# Metapopulation dynamics in the spider crab *Maja squinado*: Implications for fisheries management

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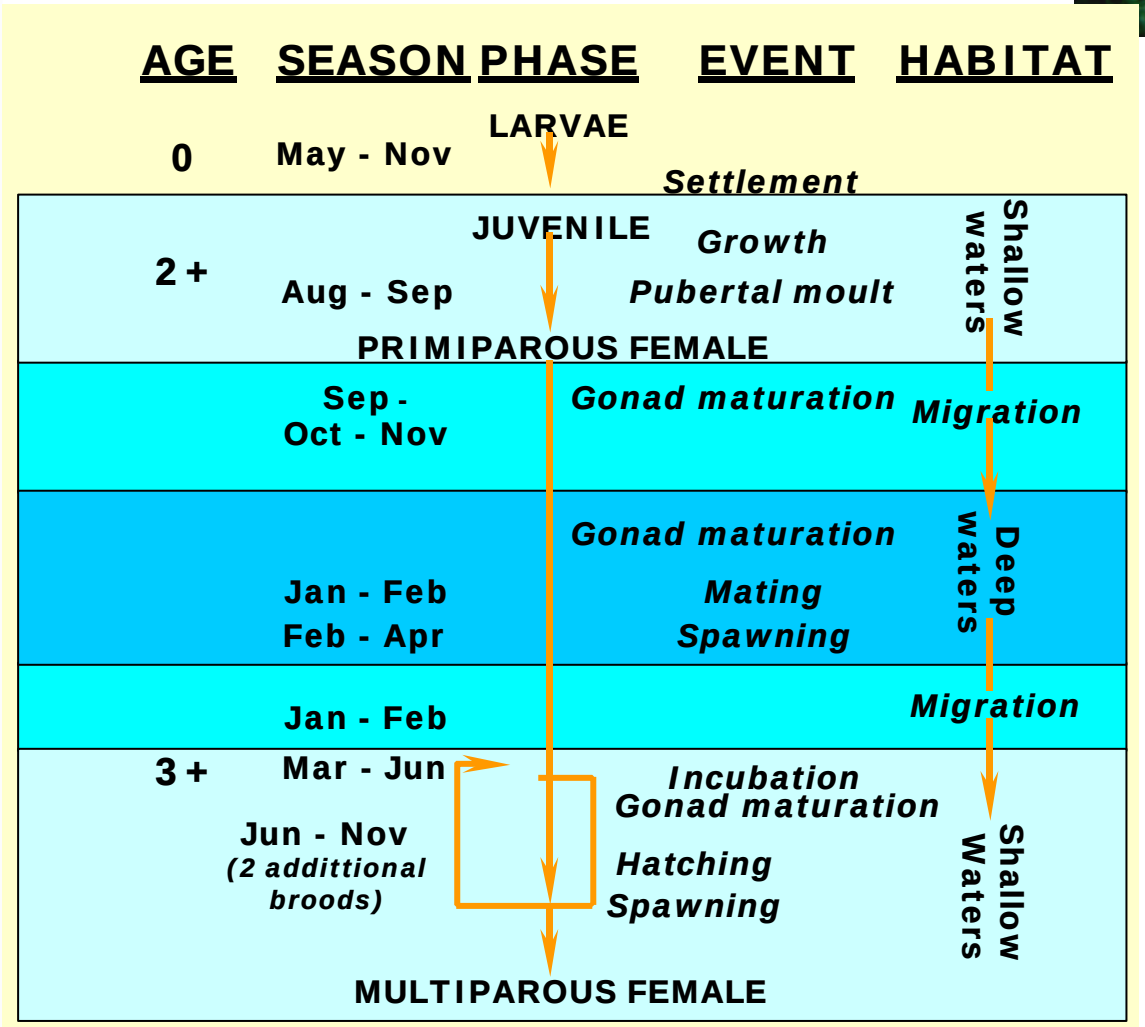
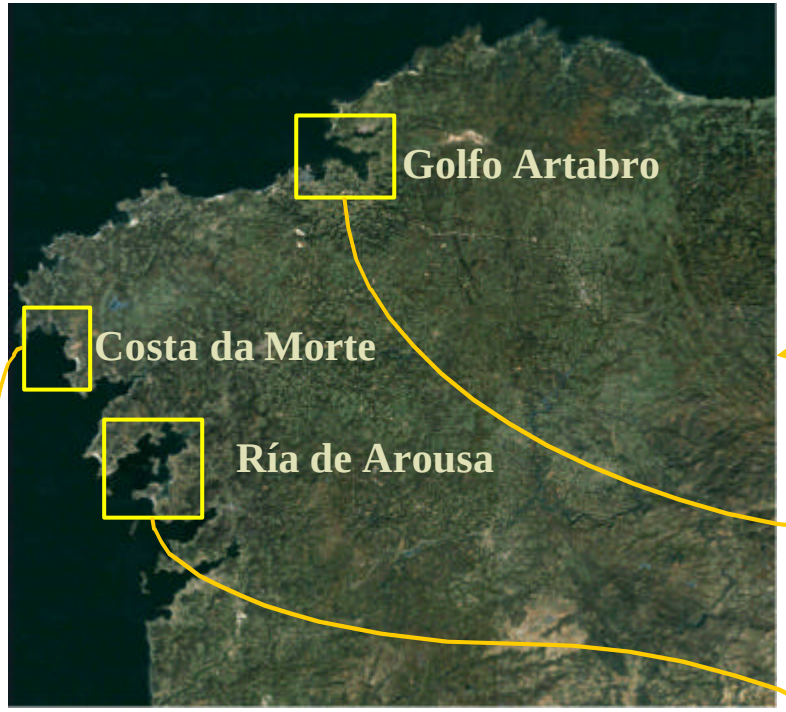
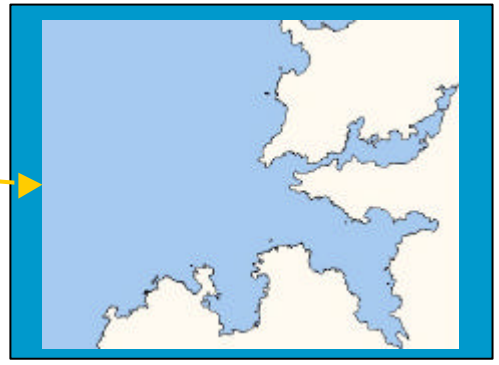
# The spider crab *Maja squinado*

