

INTER-AMERICAN TROPICAL TUNA COMMISSION

1ST TECHNICAL MEETING ON DORADO

Manta (Ecuador)
14-16 October 2014

REPORT OF THE MEETING¹

INDEX

Introduction	1
1. Executive summary	2
2. “Mini-symposium” on dorado	4
2.1. Knowledge about the fisheries	4
2.2. Knowledge about life history and stock structure	17
3. Identification and summary of available data sources (preparation of a metadata table)	23
4. Planning a future collaborative regional research plan	23
5. Other matters	23

APPENDICES

1. Agenda
2. Data sources of interest
3. Metadata table for dorado in the EPO
4. Recommendations for a future collaborative research plan for dorado in the EPO
5. List of participants

EXECUTIVE SUMMARY

Dorado (*Coryphaena hippurus*) Linnaeus, 1758, also called *mahi mahi*, *doradilla*, *lampuga*, *palometa*, and *perico*, is one of the most important species caught in the artisanal fisheries of the coastal nations of the eastern Pacific Ocean (EPO). The species is also caught incidentally in the purse-seine tuna fishery in the EPO. Under the Antigua Convention and its ecosystem approach to fisheries, it is therefore appropriate that the IATTC staff study the species, with a view to determining the impact of fishing and recommend appropriate conservation measures if required. In this context, some Members of the IATTC with coastlines in the region have requested that collaborative research on dorado be carried out with the IATTC staff so that solid scientific information is available for the management and conservation of this important resource in the region.

The IATTC held its first technical meeting on dorado in Manta, Ecuador, on 14-16 October 2014. This first meeting had three objectives: 1) promote synergy in Members of the IATTC for a regional investigation of dorado in the EPO; 2) review the current state of knowledge of dorado and identify [available data sets](#) (Appendix 3) across fisheries/regions in the EPO; and 3) plan a future collaborative research plan (Appendix 4).

¹ Suggested reference:

Anonymous. 2015. Report of the 1st Technical Meeting on Dorado. Inter-American Tropical Tuna Commission. Manta, Ecuador, 14-16 October 2014. 38 pp.

This report describes the work, discussions, and knowledge generated during the three sections of the meeting (see agenda; Appendix 1): 1) a “mini-symposium” on dorado” (23 presentations); 2) summary identification of the data sources available in the EPO region (preparation of a table of metadata); 3) discussion of research priorities and a plan for future collaborative research on dorado in the EPO.

The diverse range of topics of the talks presented at the meeting (see agenda; Appendix 1) is an indicator of the substantial data collection and research efforts that are underway for dorado in EPO coastal nations. This is in contrast with the data-poor situation found for silky shark in recent IATTC collaborative work between IATTC staff and members countries.

The quality of the commercial fishery statistics available for dorado in the EPO has been quite satisfactory since 2000. This information is notably more abundant for the dominant nations in the fishery (Peru and Ecuador), and includes fleet composition data, georeferenced fishery-dependent data, and fishing effort data. There are also reasonable fishery statistics for other EPO nations, such as Colombia and some Central American nations. An additional great amount of information on dorado is available from NGOs, universities, research centers, the industry, and the sport fishing sector operating in the region. These stakeholders are encouraged to stay involved in future collaborative regional work activities.

Information on the life-history of dorado in the EPO is particularly rich, with several studies concluded and ongoing research activities on age and growth, reproductive biology (maturity and fecundity) and feeding ecology. Despite a few population genetic studies already carried out and those that are currently underway in the region, the population structure of dorado in the EPO remains unclear. There are ongoing tagging activities of dorado in the EPO but these are limited to Mexican waters and suggest restricted movements.

There is a marked seasonality in the dorado fishery across the region (approximately October-March in Peru, Ecuador, Colombia, Panama, Costa Rica and Guatemala). In addition, there seems to be a strong relationship between the abundance of dorado and some environmental variables in the EPO (e.g., sea surface temperature, oxygen levels, chlorophyll and precipitation). For example, higher catch rates of dorado are associated with warm waters of 20-24°C in Peru and Ecuador, whereas in Guatemala and the south of Mexico this association is stronger with higher temperatures (~29-30°C). Such relationships with the environment should be further investigated, as they could be used to obtain indicators to guide management.

Conventional stock assessment modeling methods could potentially be used for dorado in the EPO with the fishery data available. However, lessons learned by the IATTC staff with similar species (e.g., skipjack) indicate that the high productivity of these species (*i.e.* high fecundity, and fast growth rates over a short lifespan) is a handicap for conventional stock assessment analysis. Recruitment seems to be highly variable and strongly influenced by environmental conditions, and it is difficult to separate the exploitation and environmental effects with conventional stock assessment models.

Relying on the existing data available across the region, the IATTC staff proposes that stock status (or stability) indicators (SSIs) are produced for dorado in continuing regional collaborative research activities. The reliability of these indicators to achieve management and conservation goals for dorado in the EPO should be investigated within a Management Strategy Evaluation (MSE) framework. The MSE process should involve scientists and policy makers and lead to decisions about management objectives, harvest control rules, and which fishery indicators should be monitored. The synergies seem to be solid for continuing the regional collaborative work on dorado in the region. A second Technical Meeting on Dorado is tentatively planned to take place in the fall of 2015 in Peru.

1. BACKGROUND

Dorado (*Coryphaena hippurus*) Linnaeus, 1758, also called *mahi mahi*, *doradilla*, *lampuga*, *palometa*, and *perico*, is one of the most important species caught in the artisanal fisheries of the coastal nations of

the eastern Pacific Ocean (EPO). The species can be considered highly resilient to overfishing due to its high productivity in all the oceans of the world (Palko *et al.* 1982). In the EPO, in particular, dorado shows high rates of growth during a very short lifespan (about three years), early maturity (50% maturity at 0.5-1 years of age), high fecundity, and spawning that occurs throughout the year (Goicochea *et al.* 2012; Zúñiga-Flores 2014). However, caution is necessary because dorado is subject to intense commercial exploitation in various nations in the EPO (Peru, Ecuador, Colombia, and most of the Central American nations) (Dapp *et al.* 2013; Lasso and Zapata 1999; Martínez-Ortiz and Zúñiga-Flores 2012; Solano-Sare *et al.* 2008). The available fisheries statistics indicate that the major fraction of the total global production of dorado is taken in the EPO (47-70% between 2001 and 2012) (Aires-da-Silva *et al.* 2014). It is estimated that the total catch of dorado in the region was about 71,000 metric tons, on average during 2008-2012. In Ecuador, for example, it represents more than 65% of the estimated unloadings and 35 to 40% of the exports of pelagic fish to the United States (Martinez-Ortiz and Zúñiga-Flores 2012). Although Peru has the greatest catches of dorado in the EPO, it is second to Ecuador in terms of imports (filleted and fresh) in the United States. Information from various sources indicates that most of the Peruvian catch is consumed domestically, while most of the Ecuadorian catch and that of other nations of the EPO is exported to the United States.

The Antigua Convention establishes one of the functions of the Inter-American Tropical Tuna Commission (IATTC) is to “adopt appropriate measures to avoid, reduce and minimize ... impacts on associated or dependent species.” Dorado is caught incidentally in the purse-seine tuna fishery in the EPO (Martínez-Rincón *et al.* 2009), although in very small quantities (<5%) compared to the total volume of the commercial catches in the EPO (Aires-da-Silva *et al.* 2014). It is therefore appropriate that the IATTC staff study the species, with a view to determining the impact of fishing and recommend appropriate conservation measures if required. In this context, some Members of the IATTC with coastlines in the region have requested that collaborative research on dorado be carried out with the IATTC staff and have asked for assistance in designing data collection forms and data entry programs for the dorado fisheries (Aires-da-Silva *et al.* 2014).

Following the recent success of the collaborative work with the IATTC staff on silky sharks (*Carcharhinus falciformis*) development with member countries, various IATTC Members of the region asked that the IATTC staff organize a series of technical meetings aimed at improving knowledge of the status of the dorado stocks for the purposes of managing and conserving the species in the EPO.

The Republic of Ecuador organized and hosted the first IATTC Technical Meeting on dorado, held in Manta, Ecuador, on 14-16 October 2014. The meeting was chaired by Dr. Alexandre Aires-da-Silva, of the IATTC staff, and brought together fisheries scientists involved in research on dorado in the EPO who wished to contribute to this collaborative regional effort. The objectives of this meeting were as follows: 1) promote synergy in Members of the IATTC for a regional investigation of dorado in the EPO; 2) review the current state of knowledge of dorado and identify [available data sets](#) across fisheries/regions in the EPO; and 3) plan a future collaborative research plan.

This report describes the work, discussions, and knowledge generated during the three sections of the meeting (see agenda; [Appendix 1](#)): 1) a “mini-symposium” on dorado” (23 presentations by scientists of the region); 2) summary identification of the data sources available in the EPO region (preparation of a table of metadata; [Appendix 3](#)); 3) discussion of research priorities and a plan for future collaborative research on dorado in the EPO ([Appendix 4](#)).

2. “MINI-SYMPOSIUM” ON DORADO

2.1. Knowledge about the fisheries

Talk 1

Background on dorado in the Eastern Pacific Ocean and structure of the workshop

Alexandre Aires-da-Silva
IATTC

The chair presented a review of current knowledge, and identified the sources of data available for dorado in the eastern Pacific. He also presented details about the problem with dorado in the EPO. He also described the stakeholders in this problem: the commercial and sportfishing sectors, national fisheries administrations, regional fisheries organizations, and non-governmental organizations. He mentioned the role of the IATTC in the EPO fisheries, as well as certain requests to the countries in the joint participation in the matter of tunas and other resources including dorado and assistance with training with the aim of arriving at an assessment and stock indicators for dorado in the EPO. He highlighted the importance of following the model of the silky shark for achieving the desired results for dorado. He pointed to the review of current knowledge and the identification of sources of data (preparation of metadata; Appendix 3) as well as the planning of a joint regional research effort (Appendix 4).

Talk 2

The dorado (*Coryphaena hippurus*) resource in Ecuador

Molke Mendoza
SRP-MAGAP, Ecuador

Summary: Dorado (*Coryphaena hippurus*) is the most important species in the artisanal fisheries of Ecuador and has a strong socioeconomic impact, generating thousands of jobs and food. In the global composition by class by year it made up between 15% and 25% of unloadings; and in the composition by species of large pelagic (bony) fish it made up 55% of the unloadings for the 2008-2013 period. It is a species with a marked seasonality with its main period being November to April of each year. During the 2000-2013 period the total unloadings fluctuated between 5428 t (2000) and 19475 t (2012). The best CPUE indices (average) are found in the first and last quarters of each year. In the Southeastern Pacific Ocean dorado may possibly be associated with the introduction of equatorial and subtropical water masses from west to east and associated with SSTs between 20°C and 26°C, but it probably prefers the isotherm between 22°C and 23°C.

According to the ECB the main export market is the USA with 96%, followed by Canada and Venezuela. According to the US NMFS imports of fresh and frozen fillets of dorado from Ecuador from 2000 to 2014 (August) reached a total of 67 398 t (US\$ 453,278,620). Future actions: The process of achieving ecocertification of the fishery for the dorado resource began in the year 2009. Initiating actions to obtain a conditional certification is planned for the year 2015, which will allow us to continue working towards a definitive ecocertification.

Discussion:

A participant asked if there is a fishery targeting dorado with surface gillnets in Ecuador. The answer was negative, but dorado may occasionally be caught as bycatch in such nets. Another participant made a comment about the apparent strong association of dorado with water masses of sea surface temperatures (SSTs) between 20°C and 26°C in the Ecuadorian artisanal fishery, noting that the preferred SSTs seem to be higher, close to 30°C, in waters exploited by Central American fleets, in particular Guatemala. A question was asked about the testing and use of circular hooks by the Ecuadorian fleets. C16 hooks performed best with tuna-billfish-shark longline gear. Circular hooks have been experimented with in dorado longline gear for three years, and some fishermen at the port of Esmeraldas have adopted them.

