLR to ensure best practice implementation of the tagging activities and to avoid unnecessary duplication of resources within the Secretariats.

The SC expressed an interest in working closely with CCAMLR on stock assessment of toothfish stocks exploited by fisheries in both Convention Areas. This could involve the sharing of data and reports and, potentially, the participation of SPRFMO toothfish experts in the relevant CCAMLR meetings. The SC asked the Secretariat to explore those possibilities intersessionaly.

6.2. Inter-Sessional deepwater assessments

Deepwater assessment for orange roughy were prepared by New Zealand and presented under report section 6.3.

6.3. SPRFMO deepwater stock assessments

In paper SC04-DW03, New Zealand reported progress on the development and testing of a data-limited approach for stock assessment of orange roughy in the western SPRFMO Area. Results of preliminary assessments combining the estimation of a spatially-disaggregated CPUE index of abundance and the fitting of a state-space biomass dynamics model (BDM) were presented. Preliminary analyses were conducted on six management areas/potential biological stocks using catch and effort information from New Zealand fishing vessels only. Spatially-disaggregated CPUE analyses provided more reliable indices of relative abundance in all stocks, which were informative for biomass dynamics modelling in four management areas. The need to compile complete catch series to improve the effectiveness and accuracy of BDM modelling and assessment outputs was stressed. Catch and effort information from Australian vessels will also assist with improving spatial CPUE indices and extend the assessment to the South Tasman Rise orange roughy stock. Results of BDM validation and case study application to a domestic stock of orange roughy within the New Zealand EEZ were presented. The BDM approach can serve to reliably estimate biomass trajectories and stock status in data-limited circumstances for a long-lived species such as orange roughy. A similar case study application and validation of the spatially-disaggregated CPUE method is ongoing. The results will of this validation be available to the scientific committee in 2017. Critical next steps include: 1) the estimation of a complete catch history for each stock; 2) fine-tuning of the spatially-disaggregated CPUE indices; and 3) BDM re-runs including process error sensitivities and initial depletion scenarios. The SC:

- **noted** New Zealand's continued work on provisional stock assessments for orange roughy in the western part of the SPRFMO Area;
- **agreed** that the assessment approach presented by New Zealand is appropriate to estimate reliable biomass trajectories and stock status of orange roughy in the SPRFMO area, based on currently limited available information.
- **noted** that simulation testing of the spatially disaggregated CPUE approach is underway and the results will be available in time for SC5;
- **noted** that the BDM modelling approach has already been simulation tested;
- **noted** that full catch histories for the assessed areas will be required to finalise these stock assessments;
- **urged** other bottom fishing nations to consider providing full catch histories with sufficient precision to be used in the CPUE and BDM analyses;
- **noted** that finalised estimates of initial biomass, productivity, and stock status for some orange roughy stocks should be available in time for SC5 in 2017
- **agreed** that this work should contribute to the development of a revised CMM for bottom fisheries in the SPRFMO Area once the stock assessments are finalised
- **noted** that opportunistic collection of fisheries independent acoustic data from commercial fishing vessels should be encouraged as this will benefit orange roughy assessments.

No progress has been made on stock assessments for other target species in the deepwater fisheries. In regard to bycatch, it was recognized that efforts should be undertaken to assess the impacts on bycatch species, in particular on low productivity species as called for in paragraph 47 of the UN FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas. To advance this work the SC will consider a risk based approach to prioritize species and areas in regard to further research and advice on conservation measures to the Commission. Until this work can be completed, the SC:

- **recommended** that the Commission discuss and consider amending the list of "other species of concern" in Annex 14 of CMM 4.02 to include deep-sea sharks in the SPRFMO Convention Area categorized as critically endangered, endangered, vulnerable or near threatened on the IUCN Red List. Annex 5 contains the current IUCN red-listed deepwater shark species and CITES appendix II relevant species.

6.4. VME distribution and spatial management approaches

In its national report, New Zealand updated SC-04 about progress on the spatial modelling of VMEs within the SPRFMO Area and on the use of the Zonation software tool to prioritise areas for protection and design candidate spatial management areas to protect VMEs from significant adverse impacts while providing for fisheries. No separate paper was provided but New Zealand anticipated using this information to develop proposals for a revised bottom fishing measure. Discussions suggested that the process of defining the most valuable areas for conservation or fishing, and appropriate levels or thresholds for protection, were not entirely scientific issues. It was noted that the percent of fishable depths and the percent of the distribution of VME taxa impacted by bottom trawling would also need to be considered in the design of spatial management areas. As foreshadowed in S-04-DW-04, therefore, New Zealand and Australia intend to convene stakeholder and other working parties to consider candidate spatial management proposals using predictive models of VME density, the distribution of fishing, and decision support software. The SC:

- **noted** steady progress made by New Zealand in the predictive modelling of the likelihood and density of VME indicator taxa and in relation to bottom fisheries;
- **urged** New Zealand to continue this work and include it in the development of proposals for a new bottom fishing measure for the consideration of SC-05.

6.5. Other Deepwater topics

The ABNJ Deep Seas Project Report (SC04-INF02) was presented by the Executive Secretary. Members discussed the recent FAO workshop of global experts on orange roughy held in June 2016. They covered historical aspects of the regional development of the fisheries, biology, stock assessment and key management issues. Recent developments in science and approaches to management were specifically highlighted with respect to the future for the sustainable management of the fisheries. Two participants of that workshop reported that, although the report was unavailable, one of the main recommendations was that CPUE indices should be avoided where possible when assessing deepwater stocks. They reported that the preferred methods involved fishery independent data, usually acoustic technology. New Zealand agreed with those preferences, but noted that the only currently available information for assessment of SPRFMO stocks was CPUE data. The SC:

- **agreed** that there would be value in collecting fisheries independent data for orange roughy assessments, and discussed ways to encourage fishery independent surveys and identify priorities areas for such surveys within the SPRFMO Area;
- **noted** that funding for the collection of fishery independent surveys using research vessels was unlikely to be available in the near future;
- **agreed** to support fishery independent data collection for orange roughy using either research voyages or commercial fishing vessels from those nations having both interests and capacities

- **agreed** to support convening a workshop on survey design, best practice, and validation techniques to develop a SPRFMO standard to collect these types of data, based on existing AUS/NZ standards;
- **noted** that this type of data collection may apply to other deepwater species such as alfonsino, as well as pelagic species such as jack mackerel.

In paper SC04-DW04, New Zealand described progress toward a revised, comprehensive measure for bottom fisheries. As foreshadowed at SC-02, this approach will require: the identification of an appropriate fishing footprint; the setting or revision of sustainable catch levels for key target species; the mapping of the distribution of vulnerable marine ecosystems (VME) within the footprint; and the design of management measures to prevent significant adverse impacts on VMEs, in particular, areas that will be open or closed to fishing within the footprint. New Zealand suggested two potential approaches to drawing this work together into a new bottom fishing measure, but acknowledged that intermediate approaches are also possible:

- A prescriptive SPRFMO bottom fishing measure with a single (bottom trawl[1]) footprint for all bottom fishing members, a consistent approach to move-on rules that applies to all bottom fishing members, and move-on triggers that apply to all bottom fishing members; or
- A high-level SPRFMO bottom fishing measure that defines just the performance objectives, standards and evaluation criteria for management; each bottom fishing member could choose how to give effect to the CMM's requirements (as in CMM 2.03 and the current CMM 4.03).

DSCC underlined the difference between existing Australian and New Zealand move-on rules, identifying strengths and short-comings in both. The discussion covered a number of topics including differing approaches amongst Contracting Parties to open and closed areas and the move-on rule. The pros and cons of the different approaches to the move-on rule were discussed at some length. DSCC considered that the move-on rule should be applied consistently to all vessels and that area from which vessels had been required to move-on should not be re-opened until the SC has determined that re-opening did not pose a threat to VMEs. Considering that the footprint might still expand within blocks, DSCC recommends applying move on rule throughout all areas opened to fishing.

SC discussed the alternative approaches suggested by New Zealand (for advantages and disadvantages refer to Appendix 1 of SC04-DW04) and:

- **agreed** that a more prescriptive bottom fishing CMM for all members may be easier to implement and control, more consistent, and more likely to work effectively, compared with a high-level CMM under which members can choose how to give effect to the CMM's requirements;
- **noted** that a single, prescriptive measure may not be possible across both western and eastern parts of the SPRFMO Area given that Chile has a historical footprint as well as Australia, New Zealand and Korea.
- **noted** that it may not be possible to develop a prescriptive bottom fishing measure for the western part of the SPRFMO Area in time for proposals to SC-05 and the 2018 Commission meeting;
- **noted** that Australia and New Zealand will continue to work together to make progress on proposals for a revised bottom fishing measure for the consideration of SC-05.

[1] Midwater trawling for bentho-pelagic species has been determined to be included within the SPRFMO definition of bottom fishing but is considered unlikely to cause significant adverse impacts on VMEs

7. Squid assessment research

7.1. Summary of papers presented

China presented a paper on biology for the jumbo flying squid, characterizing the growth pattern, longevity, hatching time and potential spawning ground off the Peru waters. Two cohorts (winter-spring and summer-autumn cohort) and two size groups (medium-size and a large-size) was defined.

SC04-33 from China was a study which applied the generalized linear models (GLMs) to standardize CPUE of the Chinese jigging fishery from 2004 to 2014 which is used as relative abundance index. SC04-34 was a Bayesian state-space surplus production model based on this derived standardized CPUE data and FAO total catch of the jumbo squid in the southeast Pacific Ocean. This model was used to assess the dynamics and status of jumbo squid stock in the Convention Area. The posterior distribution of K (carry capacity) was found sensitive to the upper boundary of its prior distribution, and subsequently six scenarios with different upper boundary values were considered and evaluated. The stock assessment suggests that the fishery was not subject to overfishing and the stock was not overfished, and this conclusion is robust regarding the scenarios considered in this study. The sensitivity analysis suggests that the stock assessment can well capture the dynamics for relative stock biomass of jumbo flying squid, but not for absolute stock biomass, suggesting that this stock assessment may not be used to provide information for advising the development of TAC-based management regulations.

- The **SC agreed and encouraged further development of this and alternative models for assessing jumbo flying squid in the region.**

SC04-20 summarized squid in the Peruvian waters. Although catches of jumbo flying squid are fairly high and increasing, the few partial assessments available suggest that the stock or stocks are in a healthy situation at present. However, this may change on short notice given the high variability in abundance typical of squids and, therefore, the SPRFMO should not wait for the stock or stocks to be in critical condition or have their sustainable use being hampered to implement adequate databases and develop and start applying appropriate stock assessment and fishery monitoring tools and procedures that would facilitate the provision of timely advice and the eventual adoption of management measures that may be needed. The medium and long term research priorities identified in the SC Research Programme 2013 adopted by the SC-01 served as a basis for defining the type and level of detail of the data to be provided to the SPRFMO Secretariat on a regular basis for regular reporting, monitoring and stock assessment purposes and this level of detail is further defined in the existing templates for reporting on the catch per tow for trawlers and per drift set for jiggers, which includes full details of the vessel and gears used and of the individual fishing operations. It is therefore recommended that the templates already available be used for recording as well as for reporting on the fishing activities of trawlers and jiggers participating in the jumbo flying squid fishery in the Convention area; that provisions be made to, to the extent possible, recover the same type of information for past fishing activities, if available; and that plans be made for the sooner implementation in the jumbo squid fishery of an Observer Programme similar to the one already existing for vessels participating in the fishery.

7.2. Discussion on squid assessment data needs

The papers summarizing the status and limitations of squid data held by the Secretariat and the paper detailing research and data needs for D gigas were presented to the SC (SC04-21 and SC04-20*)*. The SC noted that the resolution of data varies markedly and that there are data gaps. These gaps may influence the perception of recent increases in squid catches.

The SC initially addressed the question on whether the intended goal for SPRFMO was to apply a TAC and/or effort-based management to the squid fisheries The SC noted that the intention of the preliminary squid assessment modelling was not for this work to be used in setting TACs. Rather, the preliminary work allows the SC to explore possible assessment methods and the status of populations. Importantly, the kobe plots presented in the preliminary assessment use a relative scale (not absolute). Noting this caveat it does provide some information on the ratio of B/BMSY and F/FMSY.

It was discussed that the lack of the ability to estimate carrying capacity (K) was a significant limitation. However, it was also suggested that despite the general consensus that squid stocks are in good shape and are not overfished or subject to overfishing, and acknowledging that squid populations are highly variable and exhibit large changes based on prevailing environmental conditions, the lack of reliability around a K estimate should not necessarily preclude a precautionary TAC from being considered in the future should the Commission request such advice.

Adding to the uncertainty, it was discussed that there is limited information on stock structure and the biology of the species, with some discussion of spatio-temporal differences in biology, in particular length at maturity. Differences between length at maturity in squid populations have been observed between and within seasons and in different areas. It also appears that these differences are correlated with El Nino cycles. Stock structure delineation will influence how the stocks are managed. It is possible that currently, environmental conditions appear to have a larger influence on squid populations than fishing pressure.

There was some discussion around the CPUE standardization used in the assessment, noting that catch rates and the number of active vessels fluctuates throughout the year. The SC noted that for the Chinese Fleet the vessels are owned by a relatively small number of companies. However, there were likely to be some small variations in fishing power and squid catchability between boats.

There was some discussion around whether there was a correlation between recruitment and carrying capacity, with the SC noting that for this study, R and K did not appear to be strongly correlated. It appears that K was more strongly correlated with Q (catchability). Nonetheless, it appears that fishing is not currently impacting heavily on the population. The SC also discussed that the data used (last 10 years) was all of the available data and that this partly explains why the estimate of K is difficult. There are some gaps in the data used and the Secretariat proposed that the squid catch series could be improved with relatively little work.

An amendment to the distribution map presented was suggested so that the map indicates that the fishing ground extends to 41 degrees south.

The SC discussed the level of environmental data required to inform squid assessments and stock assessment more broadly and it was noted that environmental data for stock assessment can be collected through various sources external to observers. It was also noted that care is required not to overload observers. Satellite and modeling data can be useful sources for this information.

There was some discussion on the need for observer coverage in the jigging fishery, given it is such a clean fishery in terms of bycatch. It was noted that observers are important from the perspective of validating logbook data, so it is not just collection of biological and bycatch data that are important. It was raised that some squid fisheries (e.g. China) comprise many small boats, so any observer program for the squid fishery, will need to consider the feasibility of deploying at sea observers on these smaller vessels.

The SC discussed the issue of future-proofing data collection and the importance of being prepared for novel methods. The example of genetic methods was used, and it was noted that these methods are advancing quickly and are becoming less expensive to use. However, the application of some of these techniques may be impractical for squid. In designing and implementing observer programs this should be considered to ensure that data is being collected that can take advantage of these evolving methods.

The SC also discussed whether the fishery and associated stock assessments will require fishery dependent and fishery independent data in the future and noted that Peru undertakes some fishery independent surveys using acoustic methods. It was noted that sole reliance on fishery dependent data is riskier.

The SC discussed that SC04-19 represented good progress towards better understanding species biology, in particular spawning locations and reproductive biology, for squid. There was some discussion around the relationship between hatching date and the location of mature spawning females, with the hypothesis that the lag in the hatching date and the highest proportion of spawning females might be due to multiple stocks. It was thought that this lag between spawning and hatching was probably unrealistic given the life history of the species.

The SC agreed that the information specified in Annexes 1 to 6 of CMM4.02 is the minimum necessary for it to undertake effective monitoring and assessments for stocks in the Convention area. The SC requires that this information is provided in a timely manner to the Secretariat of SPRFMO so that assessments can be prepared, reviewed and used for providing scientific advice for the SPRFMO Commission.

The SC discussed that the wording of CMM4.02 para 1 (e) might not make it explicit enough that this information is important for effective monitoring and stock assessments. This has created some confusion for Members and CNCPs when preparing their data for submission to the SPRFMO secretariat. The SC advises the SPRFMO Commission that this confusion may be an important reason for delays in the provision of scientific advice on the stock(s) of jumbo flying squid in the Convention area. **The SC recommends that the SPRFMO Commission amend CMM4.02 to avoid confusion for Members and CNCPs regarding the use of the same templates for data recording and reporting.**

The SC also noted that the requirement of CMM4.02 for Members and CNCPs to provide by the 30th June, their previous (January to December) year's data on fishing activities and the impacts of fishing described in sections 1b) – 1d) of CMM4.02 is currently not possible for some fleets participating in the jumbo flying squid fishery in the Convention Area. This is due to vessels being at sea for periods longer than 12 months before returning to port and there being no current option for submission of vessel logbook data prior to this return. In this circumstance a member or CNCP may not be compliant with CMM4.02. **The SC also recommends that the SPRFMO Commission amend CMM4.02 to allow for an extension in the timing of data submissions in those cases where the Members and CNCPs do not yet hold this information for all vessels in their fleets and that an anticipated submission date is provided**.

The SC noted that CMM4.02 includes data confidentiality requirements for the SPRFMO secretariat. Specifically, it requires the Secretariat to operate comprehensive and robust processes to maintain the confidentiality of the non-public domain data that Members and CNCPs provide to it. **The SC requests the SPRFMO Commission to remind all Members and CNCPs that issues of data confidentiality are provided for in CMM4.02 and this may not be used as a reason for failure to submit data to the Secretariat**.

The preparation of stock assessments for stock(s) of jumbo flying squid fishery in the Convention area is constrained by the availability of historical fishing data. **The SC requests that the SPRFMO Commission commence a data recovery initiative to minimize the impact of this constraint. The data recovery should provide data that is consistent with the specifications of Annex4 of CMM4.02 to the extent possible**.

The SC discussed the implementation of observer programmes for jumbo flying squid fisheries in the Convention Area. It noted that CMM4.02 requires Members and CNCPs to develop, implement and improve observer programmes (see section below on observer programme).

The SC was advised that for some vessels operating in the jumbo flying squid fisheries in the Convention Area the placement of at sea observers may be logistically difficult due to the small size of these vessels. The SC was also advised that there is negligible bycatch in jigging fisheries. The SC noted that without the implementation of observer programs the SC may not have access to information to verify vessel logbook and bycatch data and to the capacity to design and implement necessary biological sampling activities. Electronic monitoring, Study fishing fleet with trained captains and crews[2], and Vessel Self-Sampling may provide opportunities to overcome this constraint. CMM4.02 currently does not provide guidance on whether these developing methods could be used to meet the SC's requirements of the data collected by at sea observers. **The SC asks the Commission to acknowledge the ongoing work to provide verification of fisheries vessel data.**

7.3. Suggested amendment to CMM4.0.2

Paragraph 1e) compile data on fishing activities and the impacts of fishing and provide these in a timely manner to the Secretariat of the South Pacific Regional Fisheries Management Organization (SPRFMO) using the SPRFMO data recording and reporting templates. ~~Such~~ [These] data are to be provided ~~in sufficient detail~~ ~~to facilitate~~ [for] effective [monitoring] and ~~stock~~ assessment [of stocks]. Members and CNCPs will provide by the 30th June, their previous (January to December) year's data on fishing activities and the impacts of fishing described in sections 1b) – 1d) above. [In exceptional cases where Members and CNCPs do not yet hold this information for all vessels in their fleets an extension in the timing of data submissions (for this missing data) is possible provided that an anticipated submission date is specified to the SPRFMO Secretariat.

7.3. Other topics

There was a discussion about the level of environmental data required to inform squid assessments and stock assessment more broadly and it was noted that environmental data for stock assessment can be collected through various sources external to observers. It was also noted that care is required not to overload observers. Satellite and modelling data can be useful sources for this information.

There was some discussion on the need for observer coverage in the jigging fishery, given it is such a clean fishery in terms of bycatch. It was noted that observers are important from the perspective of validating logbook data, so it is not just collection of biological and bycatch data that are important. It was raised that some squid fisheries (e.g. China) comprise many small boats, so any observer program for the squid fishery, will need to consider the feasibility of deploying at sea observers on these smaller vessels.

The SC discussed the issue of future-proofing data collection and the importance of being prepared for novel methods. The example of genetic methods was used, and it was noted that these methods are advancing quickly and are becoming less expensive to use. However, the application of some of these techniques may be impractical for squid. In designing and implementing observer programs this should be considered to ensure that data is being collected that can take advantage of these evolving methods.

The SC discussed whether the fishery and associated stock assessments will require fishery dependent and fishery independent data in the future and noted that Peru undertakes some fishery independent surveys using acoustic methods. It was noted that sole reliance on fishery dependent data may be riskier.

The SC discussed that SC04-19 represented good progress towards better understanding species biology, in particular spawning locations and reproductive biology, for squid. There was some discussion around the relationship between hatching date and the location of mature spawning females, with the hypothesis that the lag in the hatching date and the highest proportion of spawning

[2] "**A Study Fleet** is a subset of fishing vessels from which high quality, self-reported data on fishing effort, area fished, catch, and biological observations are collected. Participating vessels fish in commercial mode, and are selected to be representative of general commercial fishing vessels. The data collected from these vessels can be used to supplement the stock assessment process."

females might be due to multiple stocks. It was thought that this lag between spawning and hatching was probably unrealistic given the life history of the species.

8. Ecosystem Approach to Fisheries Management

The Secretariat presented paper SC04-23, which summarises the number of interaction records for certain protected species, and noted that paragraph 9 in the seabirds CMM asks for information on number and type of seabird interactions to be provided in annual reports. The Secretariat noted that some of the data collection templates are very new to SPRFMO and so data on some aspects was lacking at this time.

New Zealand thanked the Secretariat for paper SC04-23 and pointed out that the seabird captured by a NZ longliner and provisionally identified (and reported to the Secretariat) as a black petrel had since been identified by two separate seabird experts as a great-winged petrel (formerly called grey-faced petrel).

The SC discussed that there was some information on protected species interactions that is included in annual reports that was not reported in the summary document, and whether this may indicate that the mechanism for updating the interactions report needs to be strengthened. However, it was agreed that inclusion of any omissions could be resolved easily during the SC meeting. The Secretariat has formally taken submissions dating back to 2007, but any information on interactions with protected species for earlier years was not included in this paper. The SC also discussed whether there was, or should be, a separate process for collecting bycatch information for fish species. Currently, most of the information collected is for protected species. The SC discussed whether other species of concern, such as elasmobranchs and deepsea sharks, should be included in this summary report. It was agreed that porbeagle sharks should be added to the list. Additional species were tabled for annex 14 of CMM 4.0.2 that could be added to the list (see Annex 5). One future consideration is whether the SC could utilise the Bycatch Data Exchange Protocol that is being used across a range of RFMOs and national bodies. The SC provided the Secretariat with the latest WCPFC paper on the Bycatch Data Exchange protocol.

It was discussed that an assessment of the likelihood of various interactions is some work that could be done intersessionally, which may help prioritise the additional species to be included in the reporting summary and Annex 14 of CMM4.02. Given the level of new information becoming available, this idea was supported by the SC.

The EU presented paper SC04-22 on seabirds and pelagic trawlers. The SC discussed that it may be difficult to agree with some of the conclusions given the limited number of trips the data was collected from. The SC could not agree to the conclusion that pelagic trawlers did not seem to inflict a substantial mortality on seabirds. The conclusion that bird bafflers cause a greater risk to seabirds was also questioned because of the design of this study; at the same time, it was acknowledged that bafflers are likely to be less effective than bird scaring lines. The seabirds CMM states that they bird scaring lines should be used unless prevented by operational requirements. The SC discussed that presentations like this are important to build a more comprehensive picture of on-water fishing operations, and that this should be encouraged in the future.

It was discussed that some efforts have been made to develop protocols to exchange bird interactions data and it was hoped SPRFMO would help facilitate such a protocol. The Secretariat noted that it was possible to relate vessel specifics and gear configurations to the observations of interactions. Forms exist for recording seabird mitigation configurations and are completed by observers. Currently, there is no protocol for recording other observations, such as estimates of the numbers of birds attending vessels and other bird behaviour. It was suggested that the Secretariat could engage with Birdlife on ABNJ workshops on collection and analysis of data associated with observer programs for determining the effectiveness of various mitigation measures.

Regarding the ACAP best practice guidelines, there were no major adjustments made in the recent review except that the offal/discharge management was made more prominent in the guidelines.

Bauke de Vries from the EU Pelagic Advisory Council gave an informative presentation to the SC on the ecosystem focus group and its activities on ecosystem mapping focusing on pelagic stocks and their interactions in the North Sea and North Pacific Ocean. The presentation was appreciated by the SC.

9. Observer programme

9.1. OPWG

The SC was requested to comment on the draft observer programme CMM and whether the annex 7 of CMM4.02 remains adequate for observer data collection in the Convention Area. The draft observer CMM requires Members and CNCPs to develop, implement and improve observer programmes to attain the following objectives:

(i) To collect vessel information, effort and catch data for all fisheries and fished species in the Convention Area, including target, by-catch and associated and dependent species.
(ii) To collect biological or other data and information relevant to the management of fishery resources in the Convention Area, as specified in these standards, or as identified from time to time by the Scientific Committee or through processes identified by the Commission.
(iii) To collect relevant scientific information related to the implementation of the provisions of the Conservation and Management Measures (CMMs) adopted by the Commission.
(iv) To collect representative data, including length-frequency and biological samples, across the Convention Area, distribution of fishing effort, seasons, fishing fleets and fleet types.

The SC noted that the objectives of the draft CMM contain a mixture of objectives, mostly aimed at improving data on fisheries and ecosystems, but also aimed at compliance monitoring. The SC emphasizes that a potential conflict exists between scientific observation objectives and compliance objectives which could result in lower quality scientific data when the scientific monitoring is combined with compliance monitoring.

The SC noted that the focus of the draft observer CMM appears to be on the application of observers (as persons) in the collection of data. Electronic monitoring (see SC04-24), study fishing fleet with trained captains and crews[3], and Vessel Self-Sampling[4] may provide opportunities to overcome this constraint. The SC committed to conduct a study to evaluate adequate coverage of the proposed observer programme, perhaps through simulation studies or in adopting work done from other areas. This work is expected to be completed by 2019. Also, the SC discussed the sampling effort and aspects related to best practices for measuring observer coverage (refer to Annex 6 for specific comments on the Draft CMM).

9.2. E-monitoring, self-sampling and study fleet

The SPRFMO SC4 discussed progress on the data collected by electronic monitoring systems used on commercial fishing vessels and how this data may comply with CMM4.02 (Standards for the Collection, Reporting, Verification and Exchange of Data). Globally, automated and electronic collection of data is increasingly being applied to assists with monitoring fishing activities in the high seas and within national fisheries.

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[3] "***A Study Fleet*** *is a subset of fishing vessels from which high quality, self-reported data on fishing effort, area fished, catch, and biological observations are collected. Participating vessels fish in commercial mode, and are selected to be representative of general commercial fishing vessels. The data collected from these vessels can be used to supplement the stock assessment process.*" Cited from http://www.nefsc.noaa.gov/read/popdy/studyfleet/

[4] **Vessel self-sampling** is the process whereby the crew of vessels collect data for commercial and/or scientific purposes which is being shared to inform the stock assessment process.

Paper SC04-24 described the progress on the implementation of electronic monitoring in Australia fisheries in the recent period. Australia has implemented electronic monitoring in pelagic longline, demersal longline and gillnet fisheries. The Australian application is focused on the verification of vessel logbook data. Vessels in the trial are continuously monitored by camera in combination with sensors on hydraulics and drums and VMS/GPS. A random subset of the video footage collected is then analysed on return of the vessel to verify the logbook reporting for the same period. The introduction of electronic monitoring has enabled the introduction of vessel specific responses for protected species interactions and is being used to improve reporting practices. However, electronic monitoring must be supplemented by on-board observers and/or port sampling to maintain sufficient levels of biological data collection for stock assessments.

Other electronic monitoring research in the Pacific region include: (1) the GEF ABNJ Tuna Project which has set up two pilot trials of EOS systems using video cameras, and GPS to create an integrated profile of a vessel's fishing activity at sea. Purse seine vessels operators fishing out of Ghana and tuna longline vessels operators fishing out of Fiji are participating in this project; (2) WCPFC has an Electronic Reporting and Electronic Monitoring Intersessional Working Group and is implementing trials on longline vessels through its Scientific Services Provider (SPC) and ISSF; (3) New Zealand has also conducted several trails in different fisheries for different monitoring purposes and is now developing a programme for implementing electronic monitoring for all its domestic fisheries over the next few years (integrated electronic monitoring and reporting system, IEMRS). Its implementation in Australia and other trials should provide the SC with relevant information on how electronic monitoring and on-board observers can be used together to ensure that scientific data needs are met in a cost effective way for SPRFMO fisheries.

To facilitate the use of electronic monitoring in SPRFMO fisheries the SPRFMO-SC4 requests:

1. the SPRFMO Secretariat explore opportunities to collaborate with neighbouring RFMOs (WCPFC and CCAMLR) on implementing electronic monitoring;
2. that members continue to provide information from their national activities on the implementation of electronic monitoring to the SC.
3. Intersessional work is undertaken to generate a table of the CMM4.02 data fields with a corresponding indication (and evidence) on whether this data could, possibly or is unlikely to be provided by electronic monitoring. This table would be presented to SC5 for the purpose of discussing how electronic monitoring is incorporated into CMM4.02.

Both CMM4.02 and the draft observer CMM currently lacks guidance on whether these developing methods could be used to meet the SC's requirements of the data collected by at sea observers. **The SC therefore seeks a mandate from the Commission to explore where electronic monitoring, study fleets and self-sampling or a combination thereof can provide for collection and verification of fisheries vessel data as part of a wider observer programme.**

10. Collated Advice to the Commission

10.1. Jack Mackerel

Short term TAC advice on Jack Mackerel has been taken up under section 6.3. To reiterate, The Commission should aim to maintain 2017 and 2018 catches for the entire jack mackerel range in the southeast Pacific at or below 493 kt. However, should indicators of recruitment continue to be positive (as will be evaluated at SC-05), increasing the TAC in 2018 may be appropriate.

10.2. Deepwater

Recent average landings of orange roughy from SPRFMO Areas have remained below those in the reference years 2002-2006 and the average number of participating vessel has declined from 24 to 6. New Zealand has taken an average of 1,050 t over the past 5 years compared with 1,852 t in the reference years (57%) and Australian has taken an average 46 t over the past 5 years compared with 257 t in the reference years (18%). No other members have bottom fisheries in the SPRFMO Area.

The SC notes that further progress has been made on the development of stock assessment models for the eight stocks of orange roughy in the SPRFMO Area. The historic catches of all nations are required before these models can be considered reliable for management advice. There was sufficient data to test a stock assessment modelling approach for four stocks using New Zealand data alone. Initial indications of current biomass from these models were 22%, 22%, 23%, and 44% of the unfished biomass, all with broad confidence limits. If the inclusion of catch data from all nations confirms these estimates of depletion, then the Commission may wish to consider measures to increase stock biomass. Recent average New Zealand landings from these four stocks have totalled 537 tonnes compared with preliminary productivity estimates of about 470 tonnes. The short-term risk of further depletion of these stocks is considered to be low if catches continue at this level. The SC anticipates more comprehensive advice will be available in the coming year as part of the development of a new bottom fishing measure.

Some of the catches of orange roughy in the SPRFMO Area come from the straddling stock with New Zealand (ORH7A). This stock was assessed in 2014 and the stock was estimated to be at 42% of the unfished biomass.

The SC is encouraged by the progress on the difficult task of predicting and mapping the distribution of VMEs and VME indicator taxa in the SPRFMO Area. New Zealand will continue to conduct scientific studies on VMEs and spatial management and every effort will be made to use all available information. The SC supports moving towards spatial management, and recognizes that Australia and New Zealand are working closely together and with their industries and other stakeholders.

10.3. Squid

The SC agreed that the information specified in Annexes 1 to 6 of CMM4.02 is the minimum necessary for it to undertake effective monitoring and assessments for stocks in the Convention area. The SC requires that this information is provided in a timely manner to the Secretariat of SPRFMO so that assessments can be prepared, reviewed and used for providing scientific advice for the SPRFMO Commission.

The SC recommends that the SPRFMO Commission amend CMM4.02 to avoid confusion for Members and CNCPs regarding the use of the same templates for data recording and reporting.

Recognizing certain exceptional circumstances noted above for some fisheries (see section 7.2), the SC also recommends that the SPRFMO Commission amend CMM4.02 to allow for an extension in the timing of data submissions in those cases where the Members and CNCPs do not yet hold this information for all vessels in their fleets and that an anticipated submission date is provided.

The SC requests the SPRFMO Commission to remind all Members and CNCPs that issues of data confidentiality are provided for in CMM4.02 and this may not be used as a reason for failure to submit data to the Secretariat.

The SC requests that the SPRFMO Commission commence a data recovery initiative to minimize the impact of this constraint. The data recovery should provide data that is consistent with the specifications of Annex 4 of CMM4.02 to the extent possible.

The SC noted that without the implementation of observer programs the SC may not have access to information to verify vessel logbook and bycatch data and to the capacity to design and implement necessary biological sampling activities. Electronic monitoring, Study fishing fleet with trained captains and crews, and Vessel Self-Sampling may provide opportunities to overcome this constraint. CMM4.02 currently does not provide guidance on whether these developing methods could be used to meet the SC's requirements of the data collected by at sea observers. The SC asks the Commission to acknowledge the ongoing work to provide verification of fisheries vessel data.

11. SC Research Programme

In addition to the existing research programme, a non-comprehensive list of research requirements was noted:

1) Organize a stock structure workshop to define a united framework to provide management advice for management under variable stock structure assumptions
2) Evaluate the effectivity of using voluntary submissions of data collected by fisheries for assessment and management advice purposes
3) Re-estimate the ageing error conversion matrix currently used in the assessment model so that it more accurately reflects the Jack mackerel situation.
4) Specific to the jack mackerel assessment:
    a) Intersessional work is needed to ensure that the software is working well prior to the workshop (or meeting)
    b) Broader involvement in developing documentation of the model equations and assumptions (some output features in the software could use better explanations)
    c) Investment in software development (e.g., shiny app) to facilitate data entry and model specifications would be worthwhile. The goal here is to minimise potential errors.
    d) The data and configuration files need better cross checking prior to the meeting with links to where they come from (e.g., offshore age compositions).
    e) Regarding activities at SC05, the **SC recommends that SPRFMO continues providing technical support and that members continue to commit resources toward assessment activities and capacity building.**
    f) Furthermore, the SC encourages development of alternative software platforms and consider an ensemble approach. It was noted that proceeding along these lines should be limited in order to avoid requiring more time and effort (and confusion) to compile the assessment and provide advice to the commission.
5) Providing some funding to the ADMB/TMB foundation by SPRFMO to secure the support of the main assessment software used.

12. Election of Chairpersons

Chairs and vice-chairs for the SC and the Deepwater subgroup were elected by the SC. Jim Ianelli and Niels Hintzen were re-elected as Chair and vice-Chair of the Science Committee. Mauricio Galvez was elected as the Chair of the Deepwater subgroup. A new Squid subgroup was created and Gang Li was elected as its first Chair.

13. Other Matters

The Secretariat noted the update of the website and seeks feedback. The Guidelines for the annual reports were discussed and the SC requested that the Secretariat update the guidelines and circulate a draft prior to SC05.

14. Next meeting

The next meeting will be held from September the 20th to the 28th 2017 (to allow for a potential workshop) in Shanghai, China.

15. Adoption of Report

The SC unanimously adopted the report.

16. Meeting Closure

The meeting was closed at 2337 hours on the 14th of October 2016.