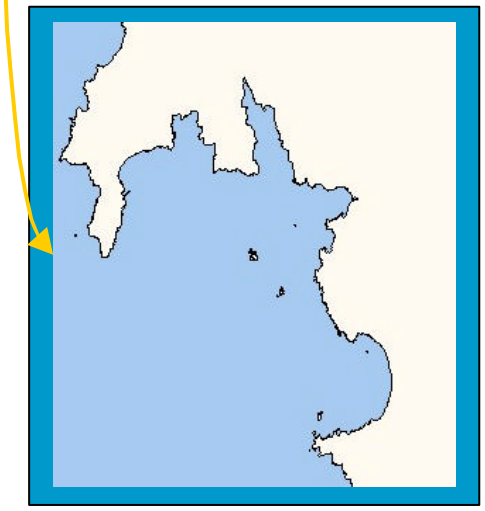


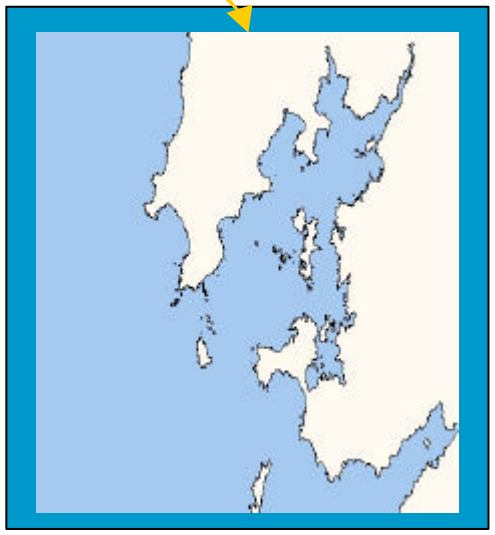

**Female life history**

# Galicia, NW Spain







# Shallow-water coastal habitats

- 0-15 m
- Rocky and sandy bottoms

# Objetives

a. **Existence and characteristics of the spider crab metapopulations**

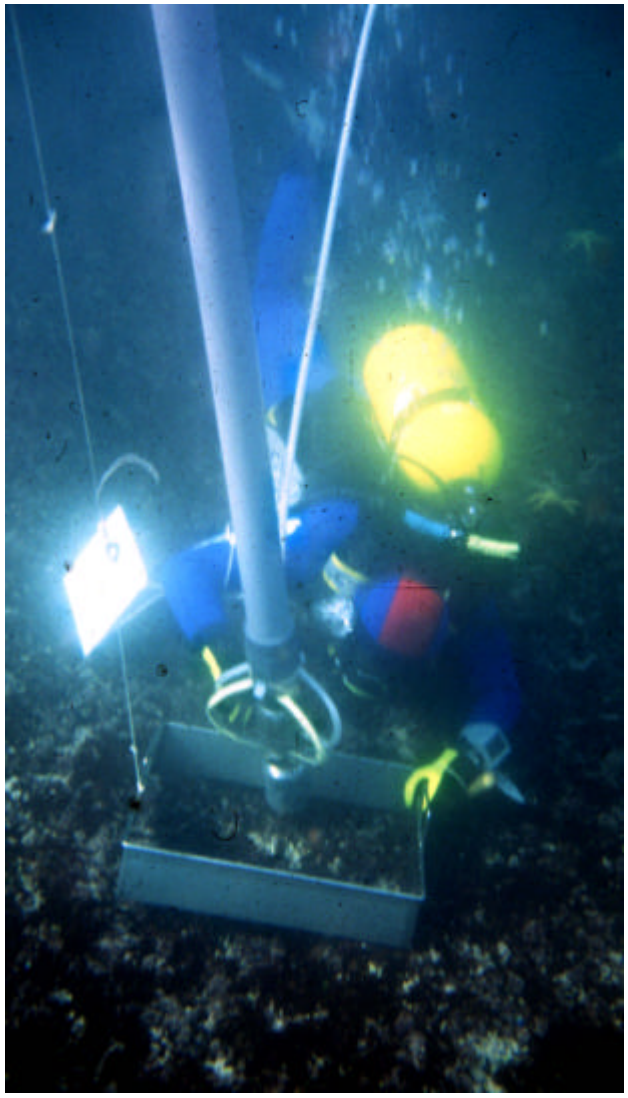
b. **Modeling population dynamics and fisheries to incorporate metapopulation characteristics**

c. **Development of alternative management policies for sustainable fisheries**

# Methods and information sources

- Sampling with suction pumps:

  *Postlarval recruitment*



# Methods and information sources

- Sampling with experimental traps and beam trawl:

  *Spatial distribution and temporal dynamics in shallow habitats, local dynamics:*

  - *recruitment*
  - *growth*
  - *mortality*

# Methods and information sources

- Ultrasonic telemetry and data storage tags:

  *Habitat use, movements and migratory behaviour*

# Methods and information sources

- Mark-recapture experiments:

  *Population structure and connectivity*

# Methods and information sources

- Observations of fishing operations with gill-nets: *Spatial distribution and temporal dynamics in deep habitats*
- Fishers' ecological knowledge (FEK):