There are significant differences in hook types used among fishing ports. The Ecuadorian government has been discouraging the use of J hooks in favor of circle hooks.

Talk 3

The process of the fisheries improvement program for the sustainability of the dorado (*Coryphaena hippurus*) resource in Ecuador

Jimmy Martinez¹, Pablo Guerrero² and Fred Sondheimer¹
¹WWF Ecuador and ²WWF Latin America and the Caribbean

Summary: Key concepts: Fisheries Improvement Projects (FIP) are a long-term participative process, with serious commitments by various parties, that can help to ensure the sustainable use of fisheries resources, promoting a fishery that is profitable over the long term and protecting the resource for future generations.

History and current situation: In Ecuador, WWF has been developing an FIP in the artisanal fishery for dorado (*Coryphaena hippurus*) since 2009, in conjunction with the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) through the Vice-Ministry of Aquaculture and Fisheries, the Undersecretariat of Fisheries Resources (SRP), the National Fisheries Institute, FENACOPEC (National Federation of Fisheries Cooperatives of Ecuador), among other partners.

The FIP was developed after a pre-assessment against the MSC standard in January 2010, which enabled 44 key activities for improving the sustainability of the fishery to be identified, relative to the MSC's three fundamental principles: the health of the fish stocks, the impact on the ecosystem, and effective management.

As of March 2014, 20 activities have been completed, with 17 more activities active with defined milestones (7 activities were eliminated or suspended). Three progress review workshops have been held (in 2012, 2013 and 2014), quantifying the progress of the fishery against the 30 standard MSC indicators. The number of high-priority indicators, which require urgent attention, has fallen from 10 (33%) to 3.5 (12%).

Achievements and challenges

Health of the fish stocks: The processes for collection and analysis of fisheries and biological information have been improved, increasing the number of inspectors and on-board observers and training national technicians. This has allowed genetic analyses to be carried out, of age, growth, fecundity and reproduction, food habits, and CPUE. Technical workshops have been held at the national, binational (with Peru), and regional level to review and share scientific knowledge.

The main challenges are finishing the identification of the population unit exploited by this fishery (goal year 1), assessing the status of the stock (goal year 3), and developing an assessment of management strategies based on reference points and limits and harvest control rules (goal year 5).

Impact on the ecosystem: Hookings and entanglements of sea turtles were identified as the most important ecosystem impact of the fishery. Activities include an on-board observer program, training of fishers in best practices for bycatch mitigation, exchanging circle hooks for 'J' hooks, eliminating import duties on circle hooks, and changing leader lines to reduce entanglements, with a special focus on certain fishing ports as examples.

The challenges are determining the optimum level of observer coverage for generating representative estimates of hooking and entanglement rates for sea turtles, finding ways of incentivizing the adoption of best practices by the fishers, and extending the implementation of the above-mentioned activities to a national level.

Effective management: Ecuador has developed, adopted, and reviewed the National Plan of Action for

the Conservation and Management of the Dorado Resource (PAN Dorado), as a national legal tool for organizing fisheries improvement activities. Within this framework, at least five Ministerial Agreements have been issued for the fishery since 2011, establishing and ratifying measures such as the official adoption of the PAN Dorado, closures, minimum lengths, a limit for lines towed per vessel, and the unique observer program. The control and surveillance system has been improved in order to apply the management measures in force.

The main challenge is promoting the harmonization of regional management of the dorado resource, since this is a highly-migratory species shared with other coastal countries.

Further information on the FIP is available at:

<https://sites.google.com/site/fisheryimprovementprojects/home/ecuador-mahi>

Discussion:

A participant asked if there has been any consideration of the sport fishery for billfishes and other pelagic species such as dorado in the elaboration of the dorado FIP, taking into account its potentially high economic value in tourism income, as in Costa Rica. The answer was that it had been considered, and that catch-and release is encouraged in the sport fishery for billfishes. Another participant asked what the greatest challenge for obtaining certification for the Ecuadorian dorado fishery was; the answer was the definition of reference points for management. In response to another question about whether stock structure is also a major challenge to getting certification, it was noted that, as long as there is great uncertainty about the population structure of dorado in the EPO, there is not much space for major debate and criticism about this topic, and it is definitely necessary to improve the understanding of the stock structure of dorado in the EPO.

Talk 4

Summary review of the dorado (*Coryphaena hippurus*) resource in Peru

Miguel Ñiquen C., Edward Barriga R., Wilbert Marín S. and Amado Solano S.
Instituto del Mar del Perú (IMARPE)

Summary: Peaks of greater unloadings were observed in the years 1983, 1987 and 1998, favored by the presence of the El Niño, however, since 2001, an increase in catches was observed, which reached a peak in 2012 of 59 thousand tons, associated with greater availability and greater fishing effort. The development of this artisanal fishery has allowed a very important socioeconomic activity to be maintained in the country.

It was observed that environmental variables have an important influence on the distribution of dorado in Peru, where these fish have a preference for warm waters, with a high oxygen content at the surface. Given the high environmental variability in the Peruvian sea, with a recurring incidence of El Niño-La Niña-type events, this preference has clear implications for the availability of this species.

In Peru, the growth parameters of *C. hippurus*, estimated on the basis of the interpretation of the microelements of the otoliths of individuals caught during February 2010 (Goycochea, 2010), off the north coast of the Peruvian sea, were:

For males: $L_{\infty} = 169.75$ cm $K = 0.893$ year⁻¹ and $t_0 = -0.115$ years

For females: $L_{\infty} = 148.94$ cm $K = 1.075$ year⁻¹ and $t_0 = -0.081$ years

Reproductively, *C. hippurus* is described as a species with asynchronous maturing of the ovaries, high fecundity (~324 416 oocytes per batch spawned), which concentrates its highest levels of maturing and spawning in the months of December to March.

From the trophic point of view, with data from samples taken between 1998 and 2014, this species

presents a wide food spectrum whose spatial, temporal, and length-group variants have been determined. The main prey are surface fish, crustaceans and cephalopod molluscs (argonauts, squid, pota, flying fish, etc). From information on catch and fishing effort in the IMARPE database (1999-2009) the catch rates of dorado for the Peruvian longline fleet were standardized, taken as explanatory variables fishing area, annual and seasonal temporal variation, well capacity and number of hooks. Information that was used for a preliminary stock assessment to 2009, which identifies some biological reference points (MSY , B_{MSY} , F_{MSY} , $F_{0,1}$), left pending was the updating of these processes including environmental variables in the calculations.

Results of the surveys carried out during the 2006-2008 and 2010 period were presented, for the Assessment of the Biology and Fishery for *Coryphaena hippurus* dorado, aboard artisanal fishing vessels and the scientific vessel IMARPE V.

The range of lengths obtained in the survey during 2006-2008 was 50 to 150 cm TL for females and 50 to 165 cm TL for males. During 2010 the range of lengths for females was 79 to 141 cm TL, for males it was 100 to 157 cm TL.

The frequency distribution of TL (cm) for males and females, using the Kolmogorov-Smirnov test, led to the conclusion that there is a significant difference between the two, with the lengths for males greater than for females.

The weight-length relationship of dorado shows allometric growth for males but isometric growth for females. The Fulton condition factor for males varied from 0.29942 to 0.45973, while for females it varied from 0.31757 to 0.39583.

The length of first gonadal maturity (LFGM) was determined as 66.04 cm total length using samples in inactive (stage 0) and active (stages 2, 3, 4 and 5) state according to the gonadal maturity protocol (Reproductive Biology Unit), from the following equation:

$$Y_i = 1/(1+\exp(12.02+(-0.182)*TL))$$

which means that at 66 cm total length female dorado are capable of reproducing for the first time. Also the average spawning length of female dorado based on the samples in stages 4 and 5 according to the gonadal maturity protocol (Reproductive Biology Unit) occurs at 73 cm total length.

A high inter-species selection with surface mainlines was found, catching 87.8% of dorado, among 08 species of fish, turtles and cephalopods. There were no significant differences in the number of individuals of dorado caught by the different sizes of hook, nor was a length selection identified for #3, #4, #5 hooks, except between #2 and #6 hooks.

5,762 parasites were found, and 8 species in four taxa identified. Parasite prevalence indicates that *Tentacularia coryphaenae* and *Bathycotyle coryphaenae* have a prevalence of 100%, followed mainly by *Hysterothylacium* sp. 61.54% and *Caligus coryphaenae* 46.15%. The greatest number of parasites found were in the stomach, with the Digeneous group most frequent.

Discussion:

A participant inquired about an apparent improvement in the quality of available Peruvian dorado landing statistics starting in 2000. The presenter mentioned that the availability of dorado increased greatly in 2000-2001 after the strong El Niño event of 1998. There was great availability of the dorado resource closer to the coast of Peru in those years and this resulted in a greater awareness of, and interest in, dorado by Peruvian artisanal fisherman. This also stimulated scientific interest and consequently the need to improve data collection.

A participant commented that, in the context of trade domestic consumption of dorado in Peru has been stronger than export interests. A participant made a comment about dorado consumption in Ecuador. During the 1950s, dorado was not considered fit for human consumption in Ecuador, but rather used as

animal food. Exports increased markedly in 1984 following a period of high availability that coincided with the strong El Niño event of 1983.

Talk 5

Artisanal fishing for dorado in Peru

Wilbert Marín

Instituto del Mar del Perú (IMARPE)

Summary: Artisanal fishing activity in Peru is covered by fisheries law. This fishery includes vessels of up to 32.6 cubic meters of well capacity and up to 15 m long. Smaller-scale vessels have the same well capacity. This fishery exploits more than 320 species. Up to 15 types of gears and methods are used. The artisanal fishery is monitored by IMARPE, which monitors this fishery at 10 locations in the coastal zone out to something more than 200 miles. Information is recorded on the beach with field observers present daily, with extended hours in high seasons. This information is taken to the regional offices where it is entered into a database (IMARSIS). This allows fisheries statistics to be obtained for different. Dorado occupies the fourth place in the artisanal unloadings. The artisanal fleet covers all the Peruvian exclusive zone and some have reached up to 200 miles from the coast. Effort (number of fishers) has grown markedly, increasing 17% since 2004, but the increase in vessels has been 66% which infers bias in one of the two comparisons.

Annual unloadings show three phases (extraordinary, moderate and weak El Niño) between 1997 and 2013. During the 1998 El Niño dorado was caught inshore by small vessels and the fleet was not technically prepared. The fishery developed and was better equipped from 2001, with higher catches. In 2012 there was a decline due to an increase in squid and flying fish with a higher price than dorado. Paita is the place with the greatest unloadings. 96% of dorado is caught with surface longline. The vessels from Paita are larger with up to 40 tons capacity. As regards fishing areas by season along the Peruvian coast, it is observed that the resource increases in concentration in spring and summer.

Talk 6

Generating alliances for promoting the sustainability of the fishery for dorado (*Coryphaena hippurus*) in Peru in the framework of the Fisheries Improvement Project

Samuel Amorós K.

WWF-Peru

Summary:

General aspects

The fishery for dorado in Peru is an artisanal fishery (vessels of less than 32.6 m³ well capacity) that uses surface mainline and is made up of at least 1,000 vessels. Its fishing trips are of more than 15 days and are made both within and outside 200 nm reaching distances of more than 400 nm from the coast. Peru is the main producer of dorado in the Eastern Pacific Ocean with more than 50 thousand tons annually and almost 60 thousand tons recorded in 2012. The port of Paita is the main location for unloading this species, followed by Chimbote, Ilo, and Pucusana. The dorado fishery has shown a growing trend since the 1990s. Dorado is consumed in both the national and international markets, with the United States as the main destination for exports.

