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Report of the 6th SNP workshop on diagnosis of the status of the Jack mackerel fishery in Peru

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REPORT OF THE 6TH WORKSHOP ON DIAGNOSIS OF THE STATUS OF JACK MACKEREL (Trachurus murphyi) FISHERY IN PERU

METHODOLOGY USED AND PRODUCTION OF SOUND PROTOCOLS

SNP Scientific Committee, Lima, Peru, 2-4 September, 2015

EXECUTIVE SUMMARY

I. INTRODUCTION

Since the year 2010, the National Fisheries Society (SNP), seeking for sustainable development of Peruvian fisheries, has been promoting and impelling scientific activities, related to the knowledge and understanding of the jack mackerel dynamics, through the use of information collected by the fishing fleet, as complement to the researches performed by Marine Research Institute of Peru- IMARPE, and as a contribution to the works of the South Pacific Regional Fisheries Management Organization (SPRFMO).

In this context, a dedicated workshop is performed each year, the last one being achieved in September, 2014. Its results were presented at the Meeting of the SPRFMO Scientific Committee in Honolulu, USA. It presented the diagnosis of the jack mackerel (JM) population in Peruvian waters, its bonds with the environmental characteristics, the improvement of the stock assessment methods, the study of the population structure, the description of the potential habitat of the population, among others.

The year 2015 represents a phase of great environmental disturbances in the Peruvian sea, with a phenomenon El Niño that is expected to grow from strong to exceptional, and threats represented by the arrival of Kelvin waves; such environmental situations are likely to deeply affect the state of JM populations. Indeed JM fishery appeared to be weak to null in Peruvian waters during this year. Facing this situation, with almost no new data to process, the SNP Scientific Committee decided to focus the activities of the 6th workshop towards a general review of the methodology used and to produce sound protocols for description and analysis of the following components: estimation of abundance by acoustic and geostatistic methods; estimation of CPUEs; estimation of the potential habitat; estimation of the modal progression of the demographic dynamics; protocol of calibration of echosounders; design of indicators of the fleet fishing effort through VMS data analysis, among others.

The 6th workshop, organized in Lima by the SNP in September, 2-4, was also supported by the College of Engineers of Peru, the College of Biologists of Peru, the World Wildlife Fund -WWF and The Natural Conservancy (TNC).

II. GENERAL OBJECTIVES

The general mission of this 6th workshop was to examine, to analyze, to describe the methodologies developed and to elaborate protocols, in its different components from the evaluations of the state of the JM resource, with data and information from the fishing vessels, to the improvement of methods and tools designed for the fisheries science.

III. SPECIFIC OBJECTIVES

The specific objectives of the 6th workshop were the followings:

1. Abundance estimates of JM by acoustic methods: Methodology, description, analysis, design of an adapted data format and construction of a general data base.
2. Abundance estimates using geostatistic methods: methodological description, analysis, data format, general protocol.
3. Estimation of CPUEs: Methodological description, analysis, data format.
4. Estimation of the JM potential habitat: methodological description, analysis, data format.
5. Analysis of the Modal progression of JM: methodological description, analysis, data format.
6. Elaboration of a Calibration protocol for echosounders aboard fishing vessels.
7. Methodological description for calculating indicators of fishing effort of the fleet through satellite SISESAT system.

IV. DEVELOPMENT OF THE 6th WORKSHOP

The 6th workshop presented two parts; one oriented to the presentations of advances of works related to the objectives of the workshop and the second to the development of the objectives of the workshop.

4.1. Presentation of works related to the objectives of the 6th workshop

The following presentations were made:

- "Protocol of calibration, measurement of noise and elimination of digital interferences in ecogramas generated on board of fishing vessels" - Cynthia Vasquez Paredes - SNP.

  The author indicated that the fishing industrial fleet in Peru accounts with digital acoustic technology, in special digital echosounders, which acoustic data are not operated for quantitative studies of marine species, because these detections have not been obtained with calibrated instruments. For the potential use of this acoustic data in ecological and fisheries research the calibration is necessary, as well as measuring the noise level and eliminating the possible interferences.