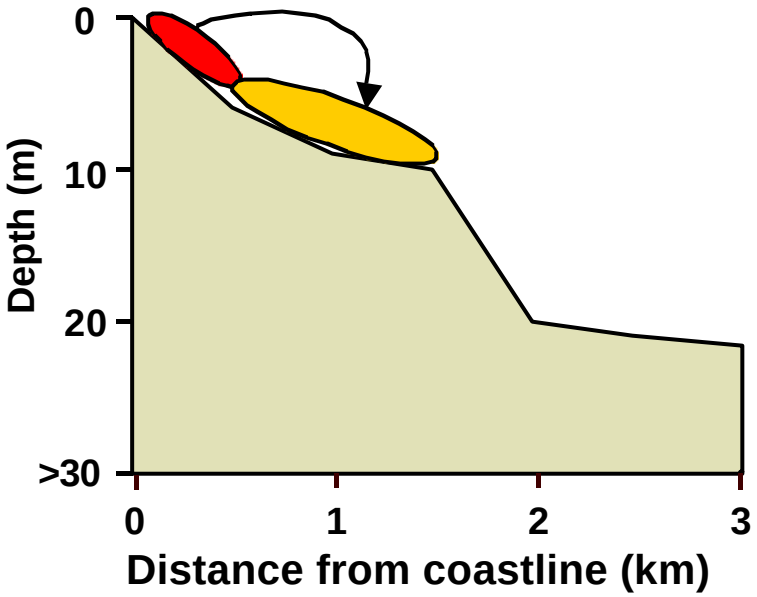
  *Habitat use, spatial distribution and temporal dynamics*

# Spatial scales involved

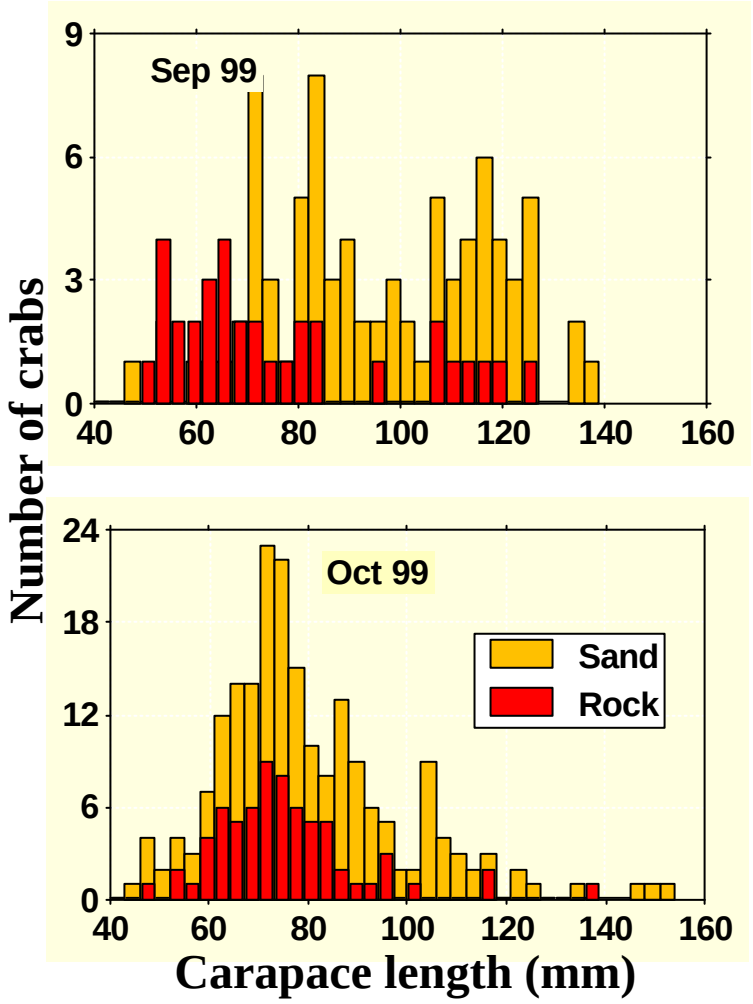
- Within local populations: 1s - 100s m
- Among juvenile local  populations: 100s - 1000s m
- Metapopulation (juvenile and adult local populations): 10s – 100s km