Strategic alliances

The project has a participatory approach. It was started in 2012 with the identification of the key actors in the fishery and the development of a pre-evaluation against the MSC standard. This pre-evaluation made it possible to identify which activities should be priorities and led to the development of a Fisheries Improvement Project (FIP). In the framework of the FIP a Plan of Action has been developed which

includes 69 activities for strengthening the fishery in terms of: 1) health of the population, 2) impact on the ecosystem, and 3) effective management.

To strengthen the fishery a Framework Convention for Cooperation was established between the Instituto del Mar del Perú and WWF. Through this projects have been implemented for collecting biological and fisheries information on dorado at the main ports. Also, a close collaboration was established with artisanal fishers' associations such as FIUPAP, AAARCUDIPA and others to establish joint activities that will support the sustainability of the resource.

Achievements

- Establishment of the season for fishing for dorado from 1 October to 30 April of each year (RM 245-2014-PRODUCE): this was done with technical recommendations by IMARPE and alliances with the artisanal fishers (see video *¿Qué pasa dorado?*). Also this management measure complements the Minimum Catch Length of 70 cm fork length established in 2011.
- Implementation of fishing logbooks: since 2013 a project has been developed with IMARPE, AAARCUDIPA and other associations of artisanal fishers to use fishing logbooks for collecting data.
- Creation of the National Working Group: on 21 August a working group was formed to strengthen research on dorado in Peru.
- Implementation of the activities of the Plan de Action: since December 2013 the activities identified in the Plan have been being implemented.

For further information contact Samuel Amorós K. (Coordinator of the Marine Program) samuel.amoros@wwfperu.org). Further information on the Peruvian FIP is available at <https://sites.google.com/site/fisheryimprovementprojects/home/peru-mahi-mahi-fip>.

Discussion:

In answer to a question, a participant from IMARPE confirmed that both WWF and IMARPE use the same categories for classifying vessels (commercial and artisanal vessels with well capacity greater and less than 32.6 mt, respectively).

Talk 7

The fishery for dorado in the Colombian Pacific

Luis Zapata and Rodrigo Baos
WWF-Colombia

Summary: The fishery for dorado (*Coryphaena hippurus*) on the Pacific coast of Colombia has been developed by two fleets, large pelagic bony fishes and shallow- and deep-water shrimp. The latter adapts longline fishing gear to target the dorado resource during the season established in the first quarter of the year (January to March). These vessels, whose main characteristics such as length vary between 11.9 and 22.5 meters, have well capacities of between 18 and 40 tons. To target their fishing effort they use two types of fishing gear, longline using J hooks (nos. 2-4-5) and circular hooks (no. 15/0), which are used in lesser proportions, the number of hooks per trip varies between 400 and 2,500, the total length between 3 and 20 nautical miles and as regards the characteristics of the gillnets, the mesh size is between 10 and 11 inches, the number of strips aboard per trip between 15 and 20 units and the total length between 2.5 and 4 miles. The number of motor vessels that made trips to catch the resource during the season in 2013 was 33, with an average of 19 days away from port. Regarding records of the volume of historical annual unloadings from 1993 to 2014 the average was 600 tons, with a representative peak in 1993 of 1,868 tons. Fisheries biological information recorded during 1994-1996 showed CPUE values between 228.7 and 310 Kg/day in February, fork-length frequency for males and females between 29 and 197 cm, with a mode of 105 cm, the fork length-total weight relationship was based on the equation $Wt = 0,0224 \times (fl)^{2,78}$ reflecting allometric growth, the growth parameters were $L_{\infty} = 194$ cm; $K = 0.91$ cm/year and $t_0 = -$

0.1049, while the male:female ratio for 3,476 individuals was 1:0.96, the diet analysis showed fish species (Exocoetidae, Scombridae and Signathidae), molluscs (Loliginidae) and crustaceans (Portunidae). The biological information recorded during 2009-2014 showed lengths for males and females between 69.5 and 199 cm, an inter-annual analysis reflected the lowest total length during 2009 and the greatest during 2011, the length-weight relationship showed no significant differences between years ($F = 1.05$; $p = 0.44$), but a lesser slope was observed in 2009, the male:female ratio for 2,080 individuals was 1:0.98. As regards information on the larvae of the species *C. hippurus* and *C. equiselis* that were collected on INPA research cruises during 1990-2000, a map was obtained of the distribution of these individuals near the coast (north-south) and in the area around Malpelo Island.

Discussion:

A participant asked whether there are length-weight observations available from the Colombian dorado fishery. The presenter clarified that although there are dorado count data available from fishing logbooks, individual length-weight records are not available. A participant commented on the concerns about the high volumes of dorado catches taken by tuna purse seiners operating in the study area. A participant from IATTC commented that existing data indicate that the catch of dorado by tuna purse seiners represents less than 5% of the total catch taken in the EPO, mainly by artisanal fisheries. However, he also pointed that these estimates are obtained from IATTC observers aboard large (class-6) purse seiners. Dorado catch estimates from smaller purse seiners (classes 1-5) which operate in more coastal waters should be obtained. On another topic, the presenter noted that dorado catches by the Colombian fishery are influenced by fuel costs. About 75% of the Colombian fleet fishing for dorado has remained inactive due to recent rises in the cost of fuel. Another participant noted the great consistency in the seasonality of dorado observed in Ecuadorian and Peruvian fisheries. South of the equator medium- and small-size fish predominate, whereas there seems to be a shift towards larger fish in Colombian waters.

Talk 8

Dorado as bycatch in the purse-seine fishery in Colombia

Christian Bustamante
AUNAP, Colombia

Summary: The tuna fishery is an important industrial fishery in the Colombian Pacific Ocean in which foreign-flag vessels affiliated with Colombian companies participate, in accordance with the provisions of Law 13 of 1990 (General Fisheries Statute), and Regulatory Decree 2256 of 1991.

Installed tuna capacity is 300 daily tons of frozen whole product, with two processing plants, one in Barranquilla and the other in Cartagena, and for their part the Ecuadorean tuna vessels affiliated with Colombian companies generally unload their product in the city of Manta (Ecuador).

Between October 2009 and July 2011 the Colombian observer program implemented a pilot program to determine the dynamics of the tuna-fishing vessels and their effect on non-target resources. Observers trained to report fisheries and biological information, in accordance with the methodologies and forms used by the observers of the Inter-American Tropical Tuna Commission, embarked on 16 foreign-flag purse-seine tuna vessels.

With the data collected, AUNAP, together with the Technical Directorate for Inspection and Surveillance and the Office for Development of Knowledge and Information, carried out spatial analyses, prioritizing the three species of tunas (yellowfin, skipjack, and bigeye) and bycatches, which were classified into five general groups: 1) dorados, with one species (*Coryphaena hippurus*), 2) billfishes (six species), 3) wahoo (1 species), 4) sharks (15 species) and 5) small bony fishes (15 species).

Each group is being worked on separately, and here AUNAP is presenting a short technical note on *Coryphaena hippurus*, which summarizes the activities of the fleet, establishes which types of set are related to catches of dorado and the temporal length structure, and develops a preliminary spatial-

temporal analysis.

This spatial analysis discovered that the dynamics of the resource in highly pelagic waters tend towards the second half of the year, whereas in longline fisheries biomasses are closer to the coast and more frequent in the northern Colombian Pacific during January-April.

This is a great step forward for Colombia in the dynamics of bycatches on fish-aggregating devices (FADs), and it is hoped that through this IATTC workshop experience and synergies will be obtained to complement the environmental analyses and thus unite regional management measures for the benefit of the sustainability of dorado in the eastern tropical Pacific.

Discussion:

A participant commented that the dorado catches of Colombian coastal artisanal fisheries are dominated by larger fish, as shown in the previous presentation. However, small dorado are common in the catches of Colombian tuna-purse seiners. This suggests selectivity differences among the fisheries.

Talk 9

The fishery for dorado in Panama, current situation and plan for improvement

Edwin Medina
CEDEPESCA, Panama

Summary The species *Coryphaena hippurus* is considered in Panama as one of the species of greatest commercial importance, being utilized by the artisanal longline fishery and by the sport fishery. However, there is no exclusive information about this fishery.

En years recientes, distintos autores han recolectado una cantidad significant de information sobre las characteristics biologicals de esta species during su paso por waters panameñas and sobre las characteristics de las activities pesqueras de la fleet panameña que incide sobre este resource.

Ángel Vega *et al.* 2010:

- The species is present seasonally in the Gulf of Chiriquí from July to February and with high catch frequency between November and January.
- Horizontal surface longlines are the fishing gear used to catch the species.
- Vessels used in the fishery for dorado are about 11 m long.
- 55-horsepower outboard motor.
- Well capacity varies between 1,000 and 2,000 kg.
- Number of circle hooks between 500 and 1,500.
- The hook most often used and most effective is no. 13.
- Other circle hooks 10, 11, 12 and 14.
- Average length of individuals caught 1.1 m.
- As the season advances, an increase in the lengths of the individuals unloaded is observed.
- The sex ratio was slightly skewed toward the females.
- The specimens analyzed had well-developed gonads in both sexes.
- In 29 sets, with an average duration of 5 hours, on average 510 hooks were deployed.
 - 16 turtles (*Chelonia mydas* and *Lepidochelys olivacea*) were captured, and only one died.
 - 11 sharks, belonging to three families (*Alopias pelagicus*, *Carcharhinus porosus* and *Sphyrna lewini*); all individuals immature.
 - Otras species caught incidentally: *Sphyrna ensis*, *Sarda orientalis*, *Tylosurus pacificus*, *Thunnus occidentalis*.

Héctor Guzmán *et al.* 2010:

- Lengths from 0.353 to 1.7 m were recorded, the average was 1.0 m and the mode 1.0 m; five age classes were observed.
- The sex ratio was slightly favorable to females (1.5:1).
- Over 90% of the individuals examined were identified as sexually mature.
- The weight-length regression was positive and showed an r^2 value = 0.84 ($p < 0.05$), reflecting allometric growth for the species.
- The greatest catch by length was recorded for age classes 2-3 (individual between 0.8 and 1.2 m).
- Age classes 2-3 showed a positive relationship with the degree of fecundity.

CPUE was estimated at about 104 Kg/day/vessel, with two annual maximums: the first between April and May, and the second between November and January.

In Panama better estimates for the fishery for *Coryphaena hippurus* are required, and should include estimates of the catches by the artisanal fleet and the sport fishery; a greater number of data.

In Panama a quali-quantitative analysis known as Productivity and Susceptibility Analysis (PSA) was applied, as regards its results, it was found that dorado has attributes associated with high productivity, but also shows a strong susceptibility to fishing.

In our country no formal management strategy has been established for the dorado fishery. The aims of management are not explicit, estimates of the health of the stock are not made and no monitoring program has been established that would allow the effectiveness of the measures to be assessed.

There are measures to limit fishing effort such as: freeze the issuing of new licences to fish for this species, allow the use of longlines only for vessels of less than 6 GRT, implement an artisanal fishing method, and limit the number de hooks per longline. However these measures for restricting fishing effort do not by themselves constitute a management strategy, strictly speaking. They are not associated with rules that indicate how the fishing effort should vary in response to the status of the fish stock, and there is no monitoring to determine the effects of the measures.

It is necessary to develop in Panama a real management strategy, which responds to the status of the dorado stock; promote the establishment of clear explicit aims, as well as implement a consultation system for adopting decision/control rules, management measures and monitoring programs.

With the help of PROME in Panama the intention is to help resolve the problem of lack of guidelines and clear objectives, promote the adoption and implementation of decision rules and management measures in a participatory framework.