4th Meeting of the Scientific Committee

The Hague, Kingdom of the Netherlands
10 - 14 October 2016
SC-04-01
Agenda

1. Welcome and Introduction
2. Administrative Arrangements
   2.1. Adoption of Agenda
   2.2. Meeting documents
   2.3. Nomination of Rapporteurs
3. Discussion of Annual Reports
4. Commission guidance and other Inter-Sessional activities
   4.1. Commission SC Workplan
   4.2. Secretariat SC related activities
   4.3. Assessment workshop report
   4.4. Fishery dependent acoustic Task Group
   4.5. Jack mackerel Age/Growth Task Team
5. Mackerel Working Group
   5.1. Report on Inter-Sessional assessment/research by Participants
   5.2. Inter-Sessional Progress with the Jack Mackerel Stock Structure Research Programme
   5.3. Jack Mackerel Stock Assessments – Technical Session
   5.4. Other Jack Mackerel topics
6. Deepwater Working Group
   6.1. Applications to fish outside the footprint or above reference period catch levels
   6.2. Inter-Sessional assessments of Deepwater species
   6.3. SPRFMO Deepwater stock assessments
   6.4. VME distribution and spatial management approaches in the Convention Area
   6.5. Other Deepwater topics
7. Squid Assessment
8. Ecosystem Approach to Fisheries Management
9. Observer Programmes
   9.1. Observer Programme Working Group
   9.2. E-monitoring
10. Advice to the Commission
    10.1. Jack Mackerel
    10.2. Deepwater
    10.3. Other
11. SC Research Program
12. Election of Chairperson and Vice-Chairperson
13. Other Matters
14. Next Meeting
15. Adoption of Report
16. Meeting Closure

4th Meeting of the Scientific Committee

The Hague, Netherlands
10-15 October 2014

Participants

CHAIR
James IANELLI
NOAA Fisheries, Alaska Fisheries Science Center
7600 Sand Point Way, NE, Seattle, WA 98115
jim.ianelli@noaa.gov

SPRFMO SECRETARIAT
Johanne FISCHER[5]
SPRFMO Secretariat
PO Box 3797, Wellington 6140, New Zealand
jfischer@sprfmo.int

Craig LOVERIDGE
SPRFMO Secretariat
PO Box 3797, Wellington 6140, New Zealand
cloveridge@sprfmo.int

MEMBERS

AUSTRALIA
Simon NICOL
Department of Agriculture and Water Resources
GPO Box 1563, Canberra ACT 2601, Australia
Simon.Nicol@agriculture.gov.au

Lee GEORGESON
Australian Bureau of Agriculture and Resource Economics and Sciences
18 Marcus Clarke St, Canberra, ACT, Australia
lee.georgeson@agriculture.gov.au

CHILE
María Ángela BARBIERI
Undersecretariat for Fisheries and Aquaculture
Bellavista 168, 14th Floor, Valparaiso, Chile
mbarbieri@subpesca.cl

Mauricio GÁLVEZ
Undersecretariat for Fisheries and Aquaculture
Bellavista 168, 14th Floor, Valparaiso, Chile
mgalvez@subpesca.cl

Cristian CANALES
Pontificia Universidad Católica de Valparaíso
Altamirano 1480, Valparaíso, Chile
cristian.canales.r@pucv.cl

[5] *Italics indicates that this person attended SC-04 only and not the preceding assessment workshop.*

Ignacio PAYA
Instituto de Fomento Pesquero
Blanco Encalada 839, Valparaiso, Chile
ignacio.paya@ifop.cl

Mario ACEVEDO
Undersecretariat for Fisheries and Aquaculture
Bellavista 168, 14th Floor, Valparaiso, Chile
macevedo@subpesca.cl

Aquiles SEPÚLVEDA
Fishery Research Institute
Av. Colón 2780 Talcahuano, Chile
asepulveda@inpesca.cl

Albert ARTHUR
Anapesca A.G.
127 244th St. SW Bothell WA 98021, USA
albarthur@gmail.com

Andrés COUVE
Sonapesca
L.Thayer Ojeda 166 Of. 902, Providencia, Santiago, Chile
andrescouve@entelchile.net

CHINA

LI Gang
Shanghai Ocean University
College of Marine Science, Shanghai Ocean University, No 999
Huchenghuan Ring Road, Shanghai
g-li@shou.edu.cn

LIU Bilin
Shanghai Ocean University
College of Marine Science, Shanghai Ocean University, No 999
Huchenghuan Ring Road, Shanghai
bl-liu@shou.edu.cn

CHEN Yong
Shanghai Ocean University
College of Marine Science, Shanghai Ocean University, No 999
Huchenghuan Ring Road, Shanghai
cheny@shou.edu.cn

ECUADOR

Willan REVELO
National Institute of Fisheries
Letamendi 102 entre Eloy Alfaro y la Ria, Guayaquil, Ecuador
direccion_inp@institutopesca.gob.ec

Viviana JURADO
National Institute of Fisheries
Letamendi 102 entre Eloy Alfaro y la Ria, Guayaquil, Ecuador
vjurado@institutopesca.gob.ec

Manuel PERALTA
National Institute of Fisheries
Letamendi 102 entre Eloy Alfaro y la Ria, Guayaquil, Ecuador

mperalta@institutopesca.gob.ec

EUROPEAN UNION

Niels HINTZEN
IMARES
Haringkade 1, 1976CP, IJmuiden, The Netherlands
niels.hintzen@wur.nl

Adrianus CORTEN
Consultant to the Ministry of Economic
Affairs De Waterdief 52
adcorten@yahoo.co.uk

Francois GERLOTTO
Institut de Recherche Pour le Development
Le Corfou, A1, 19 rue de la Galine, 34170 Castelnau-le-Lez, France
francois.gerlotto@ird.fr

Martin PASTOORS
Pelagic Freezer-trawler Association
Louis Braillelaan 80, Zoetermeer, Netherlands
mpastoors@pelagicfish.eu

Fernando GONZALEZ
Instituto Espanol de Oceanografia
Vigo, Spain
Fernando.gonzalez@vi.ieo.es

FAROE ISLANDS

Stefan SKORINI
Ministry of Fisheries
Faroe Islands
stefan.i.skorini@fisk.fo

Jan Arge JACOBSEN
Faroe Marine Research Institute
Faroe Islands
janarge@hav.fo

KOREA

Jaebong LEE
National Institute of Fisheries Science
216 Gijang Haean-ro Gijang, Busan, Republic of Korea
leejb@korea.kr

Eunjung(EJ) KIM
National Institute of Fisheries Science
216 Gijang Haean-ro Gijang, Busan, Republic of Korea
eunjung.hawaii@gmail.com

NEW ZEALAND

Martin CRYER
Ministry for Primary Industries
25 The Terrace, Wellington, 6140, New Zealand
martin.cryer@mpi.govt.nz

Marie-Julie ROUX
National Institute of Water and Atmospheric Research (NIWA)
301 Evans Bay Parade, Greta Point, Wellington
marie-julie.roux@niwa.co.nz

PERU

Jorge CSIRKE
Instituto del Mar del Peru (IMARPE)
IMARPE, PO Box 22, Callao, Peru
jorge.csirke@gmail.com

Enrique RAMOS-VASQUEZ
Instituto del Mar del Peru (IMARPE)
IMARPE, PO Box 22, Callao, Peru
enramos@imarpe.gob.pe

Teobaldo DIOSES
Instituto del Mar del Peru (IMARPE)
IMARPE, PO Box 22, Callao, Peru
tdioses@imarpe.gob.pe

Miguel NIQUEN
Instituto del Mar del Peru (IMARPE)
IMARPE, PO Box 22, Callao, Peru
mniquen@imarpe.gob.pe

Juan ARGUELLES
Instituto del Mar del Peru (IMARPE)
IMARPE, PO Box 22, Callao, Peru
jarguelles@imarpe.gob.pe

Oscar Ricardo BERNALES
Sociedad Nacional de Pesqueria
Av. Republica de Panama 3591, Piso 9, San Isidro, Lima, Peru
rbernales@diamante.co.pe

Ulises MUNAYLLA
Sociedad Nacional de Pesqueria
Av. Republica de Panama 3591, Piso 9, San Isidro, Lima, Peru
umunaylla@snp.org.pe

Mariano GUTIERREZ
Sociedad Nacional de Pesqueria
Av. Republica de Panama 3591, Piso 9, San Isidro, Lima, Peru
snpnet@snp.org.pe

Anibal ALIAGA
Sociedad Nacional de Pesqueria
Av. Republica de Panama 3591, Pisco 9 San Isidro, Lima, Peru
snpnet@snp.org.pe

RUSSIAN FEDERATION

Alexander GLUBOKOV
Russian Federal Research Institute for Fisheries and Oceanography
107140, Moscow, V. Krasnoselskaya 17
glubokov@vniro.ru

CHINESE TAIPEI

CHEN Chih-Shin

National Taiwan Ocean University
No.2, Beining rd, Jhongjheng District, Keelung City 202, Taiwan
cshen@mail.ntou.edu.tw

CHEN Nathalie Jo-Tzu
Fisheries Agency, Council of Agriculture
2, Pei-Ning Road, Keelung 20224, Taiwan
jotzu@ms1.fa.gov.tw

VANUATU

Gerry GEEN
Vanuatu Fisheries
Port Vila Vanuatu
ggeen@bigpond.net.au

INTER-GOVERNMENTAL ORGANISATION OBSERVERS

WMO

Robert STEFANSKI
World Meteorological Organization
Geneve, Suisse
rstefanski@wmo.int

NON-GOVERNMENTAL ORGANISATION OBSERVERS

BIRDLIFE INTERNATIONAL

Berry MULLIGAN
International Marine Programme Officer
Sandy, Bedfordshire SG19 2DL
berry.mulligan@rspb.org.uk

DSCC

Matthew GIANNI
Deep Sea Conservation Coalition
Postbus 59681, 1040 LD AMSTERDAM Netherlands
matthewgianni@gmail.com

NZ HIGH SEAS FISHERIES GROUP

Graham PATCHELL
NZ High Seas Fisheries Group Inc
PO Box 11, Vickerman street, Nelson, New Zealand
gjp@sealord.co.nz

Dean JURASOVICH
Sanford LTD
Timaru, New Zealand
djurasovich@sanford.co.nz

OCEANA

Liesbeth VAN DER MEER
Oceana
CP 7500875

lvandermeer@oceana.org

INVITED EXPERTS

Carmen FERNANDEZ
Stock assessment scientist
Spain
cferllxx@gmail.com

Ricardo OLIVEROS-RAMOS
Fisheries Stock Assessment Consultant
Perú
ricardo.oliveros@gmail.com

CHAIR'S ASSISTANT

LEE Qi
Graduate Research Assistant
University of Washington
leeqi@uw.edu

South Pacific Regional Fisheries Management Organisation

Stock status summary for jack mackerel, October 2016

Stock: Jack Mackerel (*Trachurus murphyi*)
Region: Southeast Pacific

Advice for 2017

The SPRFMO Science Committee advises to maintain 2017 catches at or below 493,000t.

Stock status

		2014	2015	2016
Fishing mortality in relation to	F_{MSY}	Below	Below	Below
Spawning stock biomass in relation to	B_{MSY}	Below	Below	Below

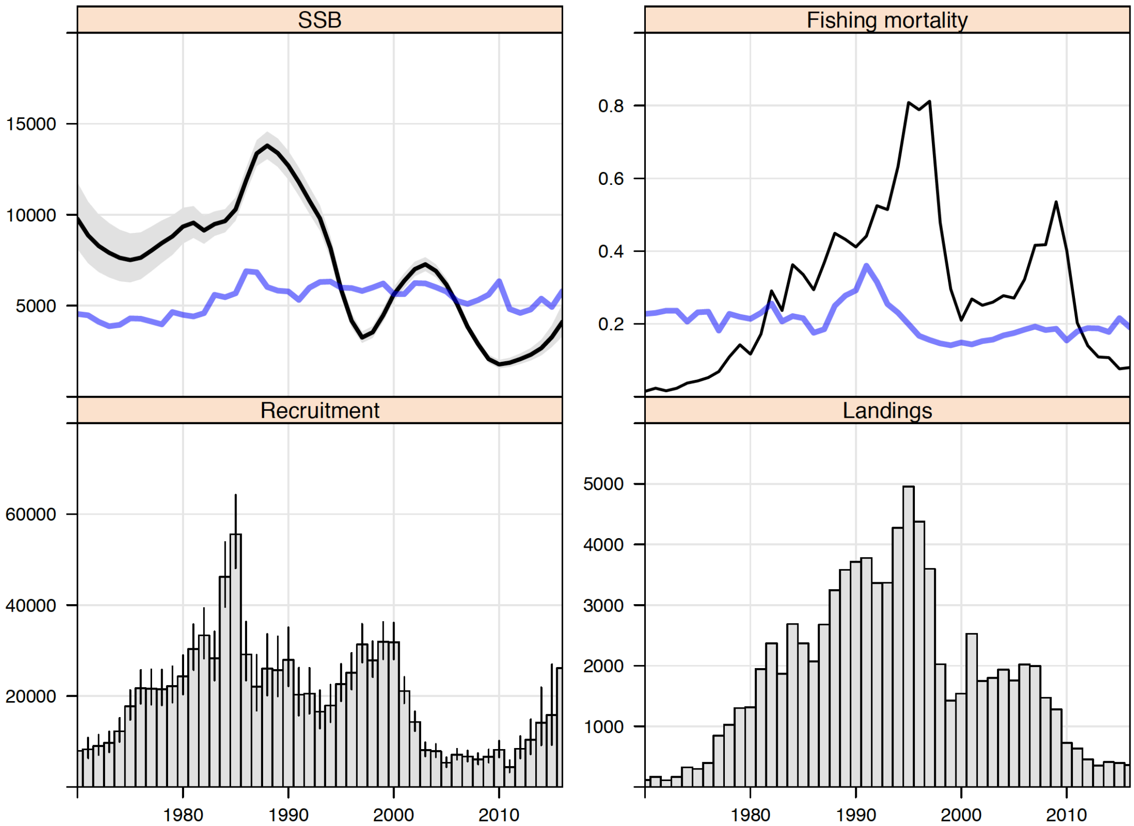

Figure 1. Jack Mackerel in the southeast Pacific. Summary of stock assessment. Recruitment is measured in thousands, SSB in thousand tonnes, catch in thousand tonnes and harvest (fishing mortality) as a rate per year. Provisional values for F_{MSY} and B_{MSY} are shown by horizontal blue lines.

Outlook for 2017

Scenarios with constant fishing mortality from 2017 onwards were explored at 125%, 100%, 75%, 50% and 0% of a reference F_{2016}; the reference F_{2016} was set to the value that would give catches equal to the full TAC in 2016 (460kt).

Table 1. Summary results for the near term predictions. Note that "B" represents thousands of t of spawning stock biomass and B_{MSY} is taken to be a provisional value of 5.5 million t of spawning biomass.

Recruitment steepness =0.65, recruitment from 2000-2013

Multiplier of reference F_{2016}	B_{2018}	$P(B_{2018} > B_{MSY})$	Catch 2017 (kt)	Catch 2018 (kt)
0.00	6,603	88%	0	0
0.50	6,269	80%	232	299
0.75	6,112	75%	344	436
1.00	5,909	67%	493	611
1.25	5,814	64%	563	691

Table 2: Advised and reported catch (t) of Jack Mackerel in the southeast Pacific.

Year	Advised catch	Reported catch
2008		1,472,631
2009		1,283,474
2010		726,573
2011	711,783	634,580
2012	520,000	454,774
2013	441,000	353,123
2014	440,000	410,698
2015	460,000	394,377
2016	460,000	360,496*

* As estimated at SC04

Annual Report Summaries

Australia

Three Australian-flagged vessels fished in the SPRFMO Convention Area in 2015; one demersal trawler and two demersal longline vessels. Logbook records from these vessels reported a catch of 25 t (16 hours trawl time) for the demersal trawler and a total of 177t (745,000 hooks) for the two demersal longline vessels in 2015. The catch composition for the demersal trawler was dominated by orange-roughy and alfonsino and for the demersal longliners: morwong, yellowtail kingfish and blue-eye trevalla. Observer coverage levels met or exceeded the minimum requirement (10 per cent coverage for non-trawl, and 100 per cent coverage for trawl trips). Observers did not record any bycatch of marine mammals, seabirds or marine reptiles in trawl or non-trawl operations in the SPRFMO Area. The threshold limits for vulnerable marine ecosystems (VME) indicators, which trigger Australia's move-on protocols, were not triggered in 2015.

Chile

Accumulated catches of Jack mackerel for Chilean fleet arose to 275,680 ton until September 2016, being 92% of the total quota allocated to Chile. Only 2% of the catches were obtained in the Area of the Convention. For the 2016 fishing season it is expected to catch 95% of the total quota allocated. During 2016, jack mackerel catches in the northern area has reached 14,400 tons, half of the catch registered in the first semester of 2015, due to a decline of the catch of anchovy as target species. It is important to note that, off northern Chile most of the jack mackerel caught was made as incidental fishing in anchovy fishery. The jumbo squid fishery includes the participation of small-scale and industrial fleets, with distribution percentages of the national annual catch quota of 80% and 20%, respectively (TAC2016= 200,000 ton). The small-scale fleet operates with hand jiggers and the industrial fleet operates mainly with mid-water trawling. National landings of squid in 2015 were 140 thousand tons. Industrial landings do not exceed 40 thousand tons due to the distribution of the catch annual quota between the two fleets. Total catch is entirely conducted within the EEZ of the country. The accumulated catch up to September 2016 is 170,000 ton. A non-take Marine Protected Area of 300,000 km^2 was created in Chilean jurisdictional waters close to Nazca Submarine ridge in order to protect VMEs. This protected area will also help to preserve the migration route of the blue whale and marine turtles, breeding and feeding grounds of seabirds, feeding grounds and migration route of swordfish, and recruitment grounds for Jack mackerel.

China

In 2015, a total of 6 Chinese large pelagic trawlers operated in the South East Pacific and annual catch was 29,180 tons with 3704 trawling hours. The nominal CPUE reached 7.9 tons per hour, and the estimated abundance was 1.02, the highest level since 2008. A total of 8867 jack mackerel was sampled with tow-by-tow information by the observer from April to July 2015 to generate the length-frequency or age-length key (600 individuals).

In 2015, a total of 252 squid jigging fishing vessels were recorded to operate in the high seas, and the number of active fishing boats varied weekly from 96 to 218. Annual catch of jumbo squid in 2015 was 323 thousand tons. Fishing effort was 60,166 fishing days with nominal CPUE 5.4 tons/day-vessel. 236 jumbo flying squid was sampled on board in the high seas off Peru from June to September 2015.

Colombia

Colombia's report was taken as read.

European Union

Catches of jack mackerel by European Union (EU) trawlers in 2016 were considerably lower than in 2015. The year-class 2012, which had appeared in the catches already in 2015, was the main target of the fleet in 2016. However, judging from the catch rates, it was less abundant in 2016 than in the previous year. Last year it was already assumed that the high catches of juvenile jack mackerel outside the Chilean EEZ had been partly the result of an abnormal distribution of this year-class (due to the El Niño conditions), rather than of its absolute size. The poor results of the fishery in 2016 seem to confirm this hypothesis.

Korea

Two Korean flag trawlers operated in the SPRFMO convention area in 2015. Total catch from the trawlers were 5,834 tons including 5,749 tons of *Trachurus murphyi* and 82 tons of *Scomber japonicus*. The level of CPUE (ton/hour) was similar with the previous year (2014). No bottom fisheries were operated in the convention area since 2007. Observer coverage was 100%. Two observers on the trawlers measured 2550 jack mackerels from June to September. More than three modes appeared in the length frequency and the relationship between body weight (BW, g) and fork length (FL, cm) was BW=0.000005FL3.202 (R2=0.977).

New Zealand

Slightly more orange roughy effort and catch in 2015 than in recent years, but some of this was from the recovering straddling stock with New Zealand waters (ORH7A). NZ noted an error in Table 4 (of their annual report) where a total effort of 7,600 tows is recorded (should be 760).

Fishing occurred in move-on blocks as well as open blocks, but the move-on rule was not triggered in 2015 (and has not been triggered since 2012). Lower line fishing effort in 2015 but similar catch to 2014 (bluenose and wreckfish). Line fishing nominal CPUE highly variable for both species. Very brief summary of the exploratory line fishery for toothfish (see separate paper). Much more detail included in the annual report this year, including length frequency distributions for several species over the past 5 or 6 years. A separate report describes the NZ observer programme and 2015 coverage in more detail, coverage was 100% for trawl, 12% for bottom line, 50% for Dahn line, and 14% for hand line.

Work to develop stock assessments and estimates of sustainable yield is described (see also separate paper):

- Simple models presented by Penney (2010)
- Seamount meta-analysis to predict unfished biomass on given features
- Re-assessment of stocks and areas using multiple lines of evidence
- Spatially disaggregated CPUE models for NZ fishing in 6 of the main SPRFMO stocks
- Preliminary biomass dynamic models using just NZ data
- Working on acquiring full catch histories to finalise stock assessments

The preliminary work on potential squid in-season assessment for New Zealand has been finalised and was also summarised. The approach might be suitable for SPRFMO stocks.

The annual report contains quite a long section on geospatial prediction of VME indicator taxa. SPRFMO-scale models were built and tested as described at SC-03 but the at-sea testing reinforced the need for caution when interpreting broad-scale. Presence-only models in data poor areas of the deep sea. New models are at a finer New Zealand region-scale developed where bathymetry and other data were better and where absences could be included as well as presence. Even finer-scale models covering individual features are now being developed. But these can be made only for features with substantial, detailed information.

The NZ report also described decision-support tools that can combine predicted distributions of VME taxa with the distribution of fishing to design spatial management areas:

- Intent is to provide for fishing while avoiding significant adverse impacts on VMEs
- NZ notes the utility of such analyses depends on the quality of the input data
- many examples are shown but this is a demonstration of a tool that can be used by stakeholders to design and examine different scenarios

Summary was given of information held on VME indicator taxa and other benthic records entered by observers (606 records in all). This could contribute to the development of the new bottom fishing measure and New Zealand's updated bottom fishery impact assessment (see separate paper on development of the new CMM).

A summary was also given of all records of seabirds and marine mammals captured since 1993 in what is now the SPRFMO Area.

Peru

Peru's report updates information on the biology and fishery of jack mackerel (*Trachurus murphyi*) in Peru presented in previous SPRFMO Scientific Committee meetings. During 2014, 2015 and the first part of 2016 the Peruvian coastal areas have been affected by warmer than normal conditions typical of a weak El Niño during 2014 and a strong El Niño during 2015 and early 2016. Environmental conditions entered into a cooling trend while still remaining warmer than normal only towards the end of the first semester of 2016. With these warmer than normal environmental conditions the front usually formed by the mixed layer of warm Subtropical Surface Waters and Cold Coastal Waters almost disappear and moved closer to the coast, disrupting was is known to be the preferred habitat of jack mackerel off Peru. This contributed to low observed abundance and low catches of jack mackerel in 2014 and particularly in 2015 and the first part of 2016. During 2014 and predominantly during 2015 and early 2016 jack mackerel concentrations were mostly found in coastal areas, within 20 nm and sometimes limited to the 10 nm from the coast, within reach of the artisanal and small scale fleet but outside the usual fishing grounds of the industrial purse seine fleet. The catch of jack mackerel drops from a total of 74,528 t in 2014 to only 22,158 t in 2015 (almost all caught by the small-scale and artisanal fleets) and so far only the small-scale and artisanal fleets have captured jack mackerel this year, reporting an estimated 9,209 t from January to June 2016. Various options for the 2016 TAC were considered during a December 2015 assessment based on the latest version of JJM model developed during the 3th Meeting of the Scientific Committee and the final decision was to accept a risk of 3.9% with an F2016 = 0.0325 and an estimated TAC of 93 000 t for 2016. The status-quo (2015 conditions) option estimated a much lower TAC with slightly lower estimated risk and F but this option was not selected based on the observation that 2015 was an abnormal year, heavily influenced by the strong effects of the most recent El Niño. A more recent 2016 assessment was made using the JJM with information updated to June 2016, and considering new estimated risks and F levels the resulting TACs were very similar to those estimated in the December 2015 assessment. Peru did not conduct any fishing in the SPRFMO Area during 2015.

Russian Federation

Russian fisheries in the Convention area for 2015. In 2015 the Russian trawler Alexander Kosarev worked in the high seas of the Southeast Pacific. The total catch was 2,561.2 t for jack mackerel and 462.5 t for chub mackerel in 38 fishing days. CPUE of JM in 2015 was similar to 2011. For the area to the south of the Juan Fernandez Islands zone, catch consisted of different-sized fish with the modal length classes of 28, 35 and 40 cm. Size composition of jack mackerel in the catches was homogeneous (a dominance of 26 cm length specimens observed) in the northern area between the island zones and the continental area of Chile. In 2015 Russian Report of the 4th Scientific Committee meeting scientific observations covered 80 hauls of 89 (89.9%).

Chinese Taipei

Jumbo flying squid inhabits in the eastern Pacific and has been targeted by the distant-water squid-jigging fleet of Chinese Taipei since 2002. The number of vessels varied between 5 and 29 from 2002 to 2015. The catch of Jumbo flying squid increased to 10,072 tons in 2015. The nominal CPUE of this fishery is stable in recent years. The major fishing ground for this fishery was located at the area around 76–83°W and 15–20°S. Data of logbook, transshipment and landing of the distant-water squid fishery of Chinese Taipei have been collected. Researches on the stock status and spatial dynamics of jumbo flying squid have been conducted. Length composition of the squid was converted from weight category. Neither observer nor port sampling program is implemented.

Vanuatu

The jack mackerel catch in 2015 for Vanuatu's vessels was 21,227t. Vanuatu seasonally transferred 250t of its catch limit to the Republic of Korea, as a result, Vanuatu's catch of 21,227t almost entirely filled its available quota. Catches of chub mackerel totaled 604 tonnes in 2015. No observers were present on the vessels during the 2015 season as a result of a need for government employees to assist in reconstruction work following the destruction caused by Cyclone Pam.

IUCN red-listed deepwater shark species and relevant CITES appendix II species

Table 1. Deepwater sharks and rays in the SPRFMO Convention area categorized on the IUCN Red List as Critically Endangered, Endangered and Vulnerable proposed for inclusion on CMM 4-02 Appendix 14 .

Source	Species types	FAO Areas	Status Categories
IUCN Red List	Deep Pelagic & Deepwater sharks and rays	Pacific - southeast Pacific - southwest Pacific - western central Pacific - eastern central	Critically Endangered Endangered Vulnerable
Bathyraja griseocauda	Arhynchobatidae	Rajiformes	Endangered
Centrophorus harrissoni	Centrophoridae	Squaliformes	Endangered
Centrophorus squamosus	Centrophoridae	Squaliformes	Vulnerable
Dipturus trachydermus	Rajidae	Rajiformes	Vulnerable
Hydrolagus ogilbyi	Chimaeridae	Chimaeriformes	Vulnerable
Odontaspis ferox	Odontaspididae	Lamniformes	Vulnerable
Rhinoraja albomaculata	Arhynchobatidae	Rajiformes	Vulnerable
Squatina albipunctata	Squatinidae	Squatiniformes	Vulnerable
Zearaja chilensis	Rajidae	Rajiformes	Vulnerable

Table 2. Deepwater sharks and rays in the SPRFMO Convention area categorized on the IUCN Red List as Near Threatened for further consideration.

Species	Family	Order	Status
Centrophorus acus	Centrophoridae	Squaliformes	Near Threatened
Centrophorus niaukang	Centrophoridae	Squaliformes	Near Threatened
Centroscymnus coelolepis	Somniosidae	Squaliformes	Near Threatened
Cephaloscyllium albipinnum	Scyliorhinidae	Carcharhiniformes	Near Threatened
Dalatias licha	Dalatiidae	Squaliformes	Near Threatened
Deania quadrispinosa	Centrophoridae	Squaliformes	Near Threatened
Dipturus cerva	Rajidae	Rajiformes	Near Threatened
Dipturus gudgeri	Rajidae	Rajiformes	Near Threatened
Dipturus innominatus	Rajidae	Rajiformes	Near Threatened
Echinorhinus cookei	Echinorhinidae	Squaliformes	Near Threatened
Heptranchias perlo	Hexanchidae	Hexanchiformes	Near Threatened
Hexanchus griseus	Hexanchidae	Hexanchiformes	Near Threatened
Hydrolagus ogilbyi	Chimaeridae	Chimaeriformes	Near Threatened
Proscymnodon plunketi	Somniosidae	Squaliformes	Near Threatened
Rhinoraja macloviana	Arhynchobatidae	Rajiformes	Near Threatened
Rhinoraja multispinis	Arhynchobatidae	Rajiformes	Near Threatened
Squalus chloroculus	Squalidae	Squaliformes	Near Threatened
Squalus grahami	Squalidae	Squaliformes	Near Threatened
Squalus hemipinnis	Squalidae	Squaliformes	Near Threatened
Squalus rancureli	Squalidae	Squaliformes	Near Threatened

Note: In additional to the above, there are a number of deepwater species of sharks and rays assessed as Data Deficient on the IUCN Red List which are not listed here. These may include additional threatened species. The Red List is updated annually to include revised assessments and new species assessments.

Marine species listed by CITES under Appendix II which are not included in CMM 4.02, Annex 14.

Only includes species of possible relevance to SPRFMO fisheries, i.e. occurring in the South Pacific and not restricted to shallow coastal areas (e.g. not included sawfishes and clarion anglefish):

Listed in October 2016 by CITES CoP 17:

- Silky shark (*Carcharhinus falciformis*); wide-ranging, highly migratory and globally distributed
- Thresher sharks, (*Alopias spp*); wide-ranging and globally distributed
- Family Nautilidae, tropical Asia Pacific region, restricted fore-reef slopes that extend into deepwater

Previously listed by CITES but not yet included in the SPRFMO CMM 4.02, Annex 14

- **Porbeagle shark** *(Lamna nasus*), listed in 2013; wide-ranging, coastal and oceanic shark, and one of the few truly high-latitude sharks that is often encountered in Arctic and Antarctic waters
- **Scalloped hammerhead shark** (*Sphyrna lewini*), Smooth hammerhead shark (*Sphyrna zygaena*); and great hammerhead shark (*Sphyrna mokarran*); listed in 2013; tropical and warm temperate waters worldwide, inhabiting coastal areas and the continental shelf
- **Black corals** (*Antipatharia spp*.); tropical, subtropical , temperate and polar regions. Often dwelling in deep waters.
- **Stony corals** (Scleractinia), global, some species in deep seas
- **Lace corals** (Stylasteridae); tropical and temperate West Pacific, many deepwater species found in the Southwest Pacific

CMM X.XX (2nd DRAFT) – *Comments by the Scientific Committee*

Conservation and Management Measure for the SPRFMO Observer Programme

The Commission of the South Pacific Regional Fisheries Management Organisation,

Explanatory Note: The preamble for this draft incorporates the suggested comments and edits received on the initial draft of this section.

Recalling that Article 28 of the Convention calls for the establishment of an observer programme to collect verified catch and effort data, other scientific data and additional information related to the fishing activity in the Convention Area, and its impacts on the marine environment.

Noting that Article 28 sets out the functions of the observer programme and specifies that the information collected by the observer programme shall, as appropriate, also be used to support the functions of the Commission and its subsidiary bodies, including the Scientific Committee and Compliance and Technical Committee, and that the observer programme shall be coordinated by the Secretariat of the Commission in a flexible manner.

If the SPRFMO OP has a dual function (scientific and compliance), then that could interfere with the collection of high quality scientific information

Desiring to implement a best practice observer programme, taking into account the similar experiences and practices implemented by other regional fisheries management organizations (RFMOs).

Acknowledging that other RFMOs have established observer programmes for similar purposes, that national observer programmes are in place, and that coordination with these programmes shall be pursued to the maximum extent possible.

Acknowledging that worldwide experience has demonstrated that observers deployed on board fishing vessels during commercial operations can provide high-quality information for management and conservation of fishing resources and their environment, and can also help to promote good communications among Members, Cooperating non-Contracting Parties (CNCPs), scientists and fishing users.

Adopts the following conservation and management measure in accordance with Article 8 of the Convention:

Part 1 Definitions

Explanatory Note: This part has been added per Australia's suggestion and includes several terms suggested by Australia as well as several additional terms. Several OPWG participants provided comments on the need for and definition of the terms "independent and impartial." Australia and the United States provided specific language for these terms, with Australia's definition focusing on the data to be collected and the United States' definition focusing on the observers themselves. Both definitions are provided in brackets below for consideration of the OPWG.

1. Terms in this measure have the following definitions:

Accredited means: an observer programme or service provider that meets the standards adopted by the Commission.

Collect means: to record information electronically or on paper by typing, writing, photograph or other means.

Debriefing means: processing data collected by observers through appropriate quality assurance or quality control systems.

Fishing effort

"Catcher vessel"

New Concepts that require definition

Catch

By-catch

Discards

[Australia: *Independent:* For data to be considered 'independent' it must be collected in an uninfluenced and unbiased manner on board any vessel regardless of which flag under which the vessel is operating. Accordingly, independent refers to data sourced from programmes or service providers accredited by the Commission. The programme will have no direct financial interest, ownership or business links with vessels, processors, agents and retailers involved in the catching, taking, harvesting processing or selling of fish or fish product.

Impartial: The collection of independent and 'impartial' data refers to data collected which is free from outside influence, from vessels, processors, agents, retailers, involved in the catching, taking, harvesting processing or selling of fish or fish product and will also be free from influence by non-governmental environmental, fishery, and other related organizations. Data collection shall be undertaken in an uninfluenced and unbiased manner on board vessels from both flag State and foreign fishing nations.

U.S.: *Independent and impartial* means that an observer:

a) May not have a direct financial interest, other than the provision of observer services, in the fishery under the purview of the Commission, including, but not limited to: i) any ownership, mortgage holder, or other secured interest in a vessel or processor involved in the catching, taking, harvesting or processing of fish; ii) any business selling supplies or services to any vessel or processor in the fishery; iii) any business purchasing raw or processed products from any vessel or processor in the fishery.

b) May not solicit or accept, directly or indirectly, any gratuity, gift, favor, entertainment, inordinate accommodation, loan or anything of monetary value from anyone who either conducts activities that are regulated by the flag Member or CNCP and the Commission or has interests that may be substantially affected by the performance or nonperformance of the observer's official duties.

c) May not serve as an observer on any vessel or at any processors owned or operated by a person who previously employed the observer in another capacity (e.g., as a crew member).

d) May not solicit or accept employment as a crew member or an employee of a vessel or processor while employed by an observer provider.]

Observer Programme: An observer programme refers to the government programme or non-government service provider that conducts the coordinated collection by human observers and/or other mechanisms and debriefing of observer data as adopted by the Commission for the purposes of implementing this CMM.

The SC report that suggests broadening the scope of the CMM (to include other data collection programmers like electronic monitoring, study fleets and self-sampling)

Part 2 Scope of the SPRFMO Observer Programme

Explanatory Note: Based on comments received, this part includes some additional language regarding the scope of the CMM. Language has been added in Paragraph 1 to clarify that the SPRFMO Observer Programme applies to all fishing vessels operating in the Convention Area while they are in the Convention Area. In other words, a fishing vessel that operates only in an Exclusive Economic Zone (EEZ) would not be subject to these requirements. However, a fishing vessel that operates in the Convention Area and in an EEZ on the same trip would be subject to the requirements of this CMM for the portion of the trip that occurs in the Convention Area. Existing domestic observer programmes would be eligible to become accredited, so multiple observers would not be needed.

2. The SPRFMO Observer Programme (SPRFMO OP) shall apply to all fishing vessels flying the flag of a Member or CNCP, as defined in Article 1, 1, (h) of the Convention, and operating in the area of application of the Convention, as defined in Article 5 of the Convention.

3. The SPRFMO OP shall consist of [independent and impartial observers] *or per Australia definition* [independent and impartial data collected by observers] that are sourced from observer programmes accredited by the Commission. The SPRFMO OP shall be consistent, to the maximum extent possible, with other regional and national observer programmes. This should include but not be limited to the sharing of information pertinent to vessel conditions and health and safety.

For scientific purposes the SC considers that the observer programme should concentrate on catcher vessels (of SPRFMO fishery resources). Noting that under the current definition of fishing vessel that is not possible.

Transhipment observation is often managed as a separate program with separate objectives

4. The SPRFMO OP shall be coordinated by the Secretariat of the Commission and operated in accordance with standards, rules and procedures established by

the Commission.

5. A key role of observers under the SPRFMO OP shall include collecting the information specified in Part 5 below.

Part 3 Objectives of the SPRFMO Observer Programme

Explanatory Note: Given the comments received on this part, it appears that it would be best to include the already agreed language and requirements from Paragraph 2 of CMM 4.02, "Conservation and Management Measure on the Standards for the Collection, Reporting, Verification and Exchange of Data," such that the objectives and core requirements of the SPRFMO OP are only located in this CMM. Accordingly, a revision to CMM 4.02 would need to be submitted along with the adoption of this CMM. The specific observer data elements and confidentiality requirements will remain in the revised "CMM on the Standards for the Collection, Reporting, Verification and Exchange of Data." I felt it appropriate to ask the Scientific Committee to review the observer data collection requirements in CMM 4.02, "Conservation and Management Measure on the Standards for the Collection, Reporting, Verification and Exchange of Data," including the data elements of Appendix 7, and provide advice on any needed amendments to include in this CMM. Comments also indicated that data collected by observers should be used for both scientific and compliance monitoring purposes, so modifications have been made to this part to incorporate those comments. In addition, language referencing Annex A and Annex B has been moved to this part and the text has been changed to refer to these documents as mandatory rights and responsibilities, rather than guidelines.

6. The objective of the SPRFMO OP is to provide Independent, impartial and representative information and data of the following types that has been subject to debriefing and quality assurance:

   a. Effort and catch and interaction data for all fisheries and fished species in the Convention Area, including target catch, and by-catch discards including seabirds, marine mammals, marine reptiles, and other species of concern.

   b. Biological or other data and information relevant to the management of fishery resources in the Convention Area, as specified in the SPRFMO Data standards, or as identified from time to time by the Scientific Committee or through processes identified by the Commission.

   c. Relevant scientific information related to the implementation of the provisions of the Conservation and Management Measures (CMMs) adopted by the Commission.

   d. Representative data, including length-frequency, species composition and biological samples, across the Convention Area, distribution of fishing effort, seasons, fishing fleets and fleet types.

7. Information collected through the SPRFMO OP shall, as appropriate, be used to support the functions of the Commission and its subsidiary bodies.

These concepts need a set of mutually exclusive and comprehensive definitions

Deleted: the following types of information that have been collected by observers and have been subject to debriefing

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Deleted: associated and dependent species

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Deleted: , including but not limited to stock assessments, development of conservation and management measures, and compliance monitoring

8. The SPRFMO OP also provides for the rights and responsibilities of observers and vessel operators, captains, and crew in Annex A and Annex B, respectively.

Paragraph 8 also does not belong in the objectives

Part 4 Roles and General Responsibilities

Explanatory Note: Multiple comments were submitted on this part, with some recommending that the standards and details for the accreditation process should be included as an annex to this CMM and some also recommending that the details of the Secretariat's role in the Observer Programme should be clearly delineated in the CMM. This draft of the CMM proposes that agreement be reached first on the framework elements of the SPRFMO OP along with an interim accreditation process, and that the final details of an accreditation process and the Secretariat's responsibilities therein be developed for adoption by the Commission and inclusion as annex to this CMM.

9. Members and CNCPs shall only use observer programmes accredited under the SPRFMO OP for fishing vessels flying their flag operating in the Convention Area.

Deleted: observers from

10. Members and CNCPs shall be responsible for meeting the level of observer coverage as set by the Commission and shall ensure that fishing vessels flying their flag operating in the Convention Area are prepared to accept observers from the SPRFMO OP.

11. The SPRFMO Secretariat shall coordinate the SPRFMO OP and shall organize and operate the SPRFMO OP in accordance with standards, rules and procedures to be fully established by the Commission.

12. Members and CNCPs shall provide the SPRFMO Secretariat with the details of any observer programmes for nomination for accreditation under the SPRFMO OP. Nominated observer programmes shall undergo an accreditation process in accordance with standards adopted by the Commission. After accreditation, each observer programme will be evaluated for continued participation in the SPRFMO OP every three [five] years, in accordance with standards adopted by the Commission.

13. Until the Commission has adopted the accreditation process, Members and CNCPs shall provide the Secretariat with the following information on any observer programmes nominated to participate in the SPRFMO OP on an interim basis: (1) the name and contact details of the observer programme coordinator; and (2) the observer programme manual, guidelines, instructions, regulations or workbooks relevant to describe the requirements and duties of the programme's observers. These programmes will be required to undergo the full accreditation process when it is implemented.

14. Members and CNCPs will ensure that data collected through the observer programme are put through an appropriate data quality / debriefing process, which will be reviewed by the Commission as part of the SPRFMO OP accreditation process.

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15. Members and CNCPs shall ensure that observer data are provided to the Secretariat in a standardized electronic format, to be included in a SPRFMO Observer Database per specifications and standards for observer data submissions on the SPRFMO website. Observer data must be identified at the fishery level. Members and CNCPs will provide

by 30 June, their previous (January to December) year's debriefed observer data.

Deleted: September

16. Members and CNCPs shall ensure that observers do not unduly interfere with the lawful operations of the vessel and in carrying out their duties shall give due consideration to the operational requirements of the vessel and to the extent practicable minimize disruption to the operation of vessels fishing in the Convention Area.

17. Members and CNCPs shall ensure that observers are not unduly obstructed in the discharge of their duties unless there is a documented safety issue.

18. Members and CNCPs shall ensure that vessel operators and crew comply with Annex A and Annex B.

Part 5 Minimum Information and Data to be Collected

Explanatory Note: As stated in the Explanatory Note for part 3, above, the specific data elements to be collected will remain in the "Conservation and Management Measure on the Standards for the Collection, Reporting, Verification and Exchange of Data." Other requirements from theat CMM except data confidentiality are included here.

19. Members and CNCPs shall ensure that observers collect the information specified in Annex 7 of the "Conservation and Management Measure on the Standards for the Collection, Reporting, Verification and Exchange of Data."

20. Members and CNCPs shall provide annual observer implementation reports as a section in the annual report, 30 days prior to the meeting of the SC and covering the previous year, which include sections covering: observer training, programme design and coverage, type of data collected, and any problems encountered during the year. These reports shall be reviewed by the Compliance and Technical Committee (CTC) and to evaluate the implementation and effectiveness of observer programmes and used by the Scientific committee to aid its work

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21. The Secretariat shall prepare an annual report on the implementation of the SPRFMO OP for presentation at each annual meeting of the CTC and Commission that will be distributed to Members and CNCPs [30] days prior to each meeting, including but not limited to information on problems that have been encountered and recommendations for improving current standards and practices. The Secretariat shall compile and disseminate a summary of observer data holdings to the Scientific Committee (SC) no later than [60] days in advance of each SC meeting to ensure that the best scientific information is available, while maintaining confidentiality following the procedures specified in Paragraph 7 of CMM 4.02, "Conservation and Management Measure on the Standards for the Collection, Reporting, Verification and Exchange of Data" and any other data confidentiality procedures developed.

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Part 6 Levels of Observer Coverage

Explanatory Note: Text in this part has been modified to reference existing CMMs specifying observer coverage. The language for all other fisheries not covered by existing CMMs mirrors language in CMM 4.01. However, I propose that it would be better to include all metrics and specified levels of observer coverage in this CMM and as other CMMs are updated these requirement need not be carried forward and the references here can be deleted. I believe it is appropriate to ask the Scientific Committee for advice on the appropriate levels of observer coverage and metrics to use for each fishery.

