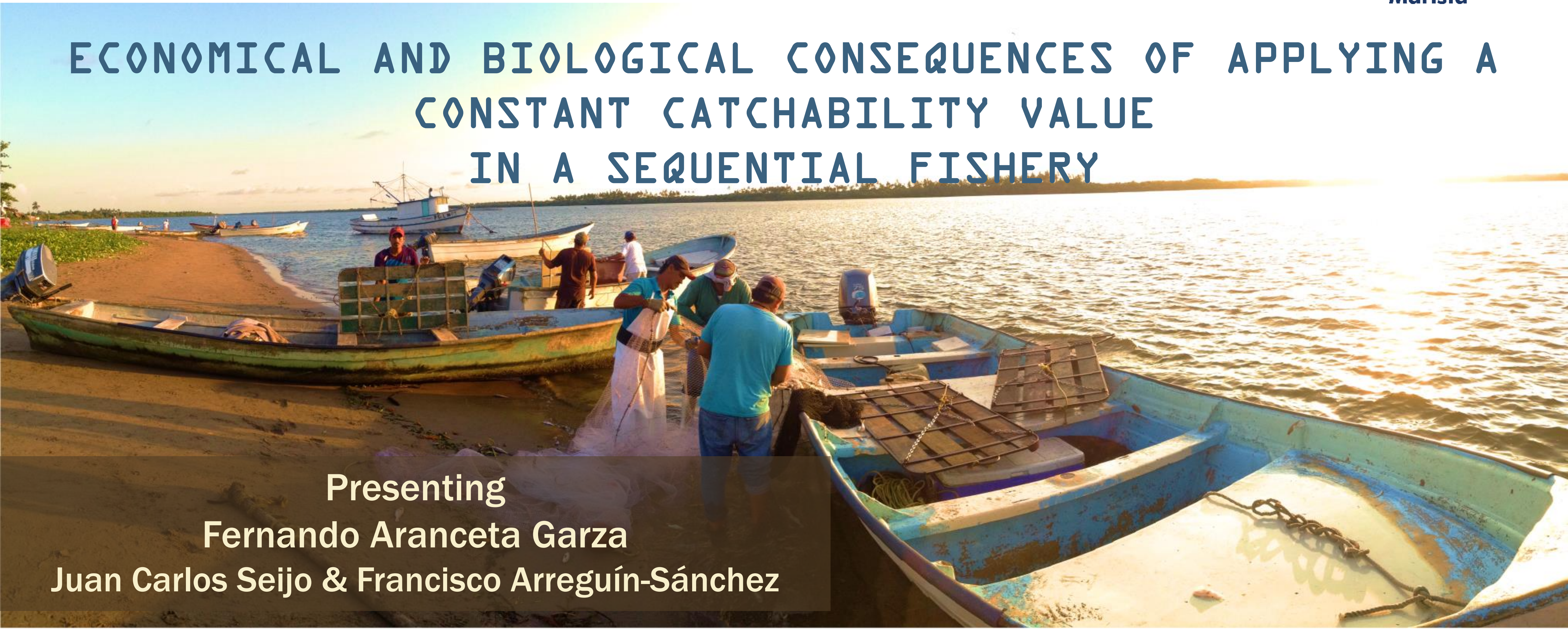
INSTITUTO POLITÉCNICO NACIONAL
CENTRO INTERDISCIPLINARIO DE CIENCIAS MARINAS

CICIMAR-IPN

Universidad Marista

ECONOMICAL AND BIOLOGICAL CONSEQUENCES OF APPLYING A CONSTANT CATCHABILITY VALUE IN A SEQUENTIAL FISHERY



Presenting
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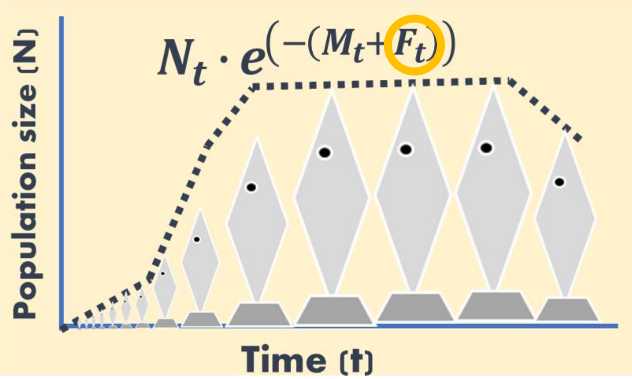
*Small scale shrimp fleet, Teacapán, Sinaloa, México

NAAFE FORUM 2017, March 22-24 La Paz, BCS, México

Importance of catchability parameter "q" in the fishery dynamics

A vital parameter in the fishing mortality coefficient (*F*) used in fishery models:

