Stock Assessment of Dorado (*Coryphaena hippurus*) in the South Eastern Pacific Ocean

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.... and many collaborators

7th Meeting of the IATTC Scientific Advisory Meeting
La Jolla, California (USA), 9-15 May 2016
Outline

• Background
  ▪ Dorado exploitation in the EPO
  ▪ IATTC and dorado

• Exploratory stock assessment (base case model)
  ▪ Fishery data
  ▪ Model assumptions (biological and fishery process)
  ▪ Model diagnostics (model fits)
  ▪ Results (recruitment, biomass, fishing mortality)
  ▪ Potential management tools (see Doc SAC-07-06a(ii) for exploratory management strategy evaluation MSE for dorado)

• Sensitivity analyses

• Summary conclusions
Important source of livelihood

- Exploited by artisanal fisheries of EPO coastal States

47-70% of world’s catch

Fuentes: FAO FishStat, SRP-Ecuador, Anuarios Estadísticos de Pesca, Perú

71,000 MT on average (2008-2012)
Growing interest in ecolabeling

- High value of dorado exports
- Certification require stock assessments (reference points and harvest control rules)
- Dorado is thought to be highly resilient to overfishing due to its high productivity
- But there are no stock assessments for dorado in the EPO
1st IATTC Meeting on Dorado

- Some coastal States requested collaborative research and guidance from staff on dorado stock assessment research
- Established collaborative research forum in the region
- Identified a large amount of biological and fishery data

Manta, Ecuador, October 2014
2nd IATTC Meeting on Dorado

- Progress on two important questions
  - Stock structure assumptions
  - Which methodologies and indicators of stock status to use for dorado

Lima, Peru, October 2015
Stock structure hypothesis

- Results from genetic studies are not conclusive
- Most data comes from Peruvian and Ecuadorian artisanal fisheries
- About 90% of catches are taken by Peruvian and Ecuadorian fisheries
- Exploratory Stock assessment for South EPO (*Stock Synthesis*)
Conceptual life-history model

- Higher seasonality in the oceanographic conditions - Mayor estacionalidad en las condiciones oceanográficas

- Higher stability in the oceanographic conditions - Mayor estabilidad en las condiciones oceanográficas

- Oceanic sub-stock - Sub-stock oceánico
- Resident sub-stock - Sub-stock residente
- Mature animals during the whole year - Animales maduros durante todo el año
- Spawning and feeding - Desove y alimentación
- Humboldt current - Corriente de Humbolt

- Movement of adults - Movimiento de los adultos
- Cold coastal waters - Aguas costeras frías
- Large animals - Animales grandes
Spatio-temporal dynamics

Assumptions
Dorado monthly catches

Data sources
Dorado annual catches

Data sources

Landings (mt) aggregated across seasons

- F1–Peru
- F2–Ecuador
- F3–PSbycatch

Equ C 2008 2010 2012 2014
Standardized CPUE - Ecuador

Index F2-Ecuador

Data sources
Standardized CPUE - Peru

Data sources
Size composition data - Peru

size comp data, whole catch, F1-Peru (max=0.12)

Length (cm)


- 0.01
- 0.11
- 0.13
Size composition data - IATTC

size comp data, whole catch, F3

(max=0.98)
Size composition data - Ecuador

size comp data, whole catch, F2-Ecuador (max=0.12)

Length (cm)

2008 2009 2010 2011 2012 2013 2014

Data sources
Age and growth

Model assumptions
Biological processes

Length-weight relationship

Model assumptions

(Zúñiga-Flores (2014); Santa Rosa Anconcito)
Biological processes

Maturity ogive

(Zúñiga-Flores (2014); Santa Rosa Anconcito)

Figura 25. Talla de primera madurez poblacional \( L_{50} \) de las hembras por caleta y año, durante el periodo del 2008 al 2012.
Between 0.43 yr\(^{-1}\) (Zuniga, 2014) and 2.5 yr\(^{-1}\) (Hoening method, data from Zuniga, 2009)

- Estimates vary among sexes

- Base case model assumes \( M = 1 \text{ yr}^{-1} \)
Biological processes

Natural mortality ($M$)

$$F = 0 \text{ yr}^{-1} \text{ (sin pesca)}$$

$$F = 2 \text{ yr}^{-1}$$

Fish numbers in equilibrium

Age (years)

Model assumptions
Relative recruits
Relative Spawning biomass
Beverton-Holt

Model assumptions

Base case assumes $h=1$
Fishery definitions

• 3 fisheries in model
  - F1 - Peru
  - F2 - Ecuador
  - F3 – Bycatch from tuna purse seine fisheries
Base case model