21bis. By 2019 the SC will complete an analysis of appropriate observer coverage along with an agreed definition of fishing effort by fishery for all fisheries is completed the following coverage levels should apply for paragraphs 22 - 24:

Noting that Coverage levels for transhipment have not been considered by the SC

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22 For the *Trachurus murphyi* fishery, the level of observer coverage shall be as specified in CMM 4.01, "Conservation and Management Measure for *Trachurus murphyi*.

a. Members and CNCPs participating in the Trachurus murphyi fishery shall ensure a minimum of 10% observer coverage of trips

b. In the case of the vessels undertaking no more than 2 trips in total, the 10% observer coverage shall be calculated by reference to active fishing days for trawlers and sets for purse seine vessels.

In the longer term, coverage should not be defined in terms of trips because they cannot be identified from the SPRFMO database.

23. For bottom fisheries, the level of observer coverage shall be as specified in CMM 4.03, "Conservation and Management Measure for the Management of Bottom Fisheries in the SPRFMO Convention Area."

a. for vessels using trawl gear in the Convention Area, ensure 100 percent observer coverage for vessels flying their flag for the duration of the trip;

b. for each other bottom fishing gear type, ensure that there is at least a 10 percent level of observer coverage each fishing year;

24. For new and exploratory fisheries, the level of observer coverage shall be as specified in CMM 4.13, "Conservation and Management Measure for the Management of New and Exploratory Fisheries in the SPRFMO Convention Area."

24bis new squid paragraph

25. [For all other fisheries, Members and CNCPs shall ensure a minimum of 10% observer coverage of trips. In the case of the vessels undertaking no more than two trips in total, the 10% observer coverage shall be calculated by reference to active fishing days or sets]

There are different views within the Scientific Committee on the need and content of paragraph 25. The OPWG should consider options including a separate paragraph for the squid fishery vs all other fisheries.

China noted that this means each vessel should be sent an observer on board in a fishing year. Furthermore, 10% observer coverage based on fishing days is too high to be realistic or operational, especially for the squid jigging fishery. At this stage, the OP should focus on the jack mackerel fishery and bottom fishery, for other fisheries, whether implement the OP should be determined by the demand of management. We oppose the OP apply to all other fisheries. Article 25 should be deleted or modified.

IF the squid jigging fishery was included the OP, two key issues must be considered. Firstly, because the jumbo flying squid is the straddling fish stock, all the squid jigging vessels that operate in the international waters or jurisdiction waters of coastal countries shall be applied the OP. Secondly, the observer coverage should be set much more scientifically and realistically, rather than arbitrarily.

Annex A: Rights and Responsibilities of Observers in the SPRFMO Observer Programme

1. The rights of observers shall include:

a. Full access to and use of all facilities and equipment of the vessel which the observer may determine is necessary to carry out his or her duties, including full access to the bridge, fish and any bycatch on board, and areas which may be used to hold, process, weigh, and store fish.
b. Full access to the vessel's records including its logs and documentation for the purpose of records inspection and copying, vessel diagrams, reasonable access to navigational equipment, charts and radios, and reasonable access to other information related to fishing.
c. Access to and use of communications equipment and personnel, upon request, for entry, transmission, and receipt of work related data or information.
d. Access to additional equipment, if present, to facilitate the work of the observer while on board the vessel, such as high powered binoculars, electronic means of communication, freezer to store specimens, scales, etc.
e. Access to the working deck or hauling station during net or line retrieval and to specimens (alive or dead) in order to collect and remove samples, as well as cooperation of the vessel crew when sampling the catch.
f. Notice by the vessel captain of at least fifteen (15) minutes before hauling or setting procedures, unless the observer specifically requests not to be notified.
g. Access to food, accommodations, medical facilities that meet international maritime standards, and sanitary facilities of a reasonable standard equivalent to those normally available to an officer on board the vessel.
h. The provision of adequate space on the bridge or other designated area for clerical work and adequate space on the deck or factory for observer duties.
i. Freedom to carry out their duties without being assaulted, obstructed, resisted, delayed, intimidated or interfered with in the performance of their duties.
j. Full access to verify safety equipment onboard (safety orientation tour provided by officers/crew), before the vessel leaves dock, and recording any pertinent information including life rafts capacity, radios, etc.
k. Full access to communication equipment onboard that allows the observer to communicate with the observer program on land at any time in case of emergencies

l. Free access to record any pertinent information including but not limited to video and still images.
m. A permanent delegate or supervisor on land to communicate with while at sea.
n. Provision of personal protective equipment, including personal locator beacon.
o. Ability to decline to board a vessel if safety issues are detected, such as expired life rafts, restricted capacity of the rafts, expired fire extinguishers, malfunctioning safety equipment, inadequate accommodations, etc., and communicate the safety issues to the vessel captain, observer provider, Secretariat, and flag State.
p. Timely medical attention in case of illness or injury.
q. Upon request, receiving reasonable assistance of the crew to perform their activities including sampling, handling large specimens, releasing incidental specimens, measurements, etc.

2. The responsibilities of the observers shall include:

a. Being capable of performing the duties set out by the Commission.
b. Accurately recording sampling data and writing reports as directed by the Commission.
c. Successfully completing training, and receiving satisfactory evaluation of performance after each cruise and briefing according to standards set by the Commission in order to be certified annually as an observer of the SPRFMO OP.
d. Carrying identification documents issued by the designating Member or CNCP in a form approved by the Commission.
e. Acceptance and compliance with agreed upon confidentiality rules and procedures with respect to the fishing operations of the vessels and of the vessel owners.
f. Maintenance of independence and impartiality at all times while on duty in the SPRFMO Observer Programme.
g. Compliance with SPRFMO Observer Programme protocols for observers carrying out SPRFMO Observer Programme duties on board a vessel.
h. Compliance with the laws and regulations of the Member or CNCP that exercises jurisdiction over the vessel.
i. Respecting the hierarchy and general rules of behavior that apply to all vessel personnel.
j. Performance of duties in a manner that does not unduly interfere with the lawful operations of the vessel and in carrying out their functions they shall give due consideration to the operational requirements of the vessel and shall communicate regularly with the captain or master of the vessel.
k. Following a mechanism established by the Commission for the resolution of conflicts.
l. Familiarity with the emergency procedures aboard the vessel, including the locations of life rafts, fire extinguishers, and first aid kits.
m. Communicating regularly with the vessel captain on relevant observer issues and duties.

n. Observance of ethnic traditions of the crew and customs of the flag State of the vessel.
o. Refraining from actions that could negatively affect the image of the SPRFMO Observer Programme.
p. Adherence to any SPRFMO codes of conduct for observers.
q. Promptly writing and submitting reports to the Commission or national programme in accordance with procedures adopted by the Commission.
r. Before boarding the vessel, ensure that the embarkation point is free of obstacles, and wear a personal flotation device and take appropriate safety precautions when embarking and disembarking.
s. Communicating at least once a day with the program managers on land.

Annex B: Rights and Responsibilities of Vessel Operators, Captain and Crew

1. The rights of vessel operators and captains shall include:

a. Expectation that at least [15] days of prior notice of the placement of SPRFMO Observer Programme observers shall be given.
b. Expectation that the observers will comply with the general rules of behavior, hierarchy, and laws and regulations of the Member or CNCP that exercises jurisdiction over the vessel.
c. Timely notification from the observer provider on completion of the observer's trip of [describe specific information to be shared – sampling information, other information?] to the vessel owner for review. The captain shall have the opportunity to review and comment on this information, and shall have the right to include additional information deemed relevant or a personal statement. [Discussion is needed to clearly specify which data can be shared with vessel owners and operators and which data is confidential and cannot be shared].

The SC agrees that discussion is needed to ensure independence and impartiality of the report.

d. Ability to conduct operations of the vessel without undue interference due to the observer's presence and performance of necessary duties.
e. Ability to assign, at his or her discretion, a vessel crew Member to accompany the observer when the observer is carrying out duties in hazardous areas.

2. The responsibilities of vessel operators and captains shall include:
a. Accepting onboard the vessel one or more persons identified as an under the SPRFMO Observer Programme when required by the Commission.
b. Ensuring vessels operating in the SPRFMO Area include certified sample stations and/or other equipment (such as MCP scales and/or flow scales) to the extent that there are established standards set by the Commission for different types of vessels.
c. Maintaining an inspection report of the sample stations, and make a station diagram available to the observers.
d. Not altering the sample stations unless approved by the Commission.

e. Informing the crew of the timing of the SPRFMO Observer Programme observer boarding as well as their rights and responsibilities when an observer from the SPRFMO Observer Programme boards the vessel.
f. Assisting the SPRFMO Observer Programme observer to safely embark and disembark the vessel at an agreed upon place and time.
g. Giving notice to the SPRFMO Observer Programme observer at least fifteen (15) minutes before the start of a set or haul onboard, unless the observer specifically requests not to be notified.
h. Allow and assist the SPRFMO Observer Programme observer to carry out all duties safely.
i. Allowing the SPRFMO Observer Programme observer full access to the vessel's records including vessel logs and documentation for the purpose of records inspection and copying.
j. Allowing reasonable access to navigational equipment, charts and radios, and reasonable access to other information related to fishing.
k. Permitting access to additional equipment, if present, to facilitate the work of the SPRFMO Observer Programme observer while onboard the vessel, such as baskets, scales, high powered binoculars, photo cameras, stationary, electronic means of communication, safety gear (life vests, hard hats, immersion suits, strobe lights, personal locator beacons) etc.
l. Allow and assist the SPRFMO Observer Programme observer to remove and store samples from the catch.
m. The provision to the SPRFMO Observer Programme observer, while onboard the vessel, at no expense to the observer or the SPRFMO Observer Programme observer's provider or government, with food, accommodation, adequate sanitary amenities, and medical facilities of a reasonable standard equivalent to those normally available to an officer onboard the vessel.
n. The provision to the SPRFMO Observer Programme observer, while onboard the vessel, insurance coverage for the duration of the observer's time onboard the vessel.
o. Allow and assist full access to and use of all facilities and equipment of the vessel that the observer may determine is necessary to carry out his or her duties, including full access to the bridge and any internet capabilities, fish onboard, and areas which may be used to hold, process, weigh, and store fish.
p. Ensuring the SPRFMO Observer Programme observer is not assaulted, obstructed, resisted, delayed, intimidated, interfered with, influenced, bribed or is attempted to be bribed in the performance of their duties.
q. Following an established mechanism adopted by the Commission for solving conflicts.

3. Rights and responsibilities of vessel crew shall include:

a. Expectation that the SPRFMO Observer Programme observer will comply with the general rules of behavior, hierarchy, and laws and regulations of the Member or CNCP that exercises jurisdiction over the vessel.
b. Expectation that a reasonable period of prior notice of the placement of a SPRFMO Observer Programme observer shall be given by the Captain.

c. Reasonable expectation of privacy in crew personal areas.
d. Ability to carry out duties associated with normal fishing operations without undue interference due to the SPRFMO Observer Programme observer's presence and performance of their necessary duties.

4. The responsibilities of the vessel crew shall include:

   a. Not assaulting, obstructing, resisting, intimidating, influencing, or interfering with the SPRFMO Observer Programme observer or impeding or delaying observer duties.
   b. Compliance with regulations and procedures established under the Convention and other guidelines, regulations, or conditions established by the Member or CNCP that exercises jurisdiction over the vessel
   c. Allowing and assisting full access to and use of all facilities and equipment of the vessel which the observer may determine is necessary to carry out his or her duties, including full access to the bridge, fish onboard, and areas that may be used to hold, process, weigh and store fish.
   d. Allow and assist the SPRFMO Observer Programme observer to carry out all duties safely.
   e. Allow and assist the SPRFMO Observer Programme observer to remove and store samples from the catch.
   f. Compliance with directions given by the vessel captain with respect to the SPRFMO Observer Programme observer duties.

5. The responsibilities of the vessel captains shall also include providing a safety orientation to the observer on boarding and before the vessel leaves the dock and ensure that the observer completes a vessel safety checklist. The orientation shall include:
   a. Safety documentation of the vessel.
   b. Location of life rafts, raft capacities, observer´s assignment, expiration, installation, etc.
   c. Location of emergency radio beacons indicating position in case of emergency.
   d. Location of immersion suits and personal floating devices, their accessibility, and the quantities for everyone onboard.
   e. Location of flares, types, numbers, and expiration dates.
   f. Location and number of fire extinguishers, expiration dates, accessibility, etc.
   g. Location of life rings
   h. Procedures in case of emergencies and essential actions of the observer during each type of emergency, such as a fire on board, recovering a person overboard, etc.
   i. Location of first aid materials and familiarity with crew members in charge of first aid.
   j. Location of radios, procedures for making an emergency call, and how to operate a radio during a call.
   k. Safety drills.
   l. Safe places to work on deck and safety equipment required.
   m. Procedures in case of illness or accident of the observer or any other crew member.

Annex 7. Jack mackerel stock assessment

Introduction

This document and content is based on discussions and analyses conducted at the SC-04 meeting. An exhaustive stock assessment input data review and discussion of model assumptions were considered in a workshop prior to the SC-04 meeting. The discussions during this workshop and subsequently during the SC04 focused on the following topics:

- Review and update of data sets
- How to weight different data sets (which are of different quality)
- How to deal with ageing error
- The assumptions on fisheries and survey selectivity over the years
- Assumptions on natural mortality
- The extent and mechanisms affecting how selectivity may vary over time
- Consideration of additional diagnostic tools (retrospective analyses, likelihood profiles)
- For projections, information within the data and model configuration that may inform stock productivity (so-called stock recruitment "steepness").

Scientific name and general distribution

The Chilean Jack mackerel (*Trachurus murphyi*, Nichols 1920) is widespread throughout the South Pacific, along the shelf and oceanic waters adjacent to Ecuador, Peru, and Chile, and across the South Pacific along the Subtropical Convergence Zone in what has been described as the "Jack mackerel belt" that goes from the coast of Chile to New Zealand within a 35^{o} to 50^{o} S variable band across the South Pacific.

Main management units

At least five management units of *T. murphyi* associated to distinct fisheries are identified in the SE Pacific: the Ecuadorian fishery, which is managed as part of a more general pelagic fishery within the Ecuadorian EEZ; the Peruvian fishery, which is managed as part of a Jack mackerel, mackerel and sardine fishery directed exclusively for direct human consumption taking place almost entirely within the Peruvian EEZ; the northern and the central-southern Chilean fisheries which are managed as separate management units, with the northern fishery being mostly within Chilean EEZ and the central-southern Chilean fishery which straddles the Chilean EEZ and the adjacent high sea; and, the purely high sea fishery which is a multinational fishery being managed entirely within the context of the SPRFMO. At present there is no directed fishery for *T. murphyi* in the central and western South Pacific and around New Zealand, where, if any, incidental catches are very small.

Stock structure

There are a number of competing stock structure hypotheses, and up to five and more separate stocks have been suggested: i) a Peruvian stock (northern stock) which is a straddling stock with respect to the high seas; ii) a Chilean stock (southern stock) which is also a straddling stock with respect to the high seas; iii) a central Pacific stock which exists solely in the high seas; iv) a southwest Pacific stock which exist solely in the high seas; v) and, a New Zealand-Australian stock which straddles the high seas and both the New Zealand and Australian EEZs. Regarding specifically the eastern and central South Pacific, the SPRFMO has identified the following four alternative stock structure working hypotheses: 1) Jack mackerel caught off the coasts of Peru and Chile each constitute separate stocks which straddle the high seas; 2) Jack mackerel caught off the coasts of Peru and Chile constitute a single shared stock which straddles the high seas; 3) Jack mackerel caught off the Chilean area constitute a single straddling stock extending from the coast out to about 120°W; and, 4) Jack mackerel caught off the Chilean area constitute separate straddling and high seas stocks.

Accordingly, the Jack Mackerel Sub-group (JMSG) of the Science Working Group (SWG) of the SPRFMO at its 11th Session (SWG-11) carried out parallel assessments of the Jack mackerel stock(s) in the Eastern South Pacific under the two main working hypothesis already identified. That is: that Jack mackerel caught off the coasts of Peru and Chile each constitute separate stocks (Peruvian or northern and Chilean or southern stocks - hypothesis 1) which straddle the high seas; and, that Jack mackerel caught off the coasts of Peru and Chile constitute a single shared stock (hypothesis 2) which straddles the high seas. In following up on the SWG-11 recommendations, the SPRFMO Commission at its 1st Commission Meeting requested the newly established Scientific Committee to continue the work on evaluating alternative hypotheses on Jack mackerel stock population. Pending more conclusive findings on the stock population structure of Jack mackerel, the 2nd Commission meeting requested the Scientific Committee (SC) to continue and expand the stock assessment work under both stock hypotheses considered in the 11th SWG Meeting, and this continues to be one of the main tasks undertaken at SC-04.

Fishery

The fishery for jack mackerel in the south-eastern Pacific is conducted by fleets from the coastal states (Chile, Peru and Ecuador), and by distant water fleets from various countries, operating beyond the EEZ of the coastal states.

The fishery by the coastal states is done by purse seiners. The largest fishery exists in Chile, where the fish are used mainly to produce fish meal. In Peru, the fishery is variable from year to year. Here the fish is taken by purse seiners that also fish for other pelagic species (e.g., anchovy, mackerel, sardines). According to government regulations, the jack mackerel in Peru may only be used for human consumption. Ecuador constitutes the northern fringe of the distribution of jack mackerel. Here the fish only occur in certain years, when the local purse seiners may take substantial quantities (80 000 tons in 2011). Part of the catch is processed into fish meal but recently jack mackerel has been promoted to be used for human consumption.

The distant water fleets operating for jack mackerel outside the EEZs have been from a number of parties including Belize, China, Cook Islands, Cuba, European Union (Netherlands, Germany and Lithuania), Faroe Islands, Korea, Japan, Russian Federation, Ukraine and Vanuatu. These fleets consist exclusively of pelagic trawlers that freeze the catch for human consumption. In the 1980s a large fleet from Russia and other Eastern European countries operated as far west as 130° W. After the economic reforms in the communist countries around 1990, the fishery by these countries in the eastern Pacific was halted. It was not until 2003 that foreign trawlers re-appeared in the waters outside the EEZ of the coastal states.

The jack mackerel fishery in Chilean and offshore waters is generally mono-specific. In the offshore fishery, the catch consists for 90 – 98% of jack mackerel, with minor bycatch of chub mackerel (*Scomber japonicus*) and Pacific bream (*Brama australis*). The available time series of jack mackerel catches in the south-eastern Pacific are shown in Table A8.1.

Management

Jack mackerel were managed by coastal states beginning in the mid-1990s. National catch quotas for jack mackerel were introduced by Peru in 1995 and by Chile in 1999. Peru introduced a ban on the use of jack mackerel for fish meal in 2002. For the international waters, the first voluntary agreement on limitation of the number of vessels was introduced in 2010. Starting from 2011, catch limits for jack mackerel were established for all countries fishing in the convention area in the south-eastern Pacific.

Information on the environment in relation to the fisheries

Important environmental events (e.g., the 2016 El Niño) affect oceanographic dynamics. During such events, the depth of the 15°C isotherm changed significantly affecting the spatial distribution of Jack mackerel and their availability in different regions. The extent that such changes affect the overall population productivity is unclear.

Reproductive biology

The main spawning season happens from October to December; however, spawning has been described to occur from July to March. Gonadosomatic index and eggs surveys have been used to determine the time of spawning.

Data used in the assessment

Fishery data

The catch data for the model sums values from Table A8.1 and forms four "fleets" which are intended to be consistent with the gear and general areas of fishing (Figure A8.1). The catches from each of these fleets are presented in Table A8.2.

Length data are available from all major fisheries both inside and outside the EEZs. Length distributions from Chile and the older international fleet were converted into age distributions using annual Chilean age-length keys. The more recent length composition data from China and EU were converted to age compositions by applying Chilean age-length keys as compiled by quarter of the year and then aggregated (Tables A8.3, A8.4, and A8.5). For Peruvian and Ecuadorian fisheries, length frequency data (Table A8.6) were used directly and fit within the model according to the specified growth curve.

Several CPUE data series are used in the model, with some changes introduced during SC-04. For the Chilean purse seiner fleet, a "General Linear Model" (GLM; McCullagh & Nelder, 1989) approach was used to standardize the CPUE. Here CPUE was modelled as a linear combination of explanatory variables with the goal to estimate a year-effect that is proportional to jack mackerel density. Factors in the GLM included year, quarter, zone, and vessel hold capacity. Effort units were computed as the number of days spent fishing by each vessel. This CPUE series was revised during SC-04 to exclude trips with no jack mackerel catches. This was preferred because it better reflects changes in management over time (particularly the introduction vessel-level quotas starting in 2000). To account for changes in fleet behaviour arising from the changes in management, the revised CPUE series from the GLM was modelled to have a catchability change in year 2000.

The Peruvian CPUE was standardized using a GAM model, allowing the inclusion of non-linear relationships among the explained and explanatory variables. The independent variable (catch by trip) in a monthly scale was previously normalized using the Box-Cox transformation and modelled using time (Gregorian) month, hold capacity, latitude, and distance to the coast as explanatory variables. The standardized CPUE was estimated fixing the hold capacity, latitude, and distance to the coast to the median value and the month to March, assuming the continuous time captures the variability in the abundance of Jack mackerel. This CPUE series was also revised during SC-04 and is now based on all trips and not just on those with jack mackerel catches above a pre-specified threshold. This is because the trips of this fleet target a collection of species (anchoveta, jack mackerel, mackerel, etc.) jointly rather than a specific target species. Effectively all trips "target" jack mackerel as part of the species ensemble.

Peruvian CPUE data were unavailable for 2015 apparently due to very low catches of jack mackerel. El Niño conditions were very strong in 2015 and jack mackerel are believed to have been distributed closer to the coast than normal and outside of where the industrial fleet is allowed. For this reason, the 2015 CPUE value was unrepresentative of stock abundance and, hence excluded. However, it was agreed that this should be examined more closely next year.

The Chinese CPUE was standardized using a GLM and updated earlier studies. This series was included as an index of exploitable biomass for offshore fleet. As from previous assessments, the Russian time series of CPUE was included but with low weight since it remains unstandardized. Also, for the international trawler fleet, a single nominal CPUE series for the offshore fleet was compiled using data from EU, Vanuatu and Korean vessels and updated through 2016.

Fisheries independent data

China has a system of observers on board fishing vessels that, among other data collection activities, routinely record environmental variables (wind direction and speed, SST, etc.) while on the fishing grounds. Although this data was presently unavailable to the SC, it may be in the future.

The Chilean Jack mackerel research program has included conducting surveys using hydro-acoustics and the daily egg production method (DEPM). Acoustic estimates and egg survey results are used as relative abundance indices. For the northern region (N-Chile) data on acoustic biomass and number and weight at age are available annually from 2006 to 2016. For the central-southern regions, these data are available from 1997 to 2009. In previous jack mackerel assessments, the acoustic survey in northern Chile was assigned the same selection-at-age curve as the northern Chile fishing fleet; however, given the survey age composition data indicate that it catches younger ages than the fishing fleet, the SC-04 considered it more appropriate to assign the survey its own selectivity. Egg surveys (through the Daily Egg Production Method), to estimate the abundance of the spawning stock, were conducted on an annual basis from 1999 to 2008 along the central zone of the Chilean coast. Besides that, for the central-southern regions there are estimates of abundance and numbers at age based on DEPM for the years 2001, 2003, 2004, 2005, 2006, 2008. Age composition data for the acoustic and DEPM Chilean surveys are shown in Tables A8.7. – A8.9.

The Peruvian Jack mackerel research programme includes egg and larvae surveys and hydro-acoustic stock assessment surveys. Results of these egg and larvae surveys provide information on the spatial and temporal variability of Jack mackerel larvae along the Peruvian coast from 1966 to-date. During SC-03, a new series of acoustic biomass was provided by Peru for years 1986-2013. This series represents estimations based on the assumption of shifts in habitat area and its impact over traditional estimations. Acoustic biomass estimates of Jack mackerel are available from 1983 to-date. Because these surveys have the Peruvian anchoveta as the main target, data only covers the first 80 miles and eventually 100 miles from the coast. Corrections to compensate for this partial coverage of acoustic biomass estimates of Jack mackerel were being made by using an environmental index describing the potential habitat of this species based on available monthly data on Sea Surface Temperature (SST), Sea Surface Salinity (SSS), water masses (WM), oxycline depth (OD) and chlorophyll (CHL), since 1983 to the present.

Yet another alternative acoustic index for Peru was presented in 2014. This was constructed using backscatter information without converting the information to biomass estimates using length-frequency data. The reasons to propose this method related to the reduced quality of the available length-frequency data in recent years. This alternative series was included in the jack mackerel assessment by SC-04, thus replacing the Peruvian acoustic series used in previous assessments. The last value provided for this series corresponds to 2013. The El Niño conditions in 2014 and 2015 affected the distribution of jack mackerel making them more dispersed and outside the area covered by the anchovy survey. Further work on standardizing and analysis of the survey data to develop a reasonable index from these data.

Acoustic surveys, to estimate the biomass and distribution of jack mackerel, have also been conducted along the Chilean coast, inside and outside of the EEZ and in the Peruvian EEZ, using scientific vessels. Additionally, comprehensive acoustic surveys have been conducted from the Chilean commercial fleet. The available acoustic estimates time series extends from 1984 to 2012 (depending on the area). All abundance indices (fishery CPUE and survey) series used in the model are presented in Table A8.10.

Biological parameters

The maturity-at-age assumed for jack mackerel was based on a Chilean study (SWG-11-JM-07). The application of these results reduced the age at first reproduction by about one year, to 2-3 years from the 3-4 years used in the assessment a few years ago. Maturity at length was consistently observed with L50 at about 23 cm fork length (FL). The maturity-at-age values, and those for the far-north stock, are shown in Table A8.11.

To fit the length composition data from the far-north fleet, a growth curve was used to convert age compositions predicted by the model to predicted lengths, with the conversion occurring within the model. The values for the von Bertalanffy growth parameters are given in Table A8.12. Ageing imprecision is acknowledged using an age-error matrix and is shown in Table A8.13. However, because this matrix is based on expert judgement instead of actual data, the discussions during SC-04 led to selecting the final assessment model with this ageing error option turned off.

Mean weight-at-age is required for all fishing fleets and biomass indices in order to relate biomass quantities to the underlying model estimates of jack mackerel abundance (in numbers). The four weight at-age matrices for the fishing fleets correspond to: fleet 1 (northern Chile), fleet 2 (central-south Chile), fleet 3 (the far north fleet) and fleet 4 (the offshore trawl fleet). These values are shown in Tables A8.14 - A8.17.

In Chile, the mean weight at age is calculated by year by taking the mean length at age in the catch and a length-weight relationship of the year. Before SC-03, the same weight at age matrix was used for the Northern Chilean Fleet (Fleet 1) and Southern Chilean Fleet (Fleet 2). From SC-03 onwards a weight at age matrix specific for Northern Chile has been applied. The method uses two information sources: the length-age keys and the parameters of the weight-at-length relationship from IFOP's monitoring program of the Chilean fisheries. The information was separated in two zones which correspond to fishing areas (and acoustic surveys) that occur in Chile. Annual weight-at-length relationship was fitted to the data by each fleet independently, and these relationships were applied to mean length at-age within each zone. The information covers the period 1974-2016; for earlier years the weight at age from 1974 was used.

In Peru the mean weight at age is calculated by year taking the invariant mean length at age estimated from the growth function (Table A8.12) and the length-weight relationship of the year. The information covers the period 1970-2016. The weights at age for the offshore fleet are derived from age-extrapolations from Chilean length frequency data and averages when unavailable.

Estimates of natural mortality are derived from Pauly´s method, using the Gili et al. (1995) growth function for Chile and the Dioses (2013) growth function for Peru. The estimated M values are assumed to be the same for all ages and all years within the given stock (see Table A8.12).

Data sets

A full description of data sets used for the assessment of jack mackerel is in Annex 3 of the SC Data workshop 2015. A summary list of all data available for the assessment is provided in Table A8.18.

The assessment model

A statistical catch-at-age model was used to evaluate the jack mackerel stocks. The JJM ("Joint Jack Mackerel Model") is implemented in ADMB and considers different types of information, which corresponds to the available data of the jack mackerel fishery in the South Pacific area since 1970 to 2016.

The JJM model is an explicit age-structured model that uses a forward projection approach and maximum likelihood estimation to solve for model parameters. The operational population dynamics model is defined by the standard catch equation with various modifications such as those described by Fournier and Archibald (1982), Hilborn and Walters (1992) and Schnute and Richards (1995). This model was adopted as assessment method in 2010 after several technical meetings (http://www.sprfmo.int/jack-mackerel-sub-group/).

JJM developments

Since its adoption, the JJM model has been improved by participating scientists. The most noted change has been options to include length composition data (and specifying or estimating growth) and the capability to estimate natural mortality by age and time. The model is now more flexible and permits the use of catch information either at age or size for any fleet, and explicitly incorporates regime shifts in population productivity.

The model can be considered to consist of several components, (i) the dynamics of the stock; (ii) the fishery dynamics; (ii) observation models for the data; and (v) the procedure used for parameter estimation (including uncertainties).

Stock dynamics: recruitment is considered to occur in January while the spawning season is considered as an instantaneous process at mid-November. The population's age composition considers individuals from 1 to 12+ years old for the single stock hypothesis (hypothesis 2) as well as for the southern stock in the two-stock hypothesis (hypothesis 1), while for the northern stock (hypothesis 1) 1 to 8+ years old are considered. In all cases a stochastic relationship (Beverton & Holt) between stock and recruitment is included. The survivors follow the age-specific mortality composed by fishing mortalities at-age by fleet and the natural mortality, the latest one supposed to be constant over time and ages. The model is spatially aggregated except that the fisheries are geographically distinct. The initial population is based on an equilibrium condition and occurs in 1958 (12 years prior to the model start in 1970) in the case of the single stock (hypothesis 2) and in the southern stock in the case of the two-stock hypothesis (hypothesis 1), while in the northern stock equilibrium condition occurs in 1962 (8 years prior to the model start in 1970).

Fishery dynamics: The interaction of the fisheries with the population occurs through fishing mortality. Fishing mortality is assumed to be a composite of several processes – selectivity (by fleets), which describes the age-specific pattern of fishing mortality; catchability, which scales fishing effort to fishing mortality; and effort deviations, which are a random effect in the fishing effort − fishing mortality relationship. The selectivity is non-parametric and assumed to be fishery-specific and time-variant. The catchability is index-specific, and there are nine abundance indexes. For some of the indices, time variations in catchability and / or selectivity have been considered.

Observation models for the data: There are five data components that contribute to the log-likelihood function − the total catch data, the age-frequency data, the length-frequency data and the abundance indexes data.

The probability distributions for the age and length-frequency proportions are assumed to be approximated by multinomial distributions. Sample size is specified to be different by gear but mostly constant over years. For the total catch by fishery (4) and abundance indexes (9), a log-normal assumption has been assumed with constant CV; the CV for the fisheries is 0.05 whereas the CVs for the abundance indices depend on the index.

Parameter estimation: The model parameters were estimated by maximizing the log-likelihoods of the data plus the log of the probability density functions of the priors and smoothing penalties specified in the model. Estimation was conducted in a series of phases, the first of which used arbitrary starting values for most parameters. The model has been implemented and compiled in ADMB and whose characteristics can be consulted in Fournier et al (2012)

Model details

Parameters estimated conditionally are listed in Table A8.19. The most numerous of these involve estimates of annual and age-specific components of fishing mortality for each year from 1970-2016 and each of the four fisheries identified in the model. Parameters describing population numbers at age 1 in each year (and years prior to 1970 to estimate the initial population numbers at ages 1-12+ and 1-8+) were the second most numerous type of parameter.

Equations for the assessment model are given in Tables A8.20 and A8.21. Table A8.22 contains the initial variance assumptions for the indices and age and length compositions.

The treatment of selectivity and how they are shared among fisheries and indices are given in Table A8.23, A8.24 and A8.25. Depending on the model configuration, some growth functions were employed inside the model to convert model-predicted age compositions to length compositions, in order to fit the model to the length composition data.

Models for stock structure hypothesis

During SWG 11, two types of population structure were evaluated and this was continued for SC-01 and SC-02 evaluations. Models under the two stock hypotheses carry the same naming convention but have the letters “N” or “S” appended to designate split-stock model runs (for North and South stock structure hypothesis).

Description of model explorations

The first set of explorations involved incrementally adding new data components relative to last year’s jack mackerel model. These are labelled “Mod0.x” where x represents the number when a component was added (Table A8.26).

The rationale for the main updates and data revisions occurring through model configurations 0.0 to 0.13 has been explained in the “Data used in the assessment” section, earlier in this Annex. The data exercise concluded with Model 0.13.

The next set of explorations (1.0 – 1.19) started from Model 0.13, renamed as Model 1.0, and evaluated aspects such as changes in selectivity, the assumption on natural mortality and weighting of specific input datasets. The most salient features from this exploration for the assessment of jack mackerel (for simplicity under the single stock hypothesis) are described below.

Some models were run purely as sensitivity tests, (e.g., Models 1.1 and 1.2). In Model 1.3, the CVs of abundance indices and multinomial sample sizes of fleets and indices were adjusted based on the overall conclusions of the data quality workshop held in 2015 (SC-03). The same weights were applied in Model 1.14. It was, however, observed that the fits to some of the datasets (such as the mean age in the catch of some fisheries) deteriorated when these weights were used. Moreover, the procedure led to increasing the weight of the Chilean Acoustic North survey index and, given the uncertainties associated with this index (related to inter-annual changes in availability), there was some concern that increasing the weight of this abundance index in the model may be inappropriate. The SC noted that the weights in Model 1.3 were based on the first-pass subjective results from the data quality workshop without further review. Consequently, another iteration of refinements to the weightings is required before adopting them as part of the new reference case.

An alternative weighting scheme for the multinomial sample sizes, based on Francis T1.8 method was proposed in SC-04-JM-07. This alternative was another initial exploration that the SC should be considered further in future assessments.

Selectivity blocks were explored in Models 1.5 and 1.6. However, the SC noted that deciding when a new block should be introduced was subjective, including how future changes might be considered. Consequently, the current approach of allowing more gradual annual evolutions via random walks was preferred.

Models 1.9, 1.10 and 1.16 evaluated alternative natural mortality assumptions. Profiling over M was conducted under Model 1.9; this showed a preference towards larger values of M that seemed to be driven mainly by the age composition data (Figure A8.2). An age-varying natural mortality, inversely related to weight-at-age (Lorenzen, 1996), and scaled to take a value of 0.23 at the oldest age, was considered in Model 1.10. The higher values of M resulted in higher estimates of recruitment and SSB. The estimated value of F_{msy} became very high in this model configuration (even higher than 1 for the period before the mid 1990s). Model 1.16 attempted to use the same age-varying M but rescaled to an average of 0.23 over all the ages. However, this model run configuration had convergence issues that require more time to investigate than was available during the SC. It was concluded that a more comprehensive analysis would be necessary before considering changing natural mortality assumptions.

Results

Results comparing the impact of new data (Models 0.0-0.13) show that especially a change in the Peruvian echo-abundance influences the biomass trends, as well as changing the selectivity in the Chilean acoustic survey. This survey observed high densities of young individuals but these observations are expected to be influenced by the strong El Nino in 2015. Models 1.0 – 1.19 evaluated changes in selectivity, the assumption on natural mortality and weighting of specific input datasets. The final model is like the 2015 model but allows more flexibility in the selectivity parameters in the acoustic survey.

Model 1.11 (and the corrected version, Model 1.18, which included additional years of selectivity changes that should have been in earlier model configurations but had been omitted by mistake) provided an important change that had a clear impact on assessment results, particularly on the recruitment (age 1) estimate for the most recent year. In 2015 and 2016 the Chile North Acoustic survey index has very high values at age 1, which are expected to have likely arisen from availability changes (e.g. they could be related to El Niño event in 2015 and 2016) rather than reflect true changes in stock abundance. The very high 2015 age 1 index in this survey is not followed by a high 2016 age 2, and the strength of the 2015 and 2016 (age 1) recruitments is considered very uncertain now. To account for the likely availability changes in 2015 and 2016, Model 1.11 (and Model 1.18) includes selectivity changes for the Chile North Acoustic survey index in these two years. The SC considered this to be a sensible way forward and, even though additional model alternatives were examined, the conclusion was that Model 1.18 should be taken as the best model for providing advice this year.

To gain additional understanding of the assessment model properties and the impact of different datasets on model results, a profiling system was created so that the population scale could be effectively changed to see how likelihood components interact and which are most influential. The parameter for mean recruitment was fixed (instead of estimated) at a grid of values and results consequently plotted in terms of the derived quantity of the spawning biomass in 2016 (SSB). This grid was completed to explore Models 1.14 and 1.18 (Figure A8.3). Results of the profiling indicate that the largest impact affecting stock size uncertainty was structural: the configuration of Model 1.18 resulted in a considerably lower 2016 SSB than the Model 1.14 configuration. Within each of these configurations, the likelihood components were affecting the result in similar directions (i.e., the fishery age-composition likelihood favoured smaller 2016 SSB and the index data favoured higher stock sizes. In both configurations, the contribution to the recruitment likelihood was quite influential presumably due to interactions with fixing the mean recruitment values in each trial.

A new diagnostic was developed at this meeting which is common in many assessment analyses. This is the so-called "retrospective analysis" and involves running the model multiple times, each time removing one more year of data. For example, if the full model spanned 50 years of data, results from this would be compared to running the same model but only to 49 years, then 48 years and so on. This shows how sensitive the model is to additional data and may reveal tendencies for systematic bias. The estimated time series of recruitment and SSB shows a slight tendency to over-estimate SSB and that as more data are accumulated, estimates of recruitment magnitude can change (Figure A8.4).

The assessment model was also run under the 2-stock hypothesis. In that case, Model 1.18 resulted in unrealistic results for the north stock (e.g. unrealistically high Fs in some years). The relatively small amount of information available for the north stock does not seem to be able to handle the high parameter complexity of Model 1.18. The simpler Model 1.6, which considers only 2 time blocks instead of annually-varying selectivity, was instead used for the north stock. Model 1.18 was used for the south stock.

Assumed fishery mean weight-at-age assumed for all models are shown in Figure A8.5. The model numbers-at-age estimates are given in Table A8.27. The fishery age and length composition fits are shown in Figures A8.6, A8.7, A8.8, and A8.9. The age composition data from the surveys are given in Figures A8.10 and A8.11. This model fit the indices reasonably well (Figure A8.12). Fits to the index and fishery mean age compositions are shown in Figures A8.13 and A8.14.

Selectivity estimates for the fishery and indices is shown over time in Figures A8.15. A summary of the time series stock status (spawning biomass, F, recruitment, total biomass) for the single-stock hypothesis is shown in Figure A8.16 and for the two-stock hypothesis in Figure A8.17. As in past years, the biomass can be projected forward based on the estimated recruits (with an adjustment due to the change in spawning biomass through the stock recruitment relationship) to evaluate the impact of fishing. This can be informative to distinguish environmental effects relative to direct fishing impacts. For jack mackerel fishing has appeared to be a major cause of the population trend with the current level at below 35% of what is estimated to have occurred had there been no fishing (Figure A8.18).

Fishing mortality rates at age (combined fleets) were relatively high starting in about 1992 but has declined in the past few years (Table A8.28). To evaluate the potential for alternative "regimes", stock recruitment curves were estimated over different periods and found that within the current period (2001-2013) the level of expected recruitment was considerably lower than the alternatives.

Management advice

New data and indicators on the status of jack mackerel suggest that conditions evaluated in detail from the last benchmark assessment (completed in 2016) are relatively unchanged. The population trend is estimated to be increasing. The indications of stock improvement (higher abundance observed in the acoustic survey in the northern part of Chile, survival of age 4 fish in 2015 to age 5 fish in 2016, better catch rates apparent in some fisheries) drive the increase.