$$\text{"}F\text{"} = C = q*s*N*f$$

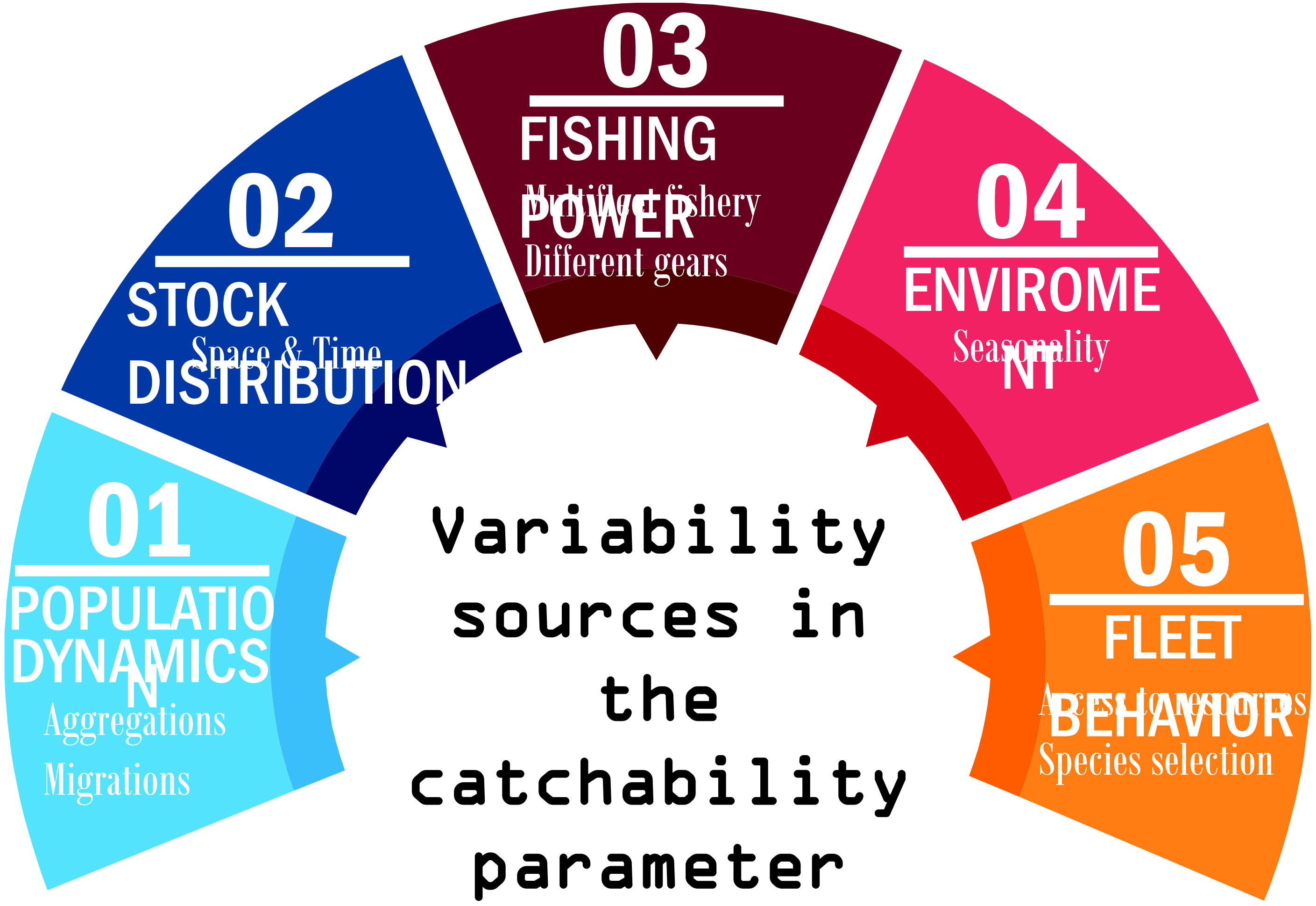


Population dynamics

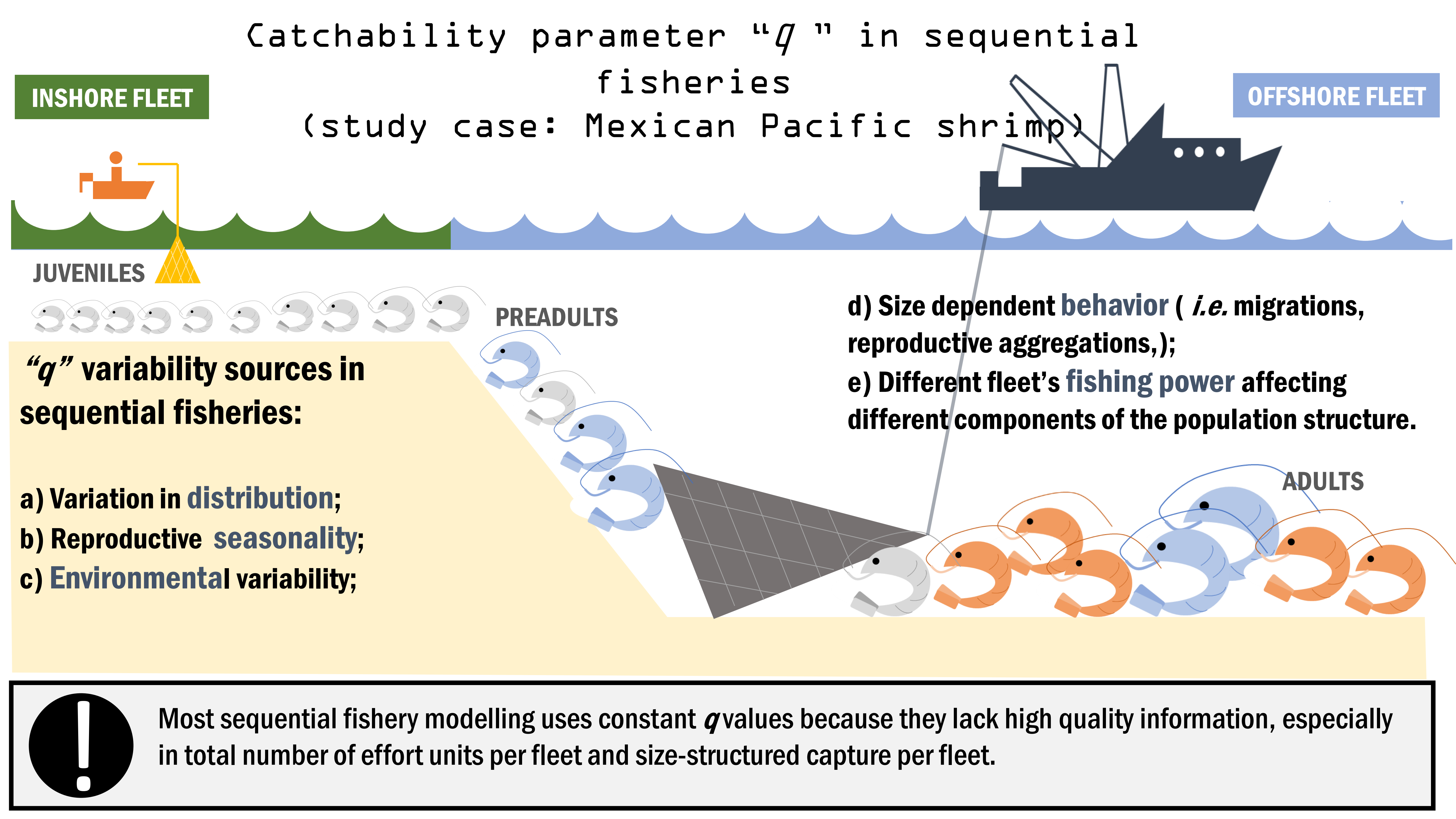
$$\widehat{C}_t = N_t \cdot \left[\frac{F_t}{F_t+M_t}\right] * \left[1 - e^{-(F_t+M_t)}\right]$$

Baranov's catch equation

Most fishery models do not estimated directly the *q* coefficient adopting constant values; this can be applied to: fisheries with similar *q* in individuals (*i.e.* Adult target fisheries); same environmental conditions; same quality fishing effort; & closed population.



