SPRFMO
South Pacific Regional Fisheries Management Organisation

Report of the Habitat Monitoring Workshop SCW12

20/21 September 2021

1 Opening of the meeting

1. The co-Chairs of the SPRFMO SC Habitat Monitoring Working Group, Dr Mariano Gutierrez and Dr Aquiles Sepulveda opened the meeting and proceedings.

2. Any new members of the working group were invited to introduce themselves. A list of participants is included in Annex 1.

3. The Chairperson sought proposed changes to the Provisional Agenda After discussion, the final agenda was adopted (Annex 2).

2 Evaluate the applicability of data collected from fishing vessels targeting pelagic species

4. Peru presented SC9-HM05 a Preliminary classification of the Peruvian fleet based on its acoustic data collection capabilities and with a proposal for its application to vessels operating in the Convention area. A preliminary classification has been adopted by the National Fisheries Society (SNP) in Peru, which, among others, attempts to establish the number of vessels in each class, with an indication of the possible uses of the data each vessel can contribute, including the collection of biological information and data on the interactions between top predator species and the fleet.

5. The Workshop asked how data can be collected from analogue equipment which has no digital output. It was clarified that echograms can be digitized to files from the output RGB connection usually available in every Display, in order to further perform qualitative analysis only.

6. The Workshop asked whether the use of sonar data has been considered. It was explained that sonar data is quite “heavy” and quantitative analysis on this data is under development and will be available in the coming years.

7. Chile Presented a report on the acoustic Equipment of the Purse Seine Fleet of Central-South Chile (Chile, SC9-HM09). In year 2000 the Fishery Research Institute (Instituto de Investigación Pesquera, INPESCA) start recording acoustic information from fishing vessels operating in the Central-South fleet of Chile for research purposes, using SIMRAD EK-60 echosounders and ES-38 split beam transducers. Since 2012, there exists a register of acoustic equipment in use by vessels of the industrial fishing fleet targeting mostly on small pelagics and Chilean jack mackerel, which is updated annually. The vessels were separated according to their acoustic equipment based on the type of echosounder. There are 29 vessels corresponding to 8 fishing companies, where most have acoustic equipment, mainly echosounders, which allow the recording and subsequent analysis of this information. It is important to highlight that a significant number of vessels are equipped with sonars that allow the collection of digital data and the measurement of fish sizes, in order to develop good fishing practices. With the purpose to identify fishing platforms able to collect ecological data, this paper provides an inventory or updated list of the acoustic equipment in use by vessels participant in the Chilean Jack mackerel fishery of Central-South Chile.

8. There was a question regarding the broadband units and whether this data can be processed in the same way as from the scientific echosounders. It was clarified that it could, but that the problem is the large quantity of data that they collect, which can amount to many terabytes. To address this problem, the data is collected in the conventional way (continuous wavelength) at a fixed frequency in order to reduce the quantity of data being collected.

9. The paper referred to semi-scientific systems which become “scientific” when they are calibrated. Note that the only difference between these digital systems is the lack of the internal algorithm to perform a calibration in the case of commercial type of digital echosounders, though is feasible to calibrate them as described in ICES 2015 (ICES Cooperative Research Report 236: Calibration of acoustic instruments). The expression “semi-scientific” for digital echosounders was used by dealers for marketing purposes only.

10. There was a question about bottlenecks that could exist in processing opportunistically collected acoustic data. It was clarified that there were indeed bottlenecks about the collection of the data, because it must be removed physically from hard disks aboard the vessels, the remote transmission of it is feasible though very expensive due to the large amount of data. Another aspect is that the analysis must be done by specialized staff and demands high-capacity computers.

3 Mapping spatial-temporal population density distribution of jack mackerel using a combination of the existing acoustic survey data and acoustic information as obtained from industry vessels

11. Peru presented SC9-HM04, on the Habitat conditions for Jack and Chub mackerel in the Peruvian Sea January 2020 to June 2021 (Peru, SC9-HM04)

12. The Workshop noted that the information provided by both the acoustic surveys and the Peruvian artisanal fleet are highly informative of the occurrence of jack mackerel in Peruvian jurisdictional waters, particularly south of 15°S, and asked whether it is planned that this data be incorporated into long-term modelling studies of jack mackerel habitat suitability, as it has not been considered in previous related studies.