Historical fishing mortality rates and patterns relative to the provisional biomass target are shown in Figure 1 (Section 10 above). Projections carried out in 2016 indicated that that if fishing mortality is maintained at or below intended 2016 levels and under the assumption of recent average recruitment at the levels estimated for the recent period (2000–2014), the likelihood of future spawning biomass increases. This led to recommended catches for 2017 in the order of 493 kt or lower (Table A4.30 of SC02). Fishing effort in the next 10 years at or below current (2016) levels were projected to have a reasonably good probability of increased spawning biomass from the 2016 level of about 4.1 million t with projected increase to 5.2 million t in 2017.

In summary, the 2016 update assessment has resulted in an upward revision in SSB relative to the 2015 estimates due to updated data presented (Table A8.29; Figure A8.19). Environmental conditions (e.g., strong El Nino that developed in 2015) likely affects jack mackerel distribution and thus age-specific vulnerability to surveys and fisheries. This may have affected the Chilean northern acoustic survey and those conducted in Peruvian waters.

Relative to the rebuilding analysis, the conclusions from SC02 benchmark assessment continues to apply and the recommendation satisfies the rebuilding plan specified by the Commission. The time series of key model estimates are presented in Table A8.30.

Assessment issues

Based on the results of the 2016 assessment workshop, as noted previously, assessment plans for 2017 should be developed several months prior to SC05 so that data coordinators can configure alternatives and conduct a careful evaluation of all available information to best guide the commission. One of the higher priority items for consideration continues to be the catch-at-age estimates (based on age-determinations being conducted from different labs) and mean body weights at age assumed in the model.

The issue of evaluating sensitivities to the early fishery age composition data was raised. The SC noted that this might be a fruitful avenue for investigation in subsequent assessments, particularly since these data (pre-1990) are less well documented.

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Tables

Table A8.1. Sources and values of catch (t) complied for the four fleets used for the assessment (2016 is preliminary)

	Fleet 1	Fleet 2	Fleet 3 (Far North)						Fleet 4 (Offshore Trawl)												
Year	Chile	Chile	Cook Islands	Cuba	Ecuador	Peru	USSR	Total	Belize	China	Cuba	European Union	Faroe Islands	Japan	Korea	Peru	Russian Federatio	Ukraine	Vanuatu	Total	Grand total
1970	101685	10309				4711		4711												0	116705
1971	143454	14988				9189		9189												0	167631
1972	64457	22546				18782		18782									5500			5500	111285
1973	83204	38391				42781		42781												0	164376
1974	164762	28750				129211		129211												0	322723
1975	207327	53878				37899		37899												0	299104
1976	257698	84571				54154		54154						35						35	396458
1977	226234	114572				504992		504992						2273						2273	848071
1978	398414	188267				386793	0	386793						1667	403		49220			51290	1024764
1979	344051	253460		6281		151591	175938	333810			12719	1180		120			356271			370290	1301611
1980	288809	273453		38841		123380	252078	414299			45130	1780					292892			339802	1316363
1981	474817	586092		35783		37875	371981	445638			38444			29			399649			438123	1944670
1982	789912	704771		9589		50013	84122	143724			74292	7136					651776			733204	2371611
1983	301934	563338		2096		76825	31769	110690			52779	39943		1694			799884			894300	1870262
1984	727000	699301		560		184333	15781	200674			33448	80129		3871			942479			1059927	2686902
1985	511150	945839		1067		87466	26089	114622			31191			5229			762903			799323	2370934
1986	55210	1129107		66		49863	1100	51029			46767			6835			783900			837502	2072848
1987	313310	1456727		0		46304	0	46304			35980			8815			818628			863423	2679764
1988	325462	1812793		5676		118076	120476	244229			38533			6871			817812			863215	3245699
1989	338600	2051517		3386	35108	140720	137033	316247			21100			701			854020			875821	3582185
1990	323089	2148786		6904	4144	191139	168636	370823			34293			157			837609			872059	3714757
1991	346245	2674267		1703	45313	136337	30094	213447			29125						514534			543659	3777618
1992	304243	2907817		0	15022	96660	0	111682			3196						32000	2736		37932	3361674
1993	379467	2856777			2673	130681		133354												0	3369598
1994	222254	3819193			36575	196771		233346												0	4274793
1995	230177	4174016			174393	376600		550993												0	4955186
1996	278439	3604887			56782	438736		495518												0	4378844
1997	104198	2812866			30302	649751		680053												0	3597117
1998	30273	1582639			25900	386946		412846												0	2025758
1999	55654	1164035			19072	184679		203751						7						7	1423447
2000	118734	1115565			7121	296579		303700		2318										2318	1540317
2001	248097	1401836			134011	723733		857744		20090										20090	2527767
2002	108727	1410266			604	154219		154823		76261										76261	1750077
2003	143277	1278019			0	217734		217734		94690					2010		7540		53959	158199	1797229
2004	158656	1292943			0	187369		187369		131020					7438		62300		94685	295443	1934411
2005	165626	1264808			0	80663		80663	867	143000		6187			9126		7040		77356	243576	1754673
2006	155256	1224685			0	277568		277568	481	160000		62137			10474		0		129535	362627	2020136
2007	172701	1130083	7		927	254426		255360	12585	140582		123523	38700		10940		0		112501	438831	1996975
2008	167258	728850	0		0	169537		169537	15245	143182		108174	22919		12600		4800		100066	406986	1472631
2009	134022	700905	0		1935	74694		76629	5681	117963		111921	20213	0	13759	13326	9113		79942	371918	1283474
2010	169012	295796	0		4613	17559		22172	2240	63606		67497	11643	0	8183	40516			45908	239593	726573
2011	30825	216470	0		69153	257241		326394	0	32862	8	2248	0	0	9253	674	8229		7617	60891	634580
2012	13256	214204	0		104	187292		187396		13012	0	0	0	0	5492	5346	0		16068	39918	454774
2013	16361	214999	0		3564	77022		80586		8329		10102	0		5267	2670			14809	41177	353123
2014	18219	254295	0		4	74528		74532		21155		20539	0		4078	2557			15324	63652	410698
2015	34886	250327			289	22158		22447		29180		27955	0		5749	0	2606		21227	86717	394377
2016	21069	270411			0	16853		16853		20000		12300			4300				15563	52163	360496

Table A8.2. Input catch (tonnes) by fleet (combined) for the stock assessment model. Note that 2016 data are preliminary.

Year	Fleet 1	Fleet 2	Fleet 3	Fleet 4
1970	101,690	10,310	4,710	0
1971	143,450	14,990	9,190	0
1972	64,460	22,550	18,780	5,500
1973	83,200	38,390	42,780	0
1974	164,760	28,750	129,210	0
1975	207,330	53,880	37,900	0
1976	257,700	84,570	54,150	40
1977	226,230	114,570	504,990	2,270
1978	398,410	188,270	386,790	51,290
1979	344,050	253,460	333,810	370,290
1980	288,810	273,450	414,300	339,800
1981	474,820	586,090	445,640	438,120
1982	789,910	704,770	143,720	733,200
1983	301,930	563,340	110,690	894,300
1984	727,000	699,300	200,670	1,059,930
1985	511,150	945,840	114,620	799,320
1986	55,210	1,129,110	51,030	837,500
1987	313,310	1,456,730	46,300	863,420
1988	325,460	1,812,790	244,230	863,220
1989	338,600	2,051,520	316,250	875,820
1990	323,090	2,148,790	370,820	872,060
1991	346,250	2,674,270	213,450	543,660
1992	304,240	2,907,820	111,680	37,930
1993	379,470	2,856,780	133,350	0
1994	222,250	3,819,190	233,350	0
1995	230,180	4,174,020	550,990	0
1996	278,440	3,604,890	495,520	0
1997	104,200	2,812,870	680,050	0
1998	30,270	1,582,640	412,850	0
1999	55,650	1,164,040	203,750	10
2000	118,730	1,115,570	303,700	2,320
2001	248,100	1,401,840	857,740	20,090
2002	108,730	1,410,270	154,820	76,260
2003	143,280	1,278,020	217,730	158,200
2004	158,660	1,292,940	187,370	295,440
2005	165,630	1,264,810	80,660	243,580
2006	155,260	1,224,690	277,570	362,630
2007	172,701	1,130,083	255,360	438,831
2008	167,258	728,850	169,537	406,986
2009	134,022	700,905	76,629	371,918
2010	169,012	295,796	22,172	239,593
2011	30,825	216,470	326,394	60,891
2012	13,256	214,204	187,396	39,918
2013	16,361	214,999	80,586	41,177
2014	18,219	254,295	74,532	63,289
2015	34,886	250,327	22,447	86,717
2016	21,069	270,411	16,853	52,163

Table A8.3. Input catch at age for fleet 1. Units are relative value (they are normalized to sum to one for each year in the model). Green shading reflects relative level. Note that 2015 data are preliminary.

	Age group (years)											
	1	2	3	4	5	6	7	8	9	10	11	12
1975	0	1	2	8	10	28	29	14	5	1	1	0
1976	0	0	0	2	10	30	37	17	3	1	0	0
1977	0	2	3	7	20	33	25	9	1	0	0	0
1978	0	1	8	15	14	9	25	20	7	1	0	0
1979	0	0	4	9	18	22	23	18	6	1	0	0
1980	0	1	3	6	17	23	27	19	4	0	0	0
1981	0	0	2	9	20	24	29	14	3	0	0	0
1982	0	0	1	14	15	20	27	16	5	1	0	0
1983	0	0	0	7	20	29	27	14	3	0	0	0
1984	0	0	11	28	13	13	17	15	3	0	0	0
1985	0	0	4	17	27	29	17	5	1	0	0	0
1986	4	13	12	7	8	15	22	13	5	1	0	0
1987	0	5	40	41	10	2	2	1	0	0	0	0
1988	0	0	11	41	38	9	0	0	0	0	0	0
1989	0	1	1	6	45	38	8	1	0	0	0	0
1990	1	9	1	3	28	48	10	1	0	0	0	0
1991	0	2	20	20	11	17	24	6	0	1	0	0
1992	0	3	21	12	23	23	13	5	1	0	0	0
1993	0	3	62	25	5	4	1	0	0	0	0	0
1994	0	14	34	10	26	13	2	0	0	0	0	0
1995	0	16	32	28	14	8	2	0	0	0	0	0
1996	8	16	31	34	9	2	0	0	0	0	0	0
1997	0	5	55	36	4	0	0	0	0	0	0	0
1998	0	2	57	24	12	4	0	0	0	0	0	0
1999	0	6	72	17	4	1	0	0	0	0	0	0
2000	7	30	17	30	14	2	0	0	0	0	0	0
2001	0	12	63	23	1	0	0	0	0	0	0	0
2002	6	12	47	21	11	2	1	0	0	0	0	0
2003	1	14	55	22	5	2	1	0	0	0	0	0
2004	0	2	13	59	24	1	0	0	0	0	0	0
2005	4	26	38	16	12	4	0	0	0	0	0	0
2006	2	3	33	52	6	2	1	0	0	0	0	0
2007	0	9	32	44	10	3	2	1	0	0	0	0
2008	1	49	24	8	9	8	1	0	0	0	0	0
2009	0	7	29	51	4	8	0	0	0	0	0	0
2010	0	46	5	32	12	3	1	0	0	0	0	0
2011	6	59	28	3	1	2	0	0	0	0	0	0
2012	4	12	15	61	8	0	0	0	0	0	0	0
2013	4	68	26	1	0	0	0	0	0	0	0	0
2014	6	93	1	0	0	0	0	0	0	0	0	0
2015	11	3	11	49	20	6	1	0	0	0	0	0

Table A8.4. Input catch at age for fleet 2. Units are relative value (they are normalized to sum to one in the model). Green shading reflects relative level. Note that 2015 data are preliminary.

Age group (years)

	1	2	3	4	5	6	7	8	9	10	11	12
1975	0	0	1	2	6	18	28	25	14	5	2	0
1976	0	1	0	0	1	14	36	31	14	2	0	0
1977	0	0	0	3	11	19	35	27	4	0	0	0
1978	0	0	1	6	19	31	26	12	3	0	0	0
1979	0	0	1	13	18	18	18	16	11	4	0	0
1980	0	0	1	9	23	25	22	12	6	1	0	0
1981	0	0	0	4	17	31	28	14	4	1	0	0
1982	0	0	0	3	18	24	26	18	7	2	0	0
1983	0	2	4	7	17	25	26	13	5	1	0	0
1984	0	0	4	8	10	23	27	20	7	1	0	0
1985	0	0	1	8	14	25	31	16	4	0	0	0
1986	0	1	1	5	15	24	33	18	3	0	0	0
1987	0	4	9	8	5	15	32	22	4	1	0	0
1988	0	0	3	21	24	10	17	18	6	1	0	0
1989	0	0	0	4	23	32	19	15	6	1	0	0
1990	0	0	0	1	8	26	33	19	11	2	0	0
1991	0	1	2	2	1	7	28	31	16	8	3	1
1992	0	0	1	4	6	7	8	24	21	18	8	3
1993	0	0	4	12	15	14	13	12	14	12	4	1
1994	0	0	1	11	17	18	11	10	15	12	4	0
1995	0	0	4	18	14	25	18	9	6	4	2	0
1996	0	1	11	14	20	18	16	11	5	2	1	0
1997	0	2	17	31	22	11	6	4	4	2	1	0
1998	0	4	28	35	14	6	3	3	3	1	1	0
1999	0	4	37	34	14	5	2	1	1	1	1	1
2000	0	1	15	40	25	10	3	1	1	1	1	1
2001	0	1	10	26	34	16	5	2	2	2	1	2
2002	0	1	12	26	26	16	6	3	2	2	2	3
2003	0	0	6	25	30	20	8	3	2	2	1	1
2004	0	0	4	14	29	29	13	5	3	2	1	1
2005	1	1	1	5	17	39	19	8	5	2	1	1
2006	0	0	1	4	8	21	27	14	10	7	4	3
2007	0	0	1	13	15	11	15	15	13	9	5	4
2008	1	2	0	1	7	21	19	15	11	9	5	9
2009	0	0	4	9	2	19	22	17	11	7	5	4
2010	0	0	4	29	20	10	10	6	9	7	2	2
2011	0	0	1	16	13	35	10	6	13	5	1	1
2012	0	0	0	7	31	31	18	7	4	1	0	0
2013	0	0	2	18	29	33	14	3	0	0	0	0
2014	0	0	4	17	38	24	14	2	0	0	0	0
2015	0	0	11	40	17	11	10	7	2	1	0	0
2016	0	0	4	28	33	20	7	4	3	1	0	0

Table A8.5. Input catch at age for fleet 4. Units are relative value (they are normalized to sum to one for each year in the model). Green shading reflects relative level. Catch-at-age 1979-2013 were calculated considering Age-Length Key from fleet 2. Note that 2015 data are preliminary.

	Age group (years)											
	1	2	3	4	5	6	7	8	9	10	11	12
1979	0	0	0	0	4	13	25	30	19	8	1	0
1980	0	1	1	5	16	24	26	17	9	2	0	0
1981	0	0	0	2	10	24	31	22	8	2	0	0
1982	0	0	0	1	7	20	31	26	11	3	1	1
1983	0	2	4	3	10	23	30	18	7	1	0	0
1984	0	0	2	7	11	19	26	23	9	1	0	0
1985	0	0	1	10	17	25	28	14	5	1	0	0
1986	0	1	2	7	20	25	26	15	3	0	0	0
1987	0	4	5	3	8	24	33	18	4	1	0	0
1988	0	1	4	15	16	16	24	17	6	1	0	0
1989	0	0	1	5	22	27	21	15	8	2	0	0
1990	0	0	0	1	10	33	28	15	10	3	0	0
1991	0	0	0	1	2	16	40	23	10	5	2	1
2000	0	3	18	27	17	11	7	6	5	4	2	0
2001	0	2	15	30	30	14	4	2	2	1	0	0
2002	1	2	20	42	21	9	3	1	1	0	0	0
2003	0	1	18	48	25	7	1	0	0	0	0	0
2006	0	0	0	1	13	37	29	10	5	3	1	0
2007	0	0	0	1	7	22	23	16	15	10	6	0
2008	0	0	0	0	1	11	30	26	16	10	6	0
2009	0	0	1	1	0	2	15	35	25	14	9	0
2010	0	1	29	14	0	0	5	10	19	15	5	0
2011	0	0	1	9	8	17	11	10	24	14	6	0
2012	0	0	0	0	0	0	2	4	50	27	8	8
2013	0	0	1	18	21	25	17	8	3	4	1	1
2014	0	2	28	21	14	14	12	5	2	1	1	1
2015	0	0	10	19	14	15	16	14	5	3	2	2

Table A8.6. Input catch at length for fleet 3. Units are relative value (they are normalized to sum to one for each year in the model). Green shading represents the relative level.

Total length (cm)

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1980	1	2	2	2	3	2	5	3	2	1	0	0	0	1	1	1	0	0	1	3	3	5	8	12	11	9	7	5	3	2	1	1	1	1	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	9	11	9	10	10	9	8	7	6	4	3	3	2	2	2	1	0	0	0	0	0	0
1982	0	0	1	3	6	6	6	5	4	5	6	4	1	0	0	0	0	0	0	1	1	4	8	12	9	6	3	2	2	2	1	1	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	7	15	18	15	13	7	5	3	2	1	1	1	1	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	6	8	8	8	11	11	10	8	6	4	3	2	1	1	1	1	1	0	1	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	7	7	8	8	7	7	7	7	6	5	3	3	2	2	2	1	2	1	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	2	4	7	10	13	12	12	8	6	5	3	3	2	2	2	1	1	1	0
1987	0	0	0	0	0	0	0	1	0	0	1	1	1	2	2	4	5	8	11	12	10	8	5	3	2	3	4	4	3	2	2	2	1	1	1	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	7	9	10	9	7	5	4	3	3	3	3	3	2	2	2	3	3	2	3	3	2	2	1	1	0
1989	0	0	0	0	0	0	0	0	0	0	0	1	7	10	5	6	4	3	2	2	2	3	4	6	8	8	8	6	4	3	1	1	1	1	1	1	1	1	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	5	6	7	9	12	13	10	8	6	4	3	3	2	1	1	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	1	1	1	2	2	3	4	5	5	7	8	8	8	7	6	4	3	3	2	2	2	2	1	1	1
1992	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	1	1	1	1	2	3	4	7	9	12	11	8	6	6	5	5	4	3	2	1	1	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	1	2	2	3	4	6	9	12	9	7	6	5	5	6	5	5	5	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	3	3	5	11	14	11	8	6	4	3	3	3	3	2	3	2	2	2	1	1	1	1	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	4	5	6	7	8	9	11	12	10	6	3	2	2	1	1	1	1	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	1	2	2	2	3	5	6	6	6	6	7	9	8	6	6	5	4	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	7	11	10	5	4	8	14	16	8	4	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	1	2	4	3	2	4	7	16	20	14	8	4	3	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	1	1	1	1	1	1	1	2	3	5	7	12	13	16	15	8	5	3	2	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	4	8	7	5	4	4	10	8	7	8	12	11	7	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	1	2	1	1	2	4	7	10	12	16	16	14	9	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	1	3	9	16	19	19	14	7	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	1	1	2	5	7	8	6	5	6	9	10	7	5	4	3	4	5	5	3	2	1	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	6	7	9	12	13	11	8	8	7	5	3	2	1	0	0	0	0	0	0	0	0
2005	0	0	1	1	1	0	0	1	3	6	8	8	10	10	6	3	1	1	1	1	1	0	0	0	0	0	0	0	2	5	9	9	5	3	2	1	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	2	3	6	8	7	8	8	8	7	8	8	8	7	5	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	8	5	6	4	3	6	10	12	11	8	6	3	1	1	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	10	18	21	17	10	6	3	2	1	2	1	1	0	0	0	0	0	0	0	0	0
2009	1	1	1	1	0	0	0	0	0	0	1	4	4	4	2	2	1	0	1	1	0	0	0	0	0	1	2	5	11	19	20	11	5	1	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	2	0	2	25	49	18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	18	23	24	18	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	15	32	27	14	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2	2	4	4	11	8	5	2	0	1	1	1	3	12	20	15	4	1	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	5	20	31	19	8	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	1	1	3	10	13	12	14	14	9	5	4	4	3	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	10	8	6	6	7	7	7	6	7	6	6	5	4	3	2	1	0	0	0	0	0	0	0	0	0

Table A8.7. Input catch at age for acoustic surveys at southern of Chile. Units are relative value (they are normalized to sum to one for each year in the model). Green shading reflects relative level.

Age group (years)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1997	0	1	39	42	12	3	1	1	1	0	0	0
1998	0	1	48	44	4	1	1	1	1	0	0	0
1999	0	2	29	43	11	6	2	1	3	2	1	0
2000	0	0	10	45	31	11	2	0	0	0	0	0
2001	0	1	21	46	23	6	1	1	1	0	0	0
2002	0	0	6	28	23	30	7	4	1	0	0	0
2003	0	0	3	23	34	26	7	2	2	1	1	0
2004	0	0	1	7	18	23	17	11	9	9	3	1
2005	0	0	0	9	21	42	18	5	2	0	1	1
2006	0	0	0	0	18	43	27	5	3	2	1	1
2007	0	0	0	0	0	7	21	20	19	17	8	8
2008	0	0	0	0	0	10	33	27	12	9	4	5
2009	0	0	0	0	0	0	1	33	21	18	16	12

Table A8.8. Input catch at age for acoustic surveys at northern of Chile. Units are relative value (they are normalized to sum to one for each year in the model). Green shading reflects relative level.

Age group (years)												
	1	2	3	4	5	6	7	8	9	10	11	12
2006	12	42	28	16	2	0	0	0	0	0	0	0
2007	0	5	17	55	21	1	0	0	0	0	0	0
2008	0	49	48	1	1	0	0	0	0	0	0	0
2009	0	41	42	16	0	1	0	0	0	0	0	0
2010	0	0	7	71	17	3	1	0	0	0	0	0
2011	0	27	12	50	4	5	1	0	0	0	0	0
2012	0	43	5	17	25	9	1	0	0	0	0	0
2013	11	35	2	17	16	15	4	1	0	0	0	0
2014	30	66	1	1	0	1	1	0	0	0	0	0
2015	62	10	5	15	4	2	1	0	0	0	0	0
2016	80	5	8	6	1	0	0	0	0	0	0	0

Table A8.9. Input catch at age for DEPM surveys at southern of Chile. Units are relative value (they are normalized to sum to one for each year in the model). Green shading reflects relative level.

Age group (years)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
2001	15	36	37	6	3	2	2	1	0	0	0	0
2003	2	15	24	10	16	11	12	6	2	1	0	0
2004	2	15	35	19	9	5	7	5	2	1	0	0
2005	0	0	1	38	24	16	11	5	3	2	0	0
2006	0	0	4	20	31	24	14	5	2	1	0	0
2008	0	0	4	12	22	27	20	9	5	0	0	0

Table A8.10. Index values used within the assessment model.

Year	Chile (1)	Chile (2)	Chile (3)	Chile (4)	Peru(1)	Peru(2)	Peru(3)	China	EU_U	Russia /USSR
1983			1.908							
1984		99	1.904							
1985		324	1.698			94				
1986		123	1.418		17811	108				
1987		213	1.698		22955	110				55
1988		134	1.503		9459	114				58.2
1989			1.476		15034	157				51.1
1990			1.262		14139	230				52.6
1991		242	1.423		16486	232				61
1992			1.327		6266	180				
1993			1.202		19659	146				
1994			1.319		10768	95				
1995			1.187		6429	54				
1996			1.189		7271	30				
1997	3530		0.992		2561	32				
1998	3200		0.854		190	44				
1999	4100		0.874	5724	342	53				
2000	5600		0.863	4688	2373	106				
2001	5950		1.031	5627	2052	132		1.462		
2002	3700		0.905		248	97	80	2.049		
2003	2640		0.797	1388	1118	67	176	1.857	81.3	
2004	2640		0.876	3287	864	52	167	1.498	105.8	
2005	4110		0.802	1043	1025	75	127	1.517	110.7	
2006	3192	112	0.876	3283	1678	111	152	1.056	140.6	
2007	3140	275	0.662	626	522	80	224	1.143	182.7	
2008	487	259	0.462	1935	223	24	187	0.911	156.6	77.4
2009	328	18	0.388		849		132	0.857	139.7	59.6
2010		440	0.299			7	81	0.604	87.5	
2011		432	0.167		678	35	232	0.347	38.1	45.2
2012		230	0.526		94	50	247	0.407	36.4	
2013		144	0.464		890	65	83	0.557	57.7	
2014		87	0.356				83	0.521	65.1	
2015		459	0.293					1.024	104.1	
2016		512	0.547						85.8	

Legend:
Chile (1): Acoustics for south-central zone in Chile
Chile (2): Acoustics for northern zone in Chile
Chile (3): Chilean south-central fishery CPUE for fleet 1
Chile (4): Daily Egg Production Method
Peru(1): Peruvian acoustic index in fleet 3
Peru(2): Peruvian echo-abundance index in fleet 3 (alternative)
Peru(3): Peruvian fishery CPUE in fleet 3
China: Chinese CPUE for fleet 4
EU_U: CPUE for EU in fleet 4
Rus./USSR: Catch per day from Russian/USSR in fleet 4

Table A8.11. Jack mackerel sexual maturity by age used in the JJM models.

Age (yr)	1	2	3	4	5	6	7	8	9	10	11	12
Single Stock	0.070	0.310	0.720	0.930	0.980	0.990	1.000	1.000	1.000	1.000	1.000	1.000
Far North Stock	0.000	0.370	0.980	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A8.12. Growth parameters and natural mortality.

Parameter	Far North stock	Single stock
L_∞ (cm) (Total length)	80 .4	74.4
k	0.16	0.16
L_0 (cm)	18.0	18.0
M ($year^{-1}$)	0.33	0.23

L_o is the mean length at the recruitment age (1 yrs).

Table A8.13. Ageing error matrix of jack mackerel.

	1	2	3	4	5	6	7	8	9	10	11	12+
1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.76	0.22	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.24	0.51	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.02	0.23	0.50	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.02	0.23	0.49	0.23	0.02	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.03	0.23	0.48	0.23	0.03	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.03	0.24	0.46	0.24	0.03	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.03	0.24	0.45	0.24	0.03	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.24	0.44	0.24	0.04	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.24	0.43	0.24	0.04
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.24	0.42	0.29
12+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.24	0.71

Table A8.14. Input mean body mass (kg) at age over time assumed for fleet 1.

	1	2	3	4	5	6	7	8	9	10	11	12
1970	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1971	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1972	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1973	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1974	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1975	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1976	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1977	0.050	0.089	0.129	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
1978	0.050	0.105	0.124	0.163	0.204	0.314	0.369	0.405	0.434	0.453	0.590	1.115
1979	0.050	0.108	0.163	0.179	0.217	0.274	0.370	0.420	0.474	0.629	0.633	1.115
1980	0.050	0.069	0.118	0.210	0.256	0.324	0.410	0.451	0.511	0.998	0.880	1.115
1981	0.050	0.094	0.139	0.214	0.269	0.331	0.412	0.481	0.580	0.661	1.112	1.115
1982	0.071	0.093	0.168	0.202	0.248	0.305	0.356	0.411	0.446	0.471	0.719	1.115
1983	0.084	0.099	0.119	0.221	0.264	0.314	0.377	0.429	0.475	0.528	0.540	1.115
1984	0.050	0.164	0.186	0.217	0.273	0.345	0.394	0.437	0.497	0.568	0.786	1.115
1985	0.050	0.167	0.173	0.224	0.271	0.340	0.401	0.465	0.536	0.582	0.726	1.115
1986	0.096	0.099	0.143	0.222	0.289	0.332	0.418	0.497	0.550	0.869	0.880	1.115
1987	0.092	0.121	0.146	0.189	0.233	0.336	0.427	0.477	0.513	0.650	0.803	1.115
1988	0.050	0.110	0.167	0.197	0.230	0.298	0.472	0.545	0.586	0.610	0.880	1.115
1989	0.050	0.123	0.167	0.230	0.270	0.310	0.379	0.491	0.541	0.569	0.713	1.115
1990	0.069	0.099	0.160	0.248	0.290	0.338	0.409	0.533	0.651	0.677	0.756	1.115
1991	0.049	0.121	0.143	0.201	0.277	0.366	0.408	0.478	0.637	0.720	0.794	0.883
1992	0.069	0.092	0.127	0.201	0.268	0.300	0.373	0.444	0.512	0.595	0.681	0.786
1993	0.021	0.116	0.152	0.205	0.298	0.364	0.422	0.489	0.528	0.596	0.774	0.889
1994	0.059	0.097	0.107	0.235	0.291	0.330	0.387	0.459	0.565	0.748	0.798	0.898
1995	0.069	0.101	0.137	0.186	0.263	0.321	0.357	0.434	0.561	0.668	0.880	1.115
1996	0.067	0.000	0.140	0.170	0.229	0.295	0.367	0.507	0.657	0.639	0.880	1.115
1997	0.029	0.063	0.125	0.177	0.246	0.357	0.503	0.615	0.584	0.728	0.880	1.115
1998	0.000	0.082	0.104	0.195	0.249	0.290	0.390	0.475	0.634	0.728	0.880	1.115
1999	0.071	0.074	0.089	0.147	0.270	0.315	0.446	0.722	0.584	0.728	0.880	1.115
2000	0.043	0.054	0.138	0.191	0.225	0.251	0.372	0.488	0.584	0.728	0.880	1.115
2001	0.066	0.093	0.112	0.133	0.204	0.286	0.421	0.488	0.584	0.728	0.880	1.115
2002	0.029	0.059	0.092	0.172	0.238	0.327	0.398	0.416	0.628	0.728	0.880	1.115
2003	0.036	0.082	0.102	0.141	0.227	0.309	0.416	0.464	0.534	0.728	0.880	1.115
2004	0.037	0.078	0.164	0.186	0.203	0.257	0.342	0.488	0.584	0.728	0.880	1.115
2005	0.029	0.076	0.111	0.175	0.222	0.268	0.281	0.488	0.584	0.728	0.880	1.115
2006	0.032	0.074	0.114	0.132	0.204	0.374	0.442	0.506	0.606	0.728	0.880	1.115
2007	0.087	0.075	0.122	0.158	0.222	0.296	0.404	0.514	0.614	0.723	0.723	1.115
2008	0.042	0.047	0.066	0.187	0.243	0.291	0.388	0.563	0.616	0.748	0.880	1.115
2009	0.015	0.047	0.106	0.138	0.239	0.285	0.335	0.526	0.584	0.728	0.880	1.115
2010	0.013	0.048	0.101	0.172	0.233	0.301	0.397	0.493	0.639	0.772	0.880	1.115
2011	0.019	0.065	0.095	0.167	0.276	0.314	0.398	0.488	0.584	0.728	0.880	1.115
2012	0.016	0.048	0.088	0.202	0.235	0.269	0.396	0.488	0.584	0.728	0.880	1.115
2013	0.038	0.052	0.069	0.151	0.255	0.430	0.495	0.664	0.525	0.687	0.821	1.086
2014	0.018	0.040	0.082	0.189	0.248	0.313	0.396	0.488	0.584	0.728	0.880	1.115
2015	0.027	0.058	0.177	0.183	0.298	0.442	0.621	0.520	0.583	0.729	0.868	1.109
2016	0.027	0.058	0.177	0.183	0.298	0.442	0.621	0.520	0.583	0.729	0.868	1.109

Table A8.15. Input mean body mass (kg) at age over time assumed for fleet 2.

	1	2	3	4	5	6	7	8	9	10	11	12
1970	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1971	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1972	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1973	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1974	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1975	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1976	0.052	0.078	0.155	0.214	0.275	0.336	0.394	0.472	0.632	0.714	0.898	1.538
1977	0.055	0.092	0.109	0.236	0.275	0.314	0.375	0.456	0.521	0.732	0.651	1.137
1978	0.052	0.084	0.104	0.147	0.211	0.327	0.394	0.449	0.514	0.583	0.631	1.538
1979	0.052	0.108	0.160	0.199	0.241	0.301	0.388	0.466	0.588	0.871	1.265	1.972
1980	0.026	0.060	0.132	0.231	0.272	0.350	0.447	0.519	0.716	0.820	1.073	1.854
1981	0.052	0.095	0.149	0.242	0.294	0.340	0.407	0.503	0.637	0.765	1.184	1.900
1982	0.055	0.085	0.166	0.207	0.269	0.323	0.378	0.472	0.536	0.644	0.987	1.185
1983	0.070	0.099	0.122	0.230	0.273	0.320	0.374	0.461	0.596	0.709	1.196	1.769
1984	0.035	0.135	0.154	0.185	0.266	0.330	0.383	0.449	0.577	0.685	1.012	1.846
1985	0.058	0.148	0.181	0.223	0.270	0.339	0.398	0.473	0.573	0.796	1.376	1.647
1986	0.073	0.075	0.172	0.247	0.286	0.346	0.427	0.518	0.640	0.844	1.351	2.110
1987	0.076	0.117	0.140	0.191	0.270	0.357	0.434	0.503	0.577	0.689	1.089	1.979
1988	0.100	0.124	0.159	0.197	0.233	0.342	0.444	0.512	0.588	0.750	1.012	1.372
1989	0.052	0.103	0.220	0.241	0.278	0.339	0.467	0.585	0.702	0.779	0.880	1.538
1990	0.064	0.091	0.153	0.264	0.309	0.373	0.461	0.582	0.694	0.835	0.970	1.598
1991	0.037	0.106	0.132	0.186	0.271	0.381	0.451	0.542	0.667	0.787	0.901	1.053
1992	0.063	0.083	0.118	0.177	0.239	0.275	0.409	0.524	0.594	0.709	0.851	1.046
1993	0.011	0.089	0.121	0.181	0.246	0.320	0.408	0.579	0.719	0.853	0.965	1.174
1994	0.041	0.084	0.112	0.224	0.270	0.336	0.462	0.643	0.808	0.868	1.058	1.421
1995	0.070	0.098	0.145	0.192	0.270	0.340	0.429	0.577	0.807	0.965	1.115	1.367
1996	0.061	0.092	0.151	0.191	0.280	0.352	0.524	0.683	0.945	1.216	1.426	1.477
1997	0.104	0.106	0.146	0.201	0.260	0.355	0.495	0.683	0.884	1.088	1.467	1.647
1998	0.084	0.128	0.138	0.178	0.248	0.340	0.545	0.806	1.035	1.246	1.412	1.655
1999	0.090	0.109	0.134	0.174	0.250	0.331	0.465	0.742	1.021	1.258	1.376	1.776
2000	0.043	0.064	0.163	0.196	0.255	0.346	0.466	0.756	0.999	1.141	1.228	1.563
2001	0.066	0.098	0.122	0.179	0.258	0.325	0.461	0.614	0.828	1.074	1.360	1.671
2002	0.031	0.074	0.130	0.200	0.257	0.329	0.445	0.645	0.883	1.102	1.321	1.649
2003	0.036	0.086	0.117	0.186	0.245	0.307	0.400	0.564	0.768	1.005	1.209	1.537
2004	0.034	0.080	0.158	0.193	0.247	0.307	0.387	0.528	0.700	0.897	1.087	1.541
2005	0.029	0.075	0.113	0.196	0.259	0.318	0.399	0.517	0.641	0.767	0.918	1.296
2006	0.033	0.076	0.116	0.141	0.261	0.350	0.419	0.516	0.631	0.752	0.924	1.263
2007	0.086	0.074	0.121	0.172	0.226	0.331	0.431	0.510	0.621	0.756	0.903	1.177
2008	0.036	0.048	0.069	0.186	0.254	0.312	0.416	0.515	0.605	0.719	0.861	1.148
2009	0.014	0.045	0.109	0.142	0.253	0.330	0.411	0.532	0.625	0.764	0.886	1.144
2010	0.014	0.052	0.101	0.175	0.237	0.313	0.415	0.539	0.649	0.787	0.964	1.473
2011	0.019	0.067	0.101	0.190	0.287	0.353	0.466	0.613	0.774	0.923	1.173	1.514
2012	0.007	0.014	0.082	0.202	0.264	0.353	0.476	0.558	0.711	0.912	1.146	1.600
2013	0.054	0.158	0.251	0.260	0.318	0.385	0.450	0.553	0.705	0.829	1.117	1.977
2014	0.052	0.093	0.182	0.247	0.375	0.485	0.534	0.682	1.094	1.281	1.302	1.656
2015	0.050	0.340	0.358	0.393	0.488	0.713	0.928	1.334	1.041	1.496	1.131	1.265
2016	0.050	0.340	0.192	0.279	0.324	0.348	0.463	0.594	0.829	0.923	1.241	1.738

Table A8.16. Input mean body mass (kg) at age over time assumed for fleet 3.