  The methodology used in this protocol is adapted from standard procedures published in international papers. It presents two phases: first it consists in the registry of digital acoustic data obtained of echosounders during calibration and second in the post processing of the acoustic data with the algorithms developed inside the Echoview software (Myriax, Australia).

- "Analysis of the technological characteristics of the anchovy fleet for direct and indirect human consumption of Peru" – Alejandro Campos - UNFV/TNC.

  The author indicates that in order to contribute to the development of the anchovy fishery it is needed to characterize the technological state of the fleets designed for direct and indirect human consumption.

  The purpose of this contribution is to elaborate a classification of the anchovy fleet in fleet segments (artisanal, smaller scale, industrial wood and steel vessels) and by technological components: (i) navigation (Radar, GPS, etc.), (ii) Detection (echosounders and sonars), (iii) gears and fishing tools (deck equipment), (iv) preservation on board (Refrigerated Sea Water- RSW, Chilled Sea Water- CSW, etc.) (v) training and (vi) support in the previous components.

  For such goal interviews to experts and suppliers of the fishing sector who determined the optimal equipment for each component are achieved. Then with the surveys to the fleet segments the state of the art of the technology of the fleet is determined. The final objective is being to recognize the major strong and weak points and to correct/optimize them.

- Digital echo trace typology from single frequency systems for the abundance estimate of the main pelagic resources. Gustavo Cuadros. UNFV/WWF.

  The author mentioned that in the last years the field of the acoustics focused to the commercial fishing has advanced substantially, the commercial boats are equipped with echosounders and sophisticated sonar systems, being some models of advanced design and yield similar to scientific echosounders used for the scientific research.

  The acoustic methods can be used to satisfy an ample range of scientific and management objectives such as characterizing the distribution of pelagic species, considering the stock abundance and observing the behavior of the fish.

  The aim of this research is to be able to review the present methods to classify and to apply typologies to digital single frequency ecogramas, which are typically the technology available in a modern fishing vessel in Peru. Also it includes a revision of the reflectivity measurements that are used for considering the abundance of fish by acoustic methods, and the alternatives analyses will be described. Therefore, a practical use will be to make practical the use of acoustic data that are recorded aboard of commercial fishing vessels equipped with echosounders operating with a single frequency.

  In this way a methodological protocol will be given that could be used for analyzing each fishing trip, whit the purpose of providing efficient tools for fishing management by the companies, which could represent a potential source of cooperation with the IMARPE, Ministry of Production/ Vice-ministry of Fisheries- PRODUCE, among others**.**

- Model of potential habitat for the jack mackerel (*Trachurus murphyi)* validated through acoustic information and catches of the industrial fishing vessels. Carlos Valdez. TASA.

  The author indicates that jack mackerel (*Trachurus murphyi*) has an wide habitat distribution from Australia (west) to Ecuador (north-east). Within this large area the fish has been historically exploited by diverse countries, mainly Chile, Russia, China, Peru, New Zealand, EU, etc. The intense exploitation of this resource in the South Pacific is responsible (among other causes) of overexploitation. During good conditions, the jack mackerel tends to expand throughout the "Jack Mackerel Belt", and in bad conditions such as the present one, is concentrated along the Peruvian coasts and in the Center-South of Chile.

  A model of potential habitat of jack mackerel has been developed based on 4 sea surface variables (temperature, thermal anomalies, salinity and chlorophyll) and 2 positional variables (depth and distance to coast) that allow to understand its behavior in national jurisdictional waters. In order to improve, to calibrate and validate the model it was necessary to integrate direct information obtained from the industrial fishing fleet dedicated to fishing for human consumption e.g. catch and acoustic data. Results of the model show that the habitat dimension increases when the probability decreases (during cold conditions) and vice versa, the habitat is reduced when the fish concentrates (during warm conditions). The model will serve as a management tool to optimize the time and expenses in the search of JM concentrations, through identification of zones with greater probability of finding fishing.

V. DEVELOPMENT OF THE OBJECTIVES OF THE 6th WORKSHOP

In order to fulfill the objectives of the 6th workshop, the following activities were organized in groups of scientists.

