



**Panulirus argus /metapopulation in the Caribbean**

FAO-WEAFC regional workshop 1997-2006, four subregions



Long lasting larval life, 6.5 months (4.5- 8), combined with marine currents favors a wide dispersal/transport between subregions.

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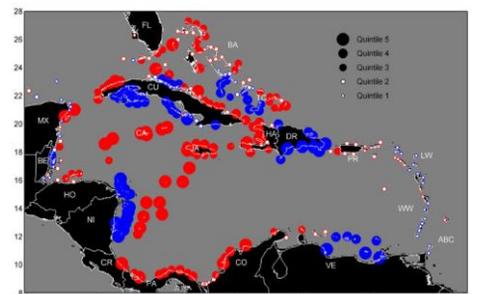
**Biophysical modelling (Kough et al. 2013)**

- **GIS-based benthic module** defines the habitats where the spawners are releasing larvae, and habitats/depths for lobster recruitment [M. Butler].
- **Physical module** introduces the current field in 3D (depth, lat and long), using daily data from hydrodynamic models [C. Paris].
- **Larval biology module** includes larval life history information, like behaviour (diurnal vertical migration), mortality and growth with time [Butler].
- **Stochastic module** for tracking the trajectory of individual larvae [Paris].
- Model runs with a known amount of larvae per site, allow to track the larval trajectory by stage/age. When a postlarvae (age\*) approaches to the coast (depth\*) it is considered as a recruit.
- Tool to identify sources and sinks areas (islands/ sectors of the shelf). Self-recruitment dominates in Bahamas, Cuba, Nicaragua, Venezuela.

\*Certain regions contribute disproportionately to the... larval pool, so maintaining the health of spawning stocks in those countries should be an international priority\*.

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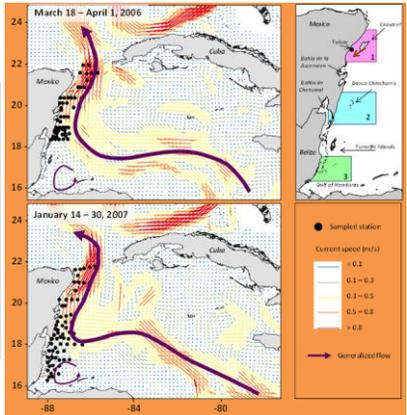
**Biophysical modelling (Kough et al. 2013)**



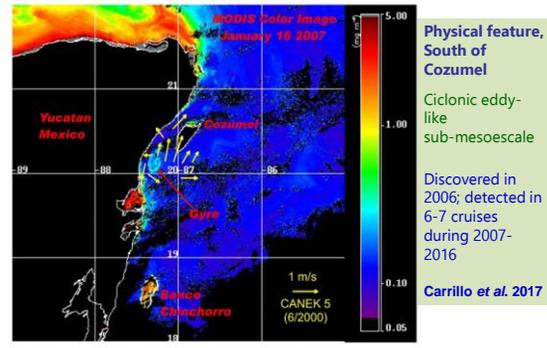
Differences (DEI) between export and import of larvae. Size of DEI is proportional to the circle diameter. Color indicates if imports (RED) or exports (BLUE) are greater.

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Larvae of local origin have some chances to return to the bays and Chinchorro Bank  
  
20% broad average  
  
(Butler, M. 2014; ICWL)



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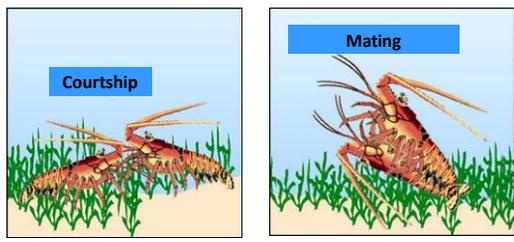


**Physical feature, South of Cozumel**  
  
Ciclonic eddy-like sub-mesooscale  
  
Discovered in 2006; detected in 6-7 cruises during 2007-2016  
  
Carrillo et al. 2017

Figure 3. MODIS color image of cyclonic gyre south of Cozumel, and near surface currents from shipboard ADCP (yellow arrows). Image from Jan 17, 2007.

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**Reproductive activity**



Courtship between male and female. During mating the male deposits a sperm package ("tar spot") to the female.

