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Report of the 5th workshop on diagnosis of the status of the South Pacific Jack mackerel fishery in Peru

SNP Scientific Committee

REPORT OF THE 5TH WORKSHOP ON DIAGNOSIS OF THE STATUS OF THE SOUTH PACIFIC JACK MACKEREL (*Trachurus murphyi*) FISHERY IN PERU
SNP Scientific Committee, Lima, Peru, 3-5 September, 2014

Following a proposal of the Peruvian Delegation to SPRFMO in 2009 (*document SP-07-SWG-JM-SA-08: Ecosystem indexes obtained from fishing monitoring (methodological proposal on direct stock assessment for marine resources of the SPRFMO area), Lima, May, 2009*), and the recommendations of SPRFMO on monitoring of South Pacific Jack Mackerel (JM) using acoustic data from the fishery (Lima, October, 2012), the Scientific Committee of the National Fisheries Society of Peru (*Sociedad Nacional de Pesqueria, SNP*) is organizing since 2011 an annual workshop on "Diagnosis on the JM resource status" using acoustic and other data recorded onboard of fishing vessels from the main fishing companies in Peru. This document reports on the 5th workshop organized in Lima, Peru, 3-5 September, 2014.

The objectives of the workshop were: to establish a diagnostic of the population of JM in the SPRFMO Far North stock i.e. the stock concentrated in the Peruvian jurisdictional waters, and to link this status with environmental characteristics; to evaluate a number of indicators that are collected routinely since March, 2011, in order to follow the changes in the environment and in the population; to provide to the SNP Scientific Committee and fishing companies tools for a better management of their own activities in the JM fishery; to understand the relationships between the JM and the main parameters of the ecosystem; to improve the stock assessment methods using new scientific information collected by the fishing vessels; to study the population structure; to build, improve and describe the potential habitat of the population in the Peruvian waters; to feed the Marine Institute of Peru (IMARPE) with a new set of data to help formulating recommendations for the management of the JM.

Note. Due to the similarities of the fisheries and behaviors of jack mackerel and mackerel (*Scomber japonicus*), when separate analyses are not specified, the results are given for the two species together.