A. Abundance estimation by acoustic methods: Salvador Peraltilla- Gustavo Cuadros
B. Abundance estimation by geostatistic methods: Mariano Gutierrez, Francois Gerlotto and Rosa Vinatea
C. Estimation of the CPUE: Aníbal Aliaga, Gloria Meneses and Alejandro Campos.
D. Estimation of the potential habitat of jack mackerel: Carlos Valdez and Cristian Vasquez
E. Analysis of the Modal progression of jack mackerel: Edwin Yarleque, Emilio Méndez and Alex Zuzunaga
F. Echosounder calibration protocol: Cynthia Vásquez, Mariano Gutiérrez and Alex Espinoza
G. Methodological description of establishment of indicators on the fishing fleet effort using SISESAT system of satellite pursuit: Rocio Joo and Rosa Vinatea.

The elaborated protocols were submitted to discussion according to their advances during intermediary session, then, finally approved during the last plenary session. They are still subject to improvements if necessary, which will be defined during ground truth trials and communicated to the members of the workshop.

The elaborated protocols are enclosed in the annexes of the present report of the workshop

RECOMMENDATIONS

1. To publish the protocols at national and international level, in universities journals and reviews, etc.
2. To transmit the protocols to the Marine Research Institute of Peru- IMARPE for information and organize a joint workshop SNP- IMARPE with the purpose to standardize protocols.
3. To spread the protocols in the different related events and particularly in the SPRFMO Scientific Committee meeting, the FAO international fisheries meetings, COP meetings of the Climate Change Convention, Biodiversity Convention and for the implementation of the Agreement between Fishery Private Sector Organization from Peru, Chile and Ecuador.
4. In the annually SNP jack Mackerel Workshop, increase the number of assessed species such as: Anchovy, mesopelagic species, zooplankton etc.
5. Propose designing and final establishment of the simultaneous monitoring operation of the marine ecosystem, using fishing vessels as scientific platform.

Annexes

Abstracts of Protocols

1. PROTOCOL FOR ABUNDANCE ESTIMATION USING ACOUSTIC METHODS

Objectives: to estimate abundance in fishing zones using acoustic information from the fishing fleet in Peruvian jurisdictional waters; to transmit the estimation to SNP for use by the fishing companies and the management staffs.

Methodology and protocol: Use of acoustic typologies on echograms collected aboard fishing vessels. This leads to a measurement of the acoustic abundance. The method consists in stratifying the sea in squares of 6' x 6' sizes in latitude-longitude.

Identification methods of echo traces are (1) using typology of typical echo traces; (2) using multifrequency algorithms (for group of species, in case multiple frequencies are available); (3) using samples from catch data; (4) using ecological information e.g. presence of predators and preys, environmental characteristics, geographical location.

Abundance is calculated in each one of the strata that have been explored by vessels using the length-TS relationship by Lillo et al. (1996). Fortnight average values of NASC (Sa) are calculated, and a monthly estimate of abundance inside the fishing area is delivered.

2. ABUNDANCE ESTIMATE OF JACK MACKEREL THROUGH GEOSTATISTICS USING GRAVITY CENTERS AND KRIGING ESTIMATES

Objectives: Considering abundance as the actual quantity of fish observed in the sampling area and biomass the total quantity of fish in the whole region, several methods must be used to calculate these two values. Biomass should be quantified as the mean density calculated on the abundance in the observed area, extrapolated to the potential habitat. Therefore the calculation of abundance is essential. Due to the particular spatial structure of the distribution, geostatistics tools should be used.

The abundance is calculated from catch data. Each set is obtained with a series of information: position, time, catch, demographic structure, etc. Calculating the abundance from this series of metrics requires calculating a series of indicators:

Definition of regions: The spatial structure of the population must be defined and regions identified in order to describe correctly the clusters of density patches. **Calculation of the gravity center:** This indicator represents the coordinates of a point averaging the positions of all the samples (fishing sets). The **inertia** which quantifies the spatial dispersion of the catches around the gravity center: it represents the area covered by the fishing sets in relation to the catches. **The variogram** which describes the spatial characteristics of the fish distribution, etc.

