Jumbo squid (Dosidicus gigas), studies from Mexico. Fishery, Ecology & Climate

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OUTLINE

• FISHERY.
  • Geographical context. Transition Climate Zone
  • Landings & Retrospective
  • Socioeconomics aspects

• ECOLOGY.
  • Gulf of California Studies
    • Populations structure variability
    • Juveniles studies
  • West Coast of Baja & California Current Studies
    • Adults Spatial Distribution
    • Growth & Age
    • Feeding
    • Paralarvae collected

• CLIMATE
  • ENSO vs. Spatial distribution changes
  • Biological Action Centers (BAC´S)
  • Some indicators of parallelisms between south/north hemispheres

• REMARKS
FISHERY
Fishery

Geographic context

Oceanic thermic condition

Transition Zone

High interannual variability
Fishery
Landings & Retrospective

- Artisanal period
- Japanese exploring
- No fishing period
- Exploring west coast
- La Niña 88-89
- El Niño conditions
- La Niña 99-00
- El Niño 97-98
- El Niño 03-04

Fishing in west coast

Landings (t) vs. Period high abundance

0 20,000 40,000 60,000 80,000 100,000 120,000 140,000
Fishery

Socioeconomics aspects

- Populations dynamics scarce knowledge.
- Fourth fishery in Mexico.
- Employs more than 3,500 fishermen in the Northwest Mexico.
- Maintain the fishery industry active & create parallel industries.
- Beneficious for the regional people.
- High potential to development add value industry.
Fishery

Socioeconomics aspects

Table I. Nominal & Real average price of Jumbo Squid in Guaymas for 1995 and 2003

<table>
<thead>
<tr>
<th></th>
<th>Pangas</th>
<th>Ships</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1.33</td>
<td>1.43</td>
</tr>
<tr>
<td>2003</td>
<td>1.32</td>
<td>1.64</td>
</tr>
<tr>
<td>Average nominal price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.33</td>
<td>1.43</td>
</tr>
<tr>
<td>Average real price*</td>
<td>0.81</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>0.34</td>
<td>0.43</td>
</tr>
<tr>
<td>Price of 2003 equivalent to 1995</td>
<td>1.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*Deflactation used Index of products-prices from Bank of Mexico 1994=0.
Source: Data from landings records of major & minor boats, Fishery Office in Guaymas, Son.
ECOLOGY

"To increase the knowledge for the management of marine resources"
1. *Interannual variability of the populations structure*

Our results indicate the existence of a strong variability in the population structure of jumbo squid within the Gulf of California, mainly at level of the sizes structure, which is reflected in the size of first maturity. The changes in the abundance and population structure of jumbo squid seem to be related not only to the occurrence of events El Niño but also to the intensity or magnitude of such. Figure show interannual variability of the mantle dorsal length (MDL) of jumbo squid in Santa Rosalía, BCS, Mexico. Data before 2003 from Markaid (2002 & 2006)

*Bazzino, et al., 2006 submitted*
2. Presence of paralarvae

During 2003 and 2004 were made in Santa Rosalia BCS monthly, nocturnal and superficial trawls with a conical simple net (60 cm of diameter and 505 µ). Organisms corresponding to the *Rhynchoteuthion* paralarvae characteristic of the Family Ommastrephidae were collected, which would indicate that the area is also used to carry out the spawning of this specie.
**Ecology**

*Presence of juveniles in the Gulf of California & West Coast*

In research cruises inside and outside the Gulf of California, juveniles organisms with MDL between 1.81 - 8.58 cm were collected with dip-net, which suggests an ample distribution of the spawning & nursery grounds. These organisms are preserved in alcohol for future genetic analyses.
Importance of the jumbo squid in the pelagic ecosystem of the Gulf of California