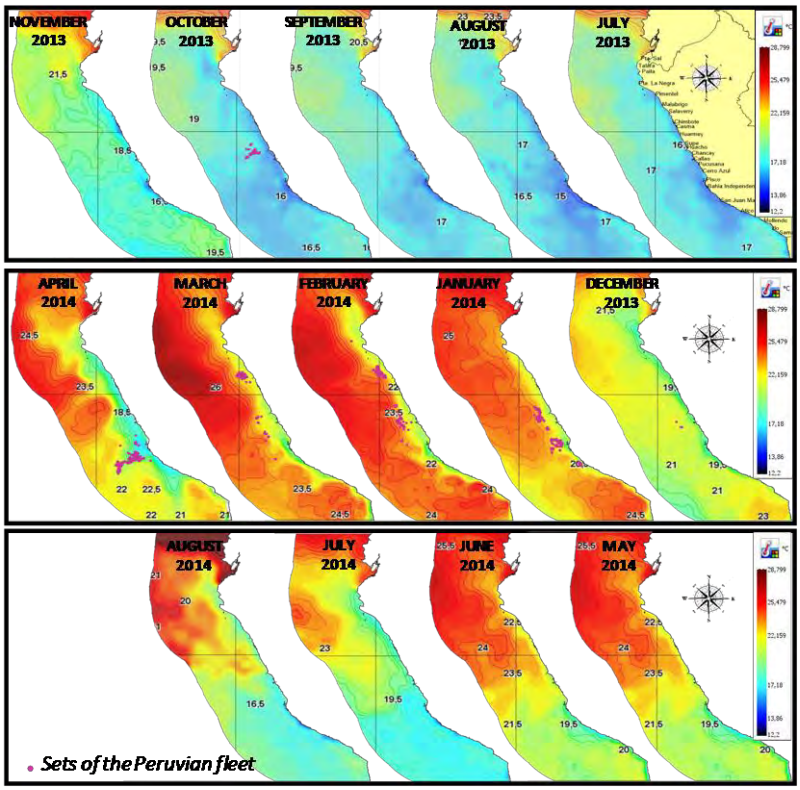
Material and methods

A series of data were collected and processed: satellite data and maps from environmental models; geo-referred catches by set by day; general landings by harbor by day; geographical positions of fishing vessels using a high resolution vessel monitoring system (SISESAT) by day; length structure information from the landings by harbor by day; acoustic data (echo integration) from the vessels equipped with Simrad ES60 echo sounders, detailed by species and geo-referred for each half nautical mile by day by vessel. These data were processed using a large set of standard methods and tools. Analysis methods are standard. Compared to the former workshop, a new analysis was performed on the use of some surveys to identify in 3D the Oxygen Minimum Zone (OMZ) and the depth of the oxycline. CPUE are calculated as the catch (in tons) / duration of the trip (in hours).

Results

Relationships between the main characteristics of the environment and the JM distribution.

Sea surface temperature. 2014 is characterized by cold waters at the beginning followed by warm temperatures since May (figure 1). Indeed the area suffered 3 Kelvin waves, the strongest occurring in May-June, and a "coastal" El Niño (Mayo 2014-august 2014). In synthesis the year 2014 presents positive anomalies compared to the average year.



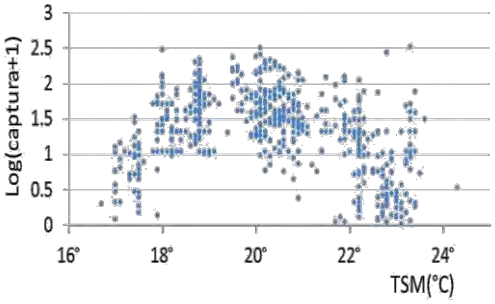


Figure 1

Above. Distribution of JM catches related to SST (July 2013 to August 2014)
Left. Sea Surface Temperature during the period July 2013 to August 2014. Monthly distribution, from right to left.

The catch data of JM showed that the distribution of this fish is limited by the isotherms 17ºC and 24ºC, as observed on figure 1.

Salinity. This parameter does not present a strong influence in the JM distribution as salinity is limited to a range of 34.9 to 35.3 ups. 2014 was an average year.

Chlorophyll. It presented high densities during the beginning of the year in the Centre area (Callao), decreasing after March, but staying at a rather high level (Figure 2). Since July high concentrations have been observed in the North. Fish concentrations are found in the surroundings of the high concentrations of Chlorophyll (figure 2)

Oxygen. For the first time this parameter was measured using the acoustic proxy as developed by Ballón et al (2011)[1] and Bertrand et al (2012)[2]. This exercise did not cover the complete fishing area but the results were encouraging enough (figure 3). They show that the oxycline was superficial along the coastline

[1] Ballón, M., A. Bertrand, A. Lebourges-Dhaussy, M. Gutiérrez, P. Ayón, D. Grados, F. Gerlotto, 2011. Is there enough zooplankton to feed forage fish populations off Peru? An acoustic (positive) answer. Progress in Oceanography 91(2011):360-381

[2] Bertrand, A., A. Chaigneau, S. Peraltilla, J. Ledesma, M. Graco, F. Monetti, F.P. Chavez, 2012. Oxygen: a fundamental property regulating pelagic ecosystems structure in the coastal southern tropical Pacific. PLoS One 6(12)

(shallower than 30 m). The relationship with plankton concentrations was also observed, the densest patches ofzooplankton being only present in areas where the oxycline is below 30 m depth (figure 3).