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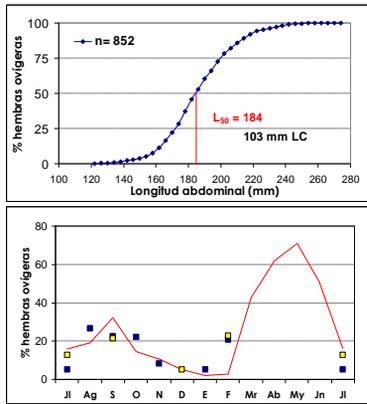
Sperm package ("tar spot") over the sternal plate of the female



Fertilization

The female moves to deeper waters. The female scratch the sperm package releasing the sperm, the eggs are fertilized as they flow through the oviducts.

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**Mexican Caribbean**

- a) Size of first maturity, **184 mm tail length**  
Banco Chinchorro.  
General:  
**140 mm tail length**  
(= 80 mm LC)
- b) Seasonality of reproductive activity, **North MX Caribbean** (line; Ramírez Estévez 1996) and **Banco Chinchorro** (squares).

Reproductive activity, two peaks:  
-September, secondary;  
-March-June, major peak.  
Closed season is OK.

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**Stock Assessment**

Data needed for stock assessment models [Methot (2009)].

- **Total catch.** Considering all the fleets, gears and sources. Special attention to illegal, unreported and unregulated catch (IUU).
- **Abundance indices.** Catch per unit effort (CPUE), index widely used. Mostly based on *fishery-dependent data*. A sample of data is enough. Also are used abundance data from SCUBA visual censuses conducted by research teams. These are *fishery-independent data*. Tagging methods. Local knowledge.
- **Life history parameters.** Growth: size-age relationships (Von Bertalanffy), natural mortality rate  $M$ , age/size of first maturity  $L_{50\%}$ , fecundity and its variation with age/size. Weight-Length relationship. More growth estimation is needed in lobster.

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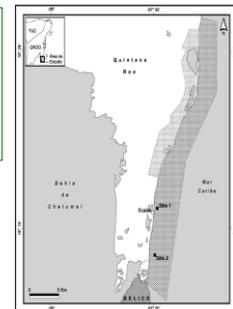
Spiny Lobster fishery in the National Park Arrecifes de Xcalak (PNAX). Monitoring and assessment.

Funding by GCFI-NOAA; ECOSUR-CONANP/PNAX collaboration.  
E. Sosa-Cordero, A. Ramírez G/ECOSUR;  
Beatriz Hernández M, Severo Díaz L.

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National Park Arrecifes de Xcalak (PNAX)/CONANP

The Xcalak community gave support to the National Park creation in 2003.  
PNAX area: 17,950 Ha (44,000 acres).  
Terrestrial, coastal and marine habitats.  
High biodiversity. Coral Reef, mangroves, seagrasses and lagoons.  
Economic activities: small-scale fisheries, tourism, recreational fishery (fly fishing).



Xcalak, fishing village.  
Close to the Mexico-Belize border

Lobster fishery. Small-scale, based on free-diving and gaff (Tails). Now are using the snear (whole lobster).

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Data Sheet 1: Catch-effort data, size and sex of lobsters caught per fishing trip (1/2)

PPD /Integradora de Pescadores SA de CV/ RB Sian Ka'an-CONANP  
 Monitoreo de la Pesquería de Langosta *Panulirus argus* / Bahía de la Ascensión  
 Formato 1: Captura-esfuerzo y talla-sexo, por viaje de pesca (1/2)

Colectores:			
#	Longitud Carapacho (mm)	Peso Total (g)	Sexo (M/F)
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			

Collector name: \_\_\_\_\_  
 \* Include: Other species, ovigerous female (OF), tail size (units cm or mm), recent molted (S)

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Data Sheet 1: Catch-effort data, size and sex of lobsters caught per fishing trip (1/2)

Ingresos del viaje de pesca:  
 Captura de langosta \_\_\_\_\_ # o Kg  entera  colas Precio \_\_\_\_\_ \$/kg Subtotal \$ \_\_\_\_\_

Especies incidentales	Kg	\$/Kg	Subtotal \$
1			
2			
3			
4			

Datos del esfuerzo de pesca:  
 Lugar \_\_\_\_\_ Nombre de la embarcación/pescador \_\_\_\_\_ Fecha \_\_\_\_\_  
 Método de pesca:  buceo a pulmón  Hábitat natural  Casitas  
 Asta de pesca:  gancho  jamo  lazo \_\_\_\_\_ Profundidad \_\_\_\_\_ brazas  
 Área de pesca: \_\_\_\_\_ Posición (GPS) \_\_\_\_\_ Hora de salida \_\_\_\_\_ Hora regreso \_\_\_\_\_ Casitas revisadas \_\_\_\_\_  
 Tripulantes: \_\_\_\_\_

Costos del viaje de pesca de la embarcación  
 Gasolina \_\_\_\_\_ l precio, gasolina \_\_\_\_\_ \$/l Aceite \_\_\_\_\_ l precio, aceite \_\_\_\_\_ /l Alimento \$ \_\_\_\_\_ Hielo \$ \_\_\_\_\_  
 Colectores: \_\_\_\_\_

Questions: **Date;** **Fisher name;** **Boat name;** **Where?** Fishing ground, local names;  
**CATCH:** Kg of lobster tails, and other species; **Fishing gear/method;**  
**EFFORT:** fishing time (hr); depth (m); number of divers, fuel consumption.