13. It was confirmed that data is being collected from the artisanal fleet, to be analysed in the future.

14. There was a question about the update of the acoustic assessment of jack mackerel not including the full extent of the data superimposed with Peruvian catches, and that the landings don't seem to match so well with the acoustic assessments either. It was clarified that during the 1980s and early 1990s the industrial purse-seine fleet were mostly targeting sardines (*Sardinops sagax*), jack mackerel was caught mostly as a by-catch, and both were mostly used for fishmeal. When sardine entered into a declining trend by the mid 1990s, the fishing effort of this fleet gradually switched and started targeting jack mackerel, while still directing most of its catches to fishmeal. National legislation passed in 2002 established that sardine, jack mackerel and chub mackerel could only be used for direct human consumption, banning its use for fish meal, thus causing a sharp cut in catches and directed fishing effort. With regards to the updating of the acoustic estimates, it was explained that the acoustic data and analyses refer to the IMARPE surveys, mainly focused on anchoveta in more coastal areas, and it has been noted that variable and sometimes large portions of the jack mackerel potential distribution, and also of the main fishing areas during the year, are not covered by the more coastal acoustic surveys carried out early in the year. Hence, the annual catches shown don’t necessarily match acoustic abundance calculations. Furthermore, jack mackerel is known to perform an active avoidance to vessels, then biasing acoustic estimations.

15. Chile presented SC9-HM07, on space-time dynamics of the Jack mackerel fishery off south central Chile 2004-2021 (Chile, SC9-HM07). During the year 2021 (January-July) there was a strong concentration of fishing activity of Chilean jack mackerel (*Trachurus murphyi*) within the coastal area of 60 nm of the coast as well as that recorded in 2020 from where 97% of the total industrial landing were landed. This was allowed by: a) the high level of commercial aggregation presented by the schools of jack mackerel near the coast; b) the high recurrence of school sighting areas throughout this strip; c) the high abundance of schools, caused largely by the presence of areas of high biological productivity, and d) because these specimens captured during this year largely met the requirements (size and quality) of the industry for the production of by-products for human consumption, as observed in 2020. The few incursions into the ocean sector did not yield positive results, and the presence of a small fleet of trawlers outside the EEZ that searched for jack mackerel and finally

maintained its operation between High Sea waters off Iquique and Antofagasta, as well as the results of the direct evaluation of jack mackerel in 2021 which indicated that the resource was distributed mainly within the 60 nm strip confirming its coastal distribution, breaks in part with the space-temporal dynamics traditionally recorded in past decades, in which commercial schools were observed to migrate to the ocean sector during June and July approaching the limit of the EEZ and outside it, which was registered in previous years by the national fleet and by the international fleet.