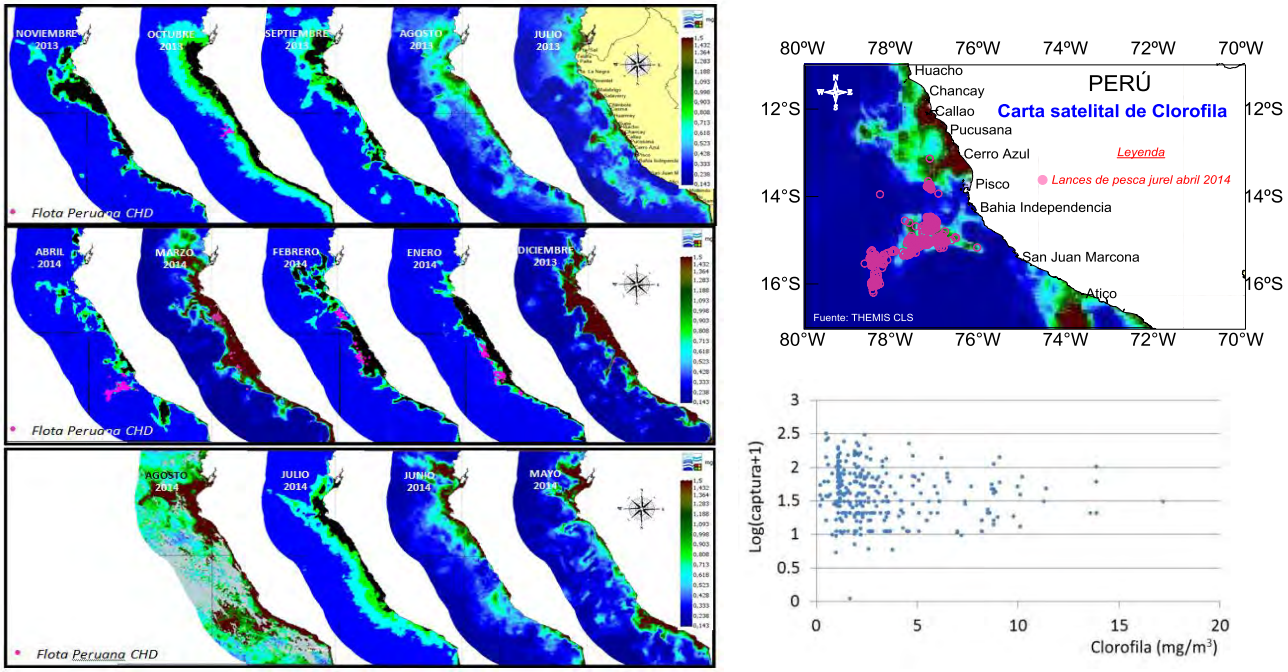


Figure 2. Left: Monthly concentration of Chlorophyll along the coast of Peru for the period July 2013 – August 2014 . Right: Relationships between jack mackerel catches and Chlorophyll. Above: example of spatial distribution of catches (purple circles) surrounding a high concentration spot in the Centre of the coastline of Peru. Below: relationships between catch and Chl concentrations.

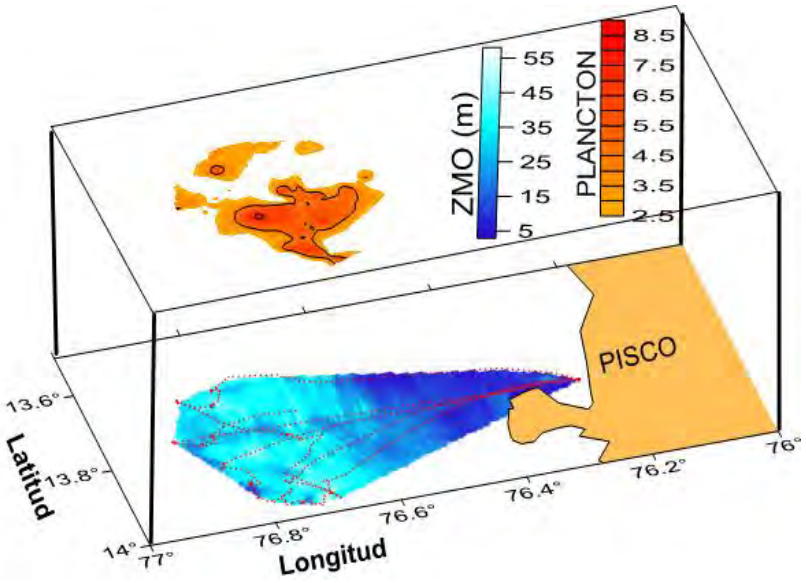


Figure 3. Example of oxycline depth mapping using acoustic information. This drawing was obtained using two vessel trips (same ship) from Pisco. Black dots show the SISESAT location of the vessel; red dots the fishing operations; the blue scale shows the oxycline depth and red scale the zooplankton concentration above 2.5 $m^2.nm^{-1}$ in this area (as observed on the echograms and evaluated using ECHOVIEW software). It allows observing that the sets as well as the plankton concentration occur outside the shallow area of the OMZ