Discussion:

A participant commented that large fish predominate in the Panamanian dorado exports after 2011. This is due to a shift of the spatial distribution of the fleet from more inshore waters before 2011 to more offshore waters after that year. Also, the fishery from March to August has disappeared. He also noted that size-composition data should be pooled across fisheries in the region so that a regional picture of the resource is obtained. Another participant asked about the importance of dorado exports in Panama. The presenter said that they represent about 95% of the total volume of fish exports.

Characterization of the unloadings of dorado (*Coryphaena hippurus*) in Costa Rica

José Miguel Carvajal
INCOPECA, Costa Rica

Summary: In Costa Rica catches and unloadings of dorado take place mainly in the Costa Rican Pacific and the main vessels that catch dorado are classified as follows:

Sport fishing: which is a fishing activity for the purpose of sport, entertainment, pleasure, recreation, tourism or pastime.

The commercial fishery, which according to the Fisheries and Aquaculture Law establishes differentiations in terms of type of fleet, taking as parameters fishing range, target resource and the fishing gear mainly used. A- Small-scale: fishing by vessels with a maximum operating range of three nautical miles; B- Medium-scale: vessels with a maximum operating range of forty nautical miles. Most have modern hydraulic equipment for hauling in the line. The duration of the trips varies between 8 and 25 days and they use ice as the method for preserving the fisheries product caught. C-Advanced: Vessels have an operating range of more than 40 nautical miles and can keep the product frozen.

The fishing gear used is the longline, and it is modified in terms of size and type of hook when targeting dorado. Also the vessels that fish for other large pelagics such as marlin, swordfish, tunas and sharks, catch dorado incidentally or as part of multi-species fishing, when it is not the dorado season. For the catches of these species shark, black skipjack tuna, mackerel, squid, among others, are used as bait.

The department of statistics of Incopecsa has two databases that record information on dorado, historical information provided in conjunction with the fishing sector, in which data between 1990 and 2009, there is an average of 4136 mt and a marked increase is observed in 2001 with over 10,000 mt unloaded. And according to the database for unloadings by the medium-scale and advanced commercial fleet, for 2009 to 2012 has an average of 1608.5 mt of dorado. This database also records the information unloaded by species marlin, shark, swordfish, tuna, sailfish, wahoo, among others. In these same years it is reflected that there is a fishery with greater catches and presence of dorados during the months of August to January.

Exports of dorado for 2013 were a little less than 2000 mt with the United States the main export market. As regards imports of dorado for 2013 they were 714 mt originating in Panama.

Currently INCOPECA, in conjunction with the IATTC, is working on developing a monitoring program for the main fishing communities where there are vessels that use longlines as their main fishing gear.

Discussion:

One participant representing the sport fishery operating in Costa Rica expressed that sector's concern about the status of the dorado resource in the region. He stated that Costa Rican artisanal fisherman may shift their effort towards other species, such as billfish, if the abundance of dorado declined in inshore waters. The presenter commented that there is no commercial fishery targeting billfish in Costa Rica. However, billfish are caught and landed as bycatch in the longline fishery targeting dorado and the multi-species longline fishery catching tuna-billfish-sharks. An IATTC participant inquired about dorado catches by the longline fleet from non-coastal countries unloading in Costa Rica. During the collaborative assessment of silky shark it was shown that this fleet unloads substantial amounts of large pelagic species. The presenter explained that this information is not available. Due to the strict Costa Rican restrictions on shark fishing, collecting data on sharks is prioritized over other species. However, dorado catches by this fleet are not believed to be substantial compared to those of sharks and other large pelagic species. In answer to a question about changes in the market price of dorado, the presenter noted that prices change as a function of the condition of the product, which mainly depends on the type of refrigeration used.

Talk 11

Status of the fishery for dorado in the Pacific in Guatemala

Manuel de Jesús Ixquiac
CEMA-FUNDAECO

Eduardo Vincio Juárez
DIPESCA/MAGA, Guatemala

Summary: The information on dorado *Coryphaena hippurus* in the Guatemalan Pacific Ocean began to be generated from the year 2000 from the unloadings of the medium-scale commercial fleet, in the case of the artisanal fleet sporadic information collection began in 2002.

The artisanal fishery is the main fleet that catches dorado, while the industrial fleet targets sharks, so the dorado resource represents less than 1% of the annual catches of dorado. The total average catch during the last 10 years reports an annual catch of 2,500 MT.

To catch the resource shark-fishing vessels are used in the artisanal fleet with lengths of up to 25 feet, 75-HP motors with a range of 1 to 2 days. In the case of the small- and medium-scale commercial fleet it consists of fishing vessels with lengths of 28 to 60 feet, 200-HP Cummins motors, with a range of 15 to 30 days of fishing operations, this resource is mainly unloaded in the port of San José and Buena Vista, Escuintla. The sport fleet sport utilizes the resource, the frequency and volume of catch by this fleet is unknown.

Guatemala has biological and fisheries information, having generated information on growth by sex, stomach contents, abundance relative to SST, biometrics and exploitation status by length structure, as a tool for assessing the status of the resource.

Discussion:

A participant noted that there seems to be a movement of smaller dorado towards the inshore waters of Guatemala, and larger sizes are more common in distant oceanic waters. There was discussion among some participants about length at first maturity as a management tool for dorado in the EPO. One participant commented that this would be difficult because reproductive studies in Ecuador indicated three different estimates of length at maturity for different ports. A participant commented that the seasonality of the dorado catches in Guatemala is apparently less strong (a less pronounced seasonal curve) than that observed in Peru and Ecuador. Another participant, citing the example of Costa Rica, highlighted the apparent link between the seasonality of sea-surface temperature and the availability of the dorado resource. It is very likely that this strong relationship also exists in the Gulf of Tehuantepec, including Guatemalan waters. There was also discussion about the possible connection between the oceanography in the Central American region and the upwellings associated with the Humboldt Current flowing northwest along the coasts of Peru and Ecuador. This could provide some leads about the connection between dorado stocks north and south of the equator. A participant noted that the productivity of dorado peaks right before the trade wind season, and this oceanographic connection across the equator should be investigated further.

Talk 12

Progress in databases on highly-migratory species in the OSPESCA countries and new perspectives

Jorge López
OSPESCA, El Salvador

Summary: The Organization of the Fisheries and Aquaculture Sector of the Central American Isthmus, in order to attend to matters specific to both sectors forms working groups, made up by specialist technicians of the fisheries and aquaculture administrations of the countries of the Central American

Isthmus and the Dominican Republic.

Thus, it organized the Regional Working Group on Sharks and Highly-migratory Species (GTEAM), which has developed a system of tools for the standardized collection of information on the fisheries related to highly-migratory species, among them dorado; it has also contributed to the formulation of the Regional Plan of Action for the management and conservation of sharks in Central America, under the FAO guidelines.

In that framework were formulated:

- a) The National Plans of Action and Regulation OSP-05-11 which prohibits the practice of finning sharks in the member countries of SICA;
- b) The pilot plan for monitoring the artisanal unloadings of sharks and rays in Central America; and
- c) The protocol for collecting unloadings data and biological sampling in the artisanal and industrial fishery for sharks and rays in Central America.

Workshops were held on standardizing unloading records for sharks in the OSPESCA member countries. The results of those meetings were the standardized forms for inspection of unloadings and biological sampling; both forms have a manual for completing them, the manual for the use of the database and the database in Access for all the countries.

Other OSPESCA initiatives are:

- Joint work with The Billfish Foundation (TBF), based on the signing of a Memorandum of Understanding has allowed, for example, a joint proposal to the IATTC that the matter of dorado be addressed regionally.
- Memorandum of understanding between the IATTC and OSPESCA, signed on 16 August 2012, whose aim is to strengthen the links between the IATTC and OSPESCA with the aim of promoting compliance with the aims of respective constitutive agreements, in particular to ensure the conservation and long-term sustainable use of the fish stocks covered by those agreements. They also express their interest in scientific exchange, technical assistance and training.
- Fishers belonging to the Central American Confederation of Artisanal Fishers and experts from the national fisheries authorities carried out a review of progress in the collection of data on artisanal fisheries with emphasis on climate change, which are held in 20 fishing communities in Central America. This is an activity that facilitates the harmonic participation of civil society and which makes it possible to know the situation of the artisanal fishery in reference points of the region. The behavior of various species is analyzed, among them dorado.
- En complemento a la collection de information de la pesca en los countries de la región centroamericana, OSPESCA promueve los trabajos que buscan relacionar los factores del clima with los aspects productivos de la pesca and la acuicultura.

In that direction OSPESCA participates in the Climate Forum and the Applications Forum sponsored by the Regional Committee on Aquatic Resources (CRRH/SICA) and the Regional Program for Food and Nutritional Security for Central America (PRESANCA/SICA), which meet every three months to analyze the information generated by the national weather services, transfer it to a regional scale and thus configure the climatic outlook for the following three months (with monthly updates).

On that basis the group of specialists from regional institutions which include OSPESCA applied that outlook to the various sectors, such as agriculture, tourism, health, fisheries and aquaculture. Through these for a the behavior of the rainfall in the region in April 2014 was known, and updated with great accuracy in July of this same year and made it possible to anticipate the probable impacts of the reduction in rainfall on the productive capacity of the region, including fisheries and aquaculture.

This work is being gone into more deeply and the implications are being analyzed of climate on the behavior of dorado in the face of the absence of rainfall, warming of the waters, cold fronts, among others.

Discussion:

A participant commented that the collection of fishery data for dorado and other pelagic species should evolve side by side with the collection of oceanographic data. The presenter agreed, noting that OSPESCA believes that the relationship between fisheries and the environment cannot be ignored. For this reason, OSPESCA has developed strong synergies with climatology agencies located in the region, in Costa Rica in particular. A participant elaborated on the relationship between the dorado fishery and the environment in Ecuador, in particular with sea-surface temperature, salinity, oxygen and precipitation (rain). For example, Ecuadorian fishermen pay attention to rain because it results in lines of floating objects at river mouths, around which dorado aggregate. However, precipitation can also have negative effects. Dorado is usually not unloaded during heavy rains because the rain affects the quality of the product: the fresh water causes a change of color in the fish.

Talk 13

Review of the state of knowledge regarding dorado *Coryphaena spp.* with emphasis on the Mexican Pacific

Sofía Ortega García
CICIMAR, Mexico

In Mexico, dorado *Coryphaena hippurus* is a species reserved for the sport fleet within 50 nautical miles, where a catch of two fish per angler per day is allowed. It also forms part of the bycatch of the longline fleet with permits for shark or swordfish and of the tuna fleet, in addition to being caught seasonally by the artisanal fleet in various fishing locations along the coast of the Mexican Pacific. Due to its importance, various investigations of this resource have been carried out, on aspects such as spatiotemporal distribution of the bycatches and of larvae, predictive models related to the environment, analysis of catch rates and their relationship with sea-surface temperature, age and growth, mortality, length-structure analysis, weight-length relationship, reproductive cycle using histological methods, fecundity, trophic spectrum, genetics and tagging (conventional and satellite). The results and progress of the research carried out by the Centro Interdisciplinario de Ciencias Marinas on the dorado resource are presented as well as those of various studies published by researchers from other Mexican institutions.

Discussion:

One participant asked what the longest time at liberty was for a dorado tagged in Mexican waters. The presenter answered that it was from February to July of the same year. Another participant asked if any of the tagged dorado were recaptured in waters of other countries. The presenter said that they were all tagged and recaptured in Pacific Mexican waters. A participant hypothesised that the Coriolis effect may have an effect on the distribution of large pelagic species.