	1	2	3	4	5	6	7	8	9	10	11	12
1970	0.045	0.171	0.377	0.642	0.945	1.265	1.587	1.900	2.196	2.470	2.721	2.946
1971	0.045	0.171	0.377	0.643	0.946	1.266	1.588	1.902	2.198	2.472	2.723	2.949
1972	0.030	0.130	0.306	0.548	0.835	1.148	1.470	1.789	2.095	2.382	2.647	2.887
1973	0.037	0.147	0.330	0.568	0.842	1.134	1.430	1.718	1.991	2.246	2.478	2.688
1974	0.038	0.147	0.326	0.558	0.825	1.108	1.393	1.671	1.934	2.178	2.402	2.603
1975	0.034	0.136	0.310	0.540	0.808	1.095	1.387	1.674	1.946	2.201	2.434	2.645
1976	0.044	0.160	0.340	0.567	0.822	1.087	1.351	1.606	1.845	2.065	2.266	2.446
1977	0.032	0.130	0.294	0.510	0.760	1.028	1.300	1.566	1.818	2.054	2.270	2.465
1978	0.032	0.129	0.295	0.516	0.774	1.050	1.332	1.608	1.872	2.117	2.343	2.547
1979	0.036	0.138	0.304	0.518	0.762	1.020	1.280	1.532	1.770	1.991	2.193	2.375
1980	0.036	0.136	0.298	0.506	0.743	0.994	1.245	1.490	1.721	1.934	2.130	2.306
1981	0.041	0.148	0.314	0.524	0.758	1.003	1.247	1.481	1.702	1.905	2.089	2.255
1982	0.039	0.144	0.309	0.519	0.755	1.002	1.249	1.488	1.712	1.920	2.108	2.278
1983	0.042	0.138	0.280	0.451	0.638	0.828	1.014	1.191	1.356	1.507	1.643	1.764
1984	0.044	0.156	0.328	0.541	0.778	1.024	1.267	1.501	1.719	1.921	2.103	2.267
1985	0.040	0.149	0.322	0.541	0.789	1.048	1.308	1.558	1.794	2.012	2.211	2.389
1986	0.042	0.151	0.323	0.539	0.781	1.033	1.285	1.527	1.755	1.965	2.156	2.327
1987	0.034	0.132	0.294	0.504	0.745	1.001	1.260	1.512	1.751	1.973	2.176	2.359
1988	0.038	0.145	0.315	0.533	0.780	1.041	1.302	1.554	1.793	2.013	2.215	2.396
1989	0.044	0.158	0.337	0.561	0.812	1.074	1.334	1.585	1.821	2.038	2.236	2.413
1990	0.042	0.150	0.320	0.532	0.769	1.017	1.263	1.499	1.722	1.927	2.113	2.280
1991	0.039	0.142	0.305	0.511	0.743	0.985	1.227	1.461	1.680	1.883	2.068	2.234
1992	0.040	0.148	0.318	0.534	0.776	1.031	1.286	1.531	1.763	1.976	2.171	2.346
1993	0.039	0.147	0.323	0.549	0.807	1.080	1.354	1.620	1.871	2.104	2.317	2.508
1994	0.036	0.147	0.335	0.584	0.874	1.186	1.503	1.813	2.109	2.385	2.638	2.867
1995	0.038	0.146	0.318	0.540	0.792	1.058	1.325	1.583	1.827	2.053	2.260	2.446
1996	0.038	0.145	0.317	0.537	0.788	1.053	1.318	1.576	1.820	2.045	2.251	2.436
1997	0.045	0.152	0.312	0.506	0.720	0.940	1.155	1.361	1.553	1.729	1.889	2.031
1998	0.040	0.140	0.294	0.483	0.693	0.911	1.126	1.333	1.526	1.703	1.864	2.008
1999	0.037	0.146	0.324	0.557	0.824	1.107	1.394	1.673	1.938	2.183	2.408	2.611
2000	0.035	0.145	0.336	0.592	0.893	1.218	1.550	1.877	2.189	2.481	2.750	2.994
2001	0.033	0.139	0.324	0.572	0.864	1.180	1.504	1.822	2.127	2.412	2.674	2.912
2002	0.036	0.145	0.330	0.576	0.861	1.167	1.478	1.783	2.074	2.344	2.593	2.817
2003	0.040	0.154	0.341	0.584	0.862	1.157	1.454	1.743	2.017	2.272	2.504	2.714
2004	0.038	0.149	0.333	0.574	0.852	1.148	1.447	1.740	2.017	2.275	2.511	2.724
2005	0.037	0.150	0.341	0.595	0.890	1.206	1.527	1.842	2.142	2.422	2.678	2.911
2006	0.038	0.152	0.347	0.606	0.907	1.230	1.558	1.880	2.187	2.473	2.735	2.973
2007	0.038	0.149	0.335	0.579	0.861	1.161	1.465	1.762	2.044	2.306	2.546	2.763
2008	0.036	0.146	0.334	0.585	0.876	1.190	1.510	1.823	2.122	2.400	2.656	2.888
2009	0.038	0.150	0.337	0.582	0.865	1.167	1.474	1.773	2.057	2.321	2.563	2.782
2010	0.039	0.150	0.332	0.567	0.837	1.123	1.411	1.691	1.956	2.203	2.428	2.631
2011	0.031	0.143	0.351	0.644	1.000	1.395	1.806	2.217	2.614	2.990	3.337	3.655
2012	0.032	0.145	0.349	0.632	0.971	1.344	1.731	2.115	2.485	2.834	3.156	3.449
2013	0.032	0.145	0.349	0.632	0.971	1.344	1.731	2.115	2.485	2.834	3.156	3.449
2014	0.032	0.145	0.349	0.632	0.971	1.344	1.731	2.115	2.485	2.834	3.156	3.449
2015	0.033	0.146	0.346	0.621	0.950	1.310	1.682	2.051	2.405	2.739	3.047	3.327
2016	0.033	0.146	0.346	0.621	0.950	1.310	1.682	2.051	2.405	2.739	3.047	3.327

Table A8.17. Input mean body mass (kg) at age over time assumed for fleet 4. Weight-at-age 1970-2013 were assumed to be the same as fleet 2

	1	2	3	4	5	6	7	8	9	10	11	12
1970	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1971	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1972	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1973	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1974	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1975	0.052	0.093	0.131	0.178	0.262	0.294	0.340	0.396	0.549	0.738	0.984	1.093
1976	0.052	0.078	0.155	0.214	0.275	0.336	0.394	0.472	0.632	0.714	0.898	1.538
1977	0.055	0.092	0.109	0.236	0.275	0.314	0.375	0.456	0.521	0.732	0.651	1.137
1978	0.052	0.084	0.104	0.147	0.211	0.327	0.394	0.449	0.514	0.583	0.631	1.538
1979	0.052	0.108	0.160	0.199	0.241	0.301	0.388	0.466	0.588	0.871	1.265	1.972
1980	0.026	0.060	0.132	0.231	0.272	0.350	0.447	0.519	0.716	0.820	1.073	1.854
1981	0.052	0.095	0.149	0.242	0.294	0.340	0.407	0.503	0.637	0.765	1.184	1.900
1982	0.055	0.085	0.166	0.207	0.269	0.323	0.378	0.472	0.536	0.644	0.987	1.185
1983	0.070	0.099	0.122	0.230	0.273	0.320	0.374	0.461	0.596	0.709	1.196	1.769
1984	0.035	0.135	0.154	0.185	0.266	0.330	0.383	0.449	0.577	0.685	1.012	1.846
1985	0.058	0.148	0.181	0.223	0.270	0.339	0.398	0.473	0.573	0.796	1.376	1.647
1986	0.073	0.075	0.172	0.247	0.286	0.346	0.427	0.518	0.640	0.844	1.351	2.110
1987	0.076	0.117	0.140	0.191	0.270	0.357	0.434	0.503	0.577	0.689	1.089	1.979
1988	0.100	0.124	0.159	0.197	0.233	0.342	0.444	0.512	0.588	0.750	1.012	1.372
1989	0.052	0.103	0.220	0.241	0.278	0.339	0.467	0.585	0.702	0.779	0.880	1.538
1990	0.064	0.091	0.153	0.264	0.309	0.373	0.461	0.582	0.694	0.835	0.970	1.598
1991	0.037	0.106	0.132	0.186	0.271	0.381	0.451	0.542	0.667	0.787	0.901	1.053
1992	0.063	0.083	0.118	0.177	0.239	0.275	0.409	0.524	0.594	0.709	0.851	1.046
1993	0.011	0.089	0.121	0.181	0.246	0.320	0.408	0.579	0.719	0.853	0.965	1.174
1994	0.041	0.084	0.112	0.224	0.270	0.336	0.462	0.643	0.808	0.868	1.058	1.421
1995	0.070	0.098	0.145	0.192	0.270	0.340	0.429	0.577	0.807	0.965	1.115	1.367
1996	0.061	0.092	0.151	0.191	0.280	0.352	0.524	0.683	0.945	1.216	1.426	1.477
1997	0.104	0.106	0.146	0.201	0.260	0.355	0.495	0.683	0.884	1.088	1.467	1.647
1998	0.084	0.128	0.138	0.178	0.248	0.340	0.545	0.806	1.035	1.246	1.412	1.655
1999	0.090	0.109	0.134	0.174	0.250	0.331	0.465	0.742	1.021	1.258	1.376	1.776
2000	0.043	0.064	0.163	0.196	0.255	0.346	0.466	0.756	0.999	1.141	1.228	1.563
2001	0.066	0.098	0.122	0.179	0.258	0.325	0.461	0.614	0.828	1.074	1.360	1.671
2002	0.031	0.074	0.130	0.200	0.257	0.329	0.445	0.645	0.883	1.102	1.321	1.649
2003	0.036	0.086	0.117	0.186	0.245	0.307	0.400	0.564	0.768	1.005	1.209	1.537
2004	0.034	0.080	0.158	0.193	0.247	0.307	0.387	0.528	0.700	0.897	1.087	1.541
2005	0.029	0.075	0.113	0.196	0.259	0.318	0.399	0.517	0.641	0.767	0.918	1.296
2006	0.033	0.076	0.116	0.141	0.261	0.350	0.419	0.516	0.631	0.752	0.924	1.263
2007	0.086	0.074	0.121	0.172	0.226	0.331	0.431	0.510	0.621	0.756	0.903	1.177
2008	0.036	0.048	0.069	0.186	0.254	0.312	0.416	0.515	0.605	0.719	0.861	1.148
2009	0.014	0.045	0.109	0.142	0.253	0.330	0.411	0.532	0.625	0.764	0.886	1.144
2010	0.014	0.052	0.101	0.175	0.237	0.313	0.415	0.539	0.649	0.787	0.964	1.473
2011	0.019	0.067	0.101	0.190	0.287	0.353	0.466	0.613	0.774	0.923	1.173	1.514
2012	0.007	0.014	0.082	0.202	0.264	0.353	0.476	0.558	0.711	0.912	1.146	1.600
2013	0.052	0.125	0.268	0.263	0.310	0.362	0.431	0.507	0.678	0.726	0.936	1.143
2014	0.052	0.093	0.217	0.266	0.372	0.470	0.603	0.650	0.747	0.753	1.636	1.720
2015	0.050	0.340	0.358	0.393	0.488	0.713	0.928	1.334	1.041	1.496	1.131	1.265
2016	0.050	0.340	0.358	0.393	0.488	0.713	0.928	1.334	1.041	1.496	1.131	1.265

Table A8.18. Years and types of information used in the JJM assessment models.

Fleet	Catch-at-age	Catch-at-length	Landings	CPUE	Acoustic	DEPM
North Chile purse seine	1975-2015	-	1970-2016	-	Index: 1984-1988; 1991; 2006-2015 Age comps: 2006-2015	Index: 1999-2008 Age comps: 2001-2008
South-central Chile purse seine	1975-2016	-	1970-2016	1983-2016	1997-2009 Age comps: 1997-2009	-
FarNorth	-	1980-2016	1970-2016	2002-2009, 2011-2013	1983-2013	-
International trawl off Chile	1979-1991	2007-2015*	1970-2016	China (2001-2015); EU, Korea & Vanuatu (2003-2016); Russian (1987-1991, 2008-09, 2011)	-	-

(*) Are converted to age using age-length keys of central-southern area off Chile

Table A8.19. Symbols and definitions used for model equations.

General Definitions	**Symbol/Value**	**Use in Catch at Age Model**
Year index: i = {1970, …., 2016}	I	
Fleets (f) and surveys (s)	f,s	Identification of information source
Age index: j = { 1,2,…, 12^+}	J	
length index: l = { 10,11,…, 50}	l	
Mean length at age	L_j	
Variation coefficient the length at age	cv	
Mean weight in year t by age j	$W_{t,j}$	
Maximum age beyond which selectivity is constant	$Maxage$	Selectivity parameterization
Instantaneous Natural Mortality	M	Constant over all ages
Proportion females mature at age j	p_j	Definition of spawning biomass
Ageing error matrix	T	
Proportion of length at some age	Γ	Transform from age to length
Sample size for proportion in year i	T_i	Scales multinomial assumption about estimates of proportion at age
Survey catchability coefficient	q^s	Prior distribution = lognormal(μ_q^s , σ_q^2)
Stock-recruitment parameters	R_0	Unfished equilibrium recruitment
	h	Stock-recruitment steepness
	σ_R^2	Recruitment variance
Unfished biomass	φ	Spawning biomass per recruit when there is not fishing
Estimated parameters		
$\phi_i(\#), R_0, h, \varepsilon_i(\#), \mu^f, \mu^s, M, \eta_j^s(\#), \eta_j^f$		

Note that the number of selectivity parameters estimated depends on the model configuration.

Table A8.20. Variables and equations describing implementation of the joint jack mackerel assessment model (JJM).

Eq	Description	Symbol/Constraints	Key Equation(s)
1)	Survey abundance index (s) by year. The symbol Δ^s represents the fraction of the year when the survey occurs.	I_i^s	$I_i^s = q^s \sum_{j=1}^{12} N_{ij} W_{ij} S_j^s e^{-\Delta^s Z_{ij}}$
2)	Catch biomass by fleet (f=1,2,3,4), year(i) and age (j) /length (l)	$\hat{C}_{il}, \hat{C}_{ij}, \hat{Y}_i$	$\hat{C}^f_{i,j}, = N_{i,j} \frac{F^f{}_{i,j}}{Z^f{}_{i,j}} \left(1 - e^{-Z^f{}_{i,j}}\right)$ $\hat{Y}^f{}_i = \sum_{j=1}^{12+} \hat{C}^f_{i,j} w^f_{i,j}$
	(transformation from age to length composition. Fleet 3, FarNorth)		$\hat{C}_{il} = \Gamma \ \hat{C}_{ij}$ $\Gamma_{l,j} = \int_j^{j+1} e^{-\frac{1}{2\sigma_j^2}(l-L_j)^2} dl$ $L_j = L_{00}(1-e^{-k}) + e^{-k} L_{j-1}$ $\sigma_j = cv\, L_j$
3)	Proportion at age j, in year i		$p^f_{ij} = \frac{\hat{C}^f_{ij}}{\sum_j \hat{C}^f_{ij}}$ $\quad p^s_{ij} = \frac{N_{ij} S^s_j e^{-\Delta^s Z_{ij}}}{\sum_j N_{ij} S^s_j e^{-\Delta^s Z_{ij}}}$
	Proportion at length l, in year i		$P_{il} = \frac{C_{il}}{\sum_{l=10}^{50} C_{il}}$
4)	Initial numbers at age	j = 1	$N_{1970,j} = e^{\mu_R + \varepsilon_{1970}}$
5)		1 < j < 11	$N_{1970,j} = e^{\mu_R + \varepsilon_{1971-j}} \prod_{j=1}^{j} e^{-M}$
6)		j = 12+	$N_{1970,12+} = N_{1970,11} e^{-M} (1 - e^{-M})^{-1}$
7)	Subsequent years (i >1970)	j = 1	$N_{i,1} = e^{\mu_R + \varepsilon_i}$
8)		1 < j < 11	$N_{i,j} = N_{i-1,j-1} e^{-Z_{i-1,j-1}}$
9)		j = 12+	$N_{i,12^+} = N_{i-1,11}\, e^{-Z_{i-1,10}} + N_{i-1,12}\, e^{-Z_{i-1,11}}$
10)	Year effect and individuals at age 1 and i = 1958, …, 2016	$\varepsilon_i, \sum_{i=1958}^{2016} \varepsilon_i = 0$	$N_{i,1} = e^{\mu_R + \varepsilon_i}$
11)	Index catchability		$q_i^s = e^{\mu^s}$
	Mean effect	μ^s, μ^f	$s_j^s = e^{\eta_j^s}$ $\quad j \le \text{maxage}$
	Age effect	$\eta^s{}_j, \sum_{j=1958}^{2016} \eta^s{}_j = 0$	$s_j^s = e^{\eta^s_{\text{maxage}}}$ $\quad j > \text{maxage}$
12)	Instantaneous fishing mortality		$F^f_{ij} = e^{\mu^f + \eta^f_j + \phi_i}$
13)	Mean fishing effect	μ^f	
14)	Annual effect of fishing mortality in year i	$\varphi_i, \sum_{i=1970}^{2016} \varphi_i = 0$	

Eq	Description	Symbol/Constraints	Key Equation(s)
15)	age effect of fishing (regularized) In year time variation allowed	$\eta^f{}_j, \sum_{j=1958}^{2016} \eta^f{}_j = 0$	$s_{ij}^f = e^{\eta_j^f}$ $j \le$ maxage $s_{ij}^f = e^{\eta^f_{\text{maxage}}}$ $j >$ maxage
	In years where selectivity is constant over time	$\eta^f_{i,j} = \eta^f_{i-1,j}$	$i \ne$ change year
16)	Natural Mortality	M	fixed
17)	Total mortality		$Z_{ij} = \sum_f F_{ij}^f + M$
17)	Spawning biomass (note spawning taken to occur at mid of November)	B_i	$B_i = \sum_{j=2}^{12} N_{ij} e^{-\frac{10,5}{12} Z_{ij}} W_{ij} p_j$
18)	Recruits (Beverton-Holt form) at age 1.	R_i	$R_i = \frac{\alpha B_t}{\beta + B_i},$ $\alpha = \frac{4hR_0}{5h-1}$ and $\beta = \frac{B_0(1-h)}{5h-1}$ where h=0.8 $B_0 = R_0 \varphi$ $\varphi = \sum_{j=1}^{12} e^{-M(j-1)} W_j p_j + \frac{e^{-12M} W_{12} p_{12}}{1-e^{-M}}$

Table A8.21. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

	Likelihood /penalty component		Description / notes
19)	Abundance indices	$L_1 = 0.5\sum_s \frac{1}{cv_s^2}\sum_i log\left(\frac{I_i}{\hat{I}_i}\right)^2$	Surveys / CPUE indexes
20)	Prior on smoothness for selectivities	$L_2 = \sum_l \lambda_2^l \sum_{j=1}^{12}\left(\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l\right)^2$	Smoothness (second differencing), Note: *l={s,* or *f}* for survey and fishery selectivity
21)	Prior on recruitment regularity	$L_3 = \lambda_3 \sum_{i=1958}^{2016} \varepsilon^2{}_i$ $\lambda_3 = \frac{0.5}{\sigma_R^2}$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
22)	Catch biomass likelihood	$L_4 = 0.5\sum_f \frac{1}{cv_f^2}\sum_{i=1970}^{2016} log\left(\frac{Y^f{}_i}{\hat{Y}^f{}_i}\right)^2$	Fit to catch biomass in each year
23)	Proportion at age/length likelihood	$L_5 = -\sum_{v,i,j} n^v P_{i,j/l}^v \log(\hat{P}_{i,j/l}^v)$	*v={s, f}* for survey and fishery age composition observations $P_{i,j/l}$ are the catch-at-age/length proportions n effective sample size
24)	Dome-shaped selectivity	$L_6 = \lambda_4 \sum_{j=6}^{12}\left(lnS_{j-1} - lnS_j\right)^2$ $S_{j-1} > S_j$	(relaxed in final phases of estimation)
25)	Fishing mortality regularity	F values constrained between 0 and 5	(relaxed in final phases of estimation)
26)	Recruitment curve fit	$L_7 = \lambda_5 \sum_{j=1970}^{2013} log\left(\frac{N_{i,1}}{\tilde{R}_i}\right)^2$ $\lambda_5 = \frac{0.5}{\sigma_R^2}$	Conditioning on stock-recruitment curve over period 1970-2013.
27)	Priors or assumptions	R_0 non-informative	$\sigma_R = 0.6$
28)	Overall objective function to be minimized	$\dot{L} = \sum_k L_k$	

Table A8.22. Coefficients of variation and sample sizes used in likelihood functions.

Abundance index	cv	Catch biomass likelihood	cv
Acoustic CS- Chile	0.20	N-Chile	0.05
Acoustic N-Chile	0.50	CS- Chile	0.05
CPUE – Chile	0.15	Farnorth	0.05
DEPM – Chile	0.50	Offshore	0.05
Acoustic-Peru	0.20		
CPUE – Peru	0.20		
CPUE- China	0.20		
CPUE-EU	0.20		
CPUE- ex USSR	0.40		
Smoothness for selectivities (indexes)	**λ**	**Proportion at age likelihood (indexes)**	**n**
Acoustic CS- Chile	100	Acoustic CS- Chile	30
Acoustic N-Chile	100	Acoustic N- Chile	30
CPUE – Chile	100	DEPM – Chile	20
CPUE- China	100		
CPUE-EU	100		
CPUE ex-USSR	100		
Smoothness for selectivities (fleets)	**λ**	**Proportion at age likelihood**	**n**
N-Chile	1	N-Chile	20
CS- Chile	25	CS- Chile	50
Farnorth	12.5	Farnorth	30
Offshore	12.5	Offshore	30
Recruitment regularity	**λ**	**S-Recruitment curve fit**	**cv**
	1.4		0.6

Table A8.23. Description of JJM model components and how selectivity was treated (Far North Stock).

Item	Description	Selectivity assumption
Fisheries		
1)	Peruvian and Ecuadorian area fishery	Estimated from length composition data (converted to age inside the model). Step change in 2002
Index series		
2)	Acoustic survey in Peru	Assumed to be the same as in fishery 1)
3)	Peruvian fishery CPUE	Assumed to be the same as in fishery 1)

Table A8.24. Description of JJM model components and how selectivity was treated (South stock).

Item	Description	Selectivity assumption
Fisheries		
1)	Chilean northern area fishery	Estimated from age composition data. Annual variations were considered since 1984
2)	Chilean central and southern area fishery	Estimated from age composition data. Annual variations were considered since 1984.
3)	Offshore trawl fishery	Estimated from age composition data. Annual variations were considered since 1980.
Index series		
4)	Acoustic survey in central and southern Chile	Estimated from age composition data. Two time-blocks were considered 1970-2004; 2005-2009.
5)	Acoustic survey in northern Chile	Estimated from age composition data. Annual variations were considered since 1984.
6)	Central and southern fishery CPUE	Assumed to be the same as 2)
7)	Egg production survey	Estimated from age composition data. Two time-blocks were considered 1970-2002; 2003-2008.
8)	Chinese fleet CPUE (from FAO workshop)	Assumed to be the same as 3)
9)	Vanuatu & EU fleets CPUE	Assumed to be the same as 3)
10)	ex-USSR CPUE	Assumed to be the same as 3)

Table A8.25. Description of JJM model components and how selectivity was treated for the single stock cases.

Item	Description	Selectivity assumption
Fisheries		
1)	Chilean northern area fishery	Estimated from age composition data. Annual variations were considered since 1984
2)	Chilean central and southern area fishery	Estimated from age composition data. Annual variations were considered since 1984.
3)	Peruvian and Ecuadorian area fishery	Estimated from length composition data (converted to age inside the model). Two time-blocks were considered, before and after 2002.
4)	Offshore trawl fishery	Estimated from age composition data. Annual variations were considered since 1984.
Index series		
5)	Acoustic survey in central and southern Chile	Estimated from age composition data. Two time-blocks were considered 1970-2004; 2005-2009.
6)	Acoustic survey in northern Chile	Estimated from age composition data 2006-2016. Selectivity changes were implemented in 2015 and 2016
7)	Central and southern fishery CPUE	Assumed to be the same as 2)
8)	Egg production survey	Estimated from age composition data 2001, 2003-2006, 2008. Two time-blocks were considered around 2003.
9)	Acoustic survey in Peru	Assumed to be the same as 3)
10)	Peruvian fishery CPUE	Assumed to be the same as 3)
11)	Chinese fleet CPUE (from FAO workshop)	Assumed to be the same as 4)
12)	Vanuatu, Korea & EU fleets CPUE	Assumed to be the same as 4)
13)	ex-USSR CPUE	Assumed to be the same as 4)

Table A8.26. Systematic model progression from the 2014 assessment data to the agreed revised datasets for 2015. Note that the data file names corresponding to each model follow the convention e.g., “Mod0.1.dat” and “Mod0.1.ctl”.

Model	Description
Models 0.x	**Data introductions...**
mod0.0	Exact 2015 model and data set through 2015
mod0.1	Extended to 2016...with revised catches through 2015 and provisional 2016 catch estimates
mod0.2	As 0.1 but with new Chinese CPUE index
mod0.3	As 0.2 but with new Peruvian CPUE index
mod0.4	As 0.3 but with updated Chilean CPUE index
mod0.5	As 0.4 but with 2012 q changed to 2000 on Chilean CPUE index
mod0.6	As 0.5 but with alternative Chilean CPUE index
mod0.7	As 0.5 but with new Offshore nominal CPUE index
mod0.8	As 0.7 but with age composition from all updated
mod0.9	As 0.8 but with selectivity in acoustic N
mod0.10	As 0.9 but with age-error turned off
mod0.11	As 0.10 but with EU only LF for 2015
mod0.12	As 0.10 but echo-abundance in Far North as an alternative, uses backscatter directly
mod0.13	As 0.12 but Updated Acoustic survey data in N Chile including 2016 biomass estimate
Models 1.x	**Configuration sensitivities...**
mod1.0	As 0.13
mod1.1	As 1.0 nominal CPUE removed
mod1.2	As 1.0 discontinued surveys dropped
mod1.3	As 1.0 Use CV according to data workshop
mod1.4	As 1.0 CV according to posteriors
mod1.5	As 1.0 Selectivity in time blocks as Cristian paper
mod1.6	As 1.0 Selectivity in time blocks as in SC02
mod1.7	As 1.0 Downweight catch-age
mod1.8	As 1.0 Rescale sample size using Francis T1.8 method
mod1.9	As 1.13 Profiles over M
mod1.10	As 1.0 M following Lorenzen age-specific
mod1.11	As 1.0 selectivity change in Chile N acoustic in 2015 and 2016
mod1.12	As 1.11 and 1.5
mod1.13	As 1.12 and 1.7
mod1.14	As 1.11 and 1.3
mod1.15	As 1.11 but selectivity change in Chile N acoustics in 2014, 2015, and 2016
mod1.16	As 1.11 but with rescaled Lorenzen curve to have mean of 0.23
mod1.17	As 1.11 but provisional age-error matrix included
mod1.18	As 1.11 but with time-varying selectivity incremented by one year in the fisheries
mod1.19	As 1.18 but provisional age-error matrix included
Models 2.x	**Projection Configuration ... to reflect regime and uncertainty in stock productivity**
mod2.0	As 1.18, steepness=0.80, recruitment from 1970-2013
mod2.1	As 1.18, steepness=0.80, recruitment from 2000-2013
mod2.2	As 1.18, steepness=0.65, recruitment from 1970-2013
mod2.3	As 1.18, steepness=0.65, recruitment from 2000-2013

Table A8.27. Estimated begin-year numbers at age (Model 1.18), 1970-2016. Green shading reflects relative level.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1970	7,933	4,839	3,327	2,346	1,570	1,224	905	800	708	626	551	5,287
1971	8,270	6,302	3,843	2,638	1,857	1,237	953	692	612	554	492	4,584
1972	8,995	6,568	5,003	3,043	2,084	1,455	952	713	517	474	432	3,959
1973	9,690	7,143	5,211	3,954	2,406	1,641	1,133	727	543	403	373	3,450
1974	12,268	7,690	5,659	4,098	3,116	1,886	1,266	851	544	419	316	2,992
1975	17,739	9,714	6,061	4,367	3,192	2,419	1,432	925	621	417	324	2,559
1976	21,694	14,078	7,697	4,767	3,427	2,472	1,815	1,019	656	470	321	2,220
1977	21,625	17,214	11,149	6,043	3,733	2,640	1,832	1,260	705	490	359	1,943
1978	21,504	17,018	13,376	8,171	4,580	2,842	1,944	1,265	862	520	373	1,753
1979	22,219	16,977	13,318	10,058	6,223	3,419	1,978	1,193	761	603	382	1,562
1980	24,309	17,563	13,324	10,121	7,698	4,637	2,334	1,135	642	504	425	1,369
1981	30,352	19,197	13,755	10,047	7,745	5,786	3,245	1,429	668	439	364	1,294
1982	33,349	23,996	15,035	10,344	7,629	5,671	3,790	1,733	712	417	305	1,152
1983	28,311	26,409	18,944	11,669	7,857	5,351	3,288	1,545	618	375	254	886
1984	46,187	22,467	20,897	14,788	9,005	5,733	3,380	1,595	660	339	231	703
1985	55,581	36,637	17,721	16,122	11,096	6,340	3,376	1,362	507	298	174	478
1986	29,153	44,104	28,964	13,810	12,212	7,904	3,860	1,471	479	228	155	340
1987	22,101	23,147	34,951	22,807	10,694	9,061	5,305	1,990	575	218	119	259
1988	26,023	17,538	18,277	27,214	17,336	7,845	6,033	2,676	731	223	96	166
1989	25,669	20,622	13,716	14,074	20,284	12,259	5,189	3,294	1,049	239	75	89
1990	27,928	20,339	16,135	10,520	10,594	14,368	7,893	2,986	1,587	393	76	52
1991	20,307	22,130	15,980	12,345	7,885	7,635	9,512	4,632	1,534	663	125	40
1992	20,539	16,095	17,404	12,264	9,229	5,725	5,155	5,538	2,204	613	195	48
1993	16,573	16,279	12,647	13,306	9,117	6,558	3,819	3,147	2,659	784	137	54
1994	17,918	13,125	12,677	9,348	9,555	6,258	4,239	2,288	1,696	1,106	176	43
1995	22,594	14,182	10,196	9,296	6,403	6,060	3,639	2,279	1,059	533	209	41
1996	25,139	17,809	10,744	6,808	5,367	3,275	2,624	1,447	819	278	88	41
1997	31,336	19,750	13,215	6,856	3,481	2,100	1,149	903	473	229	65	30
1998	27,841	24,563	14,451	8,005	2,790	1,020	621	408	314	139	61	25
1999	31,910	21,856	18,127	9,592	3,996	1,249	469	306	203	144	58	36
2000	31,838	25,186	16,663	12,685	5,803	2,243	704	278	184	116	76	50
2001	21,116	25,030	19,041	12,175	8,189	3,445	1,354	453	182	118	71	77
2002	14,288	16,328	17,564	12,989	7,767	4,549	1,911	822	284	111	68	85
2003	8,146	11,257	12,608	12,968	8,839	4,774	2,700	1,180	514	167	60	82
2004	7,854	6,385	8,516	9,195	8,951	5,619	2,890	1,679	741	295	87	74
2005	5,349	6,161	4,888	6,194	6,347	5,805	3,331	1,732	1,022	406	149	81
2006	7,107	4,195	4,678	3,513	4,312	4,265	3,441	1,967	1,040	564	209	118
2007	6,693	5,544	3,045	3,163	2,313	2,872	2,574	1,865	1,086	529	275	160
2008	6,077	5,232	4,064	1,888	1,902	1,429	1,721	1,380	881	479	220	181
2009	6,643	4,748	3,805	2,599	1,125	1,161	807	918	664	396	200	168
2010	8,099	5,204	3,565	2,627	1,522	638	562	357	358	246	137	127
2011	4,310	6,317	3,760	2,494	1,614	907	362	312	186	152	103	111
2012	8,480	3,381	4,527	2,540	1,782	1,140	572	228	202	110	93	131
2013	11,596	6,708	2,621	3,260	1,879	1,253	733	369	155	135	75	151
2014	11,281	9,184	5,226	1,990	2,426	1,338	847	503	261	108	94	157
2015	16,013	8,934	7,162	3,973	1,480	1,743	950	602	361	181	73	169
2016	27,363	12,691	7,044	5,579	2,993	1,101	1,311	709	444	259	126	168

Table A8.28. Estimated total fishing mortality at age (Model 1.18), 1970-2016. Green shading reflects relative level.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1970	0.000	0.001	0.002	0.004	0.009	0.020	0.039	0.038	0.015	0.012	0.012	0.012
1971	0.000	0.001	0.003	0.006	0.014	0.032	0.061	0.060	0.024	0.018	0.018	0.018
1972	0.001	0.001	0.005	0.005	0.009	0.020	0.040	0.043	0.020	0.011	0.011	0.011
1973	0.001	0.003	0.010	0.008	0.013	0.029	0.056	0.060	0.029	0.015	0.015	0.015
1974	0.003	0.008	0.029	0.020	0.023	0.045	0.085	0.085	0.037	0.027	0.027	0.027
1975	0.001	0.003	0.010	0.012	0.026	0.057	0.111	0.114	0.049	0.032	0.032	0.032
1976	0.001	0.003	0.012	0.015	0.031	0.070	0.135	0.139	0.060	0.038	0.038	0.038
1977	0.010	0.022	0.081	0.047	0.043	0.076	0.141	0.150	0.073	0.042	0.042	0.042
1978	0.006	0.015	0.055	0.042	0.062	0.133	0.259	0.278	0.127	0.078	0.078	0.078
1979	0.005	0.012	0.045	0.037	0.064	0.152	0.325	0.389	0.182	0.121	0.121	0.121
1980	0.006	0.014	0.052	0.038	0.056	0.127	0.261	0.301	0.150	0.096	0.096	0.096
1981	0.005	0.014	0.055	0.045	0.082	0.193	0.398	0.467	0.239	0.134	0.134	0.134
1982	0.003	0.006	0.023	0.045	0.125	0.315	0.668	0.801	0.411	0.268	0.268	0.268
1983	0.001	0.004	0.018	0.029	0.085	0.229	0.493	0.621	0.369	0.253	0.253	0.253
1984	0.002	0.007	0.029	0.057	0.121	0.299	0.679	0.917	0.564	0.440	0.440	0.440
1985	0.001	0.005	0.019	0.048	0.109	0.266	0.601	0.815	0.566	0.421	0.421	0.421
1986	0.001	0.003	0.009	0.026	0.068	0.169	0.432	0.710	0.559	0.419	0.419	0.419
1987	0.001	0.006	0.020	0.044	0.080	0.177	0.454	0.771	0.719	0.594	0.594	0.594
1988	0.003	0.016	0.031	0.064	0.117	0.183	0.375	0.707	0.890	0.853	0.853	0.853
1989	0.003	0.015	0.035	0.054	0.115	0.210	0.322	0.500	0.751	0.918	0.918	0.918
1990	0.003	0.011	0.038	0.058	0.098	0.182	0.303	0.436	0.642	0.920	0.920	0.920
1991	0.002	0.010	0.035	0.061	0.090	0.163	0.311	0.513	0.687	0.996	0.996	0.996
1992	0.002	0.011	0.038	0.066	0.112	0.175	0.263	0.504	0.804	1.267	1.267	1.267
1993	0.003	0.020	0.072	0.101	0.146	0.206	0.282	0.389	0.647	1.265	1.265	1.265
1994	0.004	0.023	0.080	0.148	0.225	0.312	0.391	0.540	0.927	1.438	1.438	1.438
1995	0.008	0.048	0.174	0.319	0.440	0.607	0.692	0.793	1.109	1.571	1.571	1.571
1996	0.011	0.068	0.219	0.441	0.708	0.817	0.837	0.888	1.043	1.217	1.217	1.217
1997	0.014	0.082	0.271	0.669	0.998	0.988	0.805	0.825	0.992	1.102	1.102	1.102
1998	0.012	0.074	0.180	0.465	0.574	0.548	0.477	0.470	0.553	0.642	0.642	0.642
1999	0.007	0.041	0.127	0.273	0.348	0.343	0.293	0.281	0.328	0.407	0.407	0.407
2000	0.011	0.050	0.084	0.208	0.291	0.275	0.212	0.190	0.217	0.262	0.262	0.262
2001	0.027	0.124	0.152	0.219	0.358	0.359	0.269	0.235	0.267	0.323	0.323	0.323
2002	0.008	0.029	0.073	0.155	0.257	0.292	0.252	0.240	0.299	0.389	0.389	0.389
2003	0.014	0.049	0.086	0.141	0.223	0.272	0.245	0.236	0.324	0.428	0.428	0.428
2004	0.013	0.037	0.088	0.141	0.203	0.293	0.282	0.266	0.372	0.457	0.457	0.457
2005	0.013	0.045	0.100	0.132	0.168	0.293	0.297	0.280	0.366	0.433	0.433	0.433
2006	0.018	0.090	0.162	0.188	0.176	0.275	0.383	0.364	0.446	0.486	0.486	0.486
2007	0.016	0.081	0.248	0.278	0.252	0.282	0.394	0.520	0.587	0.645	0.645	0.645
2008	0.017	0.089	0.217	0.288	0.264	0.341	0.399	0.502	0.569	0.642	0.642	0.642
2009	0.014	0.057	0.140	0.305	0.337	0.496	0.585	0.712	0.761	0.832	0.832	0.832
2010	0.018	0.095	0.127	0.257	0.288	0.337	0.358	0.424	0.627	0.639	0.639	0.639
2011	0.013	0.103	0.162	0.106	0.118	0.231	0.230	0.203	0.292	0.263	0.263	0.263
2012	0.004	0.025	0.098	0.071	0.122	0.212	0.208	0.157	0.171	0.160	0.160	0.160
2013	0.003	0.020	0.045	0.066	0.109	0.162	0.146	0.116	0.130	0.136	0.136	0.136
2014	0.003	0.019	0.044	0.066	0.100	0.112	0.111	0.101	0.133	0.164	0.164	0.164
2015	0.002	0.008	0.020	0.053	0.066	0.055	0.063	0.076	0.101	0.133	0.133	0.133
2016	0.001	0.005	0.014	0.042	0.067	0.068	0.066	0.078	0.107	0.144	0.144	0.144

Table A8.29. Spawning biomass of jack mackerel obtained in last four SPRFMO scientific Committee (SC) meetings.

	SC01	SC02	SC03	SC04
1971	8,761	6,629	10,082	9770
1971	8,112	6,303	9,164	8872
1972	7,818	6,105	8,527	8289
1973	7,726	5,958	8,042	7911
1974	7,676	5,861	7,673	7633
1975	7,763	5,852	7,446	7511
1976	8,141	6,039	7,454	7638
1977	8,810	6,558	7,808	8027
1978	9,551	7,124	8,224	8445
1979	10,189	7,590	8,553	8810
1980	10,854	8,256	9,085	9349
1981	11,171	8,505	9,213	9561
1982	10,806	8,110	8,679	9137
1983	11,092	8,494	8,926	9487
1984	11,122	8,629	8,942	9653
1985	11,554	9,338	9,557	10297
1986	13,159	11,352	11,531	11890
1987	14,919	13,281	13,459	13371
1988	15,496	13,714	13,895	13801
1989	15,050	13,080	13,256	13389
1990	14,228	12,204	12,371	12701
1991	13,098	11,029	11,197	11792
1992	11,909	9,854	10,018	10772
1993	10,802	8,939	9,082	9800
1994	9,271	7,516	7,634	8165
1995	7,154	5,445	5,532	5901
1996	5,819	3,817	3,862	4174
1997	4,950	2,986	2,965	3254
1998	4,985	3,152	3,074	3539
1999	5,668	3,928	3,795	4475
2000	6,671	5,008	4,834	5616
2001	7,481	5,883	5,690	6368
2002	8,083	6,692	6,544	7010
2003	8,201	6,947	6,848	7274
2004	7,641	6,560	6,475	6908
2005	6,708	5,760	5,676	6159
2006	5,486	4,679	4,595	5102
2007	4,119	3,428	3,324	3846
2008	3,067	2,543	2,382	2890
2009	2,130	1,849	1,598	2070
2010	1,709	1,648	1,291	1775
2011	1,855	1,865	1,382	1868
2012	2,304	2,126	1,552	2065
2013	3,085	2,402	1,814	2308
2014		2,767	2,222	2667
2015			2,720	3273
2016				4116

Table A8.30. Summary of results for model 1.18. Note that MSY values are a function of time-varying selectivity and average weight.