16. Chile presented SC9-HM08_rev1 on Spatial distribution and acoustic habitat monitoring of Chilean jack mackerel from fishing vessels 2021 (Chile, SC9-HM08_rev1). Mean density estimates and spatial distribution obtained from acoustic data recorded by 6 vessels of the Chilean jack mackerel (CJM) fishing fleet in their usual fishing operations during year 2021 were estimated and compared with previous years. The abundance calculation was made for the years 2019, 2020 and 2021 based on a completely random sampling design through the geostatistical method. Acoustic data was collected with eco- integration systems that allow digital recording of the information during the entire trip of the vessels from the harbour to the fishing grounds and back to the harbour. During the fishing season of 2021 and unlike previous years, the CJM was located near the coast. It was also observed that the distribution of CJM expanded towards the north during the months of January, March, April and May, arriving near to Valparaiso. In June, July and August, CJM was observed near the port of Talcahuano. The highest acoustic densities were observed during the months of May and July. In 2021, the average densities obtained during almost every month were the highest in the series, except for 2019 with higher values in April. A bimodal condition was observed in the size structure of CJM with modes at 30 and 37 cm FL and a large contribution of specimens over 40 cm FL, evidencing a significant increase in specimen size of CJM, compared to previous years. An estimated abundance of 4,612 million individuals was calculated in 2021 representing a biomass of 3,217,169 tons (CV 3.79%). Estimated abundance and biomass represent a significant increase compared to 2020 that can be explained by a high density of schools in a reduced area of distribution and an increase in fish size. A comparison with the results obtained from the scientific acoustic survey conducted in the Central-South area between June and July 2021 was considered. An important decrease depending on the period considered for the estimation of biomass was obtained, in this case a decrease in the average densities between June and July of the year 2021 was observed. The estimated abundance of CJM only in June and July of 2021 was 1,857 million individuals, which represents a biomass of 1,295,440 tons (CV 3.77%).

17. Regarding the methodology used, the Workshop wondered how it deals with potential double counting of schools, targeting behaviour of the fishery (e.g., through communication between skippers), and observations during steaming vs during fishing. It was clarified that as you can see the movement of fish, there is probably the chance of double counting of schools. However, by trying to model each month separately they hope to minimise the effect of this. Probably the most important thing in estimating the abundance is to find the main aggregation, where by far the majority of the density of fish will be found.

18. It was noted that the maps show very clearly that there is a change in the concentration of schools which used to be more offshore, and are now closer into the coast. The Workshop considered the implication of this for trip based CPUE analysis and whether, if the schools are closer to the coast now, CPUE based on catch per trip might be artificially inflated by the fact that fish are now more accessible to the fishery. It was confirmed that the CPUE index that is used for the assessment at the moment is catch per trip and could be affected by this issue, so the possibility of a different index is being investigated, using a GLM model on catch per set with variables such as month of year, hold capacity etc. It is hoped that this will be an improvement. However, the nominal values of both CPUE indices have increased in recent years, due to the increase in availability in Jack mackerel, not just due to this kind of artifact.

19. It was noted that the CVs are very small, and the authors were asked whether they were using the Petitgas approach. It was clarified that they do separately model zeroes and positive values.

4 Characterize Jack mackerel habitat

20. The EU presented SC9-HM01 on Adapting the concept of metapopulations to large scale pelagic habitats (EU, SC9-HM01). It was noted that Gerlotto et al. (2012) proposed a pelagic habitat hypothesis for Jack mackerel through the concept of the "Environment Bounded Habitat" (EBH), in order to provide a stronger support to pelagic metapopulation hypothesis (MH) for this species. MH states that “after an environmentally induced geographical expansion of the ideal habitat, the population comes back along the time to its typical abundance, leaving autonomous sub-populations in different areas during tens or hundreds of generations”. This proposal intends to answer two questions: (1) does the idea of pelagic habitat makes sense? And (2) once this pelagic habitat confirmed, is it possible to observe a pelagic metapopulation? The authors considered these two questions confirmed positively through their EBH and MH hypotheses.

21. The Workshop raised the question that considering that EBH supports the hypothesized metapopulation for jack mackerel, during what periods has EBH been observed in the southeastern Pacific and how long did it take to establish a pelagic metapopulation, considering that the generation time of jack mackerel is greater than 10 years. It was clarified that Jack mackerel, during the period of expansion of the fishery, was in a phase of maximal expanded habitat, enabling the connectivity among sub-populations. However, there is no specific study on the duration of the expansion along the southeast Pacific, though it is clear that although we cannot know when this last expansion began, by lack of fishery data, we do know that this phase ended by the mid 1990s, perhaps accelerated by the strong El Niño event in 1997-98. After the expansion the sub-populations stayed relatively –not totally- isolated, as the EBH also states. Furthermore, the distribution and abundance of every sub-population depends on a number of different habitat conditions. For the northern Peruvian current in the Humboldt system some studies considered the conditions that enabled the last expansion of the Jack mackerel habitat.