Talk 14

Collecting and managing data on dorado in the purse-seine fishery for tunas in the Eastern Pacific Ocean

Marlon Román-Verdesoto
IATTC

Summary: The purse-seine fishery for tunas is one of the most important fisheries operating in the EPO. In this fishery 3 types of set are made: unassociated sets, dolphin sets and sets on floating objects.

In 1993, observers of the Inter-American Tropical Tuna Commission (IATTC) started to collect data on bycatches of dorado (*Coryphaena hippurus*) on purse-seine tuna vessels of more than 364 metric tons carrying capacity. The length of the fish, in fork length (FL), is estimated in three categories: small: < 30cm FL; medium: 30-60cm FL, and large: >60cm FL. The IATTC, by means of guides and video presentations, has contributed to improving the level of identification of the species of the *Coryphaena*

genus, as well as of other species caught incidentally in this fishery.

Dorado is the species most caught incidentally in the tuna purse-seine fishery. Its habitat includes the entire breadth of the EPO. Sets on tunas associated with floating objects dominate the catches of *C. hippurus* with a presence in the catch of more than 75% of these sets. The spatial distribution of the lengths caught by this fishery show a greater concentration of fish greater than FL in the southwestern sector of the distribution of its catches.

Discussion:

The value of the IATTC observer data on bycatch for dorado research was discussed. As noted in the previous collaborative research on silky shark in the EPO, these data illustrate the strong transboundary nature and wide spatial distribution of the dorado resource in the EPO. This provides a good justification for a concerted regional plan involving participants from different nations.

A participant inquired about the possibility of misidentification of dorado species (*Coryphaena spp.*) by IATTC observers. The presenter noted that *Coryphaena hippurus* accounts for more than 99% of the observations of *Coryphaena spp.* in the IATTC observer database. In order to address this concern, video aids were used to train observers in identification of dorado and other bycatch species. After all observers received the training, the identification rates between the two *Coryphaena* species did not change, which suggests that the identifications are correct.

2.2. Knowledge about life history and stock structure

Talk 15

Determination of age and growth from scales of dorado (*Coryphaena hippurus*) caught in waters of the Southeastern Pacific Ocean during the June 2009–December 2012 period

Yuli Rivadeneira Cagua
SRP-MAGAP, Ecuador

Marcela S. Zúñiga Flores
INP-Mexico

Summary: During the period from October 2008 to December 2012, biological sampling of dorado (*Coryphaena hippurus*) was carried out in the most important places in Ecuador, Esmeraldas, Manta and Santa Rosa Anconcito, it consisted of measuring a number of variables of fish of different lengths and obtained the following information: fork length (cm FL), total weight (kg), sex, also the scales were collected for determining age and growth. A total of 156,104 dorados (61,031 ♂ and 95,073 ♀) were collected at the three fishing coves, it was found that in the distribution of length structures for each of the coves that the mode is different, for Esmeraldas there was a bimodality of 65 cm to 115 cm FL in Manta at 85 and 90 cm FL, for Santa Rosa/Anconcito, fish of small lengths were recorded at 65 cm FL. In the analysis of the variation of length by location significant differences were found, for the Esmeraldas cove the differences were significant by year and not by sex, at the Manta cove the differences were significant by year and also by sex. At Santa Rosa/Anconcito the differences were significant by year and by sex alike. The age of 4,847 dorados (2,222 ♂ and 2,625 ♀) was determined at the three fishing coves, the length interval of all the dorados sampled with scales was 25 to 145 cm FL, differences were observed in the sex ratio, where in some classes there were more females than males. Dorado has a negative allometric growth type for both sexes. The estimates of the parameters of the von Bertalanffy growth equation for Esmeraldas were for males ($K = 1.23$, $t_0 = -0.39$ and $L_\infty = 137.6$), for females ($K = 0.91$, $t_0 = -0.56$ and $L_\infty = 142.0$) and for combined sexes ($K = 1.03$, $t_0 = -0.51$ and $L_\infty = 141.0$), en Manta males ($K = 0.73$, $t_0 = -0.68$ and $L_\infty = 141.8$), for females ($K = 0.90$, $t_0 = -0.70$ and $L_\infty = 125.8$) and for combined sexes ($K = 0.67$, $t_0 = -0.82$ and $L_\infty = 140.5$), and Santa Rosa/Anconcito males ($K = 0.43$, $t_0 = -1.03$ and $L_\infty = 165.7$), for females ($K = 0.51$, $t_0 = -1.13$ and $L_\infty = 142.5$) and for combined sexes ($K = 0.33$, $t_0 = -1.31$ and $L_\infty = 179.5$). Also it was found that the growth in weight for both sexes is

similar during the first age groups (0 – 0.5 years) and that when dorado reach the age of one year, growth splits markedly with males reaching higher values than females. Readings of the growth marks on the scales showed 7 age groups from 0 to 3 years, with the 0.5 to 1.5 year groups being the most abundant for both sexes are the ones that predominate in the catch.

Discussion:

A participant asked whether there is any justification for estimating dorado growth curves separately by fishing port. If the areas of operation of some fleets based in different ports overlap, it is very likely that they are exploiting the same population, so there is no need to separate samples. Alternatively, they may be exploiting different segments (age classes) of the same dorado population that is migrating in the equatorial tropical Pacific Ocean. The presenter responded that the reason for considering separate growth curves by port is that there are significant differences among dorado growth curves from different ports. Another participant commented that the fleets from Anconcito and Manta could be pooled since they operate in fishing grounds that are different than those exploited by the Esmeraldas fleet.

It was noted that determining the age of dorado using scales was not so successful in Peru, and so it was decided to use otoliths. The presenter responded that scales have so far provided very satisfactory results for age determination of dorado caught by Ecuadorian fisheries. A collection of dorado scales obtained from Ecuadoran artisanal fisheries is available for research.

Talk 16

Partial fecundity of dorado (*Coryphaena hippurus*) caught in waters of the Southeastern Pacific Ocean during the 2011–2012 period

Pedro Gabriel Mero Veliz
SRP-MAGAP, Ecuador

Marcela S. Zúñiga Flores
INP-Mexico

Dorado *Coryphaena hippurus* is a migratory species, with a short lifespan, an opportunistic pelagic predator. It is of importance to commercial and sport fisheries worldwide. In Ecuador joint efforts are being made to eco-certify the commercial fishery, to achieve sustainability and conservation of the species. Biological sampling of dorado started October 2008, and continues to date. The sampling sites were: Esmeraldas, Manta, Santa Rosa and Anconcito, which come from mother ships. For this study, females in the length interval of 53 and 133 cm FL were collected. Biological sampling and collection of samples of dorado started in January 2011 and were carried out at the main unloading ports of Esmeraldas, Manta, Santa Rosa-Anconcito. After collecting the samples they are fixed in 10% formaldehyde. Placed to dehydrate in alcohol. Next placed in bleach to enable the mass of oocytes to be separated. When sifting the oocytes in 1000- and 500-micron sieves a sample is taken of the oocytes sifted out with the 1000-micron sieve and a gram is weighed. After weighing the gram the oocytes in the gram are quantified, applying the standard formula for gravimetric volume. Photographs are taken and next 50 oocytes with oil globules are measured. In the relationship between partial fecundity (number of oocytes) and fork length (mm), it was estimated with a minimum of 20,736 (OH), for a female of 82 cm FL, a maximum of 1,388,112 OH (female of 133 cm FL) and an average of 308,197 OH per female. When analyzing the relationship of partial fecundity and total weight (kg), fork length (cm) and gonad weight (g) at the different coves. Sea-surface temperature is one of the environmental parameters that has a great relationship with the production of oocytes since the availability of food is linked to the reproductive strategies of a population. The estimate of average partial fecundity was similar to those reported in other estimates for the species.

Discussion:

A participant asked if there are plans to continue the dorado fecundity studies in the future. The presenter

answered that there are plans to analyze recently-collected 2013 samples. Another participant asked differences in the fecundity of dorado were found among ports. The presenter said that there were: in the northern port of Esmeraldas, oocytes are very numerous but of small size, whereas the samples from the ports of Manta, Anconcito, and Santa Rosa contained less numerous but larger oocytes.

Talk 17

Study of the reproductive biology of dorado (*Coryphaena hippurus*) during the period between October 2008 and December 2012

Francisco Layaven Zapata
SRP-MAGAP, Ecuador

Marcela S. Zúñiga Flores
INP-Mexico

Summary: The study of the reproductive biology of dorado, began since October 2008 to December 2012, three ports were chosen (Esmeraldas, Manta, Santa Rosa-Anconcito), which is where the greatest quantities of dorado are unloaded in Ecuador. Gonads of males and females were collected for which biological-fisheries information (cm FL, total weight kg, sex) was recorded. They were then moved to EPESPO (School of the Eastern Pacific) for respective fixing in Davidson. The description of the ovarian stages were based on Zúñiga-Flores *et al.* (2011), where 6 stages for females and 4 classes for males are established. The behavior of the gonadal cycle of the females was different at all the coves. A greater representativity of females in Stage III (Esmeraldas) could be observed, not so for females in the immature stage they were observed mainly in the second half of the year. In Manta it was observed that the greatest quantity is represented by females in stage II (starting maturation). As in the previous cove, females in advanced stages could be observed throughout the year. At Santa Rosa/Anconcito stages I and II were observed from March to December. Also stage III could be observed, present throughout the year, and that the more advanced stages (IV, V, and VI) coincide with the highest average values of surface temperature. In the sex ratio by length interval for each year there were significant differences in all the coves. The average values of the gonadosomatic index of females ranged from 0.89 to 9.53, with a variation observed in the highest values of each cove. The average values of the condition factor for females did not show much variability in the coves of Manta and Santa Rosa/Anconcito, however in Esmeraldas a reduction in average values could be observed, mainly in the month of June. The minimum individual length at maturity was recorded for a female of 23.5 cm FL and for a male of 27 cm FL, both collected at the fishing cove of Esmeraldas. Furthermore that unlike the females the lowest estimated L50 was found at Esmeraldas (77.9 cm FL), and for Manta the highest (97.9 cm FL). The values of the lengths of stock maturity (L50) were estimated at 77.9 cm FL and 98 cm FL (ages of 0.9 to 1.3 years). There were years in which L50 was reached at lesser lengths (*e.g.* 2008 and 2011). It is important to mention that the estimated L50s were above those estimated in other regions of the world for this species. It was clearly observed that the reproductive season for dorado in Ecuadorean waters is intense and extensive, that is that it can be maintained throughout the year and in all the fishing coves. If the environmental conditions remain optimal for them (quantity of food for adults and larvae, optimal ranges of sea-surface temperature, *etc.*). The seasonality or the presence of immature fish or in this case juveniles and in recruitment can be clearly identified, mainly during the middle of the year (May to August).

Discussion:

A participant asked for additional information about some dorado gonad tissue samples which showed oocytes in different stages of development. The presenter explained that oocytes were found to be in the same development stage in gonads exhibiting “total spawning”, but some gonads were also found that showed “partial spawning”, in which oocytes in different developmental stages were identified. Another participant commented that dorado in Colombia do not show continuous spawning throughout the year, unlike in Ecuador. In Colombia, there seems to be a spawning peak around December-January, and the

same could occur in waters near the northern port of Esmeraldas in Ecuador. In addition, spawning individuals of smaller sizes are not found in Colombian waters. A participant attributed these differences between Colombia and Ecuador to the oceanographic conditions of the waters off Ecuador, which are characterized by several frontal systems that make Ecuadorian waters very productive. A comment was made that in Ecuador the size at first maturity for dorado is between 77 and 78 cm, but the minimum size at capture is at 70 cm. It was clarified that the 70 cm limit was established before the reproductive study was conducted.