Catches, abundance and biomass[3]

A comparative analysis of the spatial distribution of catches between the years 2011 to 2014 is given on figure 4. The catches during the first half of year 2014 are distributed all over the coastline north of latitude 15ºS. It is impossible to know whether this limit represents the actual limit of jack mackerel distribution or if it represents the limit of the fishery area of exploitation. Nevertheless it is interesting to observe that catches in 2014 were more similar in their spatial distribution to 2011 than to 2012-2013. The fishing season occurred from January to May (Austral summer and autumn) as in the former years, indicating that resource is more available during these seasons (figure 4). The CPUE is positively correlated with landings, which allows considering that they are be linked with the SST (see figure 2). Catches are also strongly related to the Chlorophyll distribution and the depth of the oxycline.

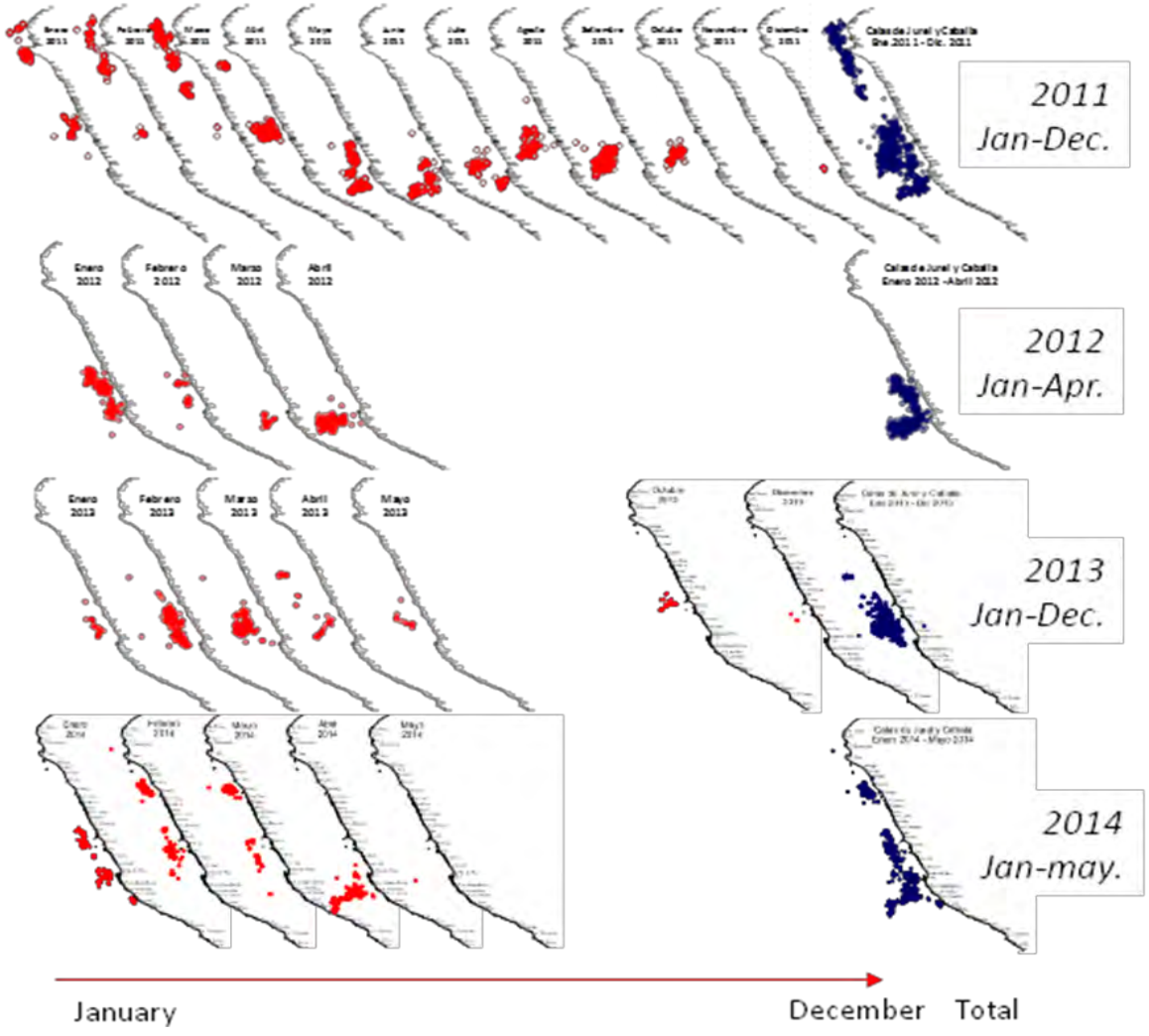


Figure 4. Monthly distribution of jack mackerel catches over the years 2011 to 2014.
Maps with red dots: monthly distribution of effort. Maps with blue dots: annual distribution of effort

Finally, although it has not been calculated, it is likely that there is a relationship between the mean CPUE and the abundance, as it can be observed on the diagram on figure 5