Year	Landings ('000 t)	SSB ('000 t)	Recruitment (age 1, millions)	Fishing mortality (Mean over ages 1-12)	Fmsy	SSBmsy ('000 t)
1970	117	9770	7933	0.014	0.228	4551
1971	168	8872	8270	0.021	0.230	4480
1972	111	8289	8995	0.015	0.236	4124
1973	164	7911	9690	0.021	0.236	3877
1974	323	7633	12268	0.035	0.206	3953
1975	299	7511	17739	0.040	0.232	4310
1976	396	7638	21694	0.048	0.234	4291
1977	848	8027	21625	0.064	0.182	4138
1978	1025	8445	21504	0.101	0.228	3980
1979	1302	8810	22219	0.131	0.219	4659
1980	1316	9349	24309	0.108	0.214	4504
1981	1945	9561	30352	0.158	0.230	4416
1982	2372	9137	33349	0.267	0.256	4598
1983	1870	9487	28311	0.217	0.207	5608
1984	2687	9653	46187	0.333	0.221	5477
1985	2371	10297	55581	0.308	0.216	5691
1986	2073	11890	29153	0.269	0.176	6907
1987	2680	13371	22101	0.338	0.185	6849
1988	3246	13801	26023	0.412	0.250	6037
1989	3582	13389	25669	0.397	0.278	5836
1990	3715	12701	27928	0.378	0.292	5791
1991	3778	11792	20307	0.405	0.360	5324
1992	3362	10772	20539	0.481	0.315	5998
1993	3370	9800	16573	0.472	0.254	6311
1994	4275	8165	17918	0.580	0.231	6336
1995	4955	5901	22594	0.742	0.199	6001
1996	4379	4174	25139	0.724	0.167	5979
1997	3597	3254	31336	0.746	0.156	5817
1998	2026	3539	27841	0.440	0.146	6009
1999	1423	4475	31910	0.272	0.141	6230
2000	1540	5616	31838	0.194	0.149	5653
2001	2528	6368	21116	0.248	0.144	5646
2002	1750	7010	14288	0.231	0.153	6253
2003	1797	7274	8146	0.239	0.157	6234
2004	1934	6908	7854	0.256	0.168	6024
2005	1755	6159	5349	0.250	0.175	5783
2006	2020	5102	7107	0.297	0.184	5276
2007	1997	3846	6693	0.383	0.193	5104
2008	1473	2890	6077	0.384	0.183	5315
2009	1283	2070	6643	0.492	0.187	5615
2010	727	1775	8099	0.371	0.154	6354
2011	635	1868	4310	0.187	0.180	4815
2012	455	2065	8480	0.129	0.189	4597
2013	353	2308	11596	0.100	0.188	4782
2014	411	2667	11281	0.099	0.179	5368
2015	394	3273	16013	0.070	0.218	4918
2016	360	4116	27363	0.073	0.191	5795

Figures

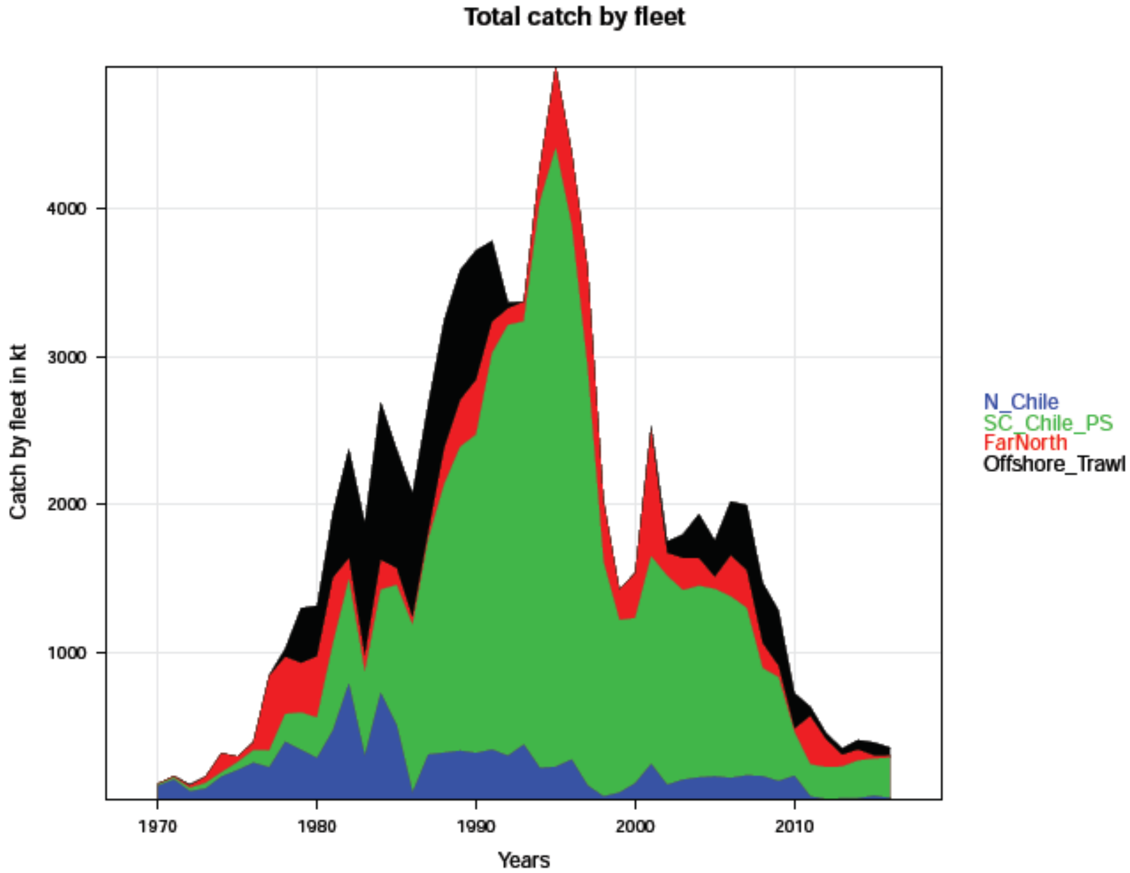

Figure A8.1. Catch of jack mackerel by fleet. Green is the SC Chilean fleet, black is the offshore trawl fleet, red is the far-north fleet, and blue in the northern Chilean fleet.

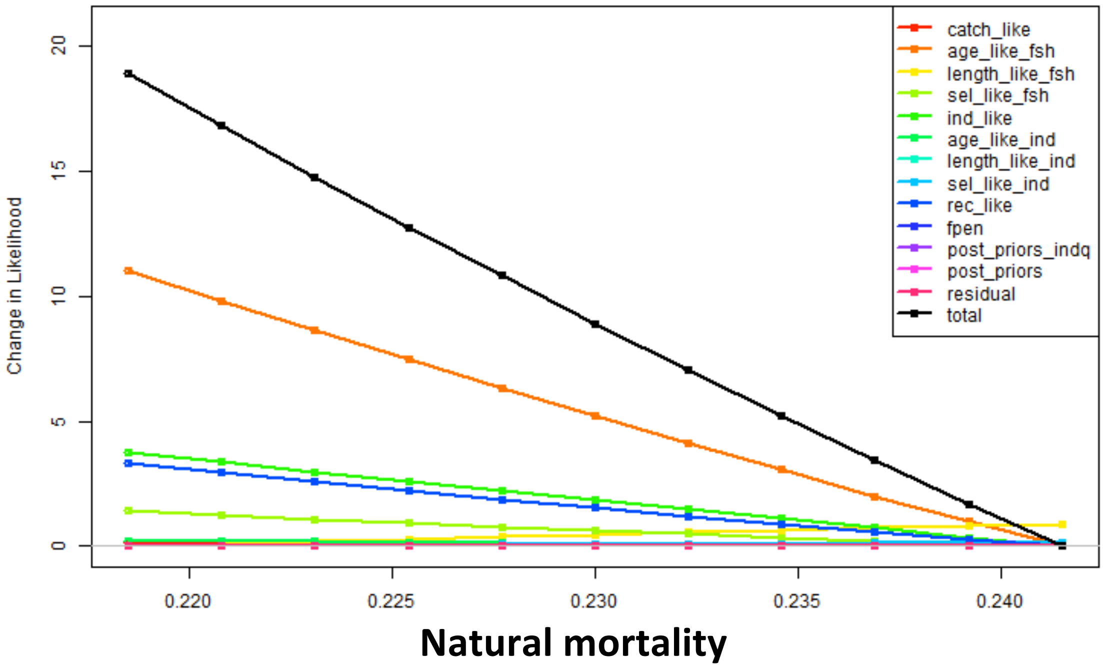

Figure A8.2. Exploratory profile likelihood of alternative fixed values of natural mortality assumed for jack mackerel. The vertical scale is the difference (in log-likelihood units) from the minimum (where the minimum represents the best model fit).

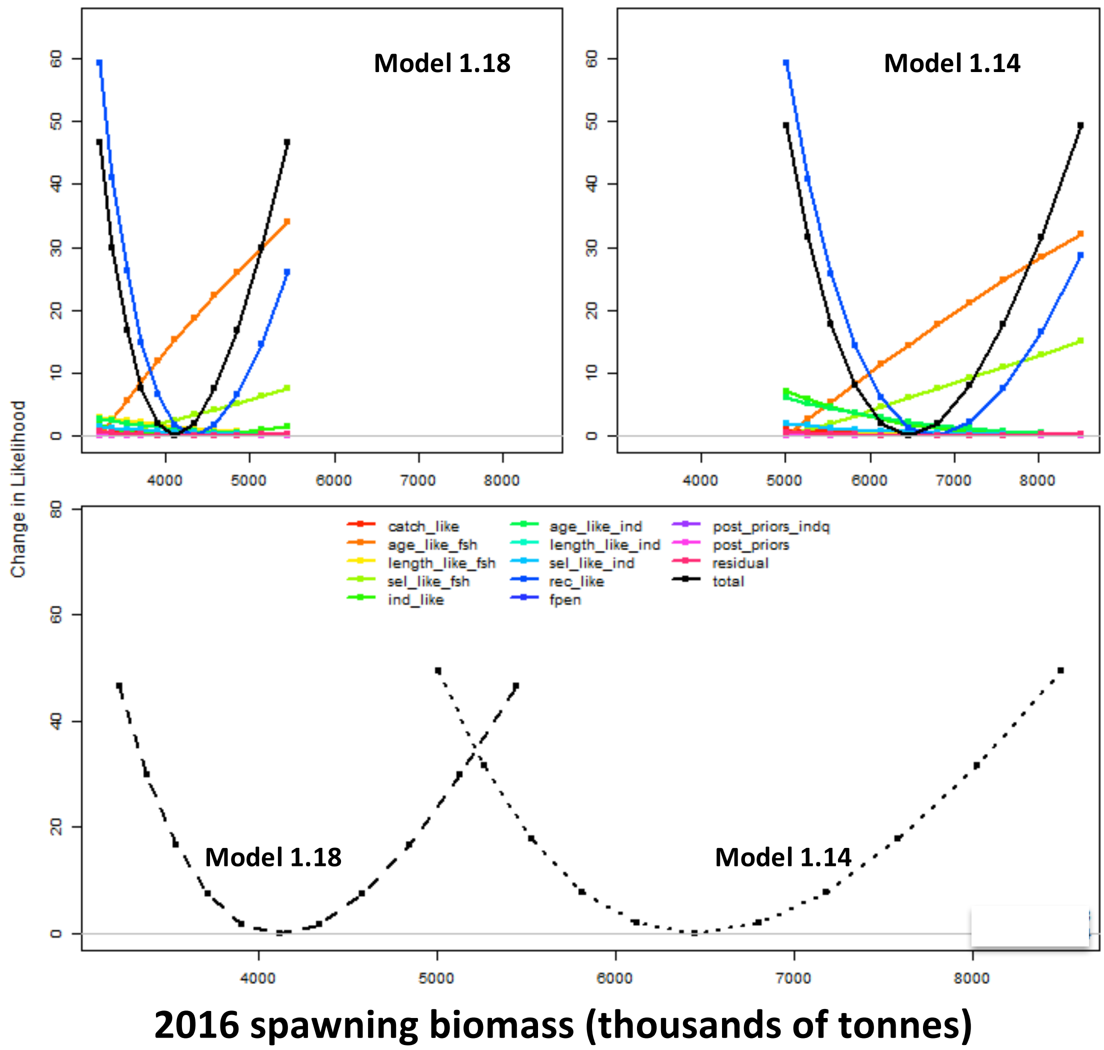

Figure A8.3. Change in likelihood components (top) and totals (bottom) when profiling over fixed mean recruitment values for two model alternatives (1.14 and 1.18). The contrast is manifested in the 2016 spawning biomass (horizontal scale).

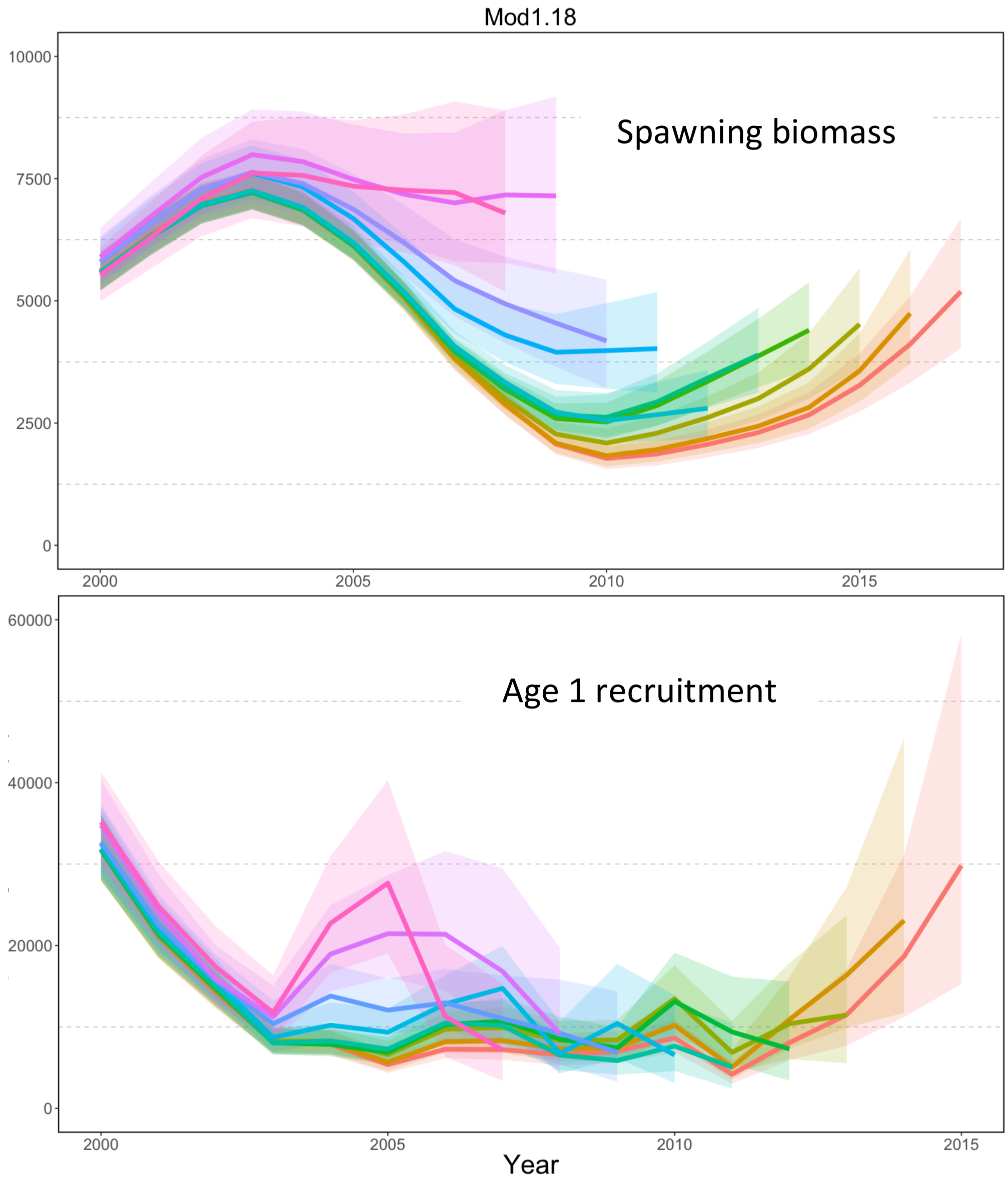

Figure A8.4. Model retrospective of spawning biomass (top) and recruitment (bottom) from 10 separate model runs.

Figure A8.5. Mean weights-at-age (kg) over time used for all data types in the JJM models. Different lines represent ages 1 to 12.

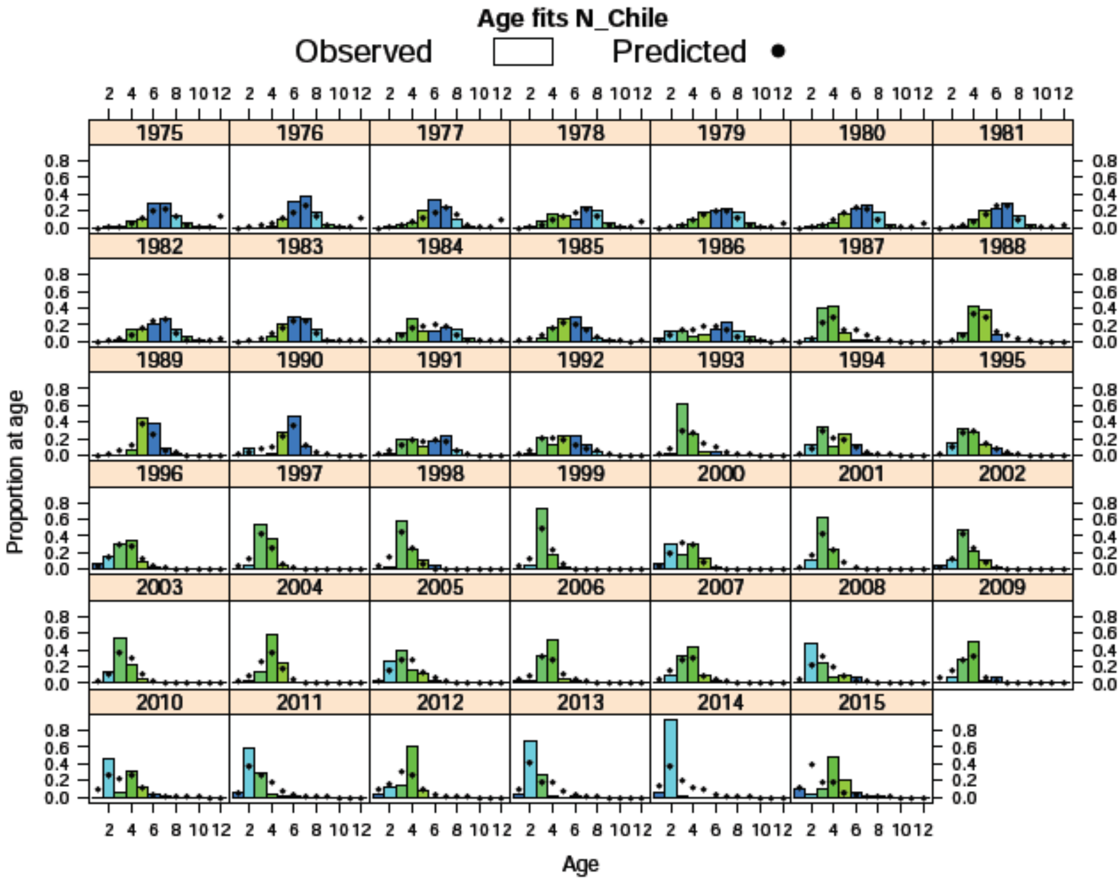

Figure A8.6. Model 1.18 fit to the age compositions for the **Chilean northern zone fishery (Fleet 1)**. Bars represent the observed data and dots represent the model fit and color codes correspond to cohorts.

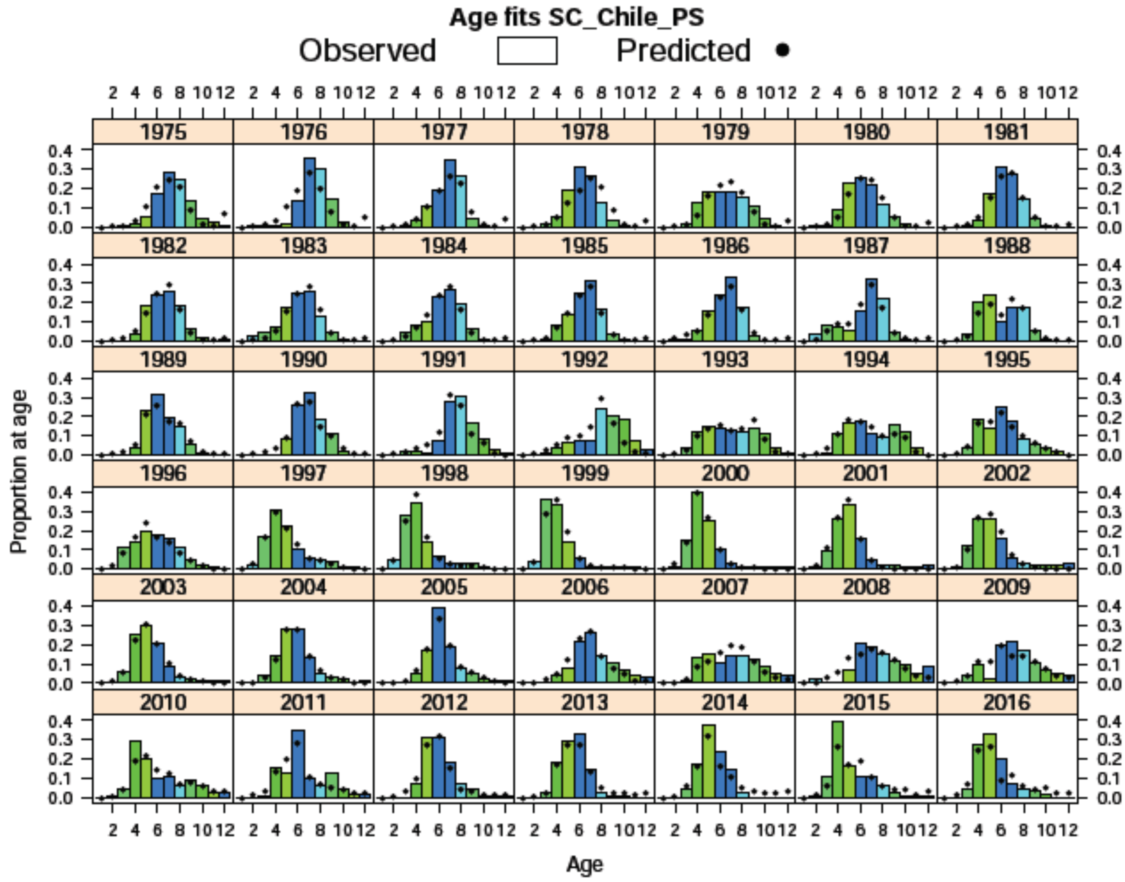

Figure A8.7. Model 1.18 fit to the age compositions for the **South-Central Chilean purse seine** fishery (Fleet 2). Bars represent the observed data and dots represent the model fit and color codes correspond to cohorts.

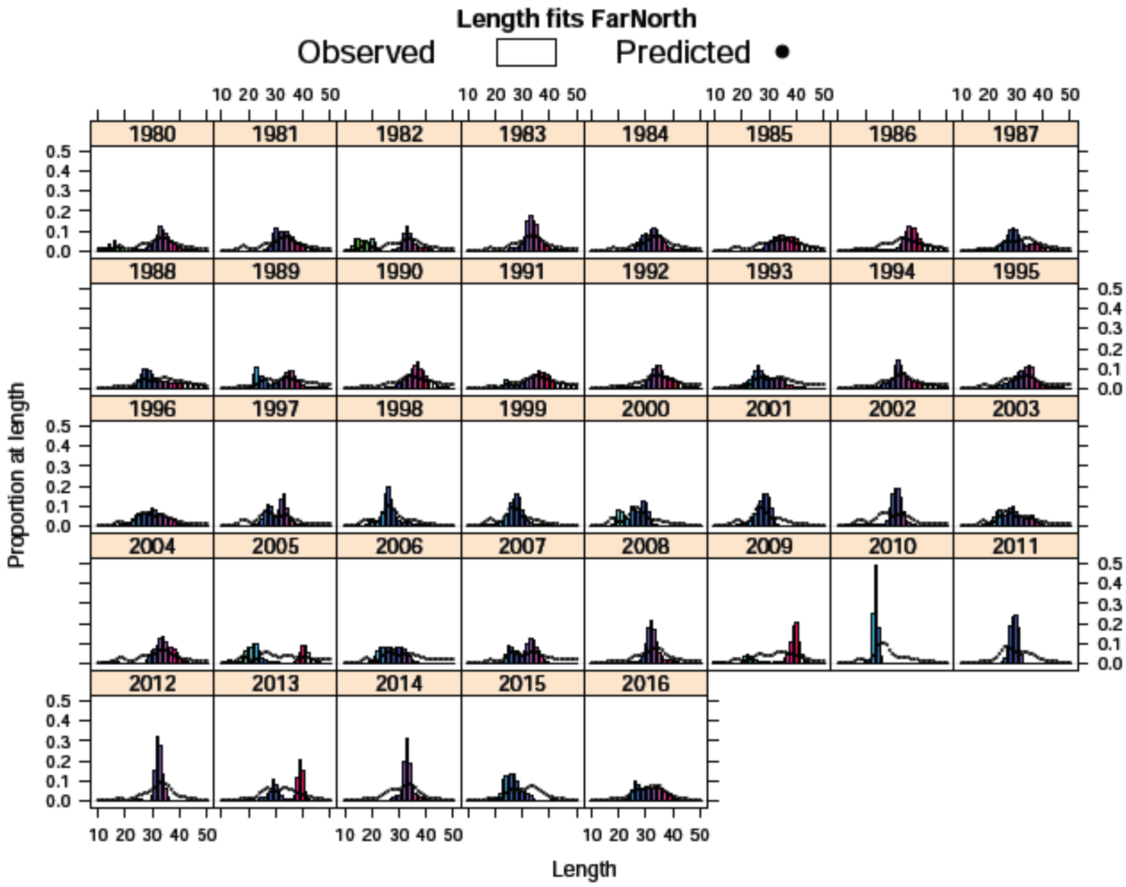

Figure A8.8. Model 1.18 fit to the length compositions for the far north fishery (Fleet 3). Bars represent the observed data and dots represent the model fit and color codes correspond to cohorts.

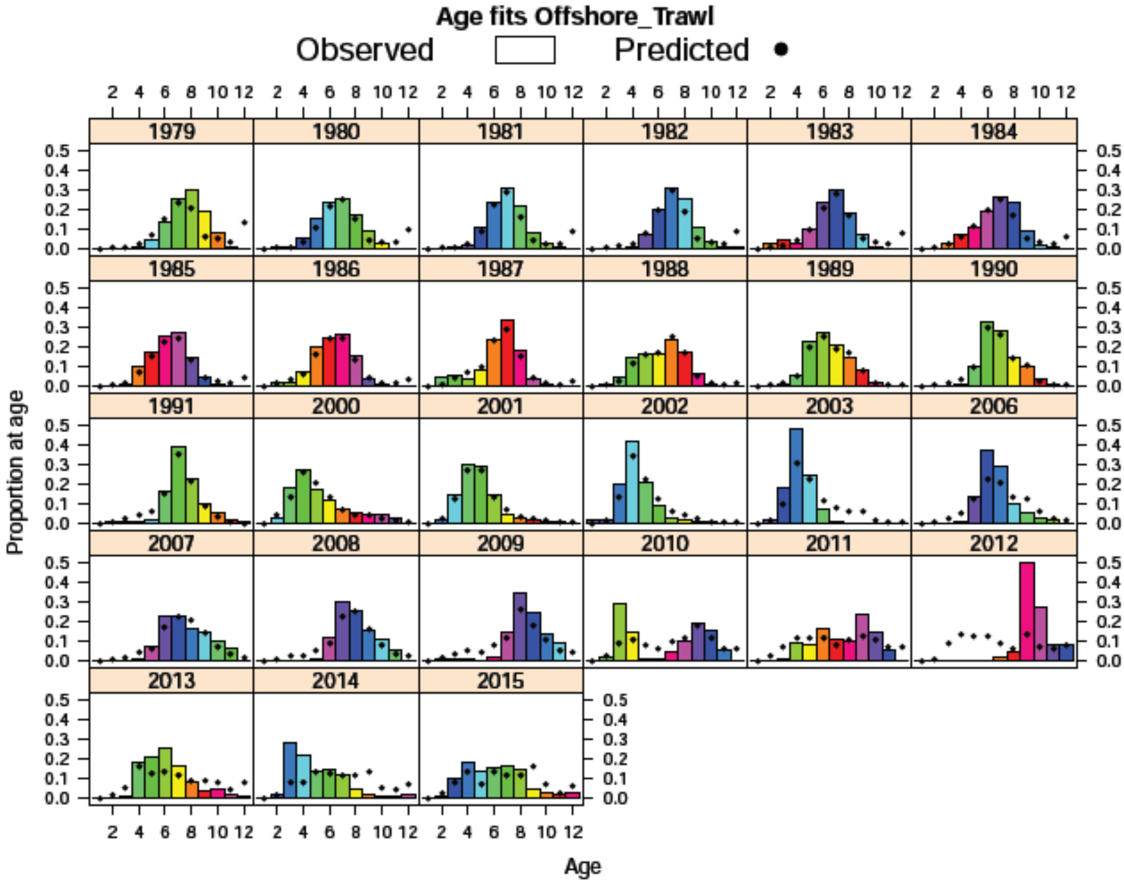

Figure A8.9. Model 1.18 fit to the age compositions for the **offshore trawl** fishery (Fleet 4). Bars represent the observed data and dots represent the model fit and color codes correspond to cohorts.

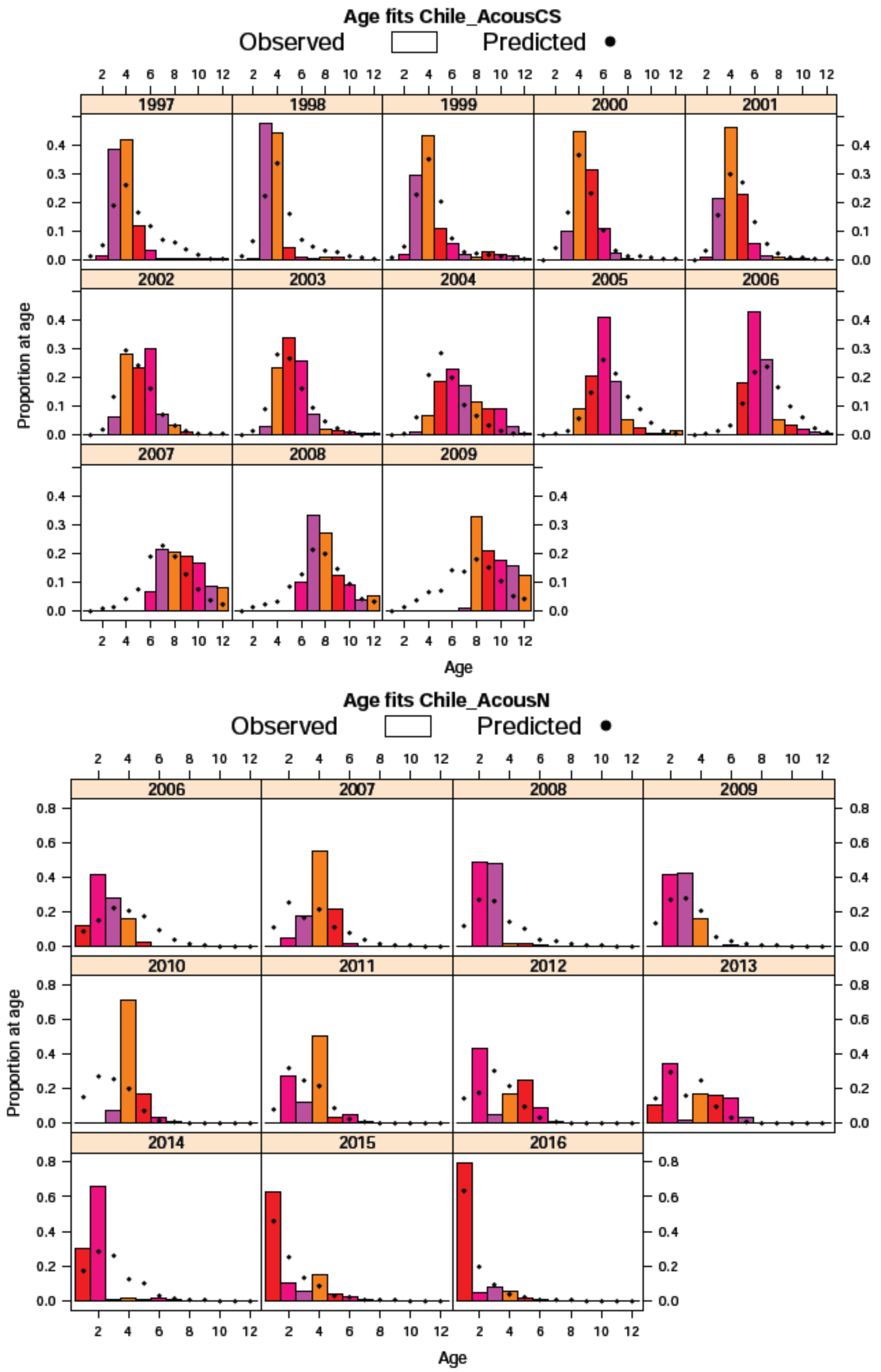

Figure A8.10. Model 1.18 fit to the age compositions for the **S-Central Acoustic survey (top) and N Chilean acoustic survey (bottom)**. Bars represent the observed data and dots represent the model fit and color codes correspond to cohorts.

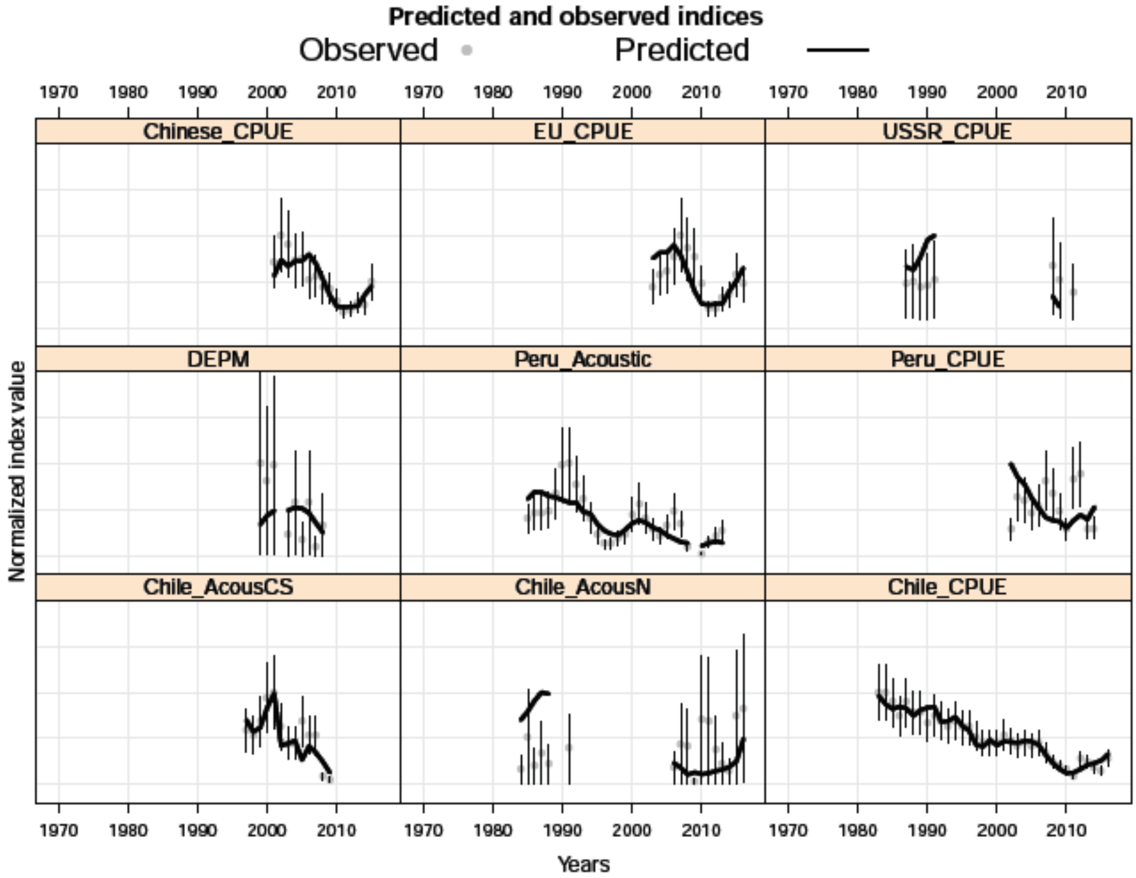

Figure A8.11. Model 1.18 fit to different indices. Vertical bars represent 2 standard deviations around the observations.

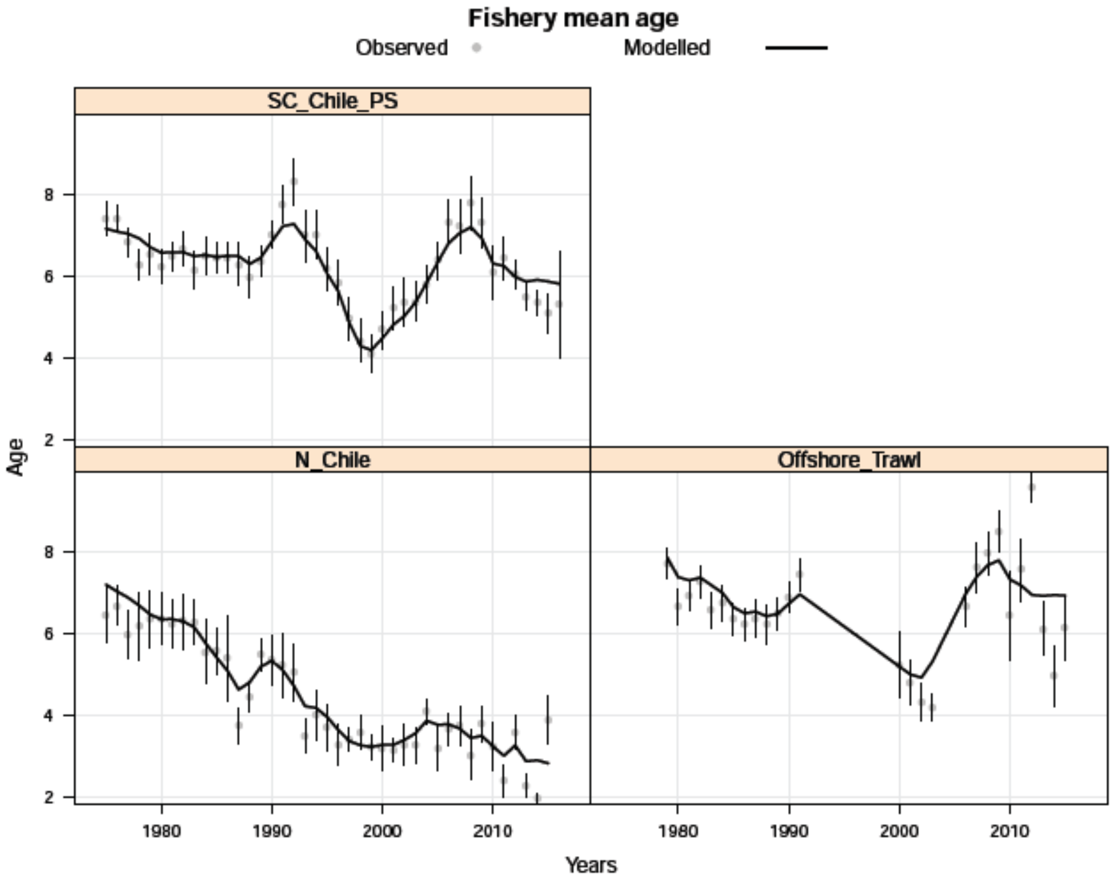

Figure A8.12. Mean age by year and fishery. Line represents the model 1.18 predictions and dots observed values with implied input error bars.