Talk 18

Biological and fisheries aspects of dorado in Peru

Edward Barriga
Instituto del Mar del Perú (IMARPE)

Summary: Combined in Peru summary above

Discussion:

The results of a preliminary stock assessment of dorado in Peruvian waters, using a Schaefer-type surplus production model, were discussed. A sharp decline was observed in the standardized CPUE from 2001 to 2005 and this trend was captured in the assessment. The seasonality factor was the most influential in the CPUE standardization.

A participant noted that recent catch levels for dorado are above the maximum sustainable yield (MSY) according to this preliminary assessment. A comment was made that the fishing pressure on dorado in northern Peruvian waters, where larger vessels predominate, is higher than in the south. Another participant expressed caution about the interpretation of the CPUE time series and how it affects the stock assessment results. The sharp decline in CPUE occurred from 2001 to 2005, but the unusually high CPUE levels in 2001 may be biased, since the availability of dorado increased greatly in 2000-2001 after the strong El Niño event of 1998. Dorado became very available in inshore waters of Peru in those years, and this resulted in increased awareness of, and interest in, this new resource by Peruvian artisanal fishermen. Therefore, there were marked changes in availability/catchability during that period, and these may not have been captured in the CPUE standardization model without detailed oceanographic/operational explanatory variables.

Talk 19

Biology and fishery of dorado in the North-Central area of Peru

Amado Solano S.
Instituto del Mar del Perú (IMARPE)

Summary: Combined in Peru summary above (see Talk 4)

Talk 20

Study of food habits of dorado (*Coryphaena hippurus*) caught in Ecuadorean waters during the October 2008-February 2012 period

Mariuxi Moreira Merchán
SRP-MAGAP, Ecuador

Felipe Galván-Magaña
CICIMAR-IPN, Mexico

Summary: The analysis of the stomach contents of 1,742 dorados, *Coryphaena hippurus*, caught by vessels of the Ecuadorean artisanal longline fleet is presented, and whose stomach samples were obtained

by on-board observers and by technicians of the Undersecretariat of Fisheries Resources. The samples collected were validated for subsequent qualitative and quantitative analysis of gastric content. The degree of fullness was determined, each of the preys found was identified to the lowest possible taxon using specialized keys. Also among the prey organisms found, their state of digestion was taken into account. The study was divided in two analyses, a first study generated with the data from the analysis of the stomach samples obtained from October 2008 to June 2011 and a second study generated on the basis of the data obtained from the analysis of the stomach samples obtained from July 2011 to February 2012. Dorado is described as a species with a wide trophic spectrum and food habits closely tied to the epipelagic environment. In the first study 39 prey organisms were identified in the trophic component of dorado, which belong to three large groups: fish, cephalopods and crustaceans, representing in order of the Index of Importance (IIMP) 50.4%, 47.8%, 1.8%, respectively. As regards the most important prey species they were *Argonauta sp.*, 27.7%; *Exocoetus monocirrhus* 15%; *Oxyporhamphus micropterus* 11.2% and *Dosidicus gigas* 9.9%. In the second study 36 prey organisms were identified in the trophic component of dorado, which belong to two large groups: fish and cephalopods, representing in order of the Index of Importance (IIMP) 41.51%, 54.45%, respectively. As regards the most important prey species they were *Argonauta sp.*, 17%; *Exocoetus monocirrhus* 15%; *Pholidoteuthis boschmai* 10.40%; *Dosidicus gigas* 9.24% and *Cheilopogon sp.* 6.1%. Taking as a reference the Shannon-Wiener Index dorado presented a diverse diet (< 2 diet not diverse) (> 2 diet dominated by various species). As regards the amplitude of the trophic niche using Levin's standardized index (1968) (< 0.6 specialists) (> 0.6 generalists). It was found in this study that dorado shows a specialist tendency because of its preferential predilection for the species: *Argonauta spp.*, and *E. monocirrhus* and due to the great trophic spectrum found in its diet it is considered a species of opportunistic habits.

Discussion:

Continuing trophic ecology studies of dorado is important, as is knowledge of the diet of dorado for quantifying important predator-prey interactions involving this key predator of the EPO.

Talk 21

Characterization of the genetic stock structure of dorado samples from the EPO

Emerik Motte
Concepto Azul, Ecuador

Summary:

This study reported on the diversity and genetic structure of dorado in the EPO using mitochondrial DNA (mtDNA) techniques. Results from the study corroborate previous investigations which showed high genetic variability for dorado. Compared with other studies, larger sample sizes were crucial to the finding of a higher number of NADH1 haplotypes for Ecuador. Some of the haplotypes were detected at very low frequencies. In order to investigate the hypothesis of localized population structure for dorado in the Pacific Ocean, a similar sampling effort should be applied in other areas of the Pacific Ocean. Such sampling efforts are critical to investigating more recent demographic dynamics for dorado. The relatively high haplotype diversity and low to moderate values of nucleotide diversity, along with negative values for the Fu neutrality test, suggest that demographic expansion is taking place.

Discussion:

A comment was made about the potential use of microchemical element analysis for dorado (*e.g.*, heavy metals). A participant noted that Ecuador is conducting heavy-metal and stable-isotope work with dorado. It was noted that the short lifespan of dorado (about 3 years) could result in a low genetic signal insufficient for genetic studies. The genetic study indicated a “recent” demographic expansion of dorado in the EPO. A participant inquired about the cause of this expansion. The presenter answered that the expansion did not occur in a focal point. There is great genetic diversity, so it is important to obtain

additional samples to better quantify halotype frequency. Certain life traits of dorado have caused its high genetic diversity.

Talk 22

Seasonal variation in stocks of dorado (*Coryphaena hippurus*) on the Pacific coast of Colombia

Ricardo Téllez, Susana Caballero
Universidad de los Andes, Colombia

Summary: Large pelagic fish are characterized by having numerous populations, great migratory capacities and cosmopolitan distributions, reducing the probability of stock structuring. For dorado (*Coryphaena hippurus*) migratory movements related to environmental changes in the eastern Caribbean have been documented. However, in other places, such as the Eastern Pacific, the possible differentiation of stocks has not been assessed. To be able to answer this question, it is important to consider the changes in the temporal and seasonal abundance of this fish on the Pacific coasts of Central America and the North of South America. In this study we investigate the possible genetic differentiation between dorado stocks of the Pacific coast of Colombia analyzing partial sequences of two genes of mitochondrial DNA and five microsatellite loci. We collected 128 tissue samples of fish in georeferenced localities of the Colombian Pacific coast between the months of November 2010 and December 2011. The genetic differentiation between sampling dates (months) calculating paired values of F_{ST} with the aim of detecting heterogeneity on a temporal scale. These analyses suggest a slight stock structuring between samples collected during the first months of the year (Nov-May) and the samples collected in the middle months of the year (Jun-Oct). Additionally, the Bayesian asignamiento suggested two population units with $K = 2$. Both analyses showed genetic heterogeneity on a temporal scale suggesting the presence of two different stocks on the Pacific coast of Colombia throughout the year. Our data suggest the incursion of individuals migrating to the Colombian Pacific during the peak catch between the months of January to May and a lesser one and that individuals collected in nearby months present less genetic differentiation than those collected in more distant months. Considering that dorado moves in the Pacific and that each country has different management strategies as well as different numbers de catches, the combined catch quantities could significantly reduce the total population of this fish and affect the sustainability of its populations.

Discussion:

The hypothesis of existing “resident” (July-December) and “non-resident” (January-June) stocks of dorado in Colombian waters was discussed. Specifically, the southern stock shared with Ecuador and Peru is mainly available in Colombian waters (resident stock), but a “fringe” of a northern (non-resident) stock also visits Colombian waters on a seasonal basis. There was extensive discussion about the optimal spatial-temporal design necessary to obtain adequate samples for genetic studies in the region. Analyzed genetic samples for dorado were obtained mainly from tuna purse seiners. A participant mentioned that samples should also be obtained from artisanal longline boats since these cover more inshore waters in Colombia and other countries usually not exploited by the tuna purse seiners. In addition, longline catches of dorado in Colombian waters are dominated by larger fish, unlike purse-seine catches. Another participant noted that sample collection times (*e.g.*, months, seasons) should be fixed while obtaining samples at different spatial locations (a “spatial-temporal” sampling grid). The genetic investigation of dorado should be expanded to include samples from other areas in the EPO, from Mexico in the north to Peru in the south. It was noted that the oceanography of the EPO should be considered when improving the sampling design for genetic studies. For example, the Equatorial Front which oscillates latitudinally around the Equator can act as a strong physical barrier but also “open up” as an area of potential mixing of populations on a seasonal basis. This area should be sampled adequately. Other important oceanographic features are current systems located between Baja California and Panama, as well as the Humboldt current with its upwellings of cold water along the Peruvian coast. It was suggested that looking at dorado life-history in the Atlantic (mainly Caribbean) may provide some insights into the EPO. It was noted that the

peak of the dorado seasonality curve in Colombia (January-March) is different from that observed in the fisheries of other countries (October-March). Another participant commented that the offshore waters of Ecuador and Peru seem to represent an important area of recruitment for pelagic fish populations, including dorado.

3. IDENTIFICATION AND SUMMARY OF AVAILABLE DATA SOURCES (PREPARATION OF A METADATA TABLE)

An important objective of the IATTC regional collaborative efforts on dorado is to progress towards the development of a stock assessment and/or fishery indicators to guide future management of the species in the EPO. In order to plan for this objective, it is critical to first identify and produce an inventory of available sources of data on dorado in the region. This inventory was produced during an open-discussion section in which participants helped the IATTC staff to complete a metadata table summarizing the existing information available for dorado in the EPO (Appendix 3).

4. PLANNING A FUTURE COLLABORATIVE REGIONAL RESEARCH PLAN

Talk 23

Preliminary results of collaborative research activities by the IATTC on dorado in the Eastern Pacific Ocean and future research plan

Alexandre Aires-da-Silva
IATTC

Summary: Alexandre Aires-da-Silva presented an update of the preliminary results from IATTC collaborative research activities on dorado (*Coryphaena hippurus*) fisheries by IATTC staff and scientists of coastal Member States (Document SAC-05-11b).

Requests have been made by some EPO coastal Member States for collaborative research with IATTC staff on dorado and assistance with the design of data collection forms and data-entry programs for dorado fisheries. The work done so far includes: analysis of available catch statistics and trade records, improvement of field data collection programs, investigation of seasonal trends, and identification of fishery units. In addition, available fishery data on dorado from IATTC members and other nations are being analyzed to develop stock status indicators (SSIs) which could potentially provide a basis for advice for managing the species in the EPO. All data for 2013 shown in the report are preliminary. Finally, a proposed IATTC Stock Assessment Group research plan for low-information and bycatch species, including dorado, is outlined.

4.1. Planning of future research activities

An open session was held to discuss and prioritize current research needs for dorado in the EPO. The outlined regional collaborative research plan covered the following topics: biological parameters, population structure, relationships with environment, management strategy evaluation (MSE), data collection, and others (Appendix 4).

5. OTHER MATTERS

The participants from Peru expressed interest in organizing the 2nd IATTC Technical Meeting on dorado in 2015. Although still subject to official confirmation, the meeting is tentatively planned to take place in Paíta, Peru, probably in October 2015. Paíta is an important landings port for dorado in the EPO.

On behalf of Dr. Guillermo Compeán, Director of the IATTC, Dr. Aires-da-Silva thanked all participants for their strong support and attendance at the 1st IATTC Technical Meeting on dorado. He also thanked the Undersecretariat of Fisheries Resources of Ecuador for taking the initiative and organizing the meeting. In addition, he acknowledged the International Seafood Sustainability Foundation (ISSF) for its financial support for the IATTC staff participants' travel to attend the meeting.