New Questions:  
 -- Lionfish, Abundance. Absent (0), Rare (1-4), Abundant (4-12), Very abundant (12+)  
 -- Disease in lobsters, "milky lobsters", PVA1 virus.

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Monitoring: Key data

- Catch of lobster, weight in Kg [tails or whole? ] or number.
- Bycatch. Main incidental species. Kg and number.
- New Questions. **Lionfish;** **non-healthy lobsters.**
- Fishing effort. Fishing time (hr). Number of divers. Depth (m). Fishing ground. Fishing gear/method.
- Fishing Costs. Fuel (L), oil, food, ice, bait (Kg).

Catch per unit effort, CPUE. a) Catch per fishing trip;  
 b) Catch per diving hour.

Number of interviews= number of data of CPUE.  
 Monthly sampling (days), between 7-10 days

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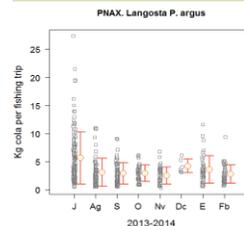
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Monitoring 2013-2014 / PNAX

Months	Interviews, catch-effort (number of trips, n)	Size of lobster measurements (n)
July	122	2,467
August	66	950
September	71	1,047
October	40	619
November	40	517
December	7	414
January	42	162
February	44	811
Total	432	7,223

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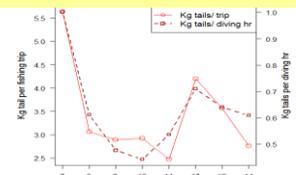
CPUE(a): Kg of tail per fishing trip/ Fishing season 2013-2014



Average CPUE was larger in July 5.6 Kg of tail per fishing trip (Kgv<sup>-1</sup>), then gradually diminished to 2.5 Kgv<sup>-1</sup> in November.

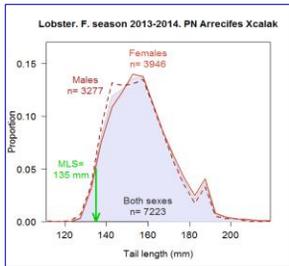
The same seasonal trend of monthly CPUE in the central and south areas of the MX Caribbean.

Comparing CPUE indices  
 • Similar trends of both CPUE indices using n= 430 data.  
 • Monthly CPUE, an index of relative abundance of lobster.



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Size structure of lobsters, by sex [Sample]



- Fishing season 2013-2014
- Sampling size  $n = 7,723$  lobsters in total.
- Sex proportion, **45.4% males**; **54.6% females**.
- Low rate of manipulation of sublegal lobsters. Only 3.7% of the caught lobsters were under the MLS.
- **MLS: 13.5 cm tail length** or **75 mm Carapace length**.
- Large lobsters (>160 mm TL) presence can be related to the local spawning stock, living in deeper waters.

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Recommendations/ Further work

- The coop must sell whole lobster instead of tails. For each Kg of tails, the fishers are losing USD \$ 13-15,
- Total catch of the 2013-2014 season was **2,719.5 Kg of tails** or **14,974 lobsters**. The value of the catch was **\$ 1,000,000 MXP**. These lobsters in the whole presentation could reach a value of \$ 1,468,000 MXP. The difference is **\$ 468,000 MXP (USD \$ 34,600)**.
- Stock assessment is hard to conduct with data for one fishing season. Descriptive indicators did not show red lights. Monitoring must continue the next fishing season.
- Interaction between fishers, management authorities (CONAPESCA, CONANP) and scientists must be enhanced.