[3] Abundance refers to the quantification of observed concentration of fish at sea using acoustic methods. It is limited to the survey areas. Biomass refers to the whole population, and is evaluated using the model developed by SNP.

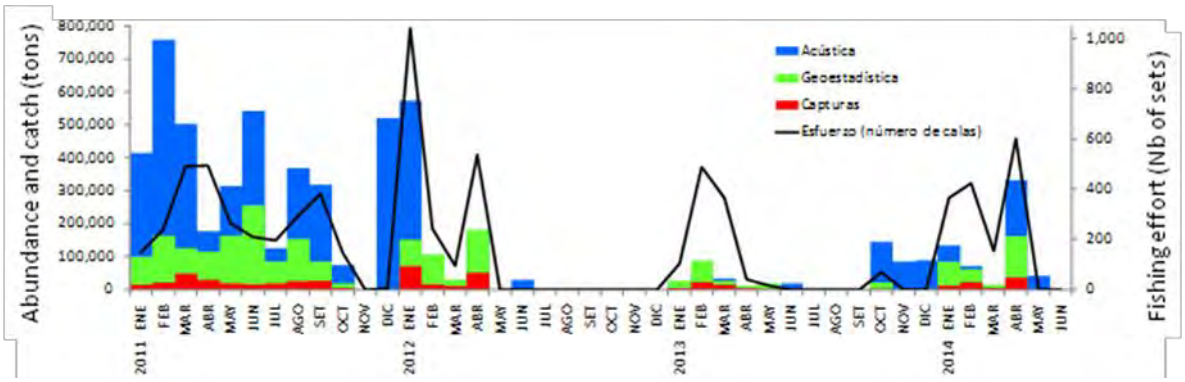


Figure 5. Diagram of the monthly evolution of abundance, catch and effort from January, 2011 until May, 2014. During the period July to November, 2012, the fishery was closed. Histograms in blue: abundance estimate by acoustics in tons. Histogram in green: abundance estimate by geostatistics in tons; histograms in red: catches in tons; solid line: fishing effort (number of sets)

Although only 10 % of the information has been used, the high number of data makes the results representative of the area covered by the fleet. The monthly abundance measured with acoustics varied between 20 000 and 332 000 tons (figure 6). During the 4 years since the beginning of the monitoring, the monthly values of abundance fluctuated between 8 000 (March, 2013) and 758 000 tons (February, 2011). According to the months, the distribution area fluctuated between 268 MN2 (May, 2013) and 3 373 NM2 (June 2011); and the catch between 1 200 and 73 000 tons. The total catch for the 4 years was 518 000 tons.