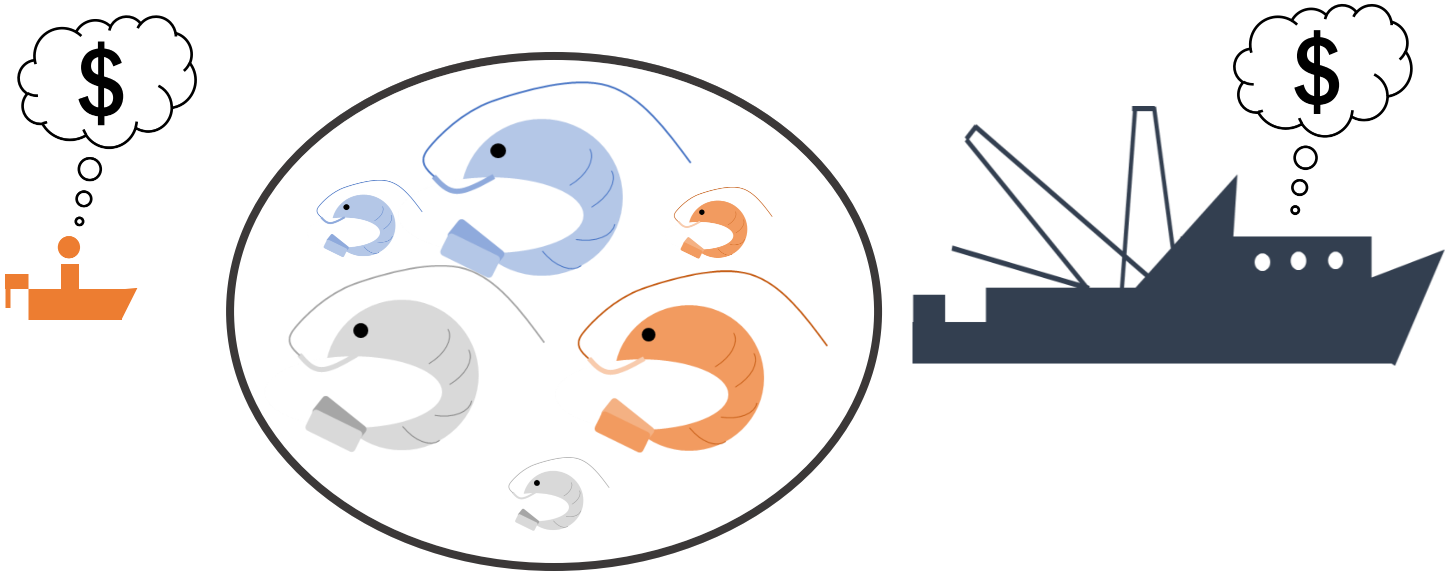
Constant *q* values: Reduces quality and resolution to fishing models with the assumptions: a) the vulnerability is constant to the total population (*i.e.* between larvae, young & adults) & CPUE is independent of resource density; b) Abundance independent of environment (*i.e.* No natural population fluctuations.


Catchability parameter "q" in sequential fisheries
(study case: Mexican Pacific shrimp)
INSHORE FLEET
OFFSHORE FLEET
JUVENILES
PREADULTS
ADULTS
"q" variability sources in sequential fisheries:
a) Variation in distribution;
b) Reproductive seasonality;
c) Environmental variability;
d) Size dependent behavior (i.e. migrations, reproductive aggregations,);
e) Different fleet's fishing power affecting different components of the population structure.
Most sequential fishery modelling uses constant q values because they lack high quality information, especially in total number of effort units per fleet and size-structured capture per fleet.

Research questions

1) In sequential fisheries, which are the biologic and economic consequences of using **constant *q*** over an **aged-dependent *q*** parameter in a fishery model ?

2) Are the consequences of **similar** magnitude between the fleets and among species ?



Methodology

Shrimp fishery data in Sinaloa sur for the 2014-2015 season :

*Fleet effort in days/number units

*Catch structure in sizes per species per fleet

*Biological data (growth, weight, reproduction).

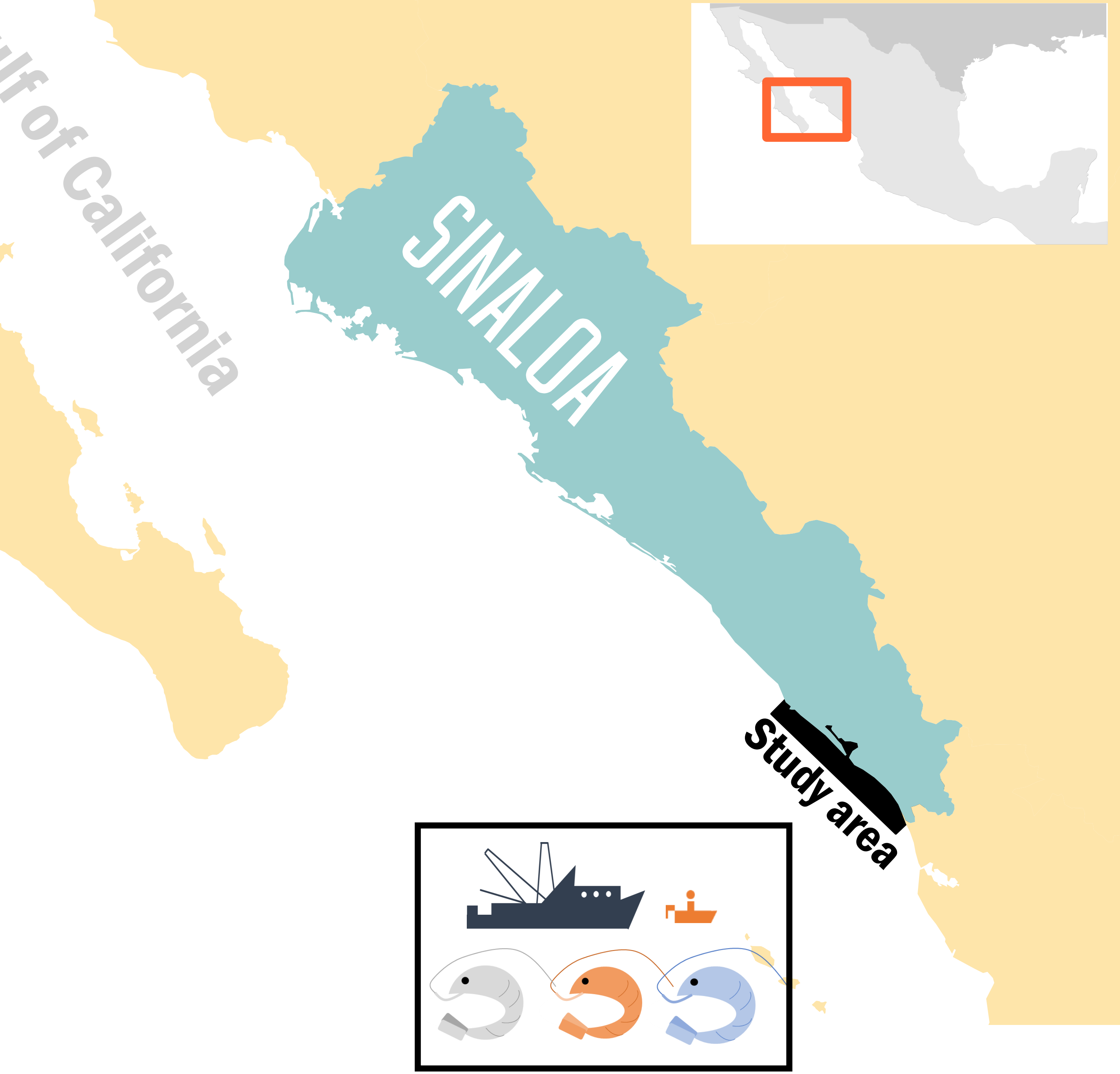
Based Model:

Construction of an aged-structured bioeconomic model with :

**M* and *q-at-aged* parameters

*Multifleet & multispecies

*Distributed delay model (gamma PDF) for recruitment seasonality (Anderson and Seijo, 2010).



Methodology

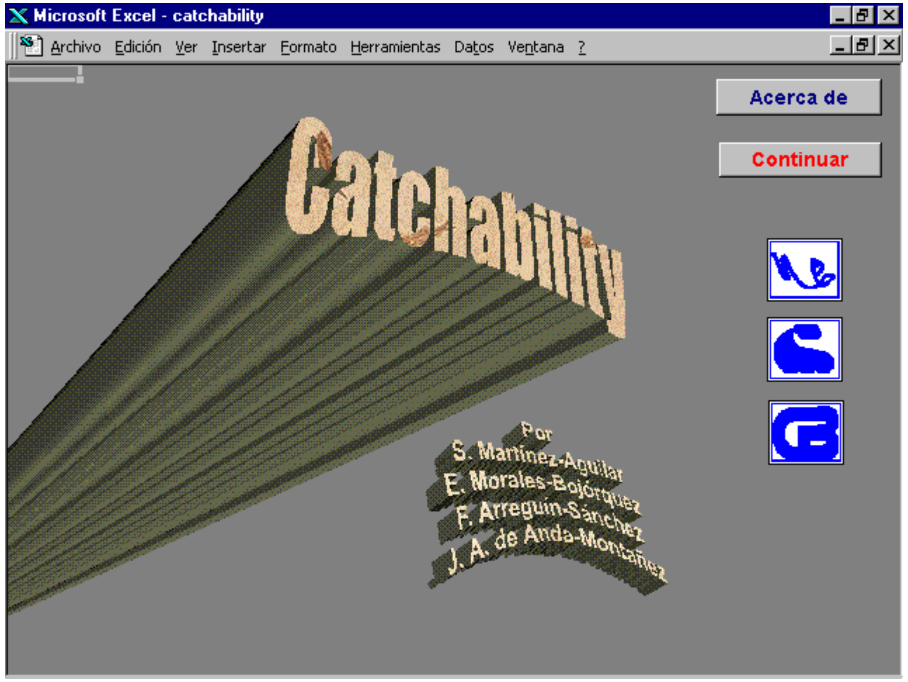
Estimation of *q- at-age*

Using a CATCHABILITY software
Data input: K, r,
$CPUE_t$ $CPUE_{t+1}$ size-structure or "$N_{(l,t+1)}$",
M & f_t.

Uses a transitional matrix ($A_{(l,k)}$) depending on individual growth "G" and survival "S", which **solves for q** minimizing differences between $N_{(l,t+1)}$ and $N_{(l,t)}$ (Arreguín Sanchez, 1996).

$$N_{(l,t+1)} = A_{(l,k)} N_{(l,t)}$$

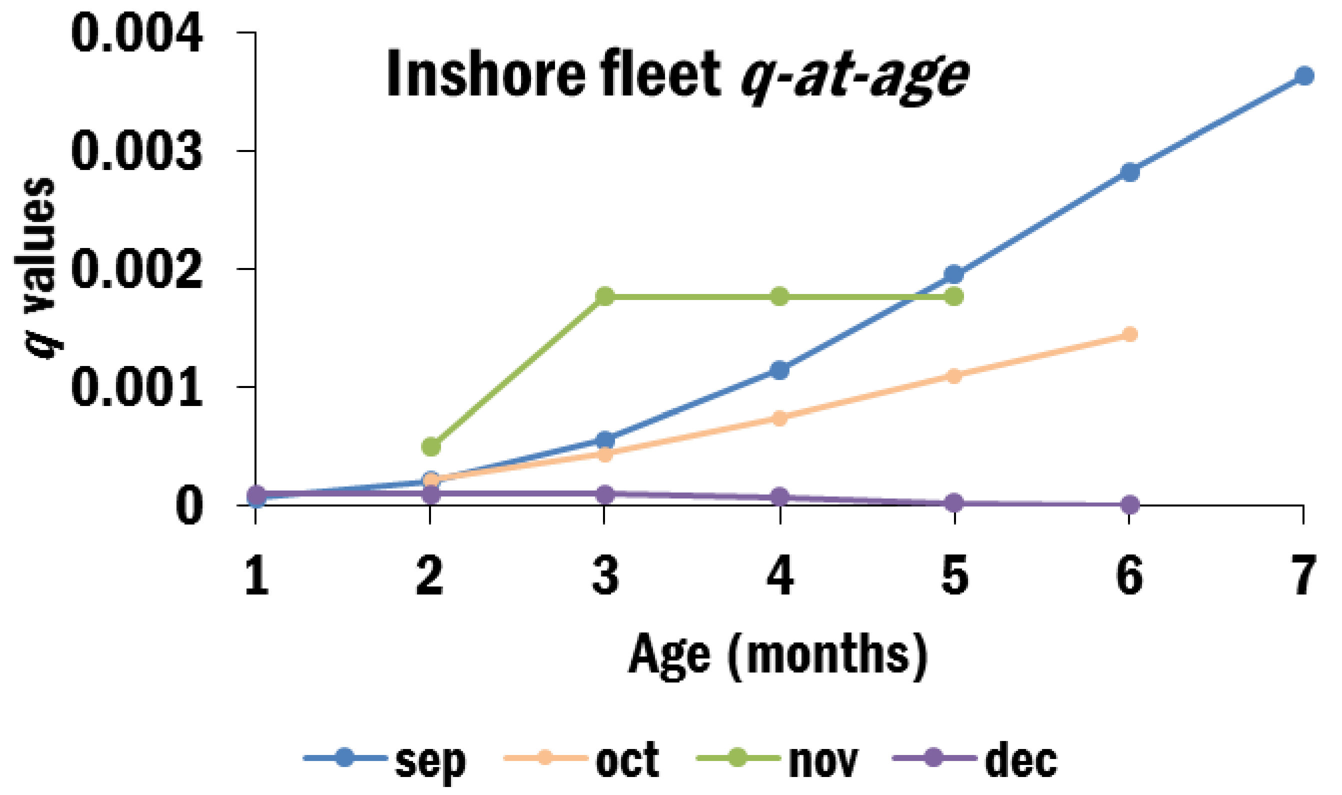
(Arreguín-Sánchez, 1996)