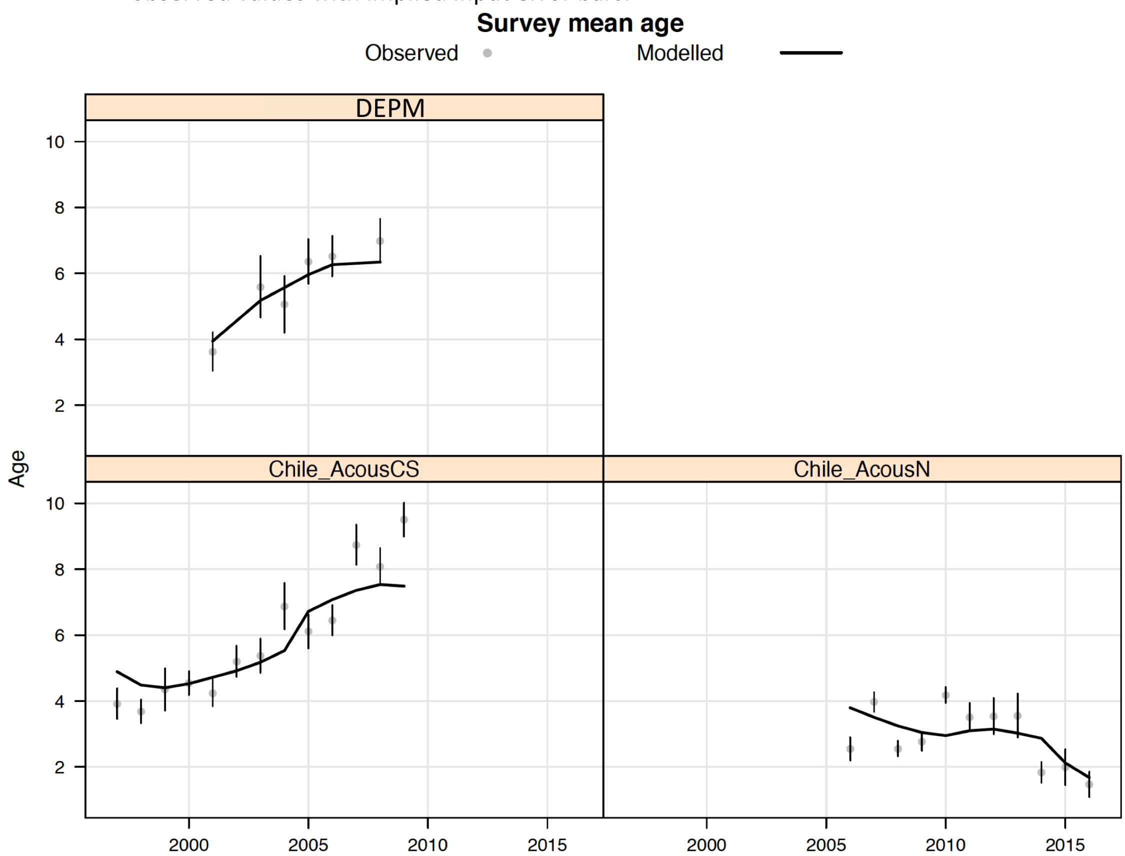

Figure A8.13. Mean age by year and survey. Line represents the model 1.18 predictions and dots observed values with implied input error bars.

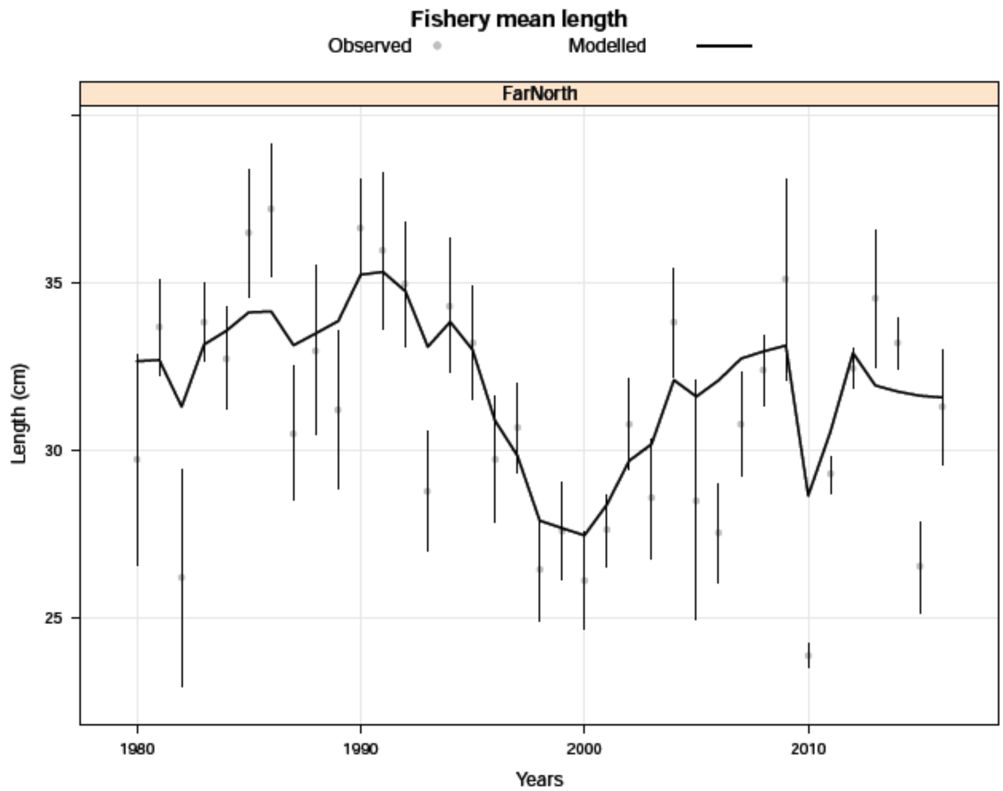

Figure A8.14. Mean length by year in fleet 3 (Far North). Line represents the the model 1.18 predictions and dots observed values with implied input error bars.

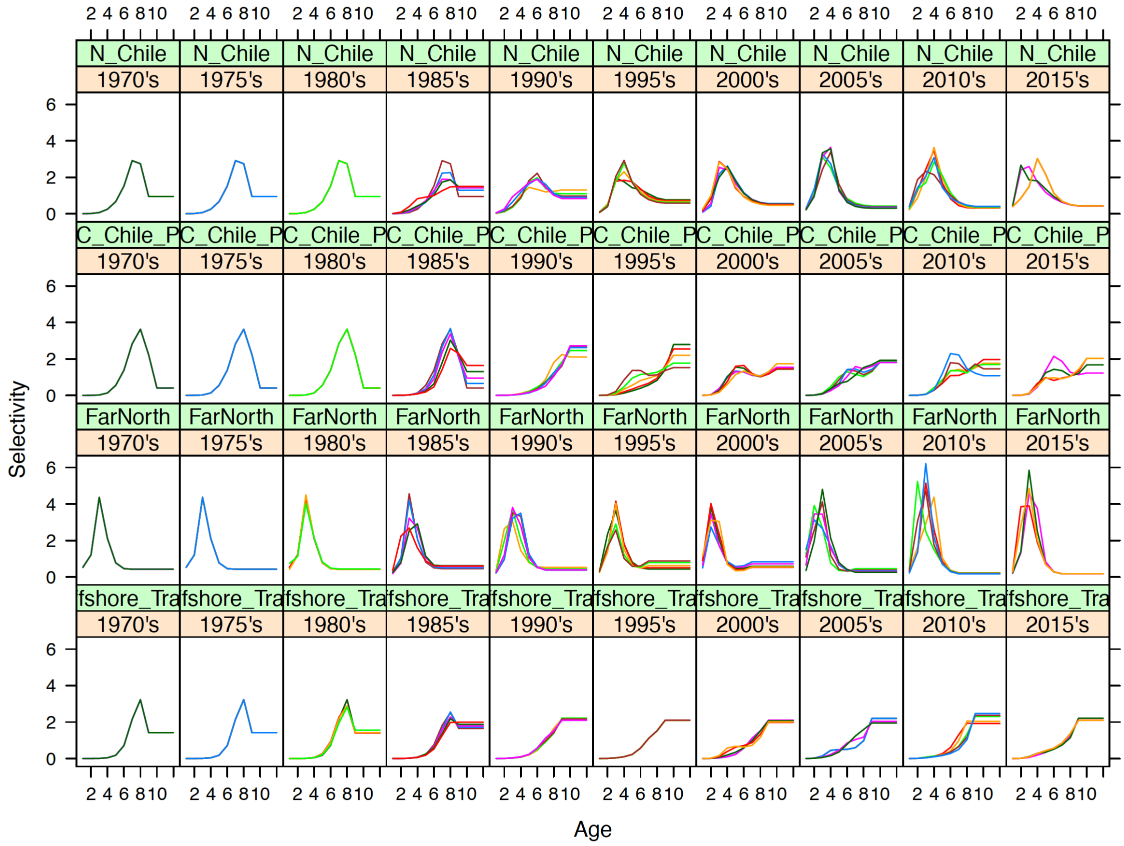

Figure A8.15. Estimates of selectivity by fishery over time for Model 1.18. Each cell represents a 5-year period).

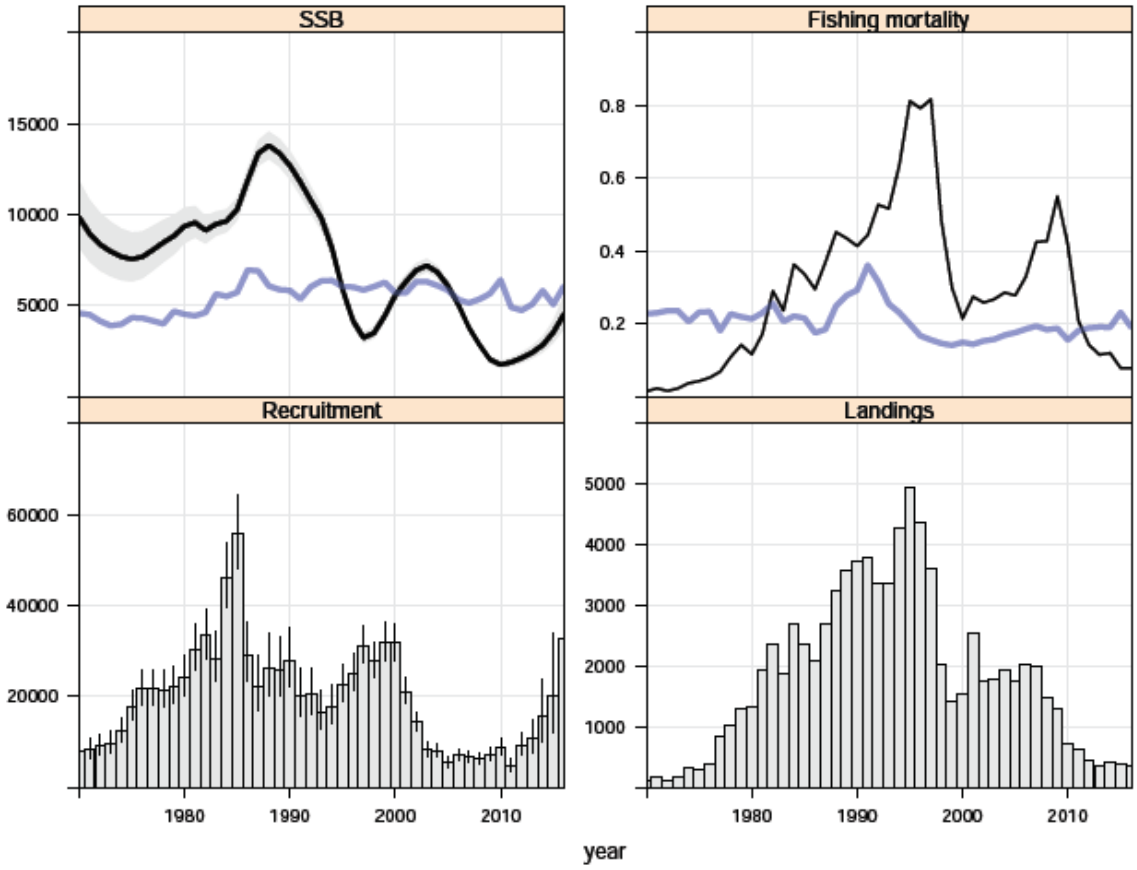

Figure A8.16. Model 1.18—single-stock hypothesis—summary estimates over time showing spawning biomass (kt; top left), recruitment at age 1 (millions; lower left) total fishing mortality (top right) and total catch (kt; bottom right). Blue lines represent dynamic estimates of B_{msy} (upper left) and F_{msy} (upper right).

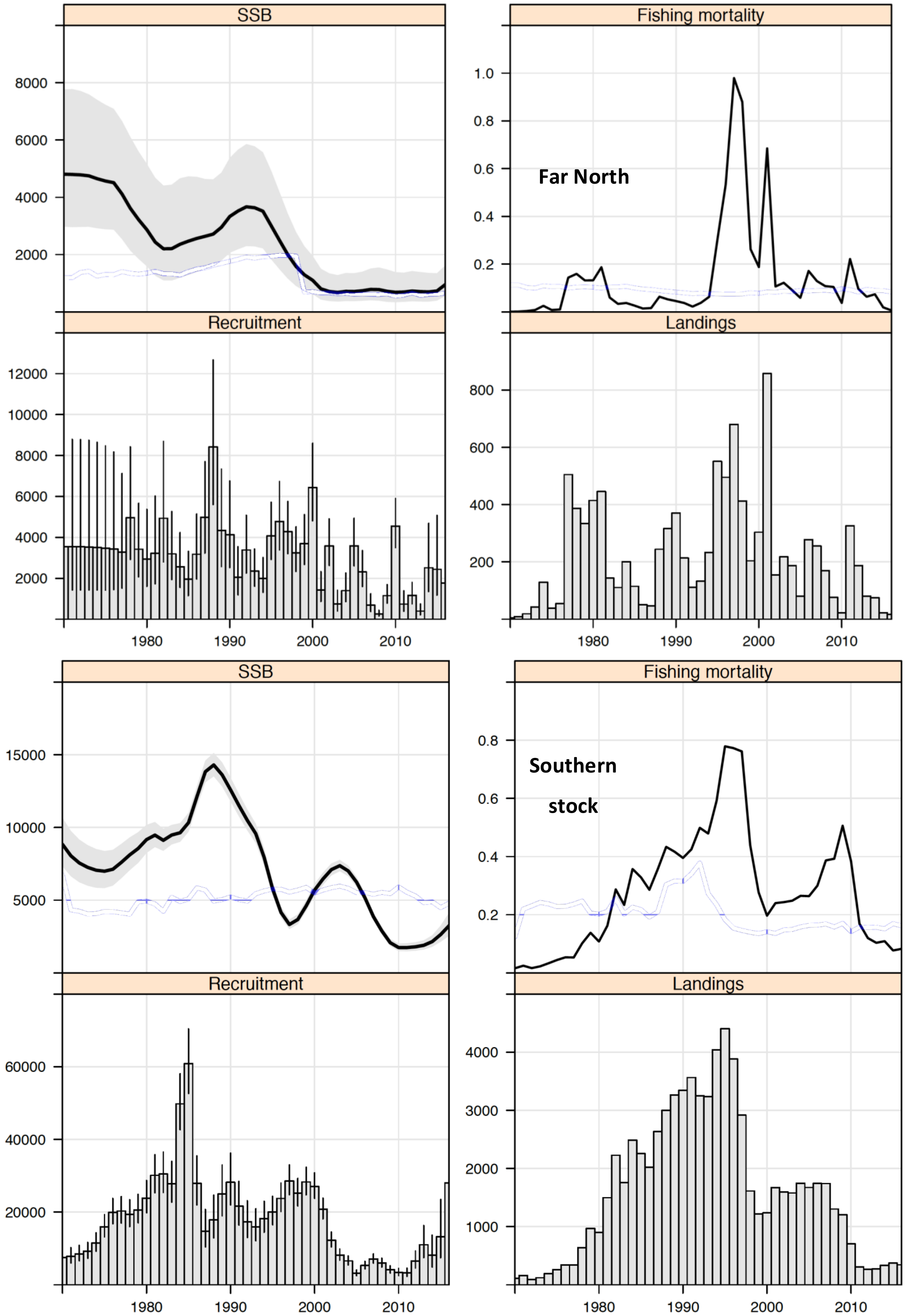

Figure A8.17. Two-stock hypothesis summary estimates over time showing spawning biomass (kt; top left), recruitment at age 1 (millions; lower left) total fishing mortality (top right) and total catch (kt; bottom right) for Models 1.6 (for the "Far North" stock, top set) and 1.18 (for the "Southern" stock.

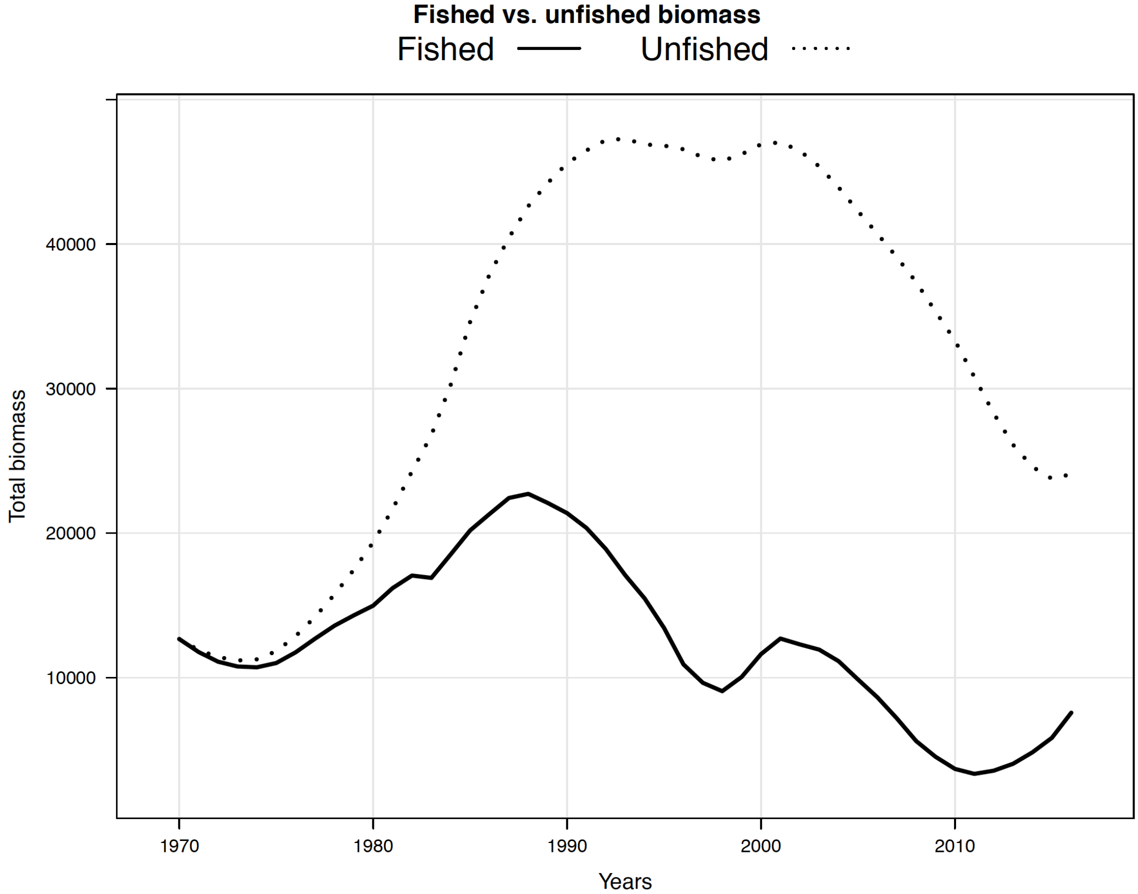

Figure A8.18. Model 1.18 results the estimated total biomass (solid line) and the estimated total biomass that would have occurred if no fishing had taken place, 1970-2016.

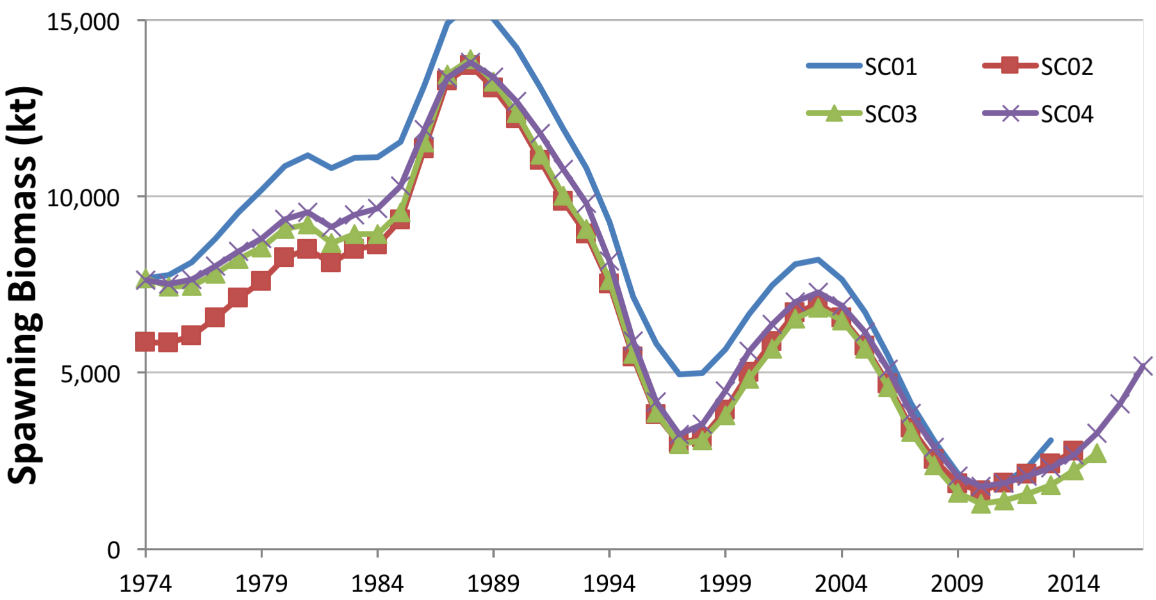

Figure A8.19. Historical retrospective of female spawning biomass (single-stock hypothesis) as estimated and used for advice from past (and present) SPFRMO scientific committees.

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Proposal by Ecuador to develop JUREL fishing in the area of the SPRFMO Convention

6th Meeting
SPRFMO
Lima, February 02nd, 2018

Financial feasibility to develop jack mackerel fishery

- The private initiative interested in developing investments in the Jurel fishery proceeded to present to the Ecuadorian Undersecretary of Fisheries a business plan of the estimated conditions on the financial feasibility to carry out an investment plan for this fishery and therefore see which would be the share of Jurel (Trachurus murphyi) that Ecuador should manage to the SPRFMO. The purpose of this quota is to ensure a net return for the project, which has the objective of acquiring a purse-seine vessel (new or used) that would operate in the areas of the SPRFMO Convention.

- In summary it was determined that:

1. The probability to develop as a profitable business the horse mackerel fishery in the SPFRMO convention area under Ecuador's current quota allocation (1,179 MT) is 0% (regardless of whether the investment is based on the acquisition of a used or new vessel).
2. That the intertemporal equilibrium point for the investment in a used vessel dedicated to the fishing of jack mackerel in waters of the SPRFMO convention is reached from the 6,500 MT; this is 5,321 TM in addition to the current quota, and that,
3. The investment consists of acquiring a new vessel, at least 12,900 MT of quota is required; this is 11,721 TM in addition to the current quota.

Requirement for development of jack mackerel fishery

Ecuador proposes, as its plan, immediate action to develop the horse mackerel fishing in the area of the SPRFMO Convention:

That the country be assigned a catch quota of 6,500 tons from 2018, with which the Ecuadorian government will be able to deliver it to the Ecuadorian company so that it can develop its business plan.

Specific requirements to Ecuador on regulations

The delegation of Ecuador proposes to the members of the SPRFMO that they consider:

- In the resolution that is approved for 2018, make an amendment to resolution WP 07 Revision of Table 1 and Table 2 of CMM 01-2017 (Jack Mackerel) on the distribution of catches and percentages to make an adjustment to Ecuador's quota allocating a quota of 6,500 tons and that its percentage of representation is 1.13% (increase of 0.89%).

- The requested increase comes from the surplus reserve that is assigned every year of the quota.

- Include Ecuador that is a member of this Commission to replace Belize, within Table 1 of CMM Resolution 01 of the members and CNCP to establish the limit of total gross tonnage (GT) of vessels participating in the Trachurus murphyi fishery in the Convention Area.

	GLOBAL QUOTAS OF JUREL					
	2013	**2104**	**2015**	**2016**	**2017**	**2018**
TOTAL RECOMMENDED FISHING QUOTA	438,000	440,000	460,000	460,000	493,000	**576,000**
Increase in% per year	0	0.46	4.55	0.00	7.20	16.84
Total quota distributed between countries		390,000	410,000	410,000	443,000	517,582
Reserve left over from total quota		50,000	50,000	50,000	50,000	58,418
Current quota of Ecuador			1,100	1,100	1,175	1,377
Additional fee requested by Ecuador						**5,123**

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Proposed modification to Table 1 and 2 of the CMM 01 17

Member/CNCP	Tonnage	%
Chile	370,888	
China	36,563	
Cooks Island	0	
Cuba	1,285	
Ecuador	6,500	1.13
European Union	35,185	
Faroe Island	6,386	
Korea	8,385	
Peru	11,684	
Rusia	18,907	
Vanuatu	26,921	
TOTAL	522,704	

Proposed modification to Table 1 of CMM 01 01

Table 1: Gross Tonnage limits as referred to in paragraph 5

Member/CNCP	GT or GRT
Ecuador	*9,814 GT*
Chile	*96,867.24 GT + 3,755.81 GRT*
China	*74,516 GT*
Cook Islands	*12,613 GRT*
European Union	*78,600 GT*
Faroe Islands	*23,415 GT*
Korea	*15,222 GT*
Peru	*75,416 GT*
Russian Federation	*74,470 GT3*
Vanuatu	*31,220 GRT*

MINISTERIO DE ACUACULTURA Y PESCA

Thanks…

SPRFMO

Ref: 006-2017

23 January 2017

To: Commission Members

Dear Members,

Re: Decisions adopted in the Fifth Meeting of the Commission

In accordance with Article 17 of the SPRFMO Convention, I am writing to notify you of the decisions adopted at the Fifth SPRFMO Commission Meeting, in Adelaide, Australia, from 18 to 22 January 2017. The decisions listed below are attached under ANNEX 8 to the Report of the Fifth Commission Meeting which will be available shortly on the SPRFMO website.

Please note that CMM numbers will change in accordance with the relevant decision taken by the Commission. The new numbers are given in Column 3 of the table below.

ANNEX 8	Decision	New CMM number	Reference
a	Amendments to CMM 4.01 (*Trachurus murphyi*)	01-2017	COMM5-WP06
b	Adopted proposal for CMM 4.02 (Data Standards)	02-2017	COMM5-Prop02-Rev1
c	SC Recommendation for CMM 4.02 (Data Standards)		COMM5-WP03
d	Adopted proposal for CMM 2.06 (VMS)	06-2017	COMM5-Prop03-Rev7
e	Review date for CMM 4.03 (Bottom Fishing)	03-2017	COMM5-Report
f	Amendments to CMM 4.04 (IUU)	04-2017	CTC4-WP06
g	Amendments to CMM 3.05 (Transhipment)	05-2017	COMM5-WP01-Rev2
h	Amendments to CMM 2.07 (Port inspections)	07-2017	CTC4-WP01-Rev4
i	Amendments to CMM 4.09 (Seabirds)	09-2017	CTC4-WP02-Rev3
j	Amendments to CMM 4.10 (CMS)	10-2017	CTC4-WP03-Rev2

Based on Article 17, paragraph 1(b), these decisions will become binding 90 days after the date of this letter, i.e. on 23 April 2017.

Sincerely yours,

Johanne Fischer
Executive Secretary

6th Meeting of the Commission
Lima, Peru, 30 January to 3 February 2018

COMM 6 - INF 03

Catch data submitted to the SPRFMO Secretariat
(as at 28 December 2017)

Table of Contents

1.0 Introduction

This paper summarises Annual Catch Totals (of key species) received by the South Pacific Regional Fisheries Organisation (SPRFMO) Secretariat as at 28 December 2017. It updates COMM5-INF03 and includes earlier information which was submitted to the Interim Secretariat (2007 - 2013) under Interim Management measures.

Key species included in this report were determined by historic catch amounts and are:

a) Jack/Horse Mackerels *(Trachurus* spp);
    a. Includes 2017 preliminary monthly catch totals
b) Scomber Mackerels (*Scomber* spp);
c) Squid (*Dosidicus gigas*) and;
d) Orange Roughy (*Hoplostethus atlanticus)*.

Other major species caught in the SPRFMO Area are summarised in Section 6.

This paper does not verify catch amounts, nor does it assess the data received with any current Conservation Management Measure.

2.0 ANNUAL REPORTED CATCHES IN THE SOUTH PACIFIC FOR *TRACHURUS* SPP (JACK/HORSE MACKERELS)

Table 2.1: Annual catch data – *Trachurus* spp (t)

Participant	Australia	Belize	Chile[1]		China	Cook Islands	Cuba	Ecuador
FAO Area	Unknown	87	87	87	87	87	87	87
High seas vs In-zone	EEZ (AUS)	HS	EEZ (CHL)	HS	HS	HS	HS	EEZ (ECU)
Species	*Trachurus* spp.	*T. murphyi*	*T. murphyi*	*T. murphyi*	*T. murphyi*	*Trachurus* spp.	*T. murphyi*	*T. murphyi*
2016			313 403	3 159	20 208			0
2015			228 409	56 805	29 180			289
2014			267 615	3 983	21 155			9
2013			226 006	5 917	8 329	0[2]		3 563
2012			223 322	4 138	13 012	0	0[2]	77
2011		0[2]	193 722	53 573	32 862	0	8[2]	69 373
2010		2 240	355 510	109 298	63 606	0		4 613
2009		5 681	491 792	343 135	117 963	0		1 934
2008		15 245	376 370	519 738	143 182	0		0
2007	680	12 585	1 040 167	262 617	140 582	7		927
2006		481	1 251 499	128 442	160 000			0
2005		867	1 158 272	272 162	143 000			0
2004			1 154 890	296 709	131 020			0
2003			975 186	446 110	94 690			0
2002			1 465 912	53 081	76 261			604
2001			1 649 933	0	20 090			133 969
2000			1 233 938	361	2 318			7 122
1999			1 202 512	17 177				19 072
1998			1 594 144	18 768				25 900
1997			2 905 830	11 234				30 302
1996			3 883 326	0				56 782
1995			4 404 193	0				174 393
1994			4 041 447	0				36 575
1993			3 236 244	0				2 673
1992			3 212 060	0			3 196	15 022
1991			3 020 512	0			30 828	45 313
1990			2 471 875	0			41 197	4 144
1989			2 390 117	0			24 486	
1988			2 138 255	0			44 209	
1987			1 770 037	0			35 980	
1986			1 184 317	0			46 833	
1985			1 456 989	0			32 258	
1984			1 426 301	0			34 008	
1983			865 272	0			54 875	
1982			1 494 683	0			83 881	
1981			1 060 909	0			74 227	
1980			562 262	0			83 971	
1979			597 511	0			19 000	
1978			586 681	0				
1977			340 806	0				
1976			342 269	0				
1975			261 205	0				
1974			193 512	0				
1973			121 595	0				
1972			87 003	0				
1971			158 442	0				
1970			111 994	0				

[1] Chile has submitted annual catch data for *T. murphyi* dating back to 1960.

[2] Preliminary figure derived from monthly catch returns.

Table 2.1: Continued

Participant	European Union[3]				Faroe Islands	Japan	Korea
FAO Area	71/77/81	87	87	87	87	87	87
High seas vs In-zone	HS + EEZ	EEZ (PER)	HS	Unknown	HS	HS + EEZ	HS
Species	*Trachurus* spp.	*T. murphyi*	*T. murphyi*	*T. murphyi*	*T. murphyi*	*T. murphyi*	*T. murphyi*
2016			11 962				6 430
2015			27 955		0		5 749
2014			20 539		0		4 078
2013			10 101		0		5 267
2012			0		0[2]	0[2]	5 492
2011			2 248		0[2]		9 253
2010			67 497		11 643	0[2]	8 183
2009			111 921		20 213	0	13 759
2008			108 174		22 919		12 600
2007			123 523		38 700[4]		10 940
2006			62 137				10 474
2005			6 187				9 126
2004							7 438
2003							2 010
2002							
2001							
2000							
1999						7	
1998							
1997							
1996							
1995							
1994							
1993							
1992				7 842			
1991	12 752			109 292			
1990	6 160			80 874		157	
1989	5 571			102 980		701	
1988	2 633			75 122		6 871	
1987			82 955			8 815	
1986			79 454			6 835	
1985			81 361			5 229	
1984			178 877			3 871	
1983			79 698			1 694	
1982			51 710				
1981		1 215	78 152			29	
1980		5 295	46 387				
1979		43 701	60 135			120	
1978	[5]	[5]	4 308			1 667	403
1977		[5]				2 273	
1976	118	[5]				35	
1975	680						
1974	34	[5]					

3 Lithuanian catches are included within both European Union and Russian Federation annual catch data for years prior to the dissolution of the former Soviet Union.

4 The Faroe Islands 2007 Figure includes small quantities of unspecified mackerel.

5 Figure not displayed as data is from less than 3 vessels, and has not yet been made public.

Table 2.1: Continued

Participant	New Zealand[6]			Peru[7]		Russian Federation[3, 6, 8, 9]		
FAO Area	81	81	81	87	87	81	87	87
High seas vs In-zone	EEZ (NZL)	EEZ (NZL)	EEZ (NZL)	EEZ (PER)	HS	unknown	EEZ (PER)	HS
Species	*T. murphyi*	*T. declivis*	*T. novaezelandia*	*T. murphyi*	*T. murphyi*	*T. declivis*	*T. murphyi*	*T. murphyi*
2016				15 087	0			0
2015				22 158	0			2 561
2014				74 528	2 557			
2013				77 022	2 670			0
2012				187 292	5 346			0[2]
2011				257 241	674			8 229[2]
2010	3 303	22 591	14 984	17 559	40 516			[10]
2009	3 964	21 820	14 390	74 694	13 326			9 113[11]
2008	6 500	26 231	14 664	169 537				4 800
2007	4 186	25 923	16 265	254 426		0		0
2006	5 253	16 873	14 226	277 568		0		0
2005	6 730	15 564	23 442	80 663		0		7 040
2004	6 184	21 335	15 650	187 369		0		62 300
2003	6 538	17 548	13 663	217 734		0		7 540
2002	7 486	14 831	9 986	154 219		0		0
2001	7 916	9 805	11 768	723 733		0		0
2000	8 677	10 033	3 844	296 579		0		0
1999	18 058	13 412	2 889	184 679		223		0
1998	20 993	6 229	8 796	386 946		52		0
1997	21 543	5 119	8 374	649 751		886		0
1996	26 386	6 212	10 133	438 736		2 280		0
1995	19 678	7 775	8 898	376 600		1 602		0
1994	22 434	14 917	4 934	196 771		1 804		0
1993	22 046	13 901	13 336	130 681		4 260		0
1992	12 664	12 447	12 576	96 660		2 892		32 000
1991	8 674	12 174	12 880	136 337		127 000	47 172	544 628
1990	4 698	11 650	10 859	191 139		67 518	116 052	1 006 245
1989	2 164	14 529	6 677	140 720		56 543	105 239	991 053
1988	1 589	14 538	8 027	118 076		58 797		938 288
1987	0	10 064	9 365	46 304		107 329		818 628
1986	2 206	7 395	7 894	49 863		146 200		785 000
1985				87 466		133 300	48 708	788 992
1984				184 333		22 300	98 340	958 260
1983				76 825		10 651	34 847	831 653
1982				50 013		4 953		735 898
1981				37 875				771 630
1980				123 380		13		544 970
1979				151 591				532 209
1978				386 793		254		49 220
1977				504 992		710		0
1976				54 154		0		0
1975				37 899		0		0
1974				129 211		0		0
1973				42 781		0		0
1972				18 782		0		5 500

[6] Catches of *Trachurus* spp made by Ukrainian vessels operating within the New Zealand EEZ are included within New Zealand, Russian Federation (years < 1992) and Ukrainian annual catch data.

[7] Peru has submitted annual catch data for *T. murphyi* dating back to 1939.

[8] Russian Federation figures pre-2009 have been proportioned between the High Seas and Peru's EEZ using SWG-09-INF-06.

[9] Ukraine operations prior to 1992 were conducted under the flag of the former Soviet Union.

[10] 2010 Annual catch data was provided for a single vessel (the *Lafayette*) however it has not been included, pending receipt of operational fishing information.

[11] The Russian Federation 2009 figure was taken by 5 of the 6 vessels that were present in the Area.