Once these metrics calculated, it is necessary to build a data base, which is described in the document. Finally a protocol for estimating the abundance from catch data is detailed, and in particular:

- Determining the region to which belong each set
- Determining the time interval to which belong each set
- Calculating the gravity center
- Calculating the inertia
- Evaluate the mean catch as an indicator of density for each region
- Estimating the abundance according to the demographic structure
- Estimating the biomass in each time interval
- Estimating the changes in the position index
- Calculating the coefficient of variation as statistical indicator of the dispersion

3. CALCULATION OF ABUNDANCE USING ACOUSTIC DATA

The spatial characteristics of the fish distribution as well as the "sampling" design represented by the fishing vessels trajectories, makes it impossible to use standard statistics. Geostatistics is likely the only method that takes into account the regionalized variables. A regionalized variable (Matheron, 1973) presents a non random distribution in space: the value of two samples are spatially correlated, the value of z_1 on location x_1 gives information on the value of z_2 on x_2. This spatial distribution is described by the variogram, as follow:

$$\gamma(h) = \frac{\sum_{x_i - x_j = h} (z_i - z_j)^2}{2.N(h)}$$

(See annex for definition of terms).

The method consists in the following steps:

- Defining the boundaries of the sampling area;
- Calculating the experimental variogram
- Adjusting a model
- With the values of the model, designing the distribution map through kriging ;
- From the map, calculating the abundance.

4. ESTIMATE OF CPUE: METHODOLOGY, ANALYSIS, DATA FORMAT.

The catch per unit effort (CPUE) is a density and abundance index of the exploited fish resources. The CPUE of the industrial fleet is estimated with the total catches and the total fishing effort. Fishing effort is estimated in number of hours of fishing trips (from time of

leaving to time of return to harbor). A specific format was established for data standardization. Informations recorded are: date, time of leaving and return, total catch.

In order to determine the significance lever of the estimated CPUE a regression vs. the total catch is calculated using a GLM. This one gave significant values for the coefficient R^2=0.6379 and the value of $p < 0.05$. We can conclude that the Effort used (total time in hours) is precise enough for estimating CPUEs.

5. PROTOCOL FOR DESIGNING THE POTENTIAL HABITAT MODEL FOR JACK MACKEREL

Potential habitat models are currently used for sustainable management in the case of jack mackerel because of the effect of the climatic variability and its impact on fish stocks all over the world (Mahon, 2002). The contribution of all the sources of scientific information is needed, and especially that on the fishing fleet as scientific platforms, which represent an essential source of data for scientific research, not only thanks to the huge volume of data obtained through the fishery (SNP, 2011; Mitson et al., 2014) but also because they can help to generate models based on the particular characteristics of the available sources of information (SNP, 2011).

6. ANALYSIS OF MODAL PROGRESSION OF JACK MACKEREL (*Trachurus murphyi)*

The methods based on the Length Frequency Analysis (LFA)) appear as an acceptable methodological alternative to compare and to validate the parameters considered by the reading of otholiths. Besides to offer a source of independent analysis, the use of the LFA allows the use of information abundant and easy to obtain, as the length frequencies, and the smaller time required for the estimations (Diaz 2013).

The obtaining of the information for the LFA from the fishing fleet offers a panorama of the distribution in the space and time of the resource; and also makes it possible to determine the oceanographic characteristics in which they were captured.

A disadvantage of the methods based on the LFA is its high sensitivity to the low representativeness of the extreme lengths. Generally, the next length or underneath the recruitment size usually are sub-represented in the samplings, whereas the greatest size also can be little represented by availability problems or for being little by effect accumulated total mortality. (Diaz 2013).

Objective

To establish guidelines for the obtaining of information of the fishing fleet through biometrics samplings to consider the parameters of growth being used the analysis of modal progression.

Methodology

A specific format will be used for biometry by made coves of the fleet of length overall of jack mackerel (*Trachurus murphyi)* of the coves made in the tasks of fishing of a determined period of all the fishing fleet.