Participants at the 1st IATTC Technical Meeting on dorado, held in Manta, Ecuador, October 2014. See list of participants in Appendix 5.

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Appendix 1.

1ST TECHNICAL MEETING ON DORADO

Review current state of knowledge and identify available data sources for dorado in the eastern Pacific Ocean

14-16 October 2014, Manta, Ecuador

AGENDA

Note to presenters: Please limit your presentations to 30 minutes (20 min presentation + 10 minutes discussion). There will be additional time for discussion at the end of every session.

Day 1, Tuesday, 14 October

8:00 Registration (open all day)

Inauguration and Opening

8:30 Welcome. *Molke Mendoza, Director of Control of Fisheries Resources, Vice-Ministry of Aquaculture and Fisheries, Ecuador*

National Anthem of Ecuador

Presentation of the event. *Alexandre Aires-da-Silva, Senior Scientist, Inter-American Tropical Tuna Commission (IATTC)*

Inauguration of the event. *Pilar Proaño, Vice-Minister of Agriculture, Livestock, Aquaculture and Fisheries, Ecuador*

9:15 Break

9:30 Background to dorado in the Eastern Pacific Ocean and structure of the workshop
Alexandre Aires-da-Silva, IATTC

SESSION 1. Knowledge of the fisheries

10:00 The dorado (*Coryphaena hippurus*) resource in Ecuador. *Molke Mendoza, SRP-MAGAP, Ecuador*

10:30 The process of the fisheries improvement program for the sustainability of the dorado (*Coryphaena hippurus*) resource in Ecuador. *Jimmy Martinez¹, Pablo Guerrero² & Fred Sondheimer¹. ¹WWF Ecuador and ²WWF Latin America and Caribbean*

11:00 Summary review of the dorado (*Coryphaena hippurus*) resource in Peru *Miguel Ñiquen, IMARPE, Peru*

11:30 Break

11:45 Artisanal fishing for dorado in Peru. *Wilbert Marin, IMARPE, Peru*

12:15 Generating alliances for promoting the sustainability of the fishery for dorado (*Coryphaena hippurus*) in Peru in the framework of the Fisheries Improvement Project. *Samuel Amorós K., WWF-Peru*

12:45 The fishery for dorado in the Colombian Pacific. *Luis Zapata and Rodrigo Baos, WWF-Colombia*

13:15 Lunch

- 14:30 Dorado as bycatch in the purse-seine fishery in Colombia. *Christian Bustamante, AUNAP, Colombia*
- 15:00 The fishery for dorado in Panama, current situation and plan for improvement. *Edwin Medina, CEDEPESCA, Panama*
- 15:30 Break
- 15:45 Characterization of the unloadings of dorado (*Coryphaena hippurus*) in Costa Rica. *José Miguel Carvajal, INCOPECA, Costa Rica*
- 16:15 Status of the fishery for dorado in the Pacific in Guatemala. *Manuel de Jesús Ixquiac, FUNDAECO, Guatemala*
- 16:45 Progress in databases on highly-migratory species in the OSPESCA countries and new perspectives. *Jorge López, OSPESCA, El Salvador*
- 17: 15 Review of the state of knowledge regarding dorado *Coryphaena spp.* with emphasis on the Mexican Pacific. *Sofía Ortega García, CICIMAR, Mexico.*
- 17: 45 Collecting and managing data on dorado in the purse-seine fishery for tunas in the Eastern Pacific Ocean. *Marlon Román-Verdesoto, IATTC*
- 18:15 Close

Day 2, Wednesday, 15 October

SESSION 1 (continued). Knowledge of the fisheries

- 8:30 Discussion session

SESSION 2. Knowledge about life history and stock structure

- 9:00 Determination of age and growth from scales of dorado (*Coryphaena hippurus*) caught in waters of the Southeastern Pacific Ocean during the June 2009–December 2012 period. *Yuli Rivadeneira Cagua, SRP-MAGAP, Ecuador*
- 9:30 Partial fecundity of dorado (*Coryphaena hippurus*) caught in waters of the Southeastern Pacific Ocean during the 2011–2012 period. *Pedro Gabriel Mero Veliz, SRP-MAGAP, Ecuador*
- 10:00 Study of the reproductive biology of dorado (*Coryphaena hippurus*) during the period between October 2008 and December 2012. *Francisco Lavayen, SRP-MAGAP, Ecuador*
- 10:30 Break
- 10:45 Biological and fisheries aspects of dorado in Peru. *Edward Barriga, IMARPE, Peru*
- 11:15 Biology and fishery of dorado in the North-Central area of Peru. *Amado Solano, IMARPE, Peru*
- 11:45 Study of food habits of dorado (*Coryphaena hippurus*) caught in Ecuadorean waters during the October 2008-February 2012 period. *Mariuxi Moreira Merchán, SRP-MAGAP, Ecuador*
- 12:15 Characterization of the genetic stock structure of dorado samples from the EPO. *Emmerik Motte, Concepto Azul, Ecuador*
- 12:45 Seasonal variation in stocks of dorado (*Coryphaena hippurus*) on the Pacific coast of Colombia. *Susana Caballero, Universidad de los Andes, Colombia*
- 13:15 Discussion session
- 13:30 Lunch

SESSION 3. Summary of available data (open session)

14:30 Construction of the summary metadata table of available data for dorado in the Eastern Pacific Ocean (list of data of interest)

15:30 Break

15:45 Discussion

17:00 Close

Day 3, Thursday, 16 October

SESSION 4. Planning a joint research effort

8:30 Preliminary results of collaborative research activities by the IATTC on dorado in the Eastern Pacific Ocean and future research plan. *Alexandre Aires-da-Silva, IATTC*

9:00-17:00 Discussion, with breaks at 10:30 and 15:30; lunch 13:15-14:30

Appendix 2.

1ST TECHNICAL MEETING ON DORADO

Review current state of knowledge and identify available data sources for dorado in the eastern Pacific Ocean

14-16 October 2014, Manta, Ecuador

LIST OF DATA OF INTEREST

Review of assumptions and data sources

- a. Catch
 - Fleet characteristics
 - Expand to total catch
 - By gear type, region, country
- b. Effort
 - Total or index
 - By gear type, region, country
- c. Indices of abundance
 - Catch-per-unit-effort (CPUE)
- d. Composition
 - Age
 - Length
 - Weight
 - Length/weight categories
 - Stage/sex
- e. Biology
 - Length-weight
 - Growth
 - Natural mortality
 - Reproduction (maturity, fecundity, frequency)
 - Stock structure
 - Tagging
 - Genetics
- f. Other
 - Species composition of the catches (identification of pompano *Coryphaena equiselis*)

Appendix 3.

Data table

Data type	Source	Description
BIOLOGY		
Age and growth	Sofia Ortega (CICIMAR-Mexico) Manuel Ixquiac (Guatemala) Yuli Cagua (SRP-Ecuador) Carlos Goycochea (IMARPE-Peru)	Analysis of age and growth done with sportfishing fleet data, 2004-2006, with scales. There is a collection of otoliths that have not yet been analyzed, and separated by sex, and analyses of modal composition available. Analysis of age and growth done with data for the artisanal longline fleet, 2006-2008, by sex, length. Analysis of age and growth done with scales and otoliths (available), 2008-2012. Sexes separated. Age- and sex-composition data available. Analysis of age and growth done with otoliths (microincrements 2010), by sex.
Length-weight relationship	Sofia Ortega (CICIMAR, Mexico) Manuel Ixquiac (Guatemala) Yuli Cagua (SRP-Ecuador) Amado Solano (IMARPE-Peru) Luis Zapata and Rodrigo Baos (WWF-Colombia)	Sexes separated, 2002-2013. Possibly other sources of data in the south Mexico. Sexes separated, years 2002, 2006-2008. Sexes separated. Analysis by port, 2008-2012 Sexes separated, fishery survey data, 2006-2008 and 2010. Monitoring of artisanal fisheries, annual, 2008-2014. Sexes separated, 1994-1996, and 2009-2014, longline fleet.
Maturity	Sofia Ortega (CICIMAR, Mexico) Ángel Vega and Héctor Guzmán (Panamanian Pacific) Francisco Lavayen (SRP-Ecuador) Javier Sánchez and Amado Solano (IMARPE, Peru) Luis Zapata and Rodrigo Baos (WWF-Colombia)	Stages of maturity (macro and micro histological method), sex ratios, condition factor, length at first maturity. Gonadosomatic index Data from the Gulf of Panama. Macroscopic analysis of gonads (over 90% of the individuals were identified as sexually mature), 2006-2009. Sexes not separated. By maturity stage. Analysis by port, 2008-2012. Maturity stages, macro and microscopic. Sex ratios. Condition factor. Length at first maturity. L50% (sexes separated). Stages of gonadal maturity (macro and microscopic). Length at first maturity, average length at spawning. Sexes separated, with data for 2006-2010. 1994-1996: hepatosomatic (IHS), gonadosomatic (IGS) indexes, condition factor.
Fecundity	Sofia Ortega (CICIMAR, Mexico) Héctor Guzmán Pedro Véliz (SRP-Ecuador) Javier Sánchez and Amado Solano (IMARPE, Peru)	Partial fecundity by age group, 2004-2006. Data for the Gulf of Panama, 2006-2009. Average partial fecundity, 2011-2012. Relationship with temperature. Relative fecundity, 2006-2010.
Sex ratios	Sofia Ortega (CICIMAR) Manuel Ixquiac	2002-2013. Data for 2002 and 2005-2008

Data type	Source	Description
	Héctor Guzmán and Ángel Vega Luiz Zapata and Rodrigo Baos (WWF-Colombia) Christian Bustamante (AUNAP) Javier Sánchez and Amado Solano (IMARPE, Peru)	Panamanian Pacific, 2006-2009. Sex ratio data (2009-2014). Colombian Pacific observer program, 2012-2013. Sexes separated, fisheries survey data, 2006-2008 and 2010. Monitoring of artisanal fisheries, annual, 2008-2014.
Mortality/ exploitation status	Sofía Ortega (CICIMAR) Juana López (CIBNOR) Manuel Ixquiac (Guatemala) Miguel Ñiquen, Edward Barriga, Wilbert Marín, Amado Solano (IMARPE, Peru)	Exploitation status (F/Z), artisanal fleet, industrial fleet. Analysis by length, Jones method, 2004-2006. Exploitation status (F/Z), artisanal fleet, industrial fleet. Analysis by length, Jones method, 2005-2007. Exploitation status (F/Z), artisanal fleet, industrial fleet. Analysis by length, Jones method, 2002 and 2008. Total mortality rates Z (2010). Assessment with Schaefer model (1999-2009).
Food habits	Manuel Ixquiac (Guatemala) Sofía Ortega (CICIMAR) Pepe Espinoza and Ana Alegre (IMARPE, Peru) Christian Bustamante (AUNAP) Luis Zapata and Rodrigo Baos Mariuxi Moreira (SRP-Ecuador)	Stomach content data (2008) Food habits analysis of the sportfishing fleet, 2002-2013. Food habits analysis (ontogenic, by length). Multivariate regression trees (CART). Trophic ecology, 1998-2014. Food habits analysis, trophic assemblages associated with FADs, 2009-2011 1994-1996: index of prey frequency, index of relative abundance and percentage in number. Food habits study (Oct 2008-Feb 2012). By sex, length and ecological index.
Stock structure	Díaz-Jaimes, Tripp-Valdéz and Rocha-Olivares Emmerik Motte (Concepto Azul) Susana Caballero (Univ. de los Andes, Colombia)	Mitochondrial and microsatellite molecular genetic analysis. Molecular genetic analysis of a mitochondrial gene. Molecular genetic analysis of 5 microsatellites, and 2 mitochondrial genes. Sampling from November 2010 to December 2011.
Others	(CEDEPESCA, Panama) Cristiano Araujo and Rigoberto Rosas (ULEAM) Amado Solano (IMARPE, Peru)	Productivity and Susceptibility Analysis (PSA), 2013. Studies of heavy metals, 2013-2014. Study of stable isotopes, just starting. Parasite studies. 2008 data.
FISHERIES DATA		
Catch		
Purse seine	IATTC observer and	Effort (number of sets) 1993-present.