Table 2.1: Continued

Participant	Ukraine[6,9]			Vanuatu
FAO Area	81	81	87	87
High seas vs In-zone	EEZ (NZL)	HS	unknown	HS
Species	*Trachurus* spp.	*T. murphyi*	*T. murphyi*	*T. murphyi*
2016				15 563
2015				21 227
2014				15 324
2013				14 809
2012				16 068
2011				7 617
2010				45 908
2009				79 942
2008				100 066
2007	22 067			112 501
2006				129 535
2005				77 356
2004	22 600			94 685
2003	25 016			53 959
2002	5 667			
2001	7 577			
2000	12 213			
1999	15 306			
1998	9 309			
1997	9 740			
1996	13 093			
1995	8 990			
1994	4 192			
1993	7 937			
1992	2 878		2 736	
1991	319	7 838	65 126	
1990	214	3 574	115 049	
1989		2 292	109 695	
1988		868	104 006	
1987		5 274	89 116	
1986		5 778	81 275	
1985		7 313	100 464	
1984			162 524	
1983		1 982	140 185	
1982		631	82 633	
1981			85 517	
1980	6		58 677	
1979			90 371	
1978			4 783	

Table 2.2: 2017 Preliminary catches in the South Pacific for *Trachurus murphyi* (Monthly catch returns; Jan – Nov 2017)

Participant	FAO Area	High seas vs In-zone	2017
Chile	87	ANJ	327 684
Ecuador	87	ANJ	0
Peru	87	ANJ	8 434
Chile	87	HS	3 155
China	87	HS	16 802
European Union	87	HS	22 410
Faroe Islands	87	HS	0
Korea	87	HS	1 235
Peru	87	HS	0
Russian Federation	87	HS	3 188
Vanuatu	87	HS	0
Total (t)	**87**		**382 909**

Figure 2.1: Recent catches for *Trachurus murphyi* in the SPRFMO Convention Area compared with catches from EEZs (t)

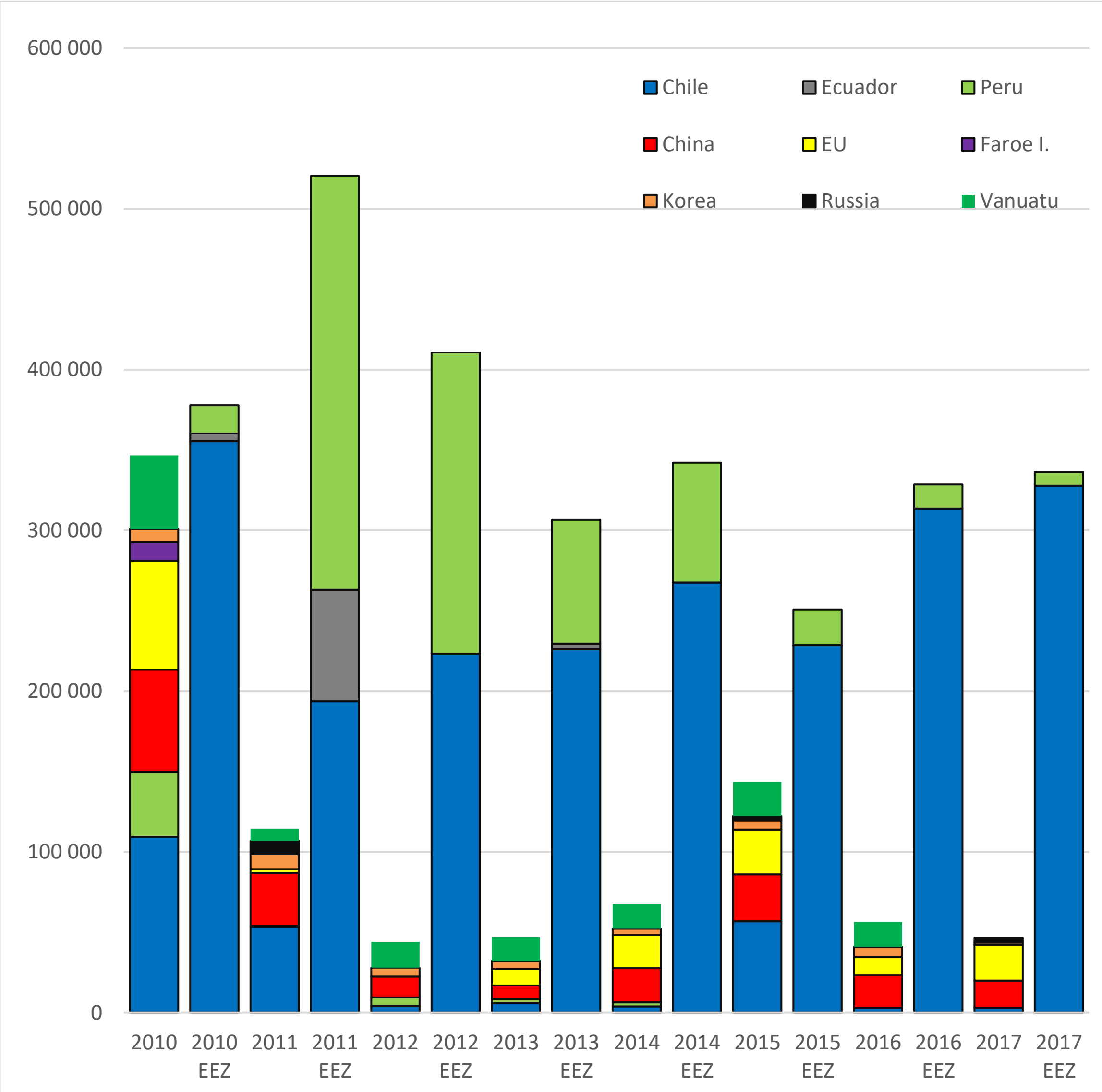
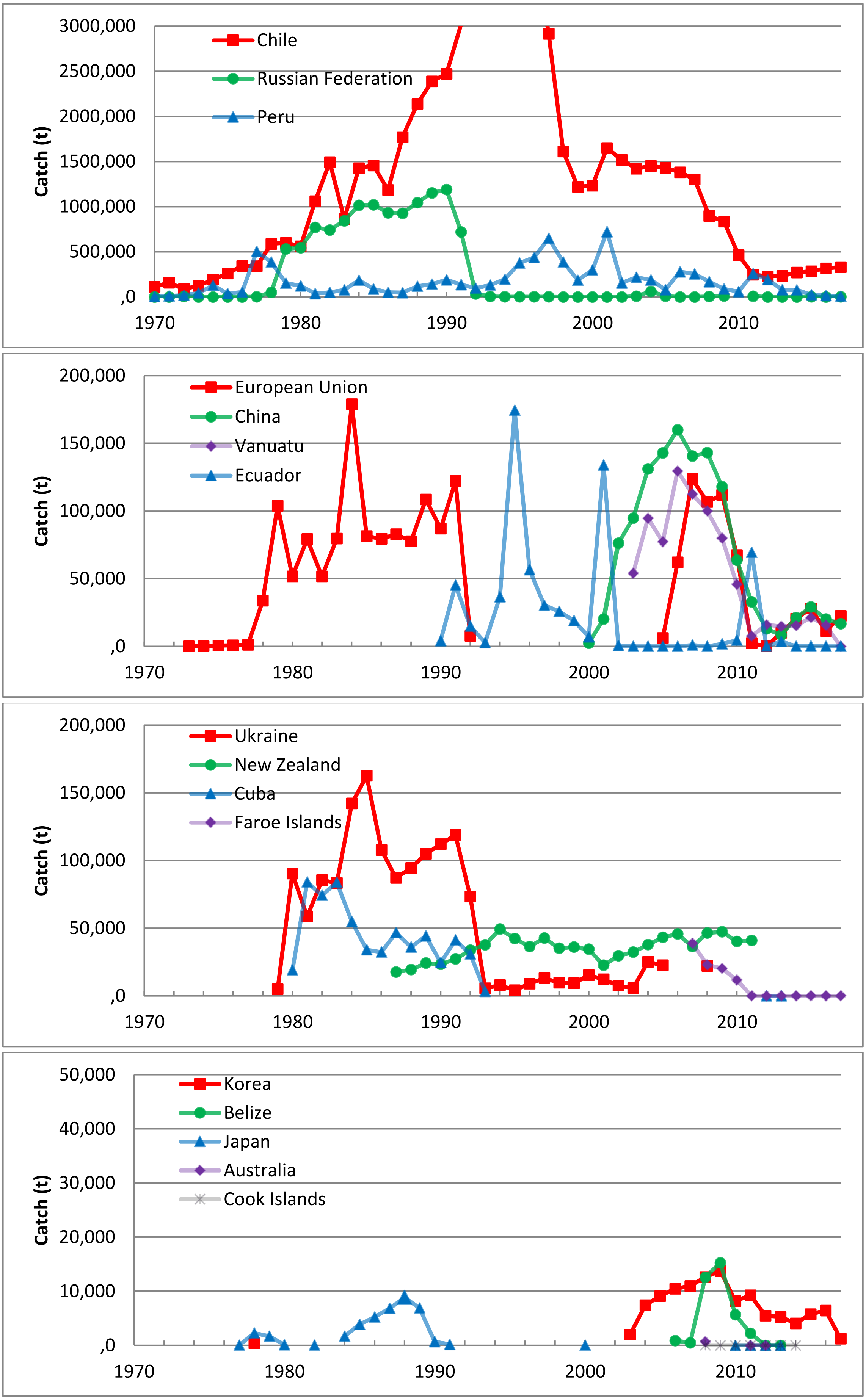


Figure 2.2: Annual reported catches in the South Pacific for *Trachurus* spp (note scale)



3.0 Annual reported catches in the South Pacific for *Scomber* spp (Mackerels)

Table 3.1: Annual catch data – *Scomber* spp (t)

Participant	Belize	Chile			China	Ecuador	Faroe Islands	Japan
FAO Area	87	87	87	87	87	87	87	87
High seas vs In-zone	HS	EEZ (CHL)	HS	HS + EEZ	HS	EEZ (ECU)	HS	HS
Species	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*
2016		88 900	790		1 615			
2015		43 835	1 820		705			
2014		24 135	31		608			
2013		31 193	431		173			
2012		24 120	199		226			
2011		23 077	2 979		666[1]			
2010	21	94 723	936		2 583[1]	52 751	[2]	
2009	295	136 516	21 936			36 679	[2]	
2008	1 104	87 316	45 702			21 758	[2]	
2007	966	233 697	63 492			43 171		
2006		345 491	23 295			37 664		
2005				280 756		115 406		
2004				577 336		51 806		
2003				572 052		33 272		
2002				343 371		17 074		
2001				365 031		85 248		
2000				95 789		83 923		
1999				120 123		28 307		1
1998				71 769		44 716		
1997				211 649		192 181		
1996				146 649		79 484		
1995				110 210		63 577		
1994				27 171		38 991		
1993				96 023		50 980		
1992				72 364		25 651		
1991				191 723		55 023		
1990				192 948		78 639		<0.5
1989				39 328		141 333		
1988				26 423		255 548		
1987				32 799		149 302		
1986				1 584		274 852		
1985				11 314		397 863		
1984						396 913		1
1983						252 667		
1982						589 375		
1981						448 088		
1980								
1979								1
1978								<0.5

[1] Preliminary figure derived from monthly catch returns only.

[2] Figure not displayed as data is from less than 3 vessels and has not yet been made public.

Table 3.1: Continued

Participant	European Union						Korea
FAO Area	71/77	87	87	87	87	Unknown	87
High seas vs In-zone	HS + EEZ	HS + EEZ	HS	HS	Unknown	HS	HS
Species	*Scomber* spp	*S. japonicus*	*Scomber* spp	*S. japonicus*	*S. japonicus*	*S. japonicus*	*S. japonicus*
2016				680			486
2015				801			82
2014				718			21
2013				226			111
2012							0
2011						1	24
2010						679	84
2009						5 168	716
2008						5 879	968
2007						9 067	1 240
2006						5 989	1 460
2005						211	381
2004							708
2003							39
2002							
2001							
2000							
1999							
1998							
1997							
1996							
1995							
1994							
1993							
1992					36		
1991					1 644		
1990					1 938		
1989	47				1 610		
1988					316		
1987				864			
1986				828			
1985				848			
1984			20	716			
1983			37	414			
1982			54	464			
1981		109		814			
1980		3 522		465			
1979		34 356		614			
1978	[2]	[2]		45			
1977		[2]					
1976		[2]					
1975		[2]					
1974							
1973							
1972							
1971							
1970							

[2] Figure not displayed as data is from less than 3 vessels and has not yet been made public.

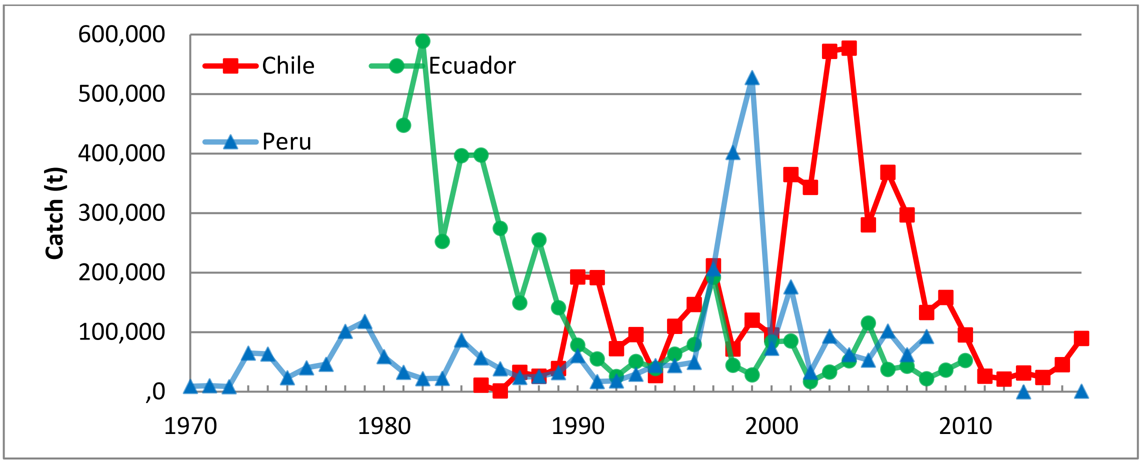
Table 3.1: Continued

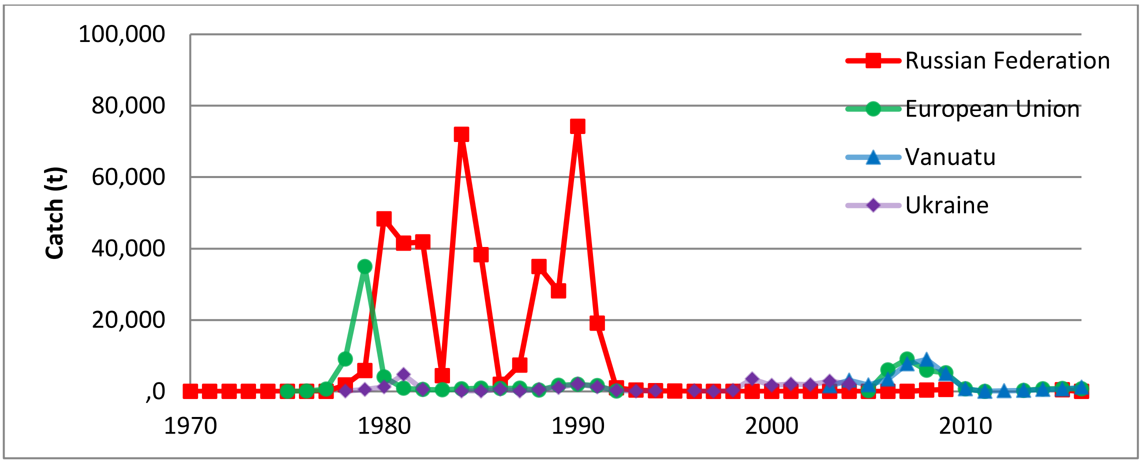
Participant	Peru		Russian Federation		
FAO Area	87	87	81	87	87
High seas vs In-zone	EEZ (PER)	HS	Unknown	HS	Unknown
Species	*S. japonicus*	*S. japonicus*	*S. australasicus*	*S. japonicus*	*S. japonicus*
2016		1 122		0	
2015				463	
2014					
2013		19			
2012					
2011					
2010					
2009				535	
2008	92 989			387	
2007	62 387		0		0
2006	102 322		0		0
2005	52 895		0		0
2004	62 255		0		0
2003	93 384		0		0
2002	32 698		0		0
2001	176 202		0		0
2000	73 263		0		0
1999	527 729		0		0
1998	401 903		0		0
1997	206 183		0		0
1996	49 221		0		0
1995	44 259		75		0
1994	44 115		204		0
1993	29 504		326		0
1992	17 939		0		970
1991	17 304		828		18 257
1990	60 776		0		74 168
1989	32 042		0		28 160
1988	25 554		95		34 805
1987	24 072		3 505		3 835
1986	38 709		20		1 920
1985	57 069		5		38 275
1984	87 134		0		71 952
1983	22 579		0		4 416
1982	22 072		0		41 878
1981	32 803		0		41 500
1980	59 062		0		48 300
1979	118 067		0		5 800
1978	101 505		0		1 773
1977	46 071		0		0
1976	40 172		0		0
1975	23 588		0		0
1974	63 270		0		0
1973	64 966		0		0
1972	8 707		0		0
1971	10 113		0		
1970	8 791		0		

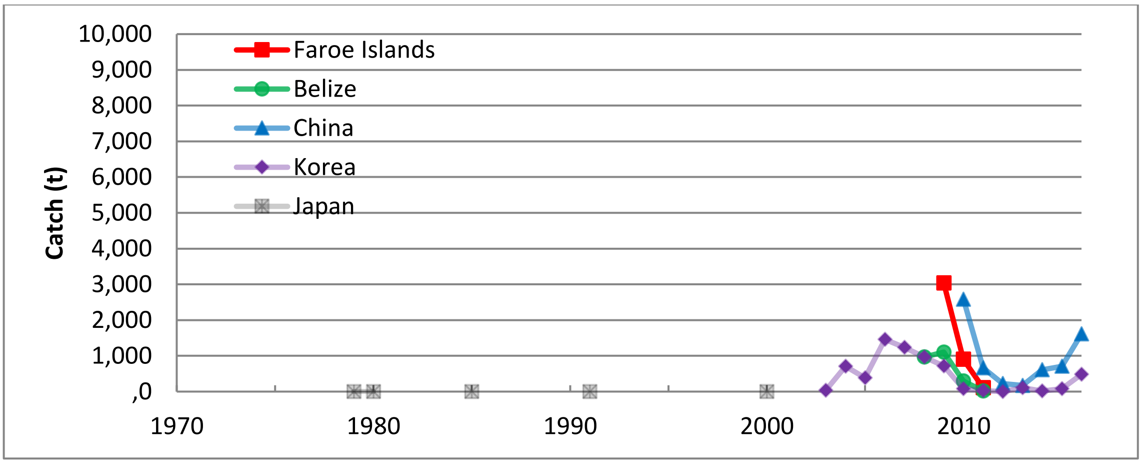
Table 3.1: Continued

Participant	Ukraine			Vanuatu
FAO Area	81	81	87	87
High seas vs In-zone	EEZ (NZL)	HS	Unknown	HS
Species	*S. australasicus*	*S. australasicus*	*S. japonicus*	*S. japonicus*
2016				1 145
2015				604
2014				484
2013				296
2012				193
2011				24
2010				676
2009				4 901
2008				8 945
2007				7 705
2006				3 352
2005				1 819
2004	2 165			3 137
2003	2 843			1 553
2002	1 849			
2001	2 040			
2000	1 677			
1999	3 457			
1998	214			
1997	9			
1996	156			
1995				
1994	133			
1993	94			
1992	213		17	
1991	224		1 063	
1990	2		2 085	
1989		25	999	
1988			519	
1987		1	79	
1986			647	
1985			39	
1984			78	
1983				
1982			565	
1981			4 708	
1980			1 282	
1979			522	
1978			122	
1977				
1976				
1975				
1974				
1973				
1972				
1971				
1970				

Figure 3.1: Annual reported catches in the South Pacific for *Scomber* spp (note scale)







4.0 ANNUAL REPORTED CATCHES IN THE SOUTH-EAST PACIFIC FOR *DOSIDICUS GIGAS* (JUMBO FLYING SQUID)

Table 4.1: Annual catch data for Jumbo flying squid (t)

Participant	Peru		Chile			China	Ecuador
FAO Area	87	87	87	87	87	87	87
High seas vs In-zone	EEZ (PER)	HS	EEZ (CHL)	HS + EEZ	HS	HS	EEZ (ECU)
Species	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*
2016		<0.5	183 123		17	223 300	
2015	513 796		143 716		0	323 636	1 500
2014	556 156	1 190	176 569		0	332 523	
2013	451 061		105 905		22	264 000	
2012	497 462		144 956		9	261 000	
2011	404 730		163 450		45	250 000	
2010	369 822		200 428			142 000	
2009	411 805		56 337			70 000	
2008	533 414		145 171			79 064	
2007	427 591		124 389			46 400	
2006	434 261			219 800		62 000	
2005	291 140			296 953		86 000	
2004	270 368			175 134		205 600	
2003	153 727			15 191		81 000	
2002	146 390			5 589		50 483	
2001	71 834			3 476		17 770	
2000	53 795			9			
1999	54 652			6			
1998	547			5			
1997	16 061						
1996	8 138			2			
1995	109 155						
1994	209 970			205			
1993	140 355			7 442			
1992	106 547			9 400			
1991	81 655			445			
1990	7 441						

Table 4.1: Continued

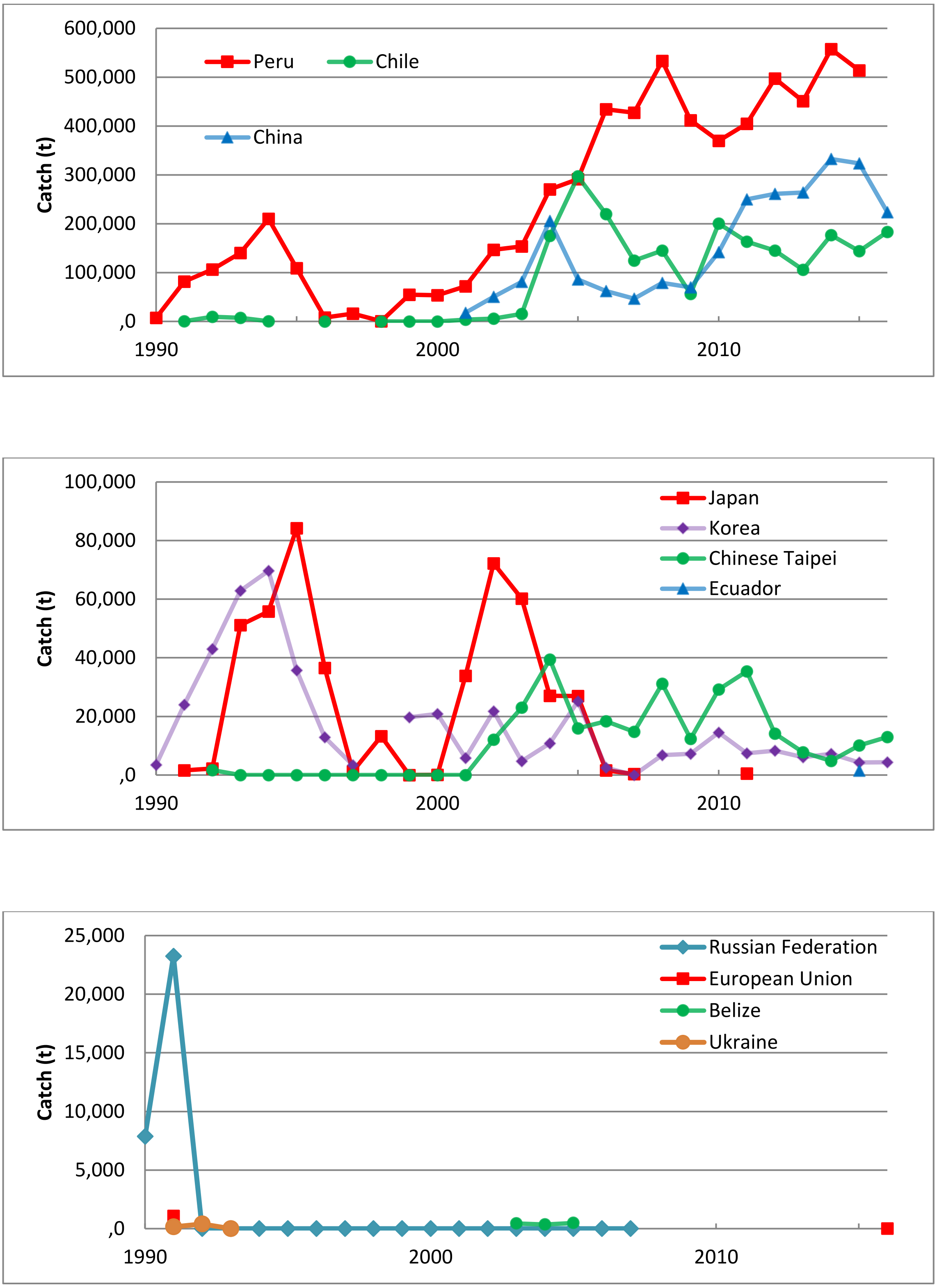
Participant	Japan			Korea			Chinese Taipei
FAO Area	87	87	87	87	87	87	87
High seas vs In-zone	HS	HS + EEZ	EEZ	EEZ (PER)	HS	HS + EEZ	HS
Species	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*	*D. gigas*	Unspecified	*D. gigas*
2016					4 388		12 989
2015					4 263		10 072
2014					7 203		4 795
2013					6 034		7 759
2012					8 310		14 177
2011					7 410		35 418
2010	498			7 764	6 742		29 206
2009				7 221	0		12 319
2008				5 971	804		31 161
2007				0	0		14 750
2006	323			2 048	437		18 349
2005	1 633			2 519	0		15 976
2004	4 615		22 385	2 026	8 761		39 450
2003	4 510		22 549	1 681	3 041		23 009
2002	33 978		26 268	13 130	8 629		12 064
2001	1 132		71 069	5 797	0		0
2000	1 704		32 174			20 822	0
1999	40		6			19 728	0
1998	0	0	0				0
1997	297		12 924			3 359	0
1996	644		557			12 896	0
1995	37		36 478			35 719	0
1994	2 698		81 507			69 664	0
1993	3 579		52 221			62 887	0
1992	1 874		49 313			43 022	1 698
1991	50		2 173			24 015	
1990	1 605		0			3 465	
1989	14		0				
1988	43		0				
1987							
1986		94					
1985		15 503					
1984		9					
1983		<0.5					
1982							
1981							
1980							
1979							
1978		7					

Table 4.1: Continued

Participant	Belize	European Union	Russian Federation	Ukraine
FAO Area	87	87	87	87
High seas vs In-zone	HS	Unknown	Unknown	Unknown
Species	Unspecified	Unspecified	Unspecified	*D. gigas*
2016		<0.5		
2015				
2014				
2013				
2012				
2011				
2010				
2009				
2008				
2007				
2006				
2005				
2004				
2003	479			
2002	353			
2001	453			
2000				
1999				
1998				
1997				
1996				
1995				
1994				
1993				
1992				1
1991		1 075[1]	23 240[1]	398
1990			7 860	142
1989			380	
1988				
1987				
1986				
1985			130	
1984			10	
1983				
1982			10	
1981			60	
1980				
1979			45	
1978				
1977				
1976				
1975				
1974				
1973				
1972			<0.5	

[1] Lithuanian catches are included within both European Union and Russian Federation annual catch data for years prior to the dissolution of the former Soviet Union.

Figure 4.1: Annual reported catches in the South-East Pacific – Jumbo flying squid (note scale)



5.0 Annual reported catches for Orange roughy in the South Pacific (*H. atlanticus*)

Table 5.1: Annual catch data – Orange roughy (t)

Participant	Australia	Belize		China	Korea	
FAO Area	Unknown	81	71	81	81	81
High seas vs In-zone	HS	HS	HS	Unknown	HS	HS + EEZ
Species	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*
2016	83					
2015	20					
2014	102					
2013	49					
2012	56					
2011	2					
2010	0	0	0			
2009	0					
2008	0				0	
2007	148	332[2]		336[2]	44	
2006	166	200		570	77	
2005	207	506		710	0	
2004	369	913	1	592	138	
2003	166	9		562	243	
2002	376			597	208	
2001	751			520	94	
2000	948					288
1999	2 514					7
1998	3 098					
1997	1 458					
1996	11[1]					
1995	11[1]					
1994	192					
1993	122[1]					
1992	122[1]					
1991	122[1]					
1990	2[1]					
1989	2[1]					
1988	2[1]					
1987	2[1]					
1986						
1985						
1984						
1983						
1982						
1981						
1980						
1979						
1978						
1977						

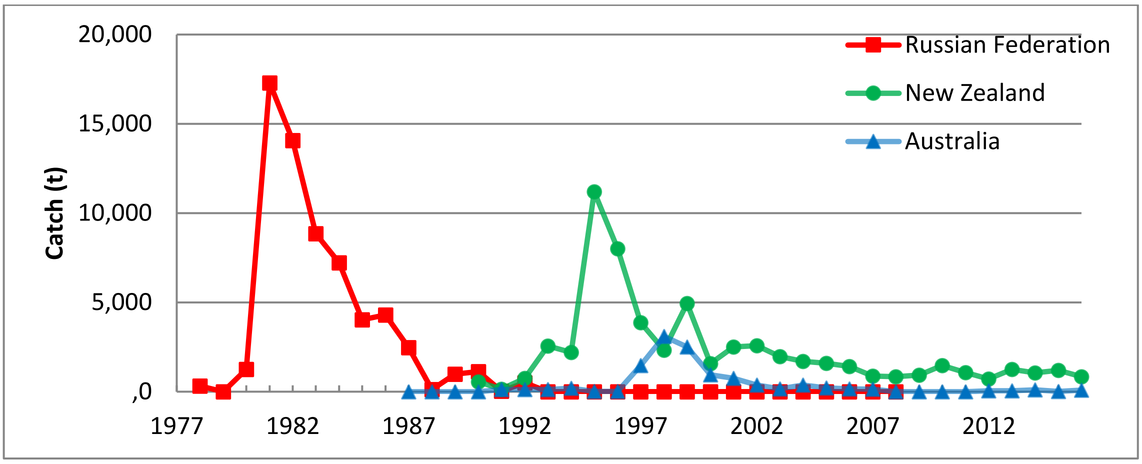
[1] Reported catch figures were grouped; these catches have been split equally between years.

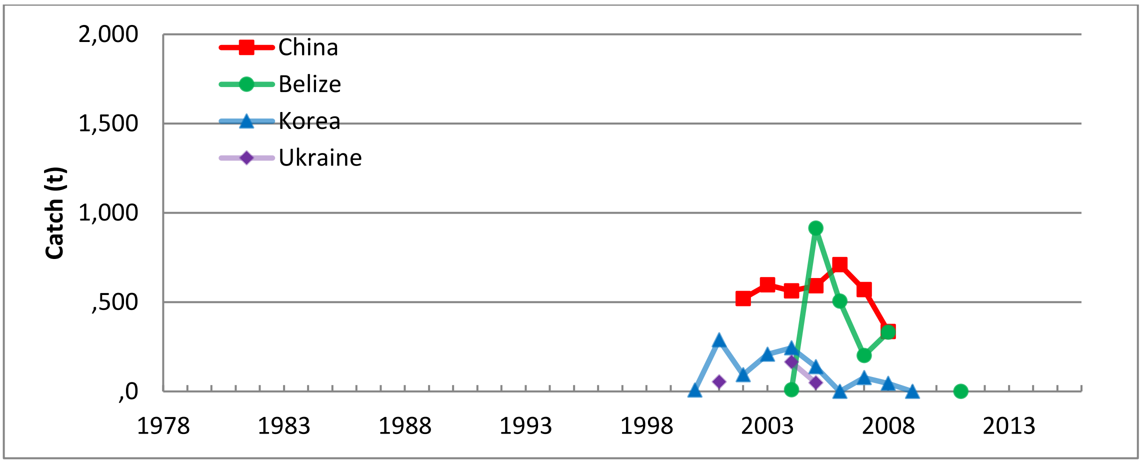
[2] This catch was reported by both Belize and China as an annual total from the same vessel fishing in the same period. Therefore, this catch amount is represented twice in this table.

Table 5.1: Continued

Participant	European Union	New Zealand	Russian Federation		Ukraine
FAO Area	81	81	81	87	81
High seas vs In-zone	HS	HS	Unknown	Unknown	HS
Species	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*	*H. atlanticus*
2016		832			
2015		1 203			
2014		1 047			
2013		1 243			
2012		721			
2011		1 079			
2010		1 474			
2009	257	928			
2008		837			
2007		866	0	0	
2006		1 415	0	0	
2005		1 597	0	0	
2004		1 697	0	0	49
2003		1 973	0	0	164
2002		2 578	0	0	
2001		2 499	0	0	
2000		1 574	0	0	53
1999		4 948	0	0	
1998		2 329	0	0	
1997		3 862	0	0	
1996		8 002	0	0	
1995		11 195	0	0	
1994		2 195	0	0	
1993		2 566	0	0	
1992		758	0	0	
1991		141	506	0	
1990		559	36	0	
1989			1 132	0	
1988			991	0	
1987			130	0	
1986			2 475	0	
1985			4 306	0	
1984			4 028	0	
1983			7 229	0	
1982			8 860	0	
1981			14 076	0	
1980			17 300	0	
1979			1 251	0	
1978			0	0	
1977			319	0	

Figure 5.1: Annual reported catches in the SPRFMO Area – Orange roughy (note scale)





6.0 Annual reported catches for other species

The following table summarises the remaining annual catch data received by the Secretariat.
Note – only major species/species groups are represented individually. Caches which were known to have been taken entirely within areas of National Jurisdiction have been excluded.

The category ''marine fishes nei" either represents information that was submitted in this manner or information that has been grouped into this category by the Secretariat.

Table 6.1: Annual catch data – other species (t)

Participant	Australia									
FAO Area	81									
High seas vs In-zone	HS									
Species	Alfonsinos	Cardinalfishes	Morwongs	Oreo dories	Ruffs, Barrelfishes	Cephalopods nei	Dogfish sharks	Gadiformes	Hapuka	Sharks, rays, skates nei
2016	1	<0.5	14	<0.5	5			<0.5	<0.5	1
2015	4	<0.5	47	1	16		0	8	2	3
2014	1	<0.5	31	<0.5	21			1	5	<0.5
2013	74	2	39	<0.5	42	0	1	<0.5	5	2
2012	167		40	<0.5	28			<0.5	1	<0.5
2011	47	0	53	0	28		0	<0.5	2	<0.5
2010	0	0	23	0	6					
2009	0	0	13	0	4					
2008	0	0	24	0	3					
2007	86	2	7	1	16					
2006	209	0	10	0	8					
2005	81	0	1	75	4					
2004	1	0	0	34	2					
2003	2	0	16	69	30					
2002	3	0	84	73	27					
2001	1	0	43	44	21					
2000	4	7	79	209	6					
1999	8	1	29	195	22					
1998	1	2	31	1 040	26					
1997	1	15	1	953	6					
1996	0	26[1]		11[1]						
1995	0	26[1]		11[1]						
1994	0	2		6						
1993	0	0		37[1]						
1992	0	0		37[1]						
1991	0	0		37[1]						
1990	0	0		0						
1989	0	0		0						
1988	0	0		0						
1987	0	0		0						

[1] Reported catch figures were grouped; these catches have been split equally between years.

Table 6.1: Continued

Participant	Belize	Chile	European Union						
FAO Area	Various	87	Various	87	Various	81	Various	81	81
High seas vs In-zone	HS	HS	HS	HS	HS + EEZ	HS	HS + EEZ	HS	HS
Species	Alfonsinos	Alfonsinos	Alfonsinos	Cardinalfishes	Cephalopods nei	Dogfish sharks	Gadiformes	Hapuka	Ruffs, Barrelfishes
2016									
2015									
2014						144	4	9	
2013									
2012									
2011									
2010						292	4		1
2009			<0.5	4		2 283	120		94
2008		0	1 497			900	5		6
2007	61[2]	0	743						
2006	101								
2005	104	5							
2004	229								
2003	73	11							
2002		2							
2001		1							
2000									
1999									
1998		144							
1997									
1996									
1995									
1994									
1993									
1992							10		
1991									
1990					6 497				
1989					2 003				
1988									
1987									
1986									
1985									
1984									
1983							5		

[2] This catch was reported by both Belize and China as an annual total from the same vessel fishing in the same period. Therefore, this catch amount is represented twice in this table.

[3] Figure not displayed as data is from less than 3 vessels and has not yet been made public.

Table 6.1: Continued

Participant	Japan				Russian Federation					
FAO Area	87				81, 87					
High seas vs In-zone	HS + EEZ				HS + EEZ					
Species	Cephalopods nei	Gadiformes	Morwongs	Sharks, rays, skates nei	Alfonsinos	Cephalopods nei	Gadiformes	Oreo dories	Ruffs, Barrelfishes	Sharks, rays, skates nei
2016										
2015										
2014										
2013										
2012										
2011										
2010										
2009										
2008										
2007										
2006										
2005										
2004				409						
2003				289						
2002				795						
2001				648						
2000				438						
1999				441		1 352	1		28	
1998				1 167		1 907			34	
1997				526		5 809	4 003		352	
1996				857	0	8 365	4 309	5	185	
1995				671	0	17 004	8 481		150	
1994				1 415	0	22 098	22 779	18	721	
1993				996	0	15 600	17 647		922	
1992				1 032	0	28 767	43 063	51		
1991				857	0	17 331	66 363	93	2 032	
1990		3	8	1 409	0	21 654	100 432	251	662	
1989	3	45		818	0	13 413	46 686	342	132	
1988		26		1 297	0	7 481	24 818	2 685	125	
1987				1 754	0	9 135	26 695	6 497	96	
1986		2	2	663	0	15 818	22 098	6 769	98	
1985		31		521	0	18 267	10 752	12 019	77	
1984		566		1 327	467	19 076	20 826	8 560	304	
1983				1 178	633	20 319	32 678	13 072	376	
1982				771	620	18 118	22 640	8 920		
1981				846	676	12 918	9 957	25 167		
1980				713	2 337	15 506	13 272	18 221	67	382
1979		4 440		728	6 230	14 308	6 356	5 568	382	291
1978		29 419	64	944	1 783	3 112	28 645	28 119	3 225	
1977		19 796	35	752	3 491	26 837	63 685	11 513	6 340	
1976		551	22	441	0	0	59 696			
1975				321	0	0	73 390			
1974					0	0	69 604			
1973					0	0	95 518			
1972					0	0	68 504			
1971					0	0				
1970					0	0				

Table 6.1: Continued

Participant	New Zealand									
FAO Area	81									
High seas vs In-zone	HS									
Species	Alfonsinos	Cardinalfishes	Cephalopods nei	Dogfish sharks	Gadiformes	Hapuka	Morwongs	Oreo dories	Ruffs, Barrelfishes	Sharks, rays, skates nei
2016	168	19	<0.5	19	76	50	4	17	30	5
2015	49	48	<0.5	40	30	73	5	26	60	6
2014	1	1	<0.5	10	6	50	16	32	47	4
2013	169	4	<0.5	12	14	45	5	41	91	8
2012	154	2		4	12	40	3	17	44	
2011	240	108		15	29	25	1	32	23	
2010	244	22		13	21	24	1	31	15	
2009	5	16		9	7	23	1	5	58	
2008	2			2	3	43	2	2	67	
2007	2			5	14	31	5	173	144	
2006	28	21		21	60	95	6	63	271	
2005	26	189		18	130	31	10	343	102	
2004	85	42		8	80	24	6	181	116	
2003	94	226		57	176	7	1	87	6	
2002	17	159		37	104			171		
2001	22	485				2		124	46	
2000	29	1851			2	9		154	17	
1999	39	325			89	8		219	52	
1998	464	182			32	15		366	115	
1997	31	351			119	27		211	168	
1996	70	265			73	23		274	127	
1995	18	320			261	57		1 000	215	
1994	86	1 058			74	60		57	41	
1993	43	245			37	98		60	4	
1992	23	10			111	16		9	<0.5	
1991					19	3		29		
1990					510	1				

Table 6.1: Continued

Participant	Ukraine[4]				
FAO Area	81,87				
High seas vs In-zone	HS + EEZ				
Species	Alfonsinos	Cardinalfishes	Cephalopods nei	Gadiformes	Oreo dories
2016					
2015					
2014					
2013					
2012					
2011					
2010					
2009					
2008					
2007					
2006					
2005					
2004		4			3
2003					
2002					
2001					
2000				58	
1999					
1998					
1997					
1996					
1995					
1994					
1993					
1992					
1991					
1990					
1989					
1988					
1987					
1986					
1985					
1984				280	
1983	32				
1982					
1981	198		12		
1980	12			189	
1979				251	

[4] Catches made by Ukrainian vessels operating within the New Zealand EEZ are also included within New Zealand annual catch data.

Table 6.2: Annual catch data – mixed species (t)

Participant	Australia	Belize	China	European Union	Japan	Korea	New Zealand	Peru	Russian Federation	Ukraine[4]
FAO Area	81	81	81	Various	81	81, 87	81	87	81, 87	81, 87
High seas vs In-zone	HS + EEZ	HS	HS + EEZ	HS + EEZ	HS + EEZ	HS + EEZ	HS	HS	HS + EEZ	HS + EEZ
Species	Marine fishes nei									
2016	73			155		16	7			
2015	21			51			9			
2014	2			87			1			
2013	6						4	8		
2012	1						23			
2011	1					100	79			
2010	49						64			
2009	79			424		59				
2008	125			20 841			2			
2007	40	28[2]	73[2]	13		4	31			
2006	95		312			6	51			
2005	18	82	162			222	106			
2004	9	1 205	304			6	97			
2003	25		314		995	23	326			28
2002	41	235	147		615	17	114			
2001	56		60		771	8	115			
2000	20				385		80			
1999	30				567		181		754	
1998	37				599		373		57	
1997	44				181		490		364	
1996	1[1]				211		674		349	
1995	1[1]				205		624		290	
1994	3				420		543		4 005	
1993	1 333[1]				291		431		2 136	
1992	1 333[1]				465		116		7 943	
1991	1 333[1]			44	294		180		36 412	
1990	2[1]			1 551	839		261		72 830	
1989	2[1]				4 062				101 606	
1988	2[1]			17	2 526				294 794	
1987	2[1]				380				351 065	
1986					648				418 434	
1985					197				383 232	262
1984				18	55				338 013	
1983				51	679				186 060	
1982				295	275				206 377	
1981					282				60 427	
1980					283				61 898	
1979					967				44 643	88
1978				58	12 155	11 043			10 026	
1977					5 600	3 116			6 868	
1976					1 346				18 324	
1975					182				5 717	
1974									32 905	
1973									21 907	
1972									22 110	
1971									10 422	

[1] Reported catch figures were grouped; these catches have been split equally between years.

[2] This catch was reported by both Belize and China as an annual total from the same vessel fishing in the same period. Therefore, this catch amount is represented twice in this table.

[4] Catches made by Ukrainian vessels operating within the New Zealand EEZ are also included within New Zealand annual catch data.