7. PROTOCOL OF CALIBRATION, MEASUREMENT OF NOISE AND ELIMINATION OF DIGITAL INTERFERENCES IN ECHOGRAMS GENERATED ON BOARD OF FISHING VESSELS

The Peruvian industrial fleet account for some years with digital acoustic technology, in special echosounders, those that must be calibrated so that the quantitative measurements, that are possible to carry out, are comparable to each other, these analyses take place with the purpose of constituting a contribution to the scientific research and monitoring of the marine ecosystem carried out by Marine Research Institute of Peru-IMARPE and other organizations of the public and private sector.

The fishing vessels have been used from 1964 in Peru as platforms of collection of acoustic data in order to detect the presence of zones of fishing and to quantify the biomass of anchoveta in relative terms (Gutiérrez, et al. 2012). So that the collected data of these fishing vessels fulfill the international standards, and to be able to use them to make quantitative estimations on fish and zooplankton, necessary that commercial digital echosounders is calibrated, as well as is measured its level of noise and eliminated the possible interferences (that they come on board from other equipment of the himself vessel, or other vessels that could be in the proximities).

Objective

To generate a technical protocol is to describe equipment, processes and methods, in order to make the calibration, intercalibration, generated removal of noise and digital interferences of ecogramas on board of fishing vessels.

Calibration procedure

An echosounder is calibrated according to the procedure indicated by Foote et al. 1987 and Simmonds et al. 1992. The calibration is based on the measurement of the reflectivity (TS) of a standard target (sphere of copper or tungsten carbide) whose TS is known.

- Election of the calibration place
- Election of the calibration sphere
- Measurement of the oceanographic conditions in the place, determination of the sonic speed and of coefficient and absorption
- Previous requirements
- Measurement of noise
- Interference
- Intercalibration
- Procedure to calibrate digital echosounders with software Echoview
- Configuration of echosounders
- Post- processing
- Procedure to measure the environmental noise
- Procedure to intercalibrate digital echosounders with Echoview Software
- Generation algorithm in Echoview

8. SPATIAL BEHAVIOUR INDICATORS OF THE JACK MACKEREL (*Trachurus murphyi*) INDUSTRIAL FISHING FLEET OF PERU THROUGH THE PROCESSING OF VMS - SISESAT DATA.

In Peru the purse seine industrial fishery has three major target species over which the effort is distributed. In the case of purse seine fishery for human consumption, that of jack mackerel plays the most representative roll.

It is know that the behavior and distribution of jack mackerel are strongly influenced by the conditions of the surroundings and mainly to the environmental conditions.

The industrial purse seine fleet that exploits jack mackerel is composed by a total of 104 vessels (Ñiquen, M. 2013); the majority of them have fishing licences for anchoveta, jack mackerel and mackerel.

All the industrial vessels count on a system of satellite pursuit SISESAT, which allows monitoring simultaneously the whole fleet, this information also is important since it allows to make an analysis of the behavior of the fleet and to determine its main indicators.

General objectives

Obtaining indicators of the spatial behavior of the Jack Mackerel industrial fleet, that serves to be able to allows measuring the efficiency of the fleet. By means of this protocol, the purpose is to offer a guide for processing easily the SISESAT data, provided by the shipbuilders of the National Fishery Society- SNP of Peru and for identifying the indicators by season.

Prnciples:

a. The System of satellite pursuit
b. Made previous works of investigation for the information processing
c. Definition of used variables
d. Reconstruction of trips
e. Calculation of the characteristics of the trips: Total duration of trip (dtv). Terminal velocity calculated between 2 consecutive emissions (vmae). Calculated minimum speed between 2 consecutive emissions(vmie). Crossed total distance(dtr). Maximum latitude reached (it licks). Minimum latitude reached (lami). Maximum length reached (hill). Minimum length reached (lomi). Maximum distance to the beginning point (dmai). Maximum distance to full stop(dmaf). Maximum distances to the coast (mdc). Distance between the first point (game port) and the last point (arrival port) (dpu). Average of distance to the coast(pdc).