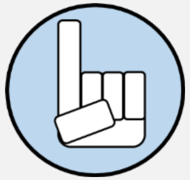


$$* \; N_{(l,t+1)} = \sum_{k} G_{(l,k)} e^{-[M + \mathbf{q_{(k,t)}} s_{(k)} E_{(t)}]} N_{(k,t)}$$

Results

Catchability parameter: constant *q* vs *q-at-age*

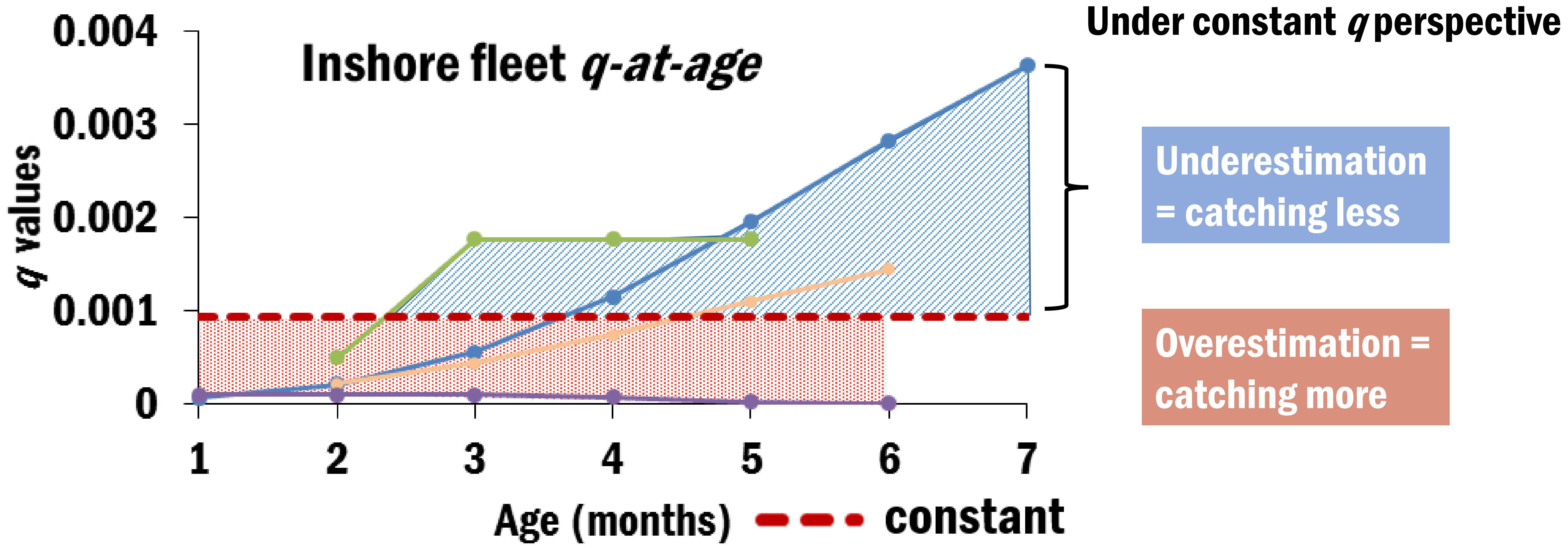




Population structures changes through time mainly by fishing mortality which reduces the stock abundance and reduces *q*-at-age values

Results

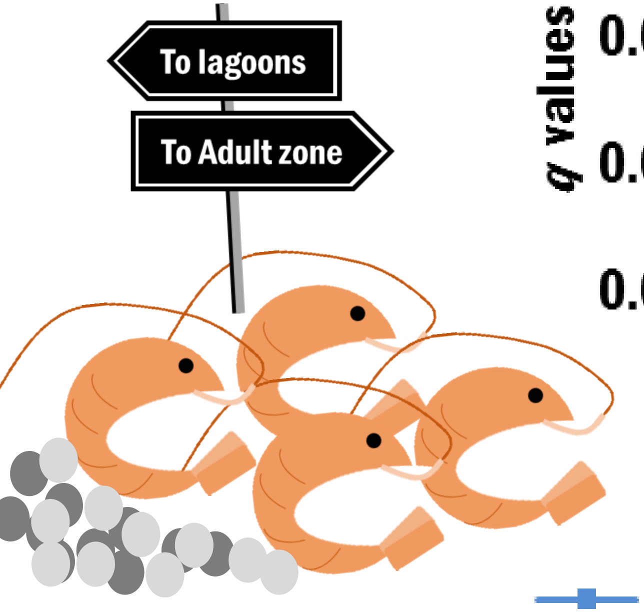
Catchability parameter: constant *q* vs *q-at-age*