- Monthly time step
- Steepness of S-R relationship = 1
- Index of abundance: monthly CPUE Ecuador (CV=0.2)
- Catchability: time-varying (one Q parameter for each year)
- Selectivity for Peru and Ecuador
  - Asymptotic selectivity for females
  - Dome-shape selectivity for males
- Weighting of data sources
  - Down-weighted size composition data for all fisheries
  - Follow the “Francis approach”
Model fit to CPUE data from Ecuador

Index F2-Ecuador

Year

Index

2008 2009 2010 2011 2012 2013 2014

Season1 Season2 Season3 Season4 Season5 Season6 Season7 Season8 Season9 Season10 Season11 Season12
“Model fit” to CPUE data from Peru
Model fit to length composition data

Peru

size comps, whole catch, F1-Peru

Fork length (cm)

Proportion

2007 - Jul  N=108  effN=39.5
2007 - Nov  N=263  effN=110.1
2011 - Jan  N=1156 effN=270
2012 - Nov  N=329  effN=199.7
2014 - Nov  N=260  effN=158.4

2007 - Aug  N=564  effN=25.3
2007 - Dec  N=699  effN=174.9
2011 - Mar  N=362  effN=97
2012 - Dec  N=390  effN=188.7
2014 - Dec  N=932  effN=256.1

2007 - Sept N=81   effN=47.9
2008 - Feb  N=151  effN=45.9
2012 - Aug  N=315  effN=52.6
2012 - Jan  N=1503 effN=784.8
2014 - Jan  N=226  effN=208.4

2007 - Oct  N=304  effN=64
2009 - Oct  N=71   effN=22.2
2012 Sept  N=313  effN=408.4
2014 - Oct  N=1407 effN=97.4
2014 - Feb  N=64   effN=89.5
Model fit to length composition data

Ecuador

size comps, whole catch, F2–Ecuador

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<th>Month</th>
<th>N</th>
<th>effN</th>
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<td>12.1</td>
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<tr>
<td>2010</td>
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<td>2.6</td>
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<tr>
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<tr>
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<td>May</td>
<td>0.3</td>
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Average model “fit” to size compositions
Size selectivity

Results

Female ending year selectivity for F1–Peru

Male ending year selectivity for F1–Peru

Female ending year selectivity for F2–Ecuador

Male ending year selectivity for F2–Ecuador

Female ending year selectivity for F3–PS bycatch, south 5N

Male ending year selectivity for F3–PS bycatch, south 5N

Length (cm)
Annual recruitment

The graph shows the annual recruitment of Age-0 recruits (in thousands) from 2007 to 2014. The data points indicate fluctuations over the years, with a peak in 2007 and a decline in 2009. The recruitment numbers vary significantly from year to year, with some years showing much higher numbers than others.
Summary biomass

Results
Spawning biomass

Results

- Spawning biomass (mt)
- Biomass values range from 0 to 80,000 mt
- Graph shows variability in spawning biomass over the years.
Fishing mortality ($F$)

Results

![Graph showing annual fishing mortality ($F$) from 2007 to 2014. The graph displays the trend of fishing mortality over the years, with error bars indicating variability.](image)
Spawning biomass ratio (SBR)
Maximum sustainable yield (MSY) and M
See Doc SAC-07-06a(ii) for exploratory management strategy evaluation (YPR, size limits, discard mortality and seasonal closures)
Recruitment

Sensitivities

Age-0 recruits (millions)

- Dome
- M_0.43
- M_1.6
- Qnotv
- Base case

Year:
- 2006
- 2008
- 2010
- 2012
- 2014
Spawning biomass

Sensitivities
Spawning biomass ratio (SBR)

![Graph showing changes in spawning biomass ratio over time with different scenarios labeled as Dome, M_0.43, M_1.6, Qnotv, and Base case. The y-axis represents spawning depletion, and the x-axis represents years from 2007 to 2014.](image_url)
Summary

- There is very strong seasonality in the population dynamics of dorado

- *Stock Synthesis* shows potential to be used as a stock assessment tool for dorado

- See Doc SAC-07-06a(ii) for exploratory management strategy evaluation (YPR, size limits, discard mortality and seasonal closures)
Questions?
Age and growth

Based on Goicochea et al. (2012)
R0 profile

![Graph showing the change in log-likelihood for different scenarios. The x-axis represents the log of unfished equilibrium recruitment (log(R₀)), and the y-axis represents the change in log-likelihood. Three lines are plotted: Total, CPUE, and Length. The Total line decreases sharply, while the CPUE and Length lines increase gradually.]
Resultados

SBR

![Graph showing changes in SBR over the years from 2006 to 2016](image)

- SBRd
- SBRs