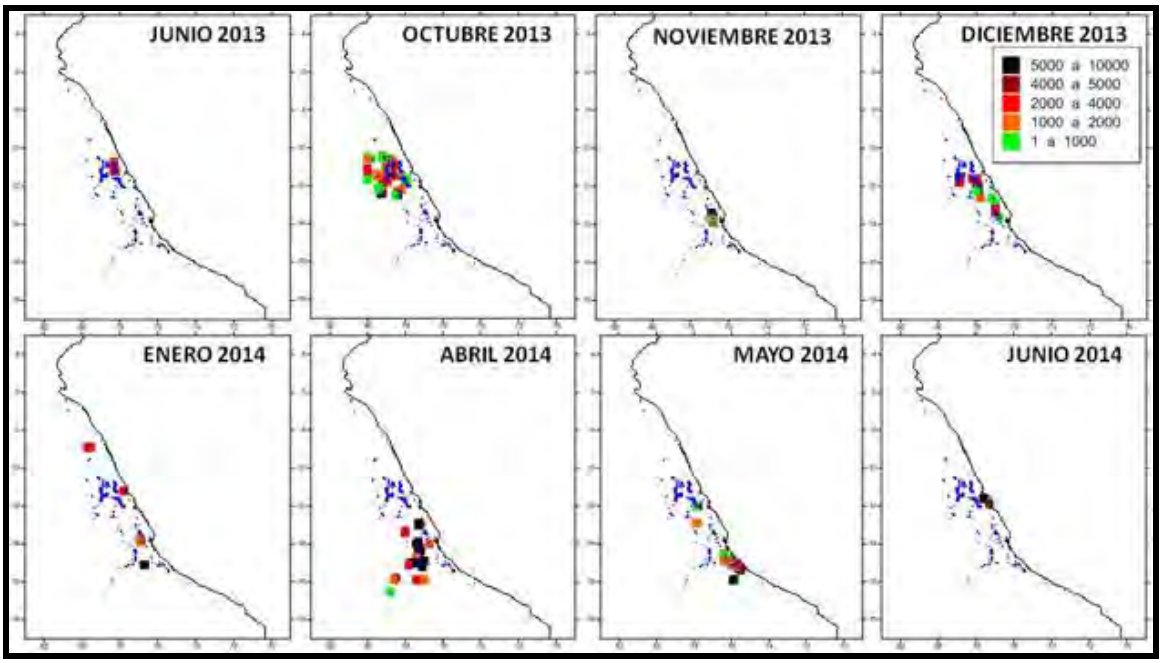


Figure 6. Acoustical monthly abundance by statistical squares for some months within the period June 2013 to June 2014. Blue points represent the location of the schools during this period.

For biomass estimates, the probability model on the JM distribution that was developed in 2013 was applied on the 2014 data first in April then in August. This model evaluated the distribution area to 14 123 MN^2, with a biomass evaluated between 207 000 and 421 000 tons in April, and between 332 000 and 673 000 tons over an area of 35 336 NM^2 in August.

Demographic structure

It is presented on the figure 7. We must point out two observations.

- During 2014 the observed modes fluctuated between 24 and 43 cm length, with a mode at 33cm, corresponding to 3-year old individuals. No old fish are caught in the Peruvian waters. Interestingly catches of young fish were reported by the artisanal fishery within the 10 NM area off the coast (out of access to the industrial fishery).This information is detailed in the National Report of Peru to SPRFMO.
- The cohort born in 2008, which was representing the bulk of the catches since 2011, was not present in 2014. Its last exploitation occurred in early 2013.
- On the other hand a new cohort appeared, likely born in 2011, which is representing most of the catch and shows that the population is maintained.