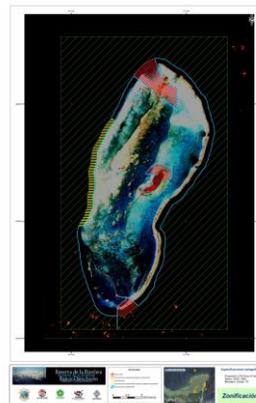
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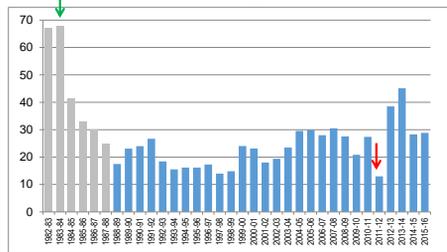
Banco Chinchorro BR.

- Atoll-like, area  $\sim 800 \text{ km}^2$ .
- Three coops: "Andrés Quintana Roo", "Pescadores de B. Chinchorro" y "Langosteros del Caribe".
- **Free diving**, depth limit  $\sim 20 \text{ m}$ ; natural habitats. Coral reef.
- SCUBA and Hookah are forbidden.
- **Snear** instead of gaff. Now they sell whole lobsters. Reef fish and Queen conch.

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Lobster Catch,  $t$  of tails

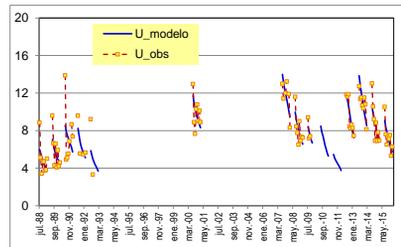
Data source: cooperatives files / CONAPESCA-State offices



Total catch per fishing season,  $t$  of tails. **34** fishing seasons. **Banco Chinchorro**. **13.0  $t$  [2011-12]** - **67.8  $t$  [1983-84]**. Average: **23.5  $t$  cola**

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Abundance index CPUE [ Kg of tails per trip]

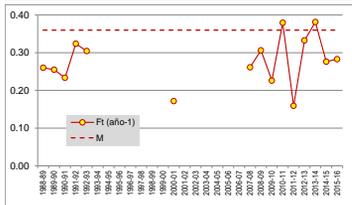


CPUE data obtained during monthly samplings. **14** fishing seasons. **Banco Chinchorro**. Data ( $\square$ ) collected by sampling vs model predictions ( $\rightarrow$ ) Predicted population size (monthly) and annual Recruitment

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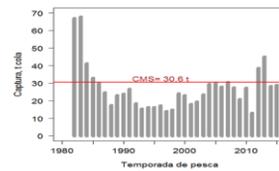
## Status of the stock

- Fishing effort (nominal), number of fishers and boats declined.
- Catch levels, with variations does not follow a clear trend.
- ¿Fishing pressure?



*F* fishing mortality rate with values lower than in other areas (bays).  
 Only two values were greater than *M*= 0.36.  
 2007-2015 [9 seasons] *F* increased with respect to values in 1989-1992.

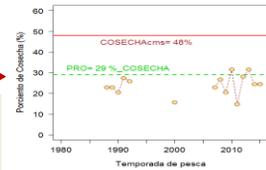
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**LRP, Maximum Sustainable Catch**  
*CMS* = 30,610 Kg of tails  
 91,830 Kg whole  
 CMS was surpassed in several fishing seasons.  
 Catch per fishing season, average is *Ct* = 23.5 t cola.

**LRP, fishing mortality *F* for CMS**  
 % Harvest = 48% *F<sub>CMS</sub>* = 0.66

**TRP, in fishing mortality *F***  
 % Harvest = 29% *F<sub>PRO</sub>* = 0.35  
 In recent seasons *F* values were close to the TRP value.



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## Stock assessment and management

- We socialize the outcomes of the stock assessment to the fishing cooperatives, managers (CONAPESCA), MPA authorities (CONANP), society (NGOs) and academics. **Fishery Improvement Program.**
- Our results seemed reasonable to fishers and other groups. Academics made critical comments.
- Fishers prefer the harvest rate (%) instead of *F* as a measure of fishing pressure, and also as LRP and TRP.
- We are working to define harvest rules. To set in advance some actions when indicators approaches to the Limit Reference Points (LRP).
- Monitoring has been conducted during the last three fishing seasons.

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## Management

- Common regulations: Closed season, no-take of berried females, Minimum Legal Size. ¿Maximum Legal Size?
- Fishing licenses or permissions.
- Fishing area grants to fishing organizations (coops).
- Nominal fishing effort controls, number of boats or/and fishers.
- Fishing gear. Prohibition of SCUBA, Hookah, nets.
- Fishing gears limitation. Number of traps.
- Internal rules of fishing organizations. Community-based. Self-Governance.
- Reference Points, Limit (LRP) and Target (TRP).
- MPA collaboration and interaction

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GRACIAS!!

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