22. The Workshop raised the question, of what the extraordinary environmental conditions that generated the population expansion of jack mackerel during the 90's would have been? It was clarified that since the early 1970s and late 1990s, at least for the northern Peruvian current in the Humboldt system, the oxygen minimum zone was consistently deeper compared to previous decades, creating the most favourable habitat conditions that benefited species like Jack mackerel, chub mackerel, sardine etc (e.g. in Bertrand et a. (2011); doi:10.1371/journal.pone.0029558). Those favourable conditions changed after the El Niño 1997-98, then reduced after El Niño 2002. Since that date, the habitat for Jack mackerel and others was modified and the abundance of these species decreased, as catches (and acoustic surveys) show.

23. The Workshop asked whether EBH requires asynchrony, and if asynchrony is lacking, does that mean EBH is wrong? What defines asynchrony? It was pointed out that the common definition of metapopulations states indeed that asynchrony between subpopulations must be the rule, but such permanent asynchrony is not compatible with EBH. Considering this last type of habitat, it was clarified that significant periods of asynchrony in local dynamics of sub populations existed (Gerlotto et al (2012)), as demonstrated by the existence of different local abundances, different fish length structures; and different spawning and recruitment in all the sub-populations. The reason why the asynchrony cannot be permanent in pelagic populations is due to the fact that, from time to time, synchronous large scale patterns of abundance exist, with e.g. the existence of strong cohorts present in the whole distribution area as observed during the 1980s and 1990s; but asynchrony is the rule during depleted periods (e.g. the last two decades) that are much longer than high abundance periods as paleostudies show (e.g. in Salvatecci et al. (2011, doi.org/10.1016/j.pocean.2019.05.006).

24. The Workshop asked whether we need continuous genetic studies with a very sensitive level of definition to solve the question as to whether Jack mackerel is establishing a kind of metapopulation. There was consensus supporting the initiative of global permanent genetic studies on the different subpopulations, to test the hypothesis. The use of new techniques that are likely to observe very small changes or drifts in the genetic pool in short periods (which is not possible using standard methods), could provide extremely interesting pieces of information. For example, it is not unlikely that some “relict” sub-population would remain in the

western part of the ocean after the huge extension during the 1990s; then observing potential drifts (and the speed of such drifts) could inform on the mechanisms and time scales of pelagic metapopulations. However, genetic studies would need to have high resolution to detect such genetic differentiation, which will depend on the number of generations and time-lapse of the different environmental phases (or regimes).

25. The Workshop noted i) the high connectivity of the habitat during the jack mackerel spawning season (Figure 7 in the EU paper); ii) the spawning records of jack mackerel throughout its entire range in the southeastern Pacific (e.g. Gerlotto et al., 2012); iii) low population segregation during early life history suggested by otolith microchemistry analysis (Ashford et al., 2011) and asked what the conditions are that would establish reproductive isolation to support the pelagic metapopulation hypothesis in jack mackerel? It was pointed out that it is not sure that there is high connectivity of habitat during the spawning season (Bertrand et al. 2016, doi.org/10.1016/j.pocean.2016.07.002), some observations on the "closure" of the habitats between the Peruvian and the Chilean subpopulation due to the narrow layer above the oxycline, on the contrary show that these two subpopulation are not connected during such a critical period. Nevertheless, this is worth a strong research effort to answer these questions, although development of certain environmental conditions are necessary to enable that connectivity.

26. The EU presented SC9-HM06 on Jack Mackerel habitat studies (EU, SC9-HM06) which consisted of two subprojects.

27. In their first sub-project, the EU noted that they found no relationship between catches and ENSO at any time lag.

28. Peru noted that in contrast, in their research, they found that both La Nina and El Nino conditions were affecting catches negatively; with higher catch rates found in years with slightly higher temperatures, or neutral La Nina/El Nino. It was agreed that El Nino/La Nina affect the ability to catch Jack mackerel, but this project could not find evidence for a correlation with distribution of the fish.