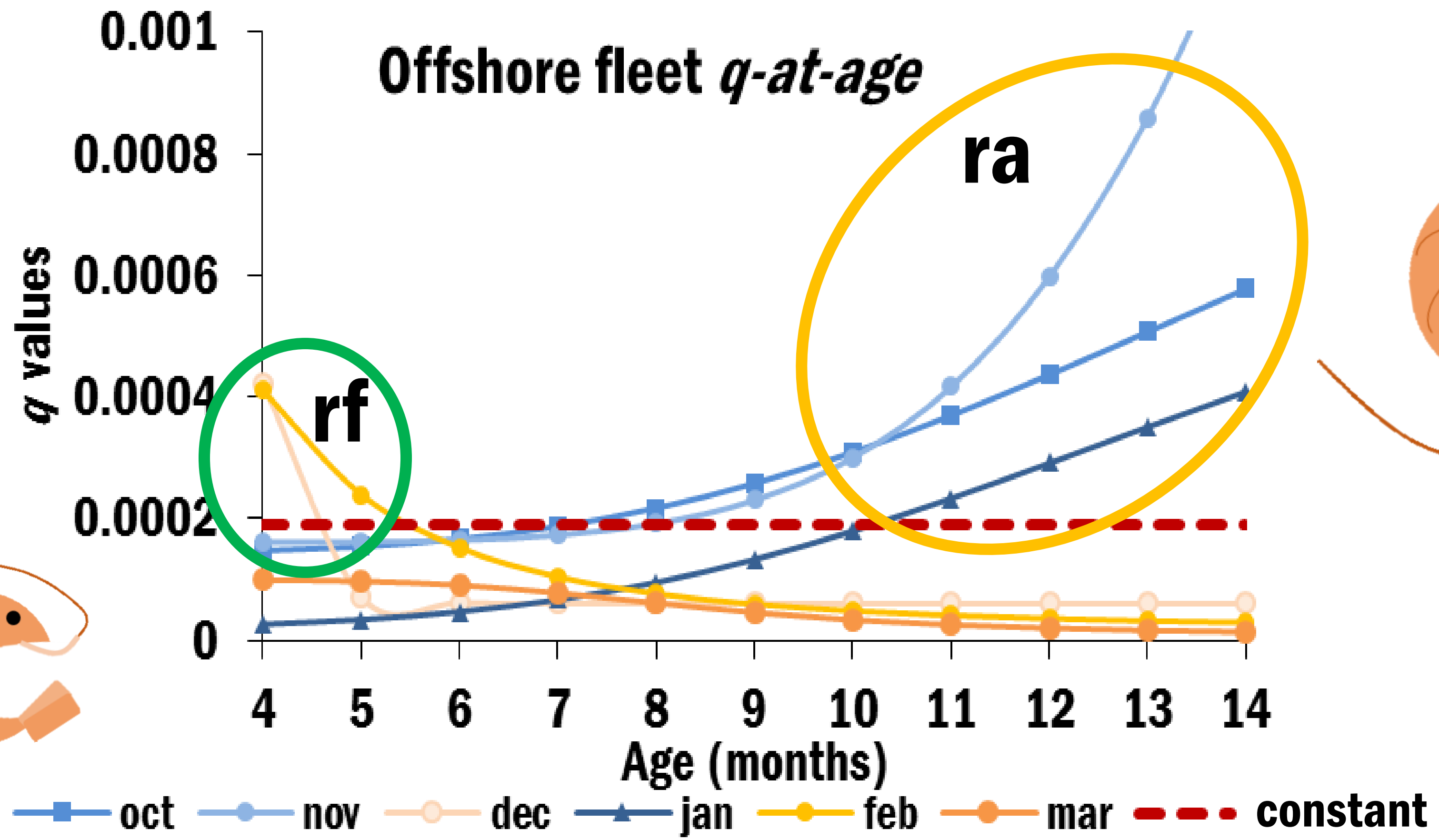


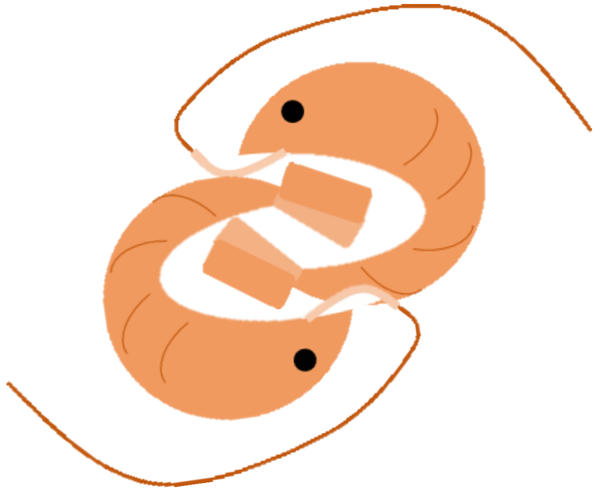
Using a constant *q* value, assigning the same vulnerability to the size/age population structure, will overestimate at early ages, and underestimate towards the adulthood *q-at-age* values. **Globally, using a constant *q* value will overestimate the inshore fishery.**

Results

Catchability parameter: constant *q* vs *q-at-age*



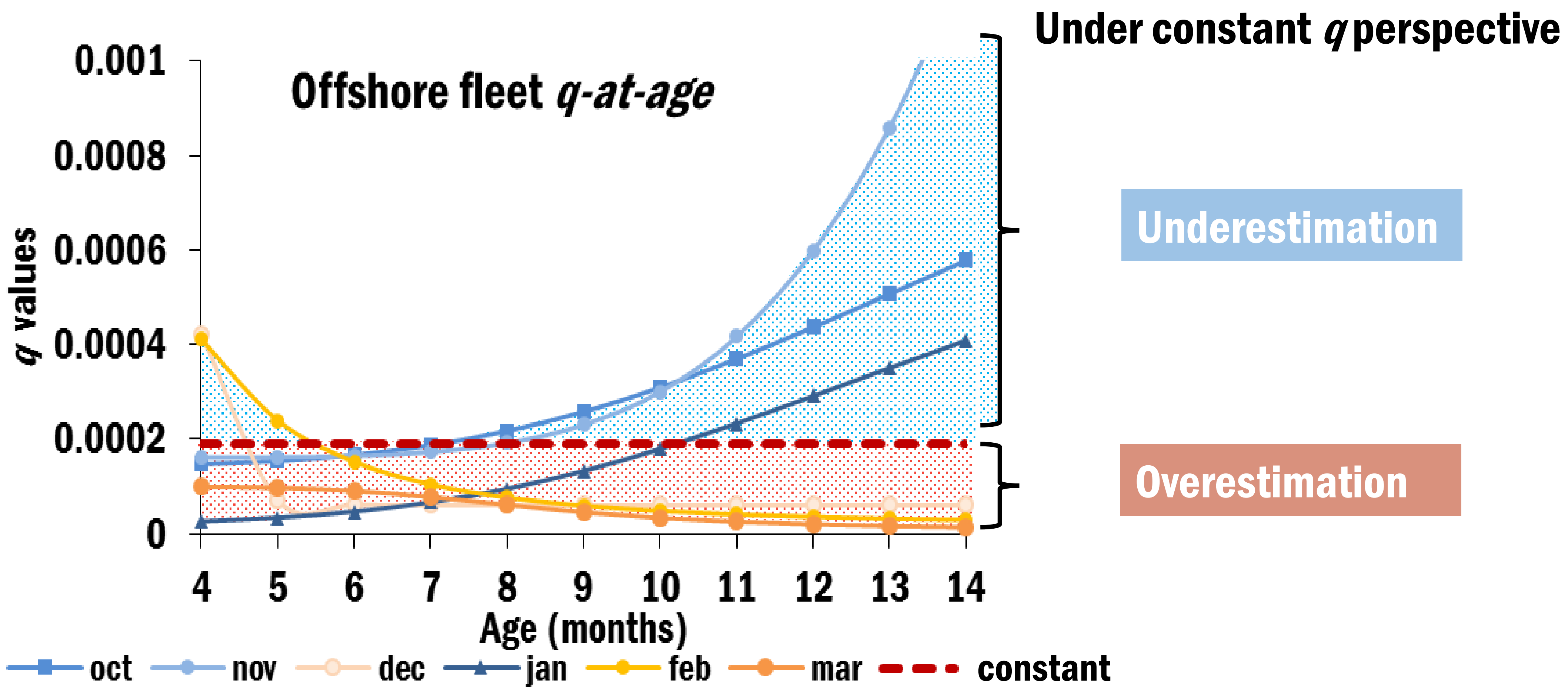




Marine population structure changes in time with the entry of new recruits to the fishery (rf) or with the reproductive aggregations (ra) reflected in the *q-at age* values.