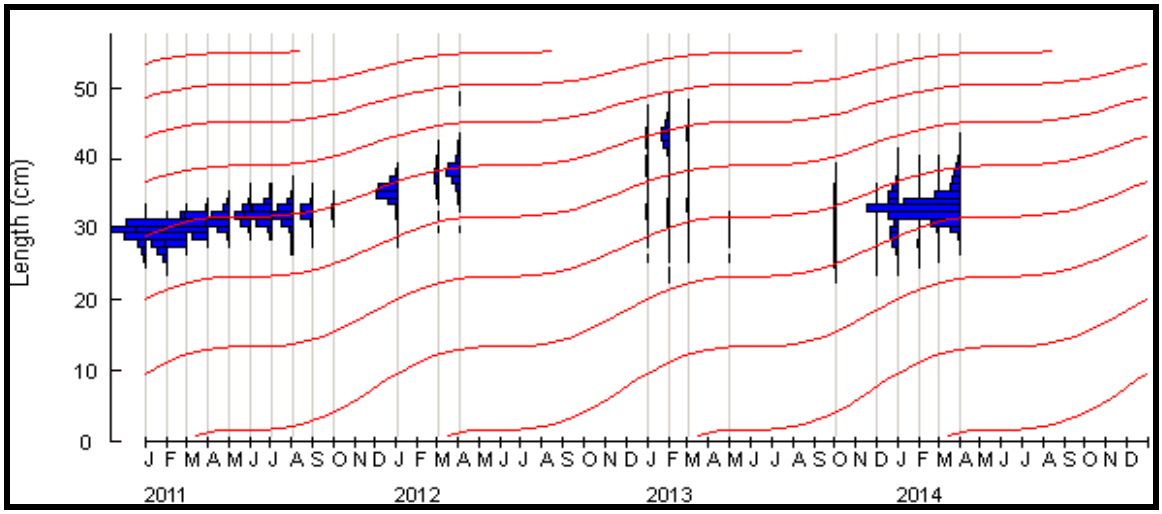


Figure 7. Detail of the demographic structure of the catch, per month, since january, 2011

Habitat

The habitat was defined with the same parameters as in 2013, as they were confirmed by the oceanographic measurements. These parameters are synthesized in the table 2.

It is worth noting that these parameters are mostly two-dimensional (horizontal) while the third dimension, especially as far as dissolved oxygen concentrations (DO) are concerned, is another key parameter to be considered. This will be a topic for the next workshops.

Table 2. Higher and lower limits of the main parameters used in the habitat definition (the distance 0-200 NM corresponds to the jurisdictional area of Peruvian waters)

Parameter	Lower limit	Higher limit
SST	15ºC	26ºC
SSS (sea surf. salinity)	35.05‰	35.15‰
Bathymetry	150 m	-
SST anomaly	-1ºC	+1ºC
Distance to the coast	0 NM	200 NM
CHL	0.13	5 µg. L^{-1}

Using these parameters, the habitat was drawn for each month. An example is given in figure 8.

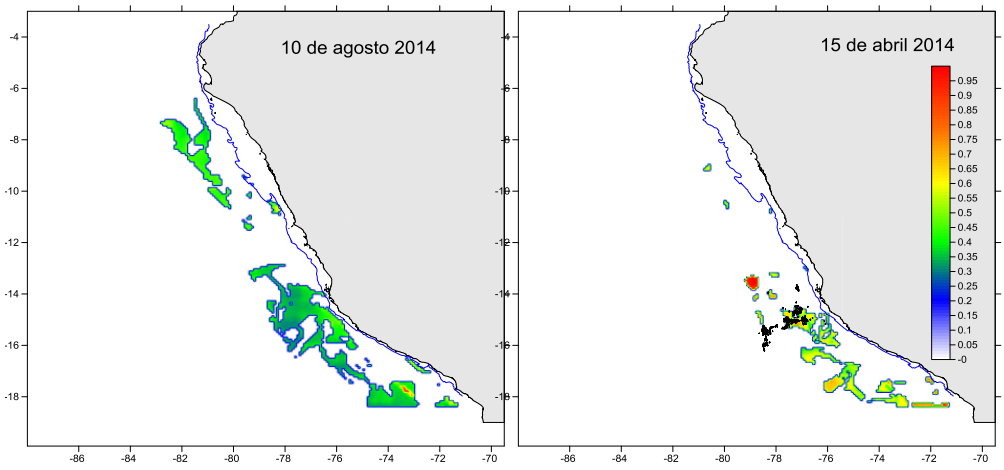


Figure 8. Result of the model calculation of the jack mackerel habitat for August and April, 2014 (values between 0 and 1, see color scale). The black dots show the location of the purse seine sets during the same period.

We can notice that fish were exploited in most of the habitat area, contrarily to 2013 where no catch was done in the northern part of the habitat. As in the former years, no jack mackerel was caught on the continental shelf (bottom depth 150 m).

Schools

Schools are more abundant by day (60%) than by night (40%). The major results are synthesized in the table 3. Schools are observed everywhere along the coastline, but mostly between 11ºS and 16ºS, with a more limited group between 4ºS and 10ºS. The year 2011 present a different pattern compared to the other, with an important concentration of schools between 4ºS and 10ºS. In 2012 and 2013 the schools were mostly concentrated south of 9ºS, and in 2014 south of 14ºS.