29. Peru also noted that El Nino/La Nina also has an effect on the anchoveta fishery, which is of higher value, and this therefore has a secondary effect on the Jack mackerel fishery.

30. It was noted that there is an oceanographic barrier between Chile and Peru, and it might be expected that this barrier may become stronger in different El Nino/La Nina conditions. This is why this research question was being investigated, but not even these big picture items could be detected in the data. It was recommended that in an update of this research the El Nino 1+2 region be also included in the analysis, not only the 3.4 El Niño area, which is less representative of changes occurring near the Peruvian coast.

31. The EU reported that they were lacking available data to progress the second sub-project as planned.

32. Peru presented SC9-HM02 on the Interannual variability of the habitat suitability of jack mackerel in the Northern Peru Current System, 2011-2019 (Peru, SC9-HM02).

33. The Workshop asked what was the effect that the seasonality of the industrial fishery in Peru (most captures occur during the first quarter) would have on the spatial-temporal modelled patterns (habitat predictors). It was agreed that the anchovy fishery has an effect on the jack mackerel fishery.

34. Considering that dissolved oxygen has been recognized as a critical variable for jack mackerel at its northern edge of distribution, the Workshop asked whether it would be possible to include it in future modelling of habitat suitability. It was agreed that this would be desirable to include, but it was not possible at present, being the goal to use the continuous acoustic detection of the upper limit of the oxygen minimum zone.

35. The catches of Jack mackerel in Peru, during seasons different than summer, strongly rely on the progress of the anchoveta fishing seasons, since the Jack mackerel fleet have permits to operate in both fisheries, with anchoveta being the main one in economic terms. It was also clarified that this research only used fishing sets where Jack mackerel was caught, so that that made it difficult for the Random Forest model to look at Jack mackerel data during colder months. To address that limitation, the feasibility of including data from artisanal vessels will be investigated.

36. The Workshop queried the significant relationship between the catch of Jack mackerel and Chlorophyll and whether Chlorophyll was related to the abundance of euphausiids for example, but it was noted that in fact Jack mackerel catch was associated with lower levels of chlorophyll. In fact, the effect of chlorophyll on the presence of Jack mackerel concentrations is an indirect one, since it has to transit up the food-web to at least the euphausids, which are one of the main prey of jack mackerel.

37. The Workshop asked about an apparent contradiction regarding the sea level anomaly (SLA), which apparently has different effects on the Random Forest and GAM described in Montero et al. (SC9-HM03). It was clarified that the Random Forest uses altimetry, not sea level anomaly (SLA) which was used by Montero et al. It was also noted that altimetry and SLA are indeed different variables, and that SLA is not affected by the seasonality, therefore in the next version of the Random Forest it will be tested as well as SLA.

38. EU presented an impromptu discussion following on the previous paper, looking at a prediction of jack mackerel presence from data collection during fishing operations using machine learning and a range of variables to see if it is possible to predict where jack mackerel may occur, including time series and using machine learning.

39. The Workshop asked whether the training includes information from the assessment, i.e. whether the "presence" model includes information on population abundance. It was clarified that this was the case. The Workshop asked whether detection of minimum oxygen from satellite was included. The presenter was not sure, but agreed that it would be sensible to include it.

40. Peru presented SC9-HM03 on Relating sea level anomaly to ocean vorticity and catches of Jack mackerel (Peru, SC9-HM03). It highlighted the finding of a larger proportion of fish and zooplankton inside six types of internal structure, all of them characterized by showing a deeper oxygen minimum zone. Every type of internal structure has also been found to specific areas by groups of dominant species. Sea level anomaly (SLA) has been found to be a key parameter to progress toward habitat modelling of Jack mackerel.