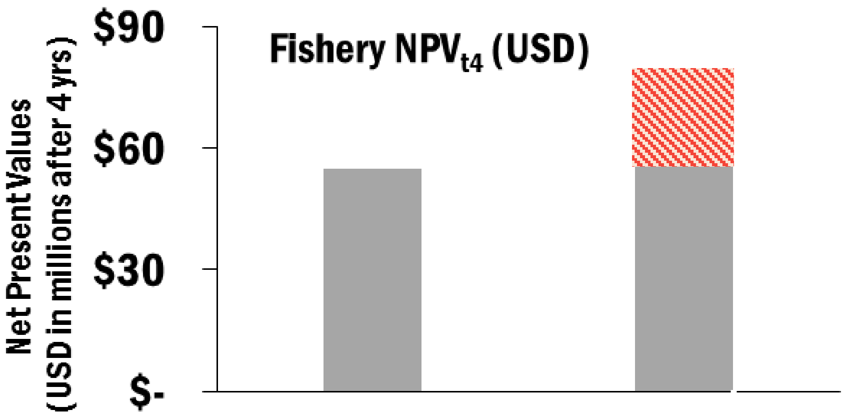
Results

Catchability parameter: constant *q* vs *q-at-age*

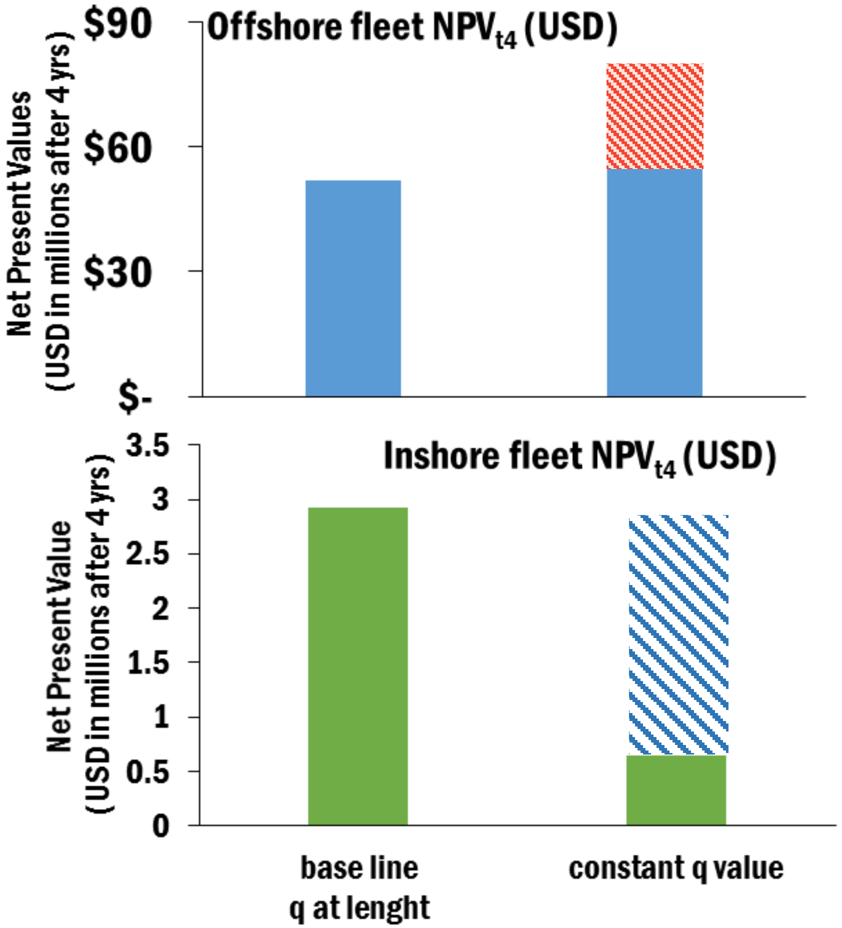


Constant *q* values denies any change in the population structure by assigning the same vulnerability & densities to the population through time.