Control top-down in central part of the Gulf of California

<table>
<thead>
<tr>
<th>Nombre del Grupo</th>
<th>Biomasa (ton/km²)</th>
<th>P/B base anual</th>
<th>Q/B base anual</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aves marinas</td>
<td>0.01300</td>
<td>0.379</td>
<td>7.3769</td>
<td></td>
</tr>
<tr>
<td>2 Cachalote</td>
<td>0.03</td>
<td>0.03</td>
<td>5.275</td>
<td></td>
</tr>
<tr>
<td>3 Mamíferos marinos</td>
<td>0.015</td>
<td>0.08</td>
<td>20.252</td>
<td></td>
</tr>
<tr>
<td>4 Tiburones pelágicos</td>
<td>0.473</td>
<td>7.628</td>
<td>0.736</td>
<td></td>
</tr>
<tr>
<td>5 Pelágicos mayores</td>
<td>0.195</td>
<td>1.257</td>
<td>9.747</td>
<td>0.7</td>
</tr>
<tr>
<td>6 Pelágicos medianos</td>
<td>1.109</td>
<td>0.885</td>
<td>5.198</td>
<td>0.965</td>
</tr>
<tr>
<td>7 Pelágicos menores</td>
<td>5.742</td>
<td>4.505</td>
<td>15.722</td>
<td>0.94</td>
</tr>
<tr>
<td>8 Demersales</td>
<td>1.792</td>
<td>0.956</td>
<td>3.782</td>
<td>0.869</td>
</tr>
<tr>
<td>9 Myctophidae</td>
<td>0.863</td>
<td>1.592</td>
<td>7.262</td>
<td>0.803</td>
</tr>
<tr>
<td>10 Calamar gigante</td>
<td>0.568</td>
<td>3.252</td>
<td>13.819</td>
<td></td>
</tr>
<tr>
<td>11 Ecaudados</td>
<td>1.1</td>
<td>7</td>
<td>24.886</td>
<td></td>
</tr>
<tr>
<td>12 Langostilla</td>
<td>2.7</td>
<td>1.201</td>
<td>17.362</td>
<td></td>
</tr>
<tr>
<td>13 Macrobentos</td>
<td>0.8320</td>
<td>3.48</td>
<td>12.704</td>
<td>0.907</td>
</tr>
<tr>
<td>14 Camarones</td>
<td>0.59</td>
<td>2.29</td>
<td>26.198</td>
<td></td>
</tr>
<tr>
<td>15 Zooplancton</td>
<td>12</td>
<td>25.678</td>
<td>86.264</td>
<td>0.900</td>
</tr>
<tr>
<td>16 Microrganismo</td>
<td>2.113</td>
<td>11.284</td>
<td>39.52</td>
<td></td>
</tr>
<tr>
<td>17 Fitoplancton</td>
<td></td>
<td>95.952</td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>18 Detritus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ecology

West Coast off Peninsula of Baja California Studies

Sampling squid
The presence of the adults has been continuously the last two years

Mejia-Rebollo, 2006
Growth & Age

Table II. Statistics comparation between growth curves of jumbo squid *D. gigas* from West coast 2004 & Gulf of California 1995-1997, in accordance for Integral Logistic Model. N number of individuals, SCR Residual square residuals, MCR Residual Exp2, *** P<0.001

<table>
<thead>
<tr>
<th>Sex</th>
<th>N</th>
<th>Parameters</th>
<th>SCR</th>
<th>MCR</th>
<th>F(3,385)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>143</td>
<td>$Y_\infty = 877.5$ K=0.009536 To=234.9</td>
<td>1255.39</td>
<td>8.9035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>247</td>
<td>$Y_\infty = 896.1$ K=0.0118 To=235</td>
<td>489250</td>
<td>2005</td>
<td>51.50</td>
<td>***</td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>46</td>
<td>$Y_\infty = 792.1$ K=0.01065 To=214.3</td>
<td>328.4971</td>
<td>7.465</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>133</td>
<td>$Y_\infty = 842.1$ K=0.0116 To=223.3</td>
<td>236077</td>
<td>1815</td>
<td>12.24</td>
<td>***</td>
</tr>
</tbody>
</table>

Data for GC from Markaida, 2002

The growing parameters are statistically different between GC and CO

Mejia-Rebollo, 2006
### Ecology

**West Coast off Peninsula of Baja California Studies**

#### Feeding

<table>
<thead>
<tr>
<th>Preys</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleuroncodes planipes</td>
<td>61.45</td>
<td>74.77</td>
</tr>
<tr>
<td>Vincingueria spp</td>
<td>12.71</td>
<td>8.41</td>
</tr>
<tr>
<td>Mictophidae</td>
<td>2.78</td>
<td>2.04</td>
</tr>
<tr>
<td>Copepoda</td>
<td>10.25</td>
<td></td>
</tr>
<tr>
<td>Pteropoda</td>
<td>2.72</td>
<td>0.51</td>
</tr>
<tr>
<td>Piscies</td>
<td>0.90</td>
<td>3.56</td>
</tr>
<tr>
<td>Octopoda</td>
<td>0.11</td>
<td>0.59</td>
</tr>
<tr>
<td>Teuthidae</td>
<td>2.91</td>
<td>1.78</td>
</tr>
<tr>
<td>MONI</td>
<td>1.63</td>
<td>2.21</td>
</tr>
<tr>
<td>Others</td>
<td>4.54</td>
<td>6.13</td>
</tr>
</tbody>
</table>