5 Habitat Monitoring Symposium

41. The Symposium Steering Committee presented SC9-HM10, the draft Terms of Reference for the Habitat Monitoring Symposium planned for December 2022. The Steering Committee have had feedback on an earlier draft of the Terms of Reference for the Habitat Monitoring Symposium. They are hoping for an audience of about 200 attendees, with workshops held in association with the symposium. They propose an abstract submission deadline for June 2022, with presentations no more than 15 minutes and publication of papers in a special issue of a journal. The Workshop suggested that there is very often a delay in getting special issues for 2022 symposiums which are already being planned. So, the steering committee may need to contact the potential journals well in advance. Some journals may also require payment to fund these special issues.

42. The Workshop asked for more specific details on the sessions- the areas to be covered in each session, and it was clarified that an amended version of the Terms of Reference would be presented as SC9-HM10_rev1 at SC9.

43. The Steering Committee identified a need for more members from the Scientific Committee to be involved in planning for this significant initiative.

6 Recommendations

44. The workshop compiled a set of recommendations to be considered by the SC and Commission:

- To review and eventually approve the ToR for the two sub-Working Groups of the HMWG (for the review of assessment methods, and classification of fishing vessels according to their technological capabilities).
- To approve the proposal of conducting a HMWG workshop testing different assessment methods on a common data base.
- To create a repository of acoustic data at SPRFMO, where Scientific Committee members can contribute samples of acoustic data and metadata to be used in the different quantitative exercises oriented to test different assessment methods to be reviewed by the HMWG.
- In connection with previous recommendation, to adopt the ICES metadata convention system (ICES 2016) in order to properly identify the collected acoustic data and its use for quantitative purposes.
- To review the CJM CPUE based on trips given the habitat monitoring review showing the relative abundance moving closer to the coast along central Chile. The workshop recommended that the CPUE index be updated to evaluate this potential impact prior to the planned Jack mackerel benchmark assessment (May 2022).
- To review the ToR of the HMWG on the scope of defining a population structure for any species, at least the ones whose specific characterization is being approached by other working groups.

Annex 1: List of Participants

HMWG CHAIRPERSONS

Mariano Gutierrez

Aquiles Sepulveda

SC CHAIRPERSON

Jim Ianelli

Chile

Sebastian Vasquez
Nicolás Alegría
Victor Espejo

European Union

Martin Pastoors
Niels Hintzen
Francois Gerlotto

Korea

Eunjung Kim

New Zealand

Marco Milardi

Peru

Jorge Csirke
Pablo Marin
Enrique Ramos
Daniel Grados
Salvador Peraltilla

OTHER WORKING GROUP MEMBERS

Mark Sytse
Carlos González

SPRFMO Secretariat

Marianne Vignaux

Annex 2: SCW12 Meeting Agenda

1.Evaluate the applicability of data collected from fishing vessels targeting pelagic species:
- Preliminary classification of fleet by acoustic data collection capabilities (Peru, SC9-HM05)
- Acoustic Equipment of the Purse Seine Fleet of Central-South Chile (Chile, SC9-HM09

2. Mapping spatial-temporal population density distribution of jack mackerel using a combination of the existing acoustic survey data and acoustic information as obtained from industry vessels :

- Habitat conditions for Jack and Chub mackerel in the Peruvian Sea January 2020 to June 2021 (Peru, SC9-HM04)
- Space-time dynamics of the Jack mackerel fishery off south central Chile 2004-2021 (Chile, SC9-HM07)
- Spatial distribution and acoustic habitat monitoring of Chilean jack mackerel from fishing vessels 2021 (Chile, SC9-HM08)

3. Characterize jack mackerel habitat

- Adapting the concept of metapopulations to large scale pelagic habitats (EU, SC9-HM01)
- Jack Mackerel habitat studies (EU, SC9-HM06)
- Interannual variability of the habitat suitability of jack mackerel in the Northern Peru Current System, 2011-2019 (Peru, SC9-HM02)
- Relating sea surface anomaly to ocean vorticity and catches of Jack mackerel (Peru, SC9-HM03)

4. Draft Terms of Reference for Habitat Monitoring Symposium (Symposium Steering Group, SC9-HM10)