Table 3. Main characteristics of jack mackerel schools during the years 2011 – 2014
(*) Value in log(NASC+1). ESDU: NASC for the whole biomass in an ESDU; Schools: NASC value for a single school
(* : modal values)

Year	2011	2012	2013	2014
Nb schools	1325	785	409	842
Dist coast (NM) *	45	50	40	20
Mean depth (m) *	17	20	10	25
Diameter (m) *	18	15	30	10

Conclusions and recommendations

The South Pacific Jack Mackerel presents a high ecological plasticity in many of the major parameters that drive the water masses, as well as because of its high capacities in movements and migrations allowing the adaptation to changes in the water masses distribution. These characteristics have an impact on the fishery (CPUE and accessibility to fishing grounds). The strong mechanisms of the South Pacific Ocean (Kelvin waves, ENSOs, etc.) are also major events that must be taken into consideration.

Conclusions

The year 2013 began as a cold year, but strong anomalies occurred from June to August (-1.4ºC), during which three Kelvin waves arrived in the Peruvian waters in autumn, 2014, resulting in an increase of the SST (+3.5ºC).

In September the SST is still above the average of this month (+0.1 to +0.3ºC). Using these hydrologic results, the potential habitat of jack mackerel could be evaluated and appeared to be less extended than in 2011, especially in the north. Besides, it has been demonstrated that the depth of the oxycline is a key parameter for drawing the potential habitat, which will be done in the future workshops.

The demographic structure of the population was analyzed and showed that during the 1st trimester 2014 the bulk of the catch was done on 3-year old fish. The growth curve of the stock in Peruvian waters is significantly different from the one in other areas of the fish distribution, confirming the specificity of the Peruvian (Far North) subpopulation.

Except in 2011, the fishing season in 2012-2014 was mostly limited to the period January-May (summer-autumn). Nevertheless, compared to the former years, 2014 presented warm situations (Kelvin waves), which effect is to concentrate jack mackerel closer to the coast, making it more accessible to the fishery. The CPUE is the lowest in 2014 compared to the high values of 2011-2012 (normal to warm situation) and the medium values of 2013 (colder situation), which is likely due to the extension of the fishing ground at larger distance to the coast. The biomass measured with acoustics varied between 20 000 and 332 000 tons. During the 4 years monitored, the biomass fluctuated between 8 000 (March, 2013) and 758 000 tons (February, 2011). The distribution area fluctuated between 268 MN2 (May, 2013) and 3 373 NM2 (June 2011); and the catch between 1 200 and 73 000 tons. The total catch for the 4 years was 518 000 tons.

Recommendations

The workshop recommends continuing to extract standardized indicators from the metrics collected aboard fishing vessels. Since a series of years already exists, the relationships between these potential indicators and the environmental (and fishery) changes will be possible to establish. This should be a new activity during the future workshops. A list of relevant indicators will be established.

Once this list been established, a standardized protocol for data collection and analysis should be defined and submitted to the fishing companies. It is recommended to the SNP developing a short and medium term project for a joint activity with the fishing companies in order to produce the protocol for routine collection and analysis of data

Demographic structures are essential for monitoring the stocks. It is recommended to develop training facilities for the crews in order to let them identify correctly the major species captured.

The future activities to be developed by the SNP Scientific Committee, following the recommendation of this workshop as well as those of the SPRFMO, should be the following:

- Monitoring the jack mackerel populations inside the Peruvian waters using existing and new (ECHOPEN) tools, following the same methods as in the former workshops.
- Analysis of the potential habitat with the fishing activities and the development of exploratory activities outside the fishing grounds and the IMARPE survey areas, as well as introducing new parameters (vertical distribution of DO, for instance).
- Considering the recommendations of the international workshop on fishing vessels as scientific platforms, especially in the need for standardized settings of the vessel instruments and the calibration procedures.
- A special recommendation is made towards SPRFMO on the opportunity to consider how to develop an international project on JM tagging (e.g. preliminary experiments, etc.).

SNP, Lima, 18 September, 2014