**Main prey**

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Rosas-Luis, in prepaion
Ecology

West Coast off Peninsula of Baja California Studies

Feeding during the day

“…..During a research cruise on board of BIP XII of the CIBNOR at March, 2005 were observed jumbo squids feeding during the day and surface at 23° 26.84´ LN and 110° 39.84´ LW (12:35 p.m.). The great abundance of red crab (*Pleuroncodes planipes*) in the surface was evident and the squids swam throughout of them. When they were feeding elevated its arms and tentacles outside the water. Nine organisms were collected, eight were females in stages III, IV & V of maturity and one male in advanced stage of maturity V. The average of MDL was of 73,9 (♀) and 63,0 (♂) cm. Figure show squid feeding red crab in surface during the day and squid with red crab between arms…..”
Ecology

West Coast off Peninsula of Baja California Studies

Paralarvae preserved on ethanol

252 Rhynchoteuthion
2005

Ramos-Castillejos, in preparation
CLIMATE

“Scales of variability & marine resources”
Climate

ENSO vs Changes Distribution of Jumbo Squid

La Niña 1999

El Niño 1997

<table>
<thead>
<tr>
<th>AREA</th>
<th>Fishing site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Rosalía</td>
<td>Santa Rosalía, Santa María, Cabo Virgenes</td>
</tr>
<tr>
<td>San Lucas</td>
<td>San Lucas</td>
</tr>
<tr>
<td>San Bruno</td>
<td>San Bruno</td>
</tr>
<tr>
<td>Mulegé</td>
<td>Mulegé, Bahía Concepción, Punta Chivato, San Nicolás, Bahía de Santa Inés, El Coloradito, Isla San Marcos, Roca Lobos</td>
</tr>
<tr>
<td>Loreto</td>
<td>Ensenada Blanca, Ligüí, Loreto</td>
</tr>
<tr>
<td>La Paz</td>
<td>Bahía de la Paz, Isla Espíritu Santo, San Juan de la Costa, El Coyote, Isla San José, El Sausoso, Pichilingue, San Evaristo</td>
</tr>
<tr>
<td>Bahía Magdalena</td>
<td>Puerto Adolfo López Mateos, Buena Vista, Aguas Litorales, Bahía Magdalena, Isla Magdalena, Puerto San Carlos, Banderitas, Punta Entrada</td>
</tr>
</tbody>
</table>

Dimaté, 2004
Climate

Basin effects on changes distribution of Jumbo Squid?

Pacific Decadal Oscillation

El Niño/Southern Oscillation

Charts showing climate oscillations with graphs below.
Jumbo squid from West Coast off Baja
Possible mechanism to explain the expansion of *Dosidicus gigas* population into the north hemisphere
When El Niño events...

BACs
Punta Banda
Punta Eugenia
Bahía Magdalena
San Diego Bight
Monterey Bay

1997
1997
2000+
2000+

Concentración de pigmentos 1978-86, promedio total

Oligotrophic waters

mg Chl m$^{-3}$

1.0
1.5
2.0
2.5
Exist parallelisms between South & North Hemispheres?
Jumbo squid Landings

**Mexico**

- Captura (t)
- Jigging Fleet
- Artisanal fleet
- Total

**Peru**

- Landings (t)
- Jigging Fleet
- Artisanal fleet
- Total

**Chile**

370,000 t in 2005!
Spreading distribution

37° N - 40° S
125° W
Surface – 1500 m

Main concentrations zones

México: Central region of the Gulf of California
- Sudamérica: Coast of Perú & Chile

After Wormuth, 1998

Photo: Dr. Hochberg
Strandings

La Jolla, 2002

New Port Beach 2004

Puerto Montt, Chile 2004

Chiloe, Chile 2004
JUMBO SQUID ARE SPREADING ITS GEOGRAPHIC DISTRIBUTION IN BOTH HEMISPHERES.

KEY QUESTION

YES
Remarks

✓ Jumbo squid is one of the most important fishery in Mexico
✓ Recently is more frequently in the California Current
✓ This specie is a voracious and active predator
✓ It has an important paper in the trophic structure of the pelagic ecosystem
✓ ENSO affect the distribution of Jumbo Squid in northwest Mexico
✓ Already cross the border!

The next questions are:

How many years it will remain here?

Exist parallelism between south & north hemisphere spreading squids?

We need study the habitat & long term climate fluctuations
New Horizon cruise, 2006

Artificial fertilization

Thanks!

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Dosidicus gigas  
wild egg mass