Data type	Source	Description
	logbook databases	Total bycatch (number of individuals), 1993-present. Large vessels (class 6): bycatch per set x total sets.
Tuna longline (high seas)	IATTC longline database. (Contact countries involved)	Effort 1993-present. Of: 1) sum of effort data 5x5; or 2) the totals prorated with effort 5x5
Mexico	FIDEMAR, INAPESCA, CONAPESCA, IATTC and CICIMAR	Spatial distribution of the average annual bycatch of dorado (in numbers of individuals) with the data for 50% of the Mexican tuna purse-seine fleet that operated in the Mexican Pacific Exclusive Economic Zone (EEZ) 2000-2007, for the Mexican longline fleet, 1997-2002 and 2010, and for sportfishing, 2000-2014 (source: CICIMAR).
Central America	Vinicio Juárez (DIPESCA, Guatemala) CEDEPESCA, ASOPEACE, Asociación San José and Empresa Pesca SA. (Guatemala) José Carvajal (INCOPECA, Costa Rica) Edwin Medina (CEDEPESCA, group PANALANG, Panama) OSPESCA	Catch composition by fleet (artisanal and industrial; 2000-2014). Export data, 2008-2014. Catch, effort, export data. Historical data, 1990-2012 and exports and imports, 2010-2013. Species composition data since 2006 (longline fleet). There are also composition data for the fleets (Costa Rican vessels). Export data based on the classification of dorado by weight (large: >10lb, medium; 5-10lb, small: < 5lb), 2008-2014. Will facilitate the data contributions (if any) of countries not present at the meeting.
Colombia	Luis Zapata and Rodrigo Baos (WWF-Colombia) Christian Bustamante (AUNAP)	Effort in days fishing (2006-2014). Total days/month, average days/month. Active/inactive fleet. Detailed description of gear. Various sources of catch data on the Pacific coast of Colombia (1993-2014). Spatiotemporal analysis of the tuna fishery, its bycatches by part of the foreign fleet in Colombian waters. Composition of the catches by species and type of tuna set (2009-2011). Correlations between these data and environmental variables.
Ecuador	Molke Mendoza (SRP-Ecuador) INP	Areas of the occurrence of dorado with the data of the longline fleet targeting dorado and tuna, billfishes and sharks (TBS), during 2008-2012 as well as the seasonality of the unloadings of the artisanal fishery: surface longline and surface gillnets, 2008-2012. Time series of catches, 2008- 2013, by gear. Historical data series since 1980 (statistical yearbooks).
Peru	IMARPE, PRODUCE, WWF-Peru: Samuel Amoros	Unloadings: annual (1990-2014), monthly (1997-2014). Artisanal longline fleet. Relationship of monthly unloadings with environmental data (sea surface temperature, sea surface salinity, oxygen; 1997-2014). Effort (2000-2014): number of trips, duration of trips, effective hours, number of hooks.

Data type	Source	Description
		On-board data (fisheries surveys 2008 and 2010), on-board observations, fishing logbooks, 2013-2014.
Length composition		
Purse seine	IATTC observer database (large vessels only)	Length-composition data: 1) Length categories (< 30 cm FL; 30-60 cm FL; > 60 cm FL), 1993-2010
Tuna longline (high seas)	Do not exist, Alex da Silva will contact colleagues	
Mexico	Sofia Ortega (CICIMAR). INAPESCA (fleet longline)	Length composition of the catches of the sportfishing fleet (2002 -2013). Longline fleet, 2005-2011 data.
Central America	Eduardo Juárez (INPESCA), Manuel Ixquiác (Guatemala)	Length composition of the catches of the artisanal longline fleet (2005-2008). Catch composition classified by marketable lengths of the industrial fleet (large, medium, small), 2000-2014.
	Héctor Guzmán and Ángel Vega	Average lengths (Gulf of Chiriqui and Gulf of Panama area). Artisanal longline fleet. Average lengths.
Colombia	Luis Zapata and Rodrigo Baos (WWF-Colombia) Christian Bustamante (AUNAP)	Length composition, 1994-1996 and 2009-2014. Sexes separated. Composition by length class and set type, tuna purse-seine fishery.
Ecuador	Molke Mendoza (SRP-Ecuador), Jimmy Martínez (WWF-Ecuador) INP	Length composition with the data of the artisanal longline fleet targeting dorado and tuna, billfishes and sharks (TBS) (2008-2012). Monthly data. Sexes separated. Length structure data artisanal longline fleet, 1989-1993 and 2006-present.
Peru	Miguel Ñiquen, Edward Barriga, Wilbert Marín, Amado Solano (IMARPE)	Size structure of dorado in Paita, total by years, 2000-2014. Monthly, 2008-2014. By sex and total. Length distribution by hook size (selectivity), 2008-2010.
Indices of abundancia		
Purse seine	IATTC observer database (large vessels only)	See Aires-da-Silva <i>et al.</i> 2014. IATTC Document SAC-05-11b
Tuna longline (high seas)	Do not exist. Alex da Silva will contact colleagues.	
Mexico	Sofia Ortega (CICIMAR)	Catch data for the sportfishing fleet, 2002-2013.
Central America	Manuel Ixquiác (Guatemala) Héctor Guzmán	Abundance (CPUE) of dorado and sea-surface temperature (SST); Relationship of abundance of organisms ln(org) (2004-2007 and SST °C). Information obtained by part of the artisanal fleet of the Gulf of Panama on abundance is 104kg/day/vessel.
Colombia	Luis Zapata and Rodrigo Baos (WWF-Colombia)	Data for the industrial longline fleet. Monthly CPUE (1994-1996)
Ecuador	Jimmy Martínez (WWF-Ecuador) en colaboración with Cleridy-Lennert-Cody and Alex da Silva (IATTC)	Analysis of standardised CPUE (GAM). See Aires-da-Silva <i>et al.</i> 2014. IATTC Document SAC-05-11b
Peru	Miguel Ñiquen, Edward Barriga, Wilbert Marín, Amado Solano	Catch and effort by fishing season, 1998-1999, 2013-2014. (CPUE ton/trip). Standardisation of CPUE with data for the artisanal longline

Data type	Source	Description
	(IMARPE).	fleet 1999-2009 (GLM). Network of IMARPE field observers. By area (North, Central, South), three fleet categories.
Management measures		
Mexico		Prohibition of commercial fishing for dorado; resource available only for sportfishing within 50 miles of the EEZ.
Centroamérica	INCOPECA, Costa Rica CEDEPECA, Panama	Restriction of fishing effort for new entrants to the longline fishery. Prohibition on fishing on FADs in the tuna purse-seine fishery since 1999. Prohibition of fishing in marine national parks. Freeze on issuing of new licenses for fishing for the species; use of longlines allowed only for vessels of less than 6 GRT; a method of hand fishing is implemented; the number of hooks on the longline is limited to 800 per line or vessel.
Colombia	AUNAP	Annual quota of 2000 tons for catches of dorado by industrial longline, since 2013. Exclusive zone for artisanal fishing (ZEPA), of 2.5 miles to the north of Chocó. Exclusive fisheries management zone (ZEMP), 12 miles.
Ecuador	SRP	National Plan of Action for the Conservation and Management of the Dorado Resource in Ecuador (PAN-Dorado). Control and Surveillance System. Minimum catch length limit (80 cm TL). Time closure implemented from 1 July to 7 October (Ministerial agreement 070, May 2011). Incidental catches of 2% allowed during the closure for purse-seine vessels, and 8% for longline gear. Regulations limiting fishing effort to motherships in the dorado season to 10 fiberglass boats, and up to 6 for the TBS fishery.
Peru	PRODUCE	Ministerial resolution no. 249-2011-PRODUCE: minimum catch length of 70 cm FL is established, with a 10% tolerance. Ministerial resolution no. 245-2014-PRODUCE: a fishing season for the dorado resource is established from 1 October to 30 April each year.

Appendix 4.

Planning of a joint research effort

1. BIOLOGICAL PARAMETERS

Growth. Standardization of the different methodologies for determining age (different structures), training the countries needing assistance. Extend the sampling coverage of skeletal structures (scales, otoliths, etc.) in the region (Colombian Pacific and Central America, etc.) and establish the regional sampling protocol. Protocols for determining age extant in some countries (Peru, Ecuador, Guatemala, Mexico, Colombia) could be considered in this process.

Length-weight relationship. Standardization of the different measures taken in the region; for example fork length, total, gutted, complete, head removed, etc.

Reproductive biology. Efforts for the development of an *ad hoc* macroscopic scale. Comparisons of the different maturity scales and methods for determining fecundity. Standardization of maturity scales. Development of training activities in countries that need it. Development of the sampling design with a suitable spatial and temporal component. Review of the methods used in determining size at first maturity.

2. STOCK STRUCTURE

Spatiotemporal analysis. Joint spatiotemporal analyses of the length composition information available in the region and variations in its centers of concentration.

Tagging. Development of a regional tagging program for dorado considering appropriate statistical design elements (spatial and temporal component). Explore the possibility of developing/strengthening tagging activities in collaboration with the private sector (commercial and sport) and/or based on research platforms.

Length composition. Regression trees for investigating the stock structure of the region. For example, work on bigeye at the IATTC.

Genetic studies. Support existing studies and improve the sampling design (spatial and temporal component). Develop protocols for genetic information and incorporate them into existing data collection protocols. Establish coordination among the different existing genetic studies and future sampling activities.

Stable isotopes. Support the existing studies in the region, facilitating obtaining samples. Establish protocols for data collection and their standardization at the regional level.

Microchemistry of otoliths. Consider the usefulness of this methodology for dorado.

Association with oceanographic effects.

Parasites studies as possible tool for stock identification.

3. CORRELATIONS WITH THE ENVIRONMENT

Monitoring of existing studies. Temperature-oxygen correlations, chlorophyll-dynamic sea level correlation. Explore relationships with other variables

Database. Establish a joint database at the regional level on environmental variables of interest. Consider the various sources of information available and you mention it.

4. ASSESSMENT OF MANAGEMENT STRATEGIES

Management objectives. Identify them (MSY, maintain an average catch level, ensure the reproduction of the stock, establish spatiotemporal closures). Socio-economic indicators. Indicators of product quality; for example, histamine and heavy metal levels.

Stock indicators. Identify these indicators that could be estimated with the information available (CPUE, catch and effort indicators, environmental indicators, average lengths, mortality estimates). Information from on fisheries surveys, fleet dynamics, fleet type and size, characterization of gears, selectivity. Indicators of productivity and susceptibility or other risk analyses.

Define the control rules for management. Examples: effort control measures, catches, spatiotemporal closures, minimum sizes, catch quotas, fleet type and size, gear selectivity.

5. DATA COLLECTION

Monitoring. Monitor the collection of information on size and weight (small, medium, and large) class compositions obtained from industry. Standardize the definitions of these classes in the region.

Sampling protocol. Establish a consensus on collecting information. Use of the metadata as a basis for the existing information-collection protocols.

Collection of morphometric information for comparative analyses

Sampling coverage on other vessels. Explore the possibility of expanding observer coverage aboard small purse-seine vessels (Classes 1 to 5).

6. OTHER MATTERS

Toxicology studies.

Studies of trophic ecology and of communities. Example: ecosystem approaches to fisheries.

Larval studies. Example: on *Coryphaena equiselis*.

Appendix 5.

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