Results
Model economic outputs



* Per season



$ NPV per boat

56,000 USD ⬆84,000 USD

q-at-age ⟶ *q*-constant

$NPV per cayuco

975 USD ⬇216 USD

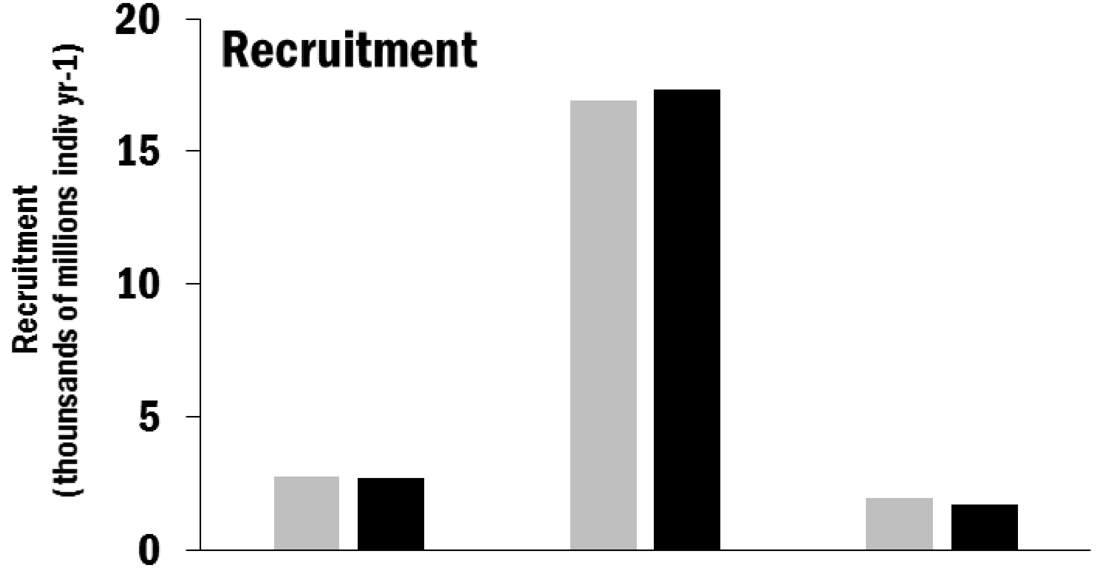
q-at-age ⟶ *q*-constant

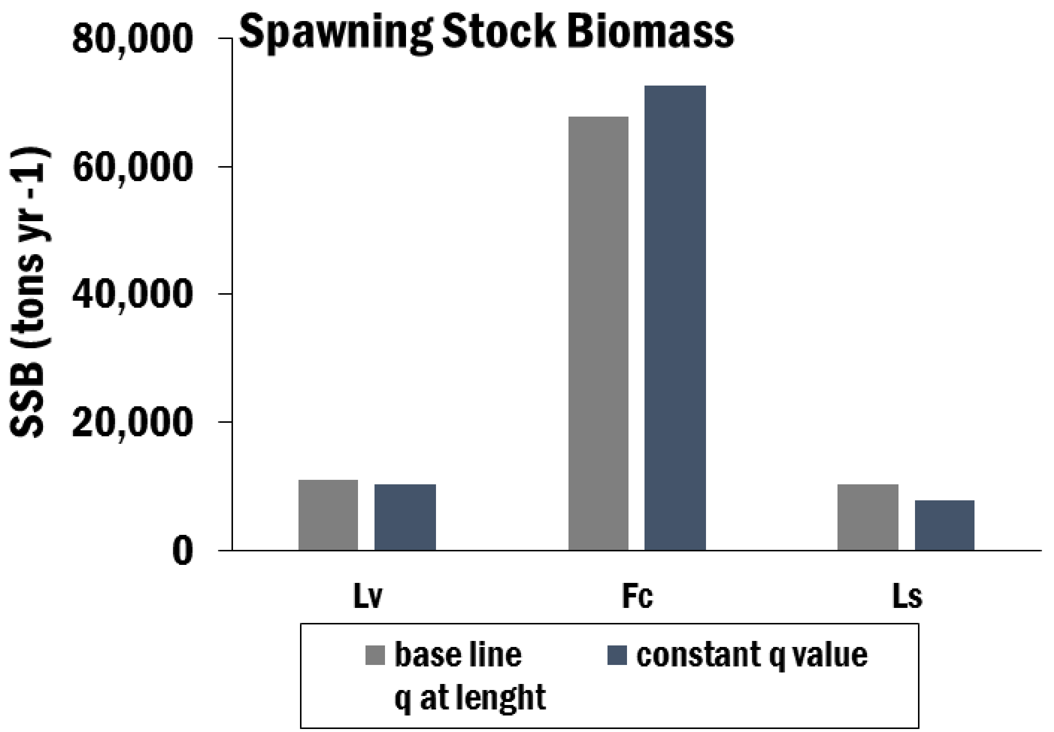
	Using constant *q*	Magnitude	Quantity
Fishery	overestimation	+0.3 x	+24 million USD
Offshore fleet	overestimation	+0.34x	+26 million USD
Inshore fleet	underestimation	- 3x	- 2.3 million USD

Results
Model biological outputs

	Using constant *q*	Magnitude	Quantity
Recruitment (Ind yr^{-1})			
Brown	overestimation	+0.02x	+432 million
White	underestimation	-0.01x	-26 million
Blue	underestimation	-0.15 x	- 257 million
SSB (ton yr^{-1})			
Brown	overestimation	+0.07 x	+4,800 ton
White	underestimation	-0.05x	-568 ton
Blue	underestimation	- 0.35x	- 2,700 ton

We observed different outcomes in a multispecies fishery; associated to population dynamics and fleet selectivity affecting *q*.





Consequences of using constant “*q* “ in sequential fisheries

Fishery modelling

Biased fishing mortality & fishery dynamics.

Biomass

Biased stock estimations; differential response in multispecies fishery

Economics

Biased estimation of economic values.

Management

Biased optimization of fish stock, fleet or economic variables.

Conclusions

1) **In sequential fisheries we observed biased values in biological (*i.e.* shrimp recruitment and spawning stock biomass) an in economic variables (*i.e.* NPV & profit per effort unit) when using constant *q*.**

2) **The magnitude outcomes differ between fleets (*i.e.* inshore = underestimation; offshore fleet = overestimation) and among the species (*i.e.* white & blue biomass were underestimated & brown shrimp was overestimated). These will depend upon the specific stock and fishing fleet spatial dynamics.**

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COFAA

CONACYT
Consejo Nacional de Ciencia y Tecnología

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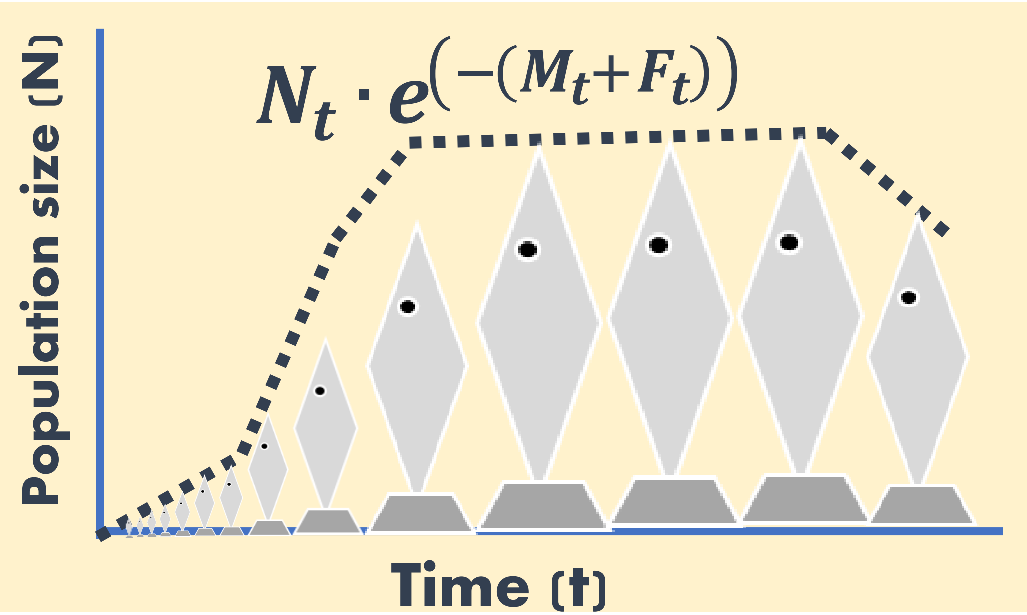
To lagoons
To Adult zone


$N_t \cdot e^{(-(M_t+F_t))}$
Population size (N)
Time (t)