# Individual behaviour

- Ontogenetic habitat shifts of juveniles

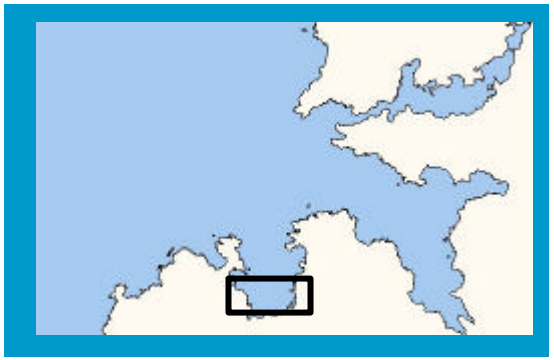


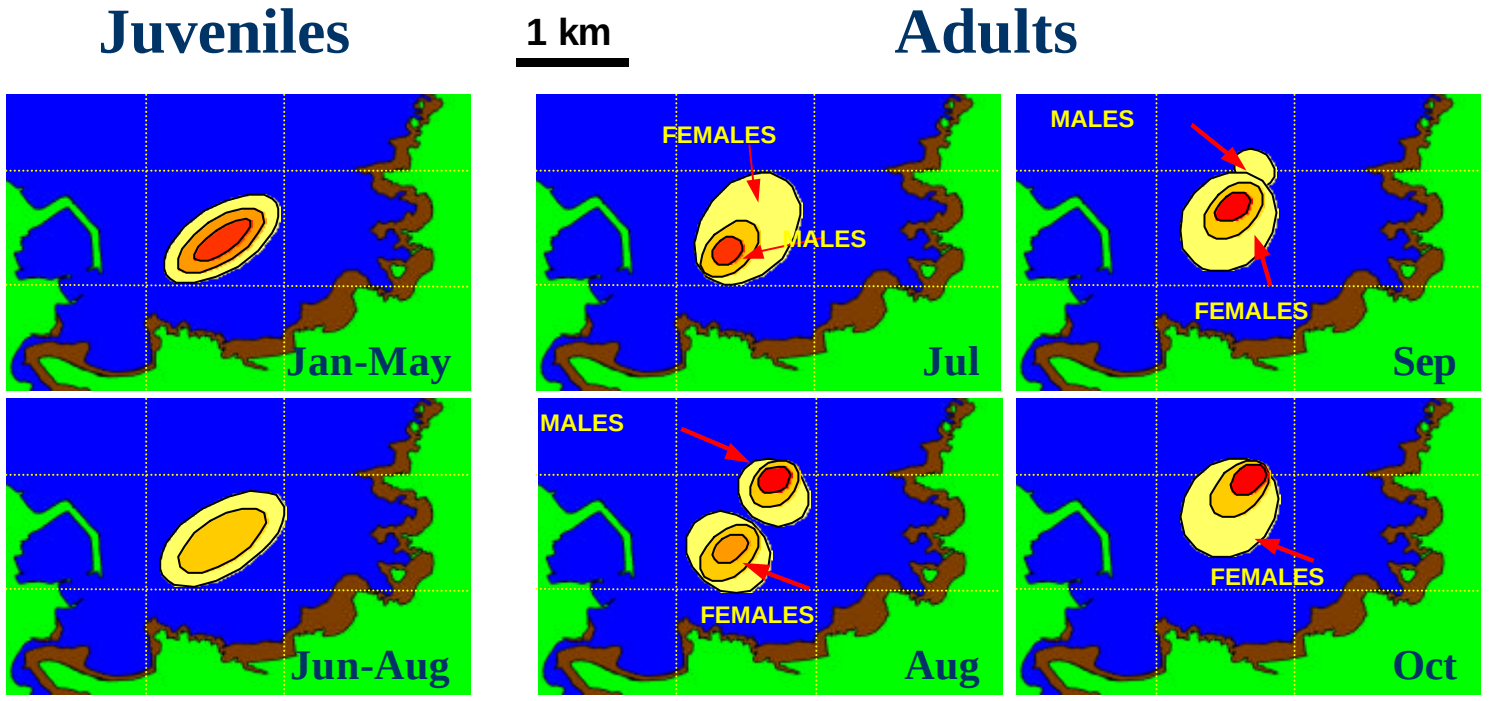

| Phase | CL (mm) | Age (months) |
|---|---|---|
| Juv. 0+ | - 105 | 0 - 18 |
| Juv. 1+ | 67 - 120 | 17 - 26 (38) |



# Spatial distribution in local populations

- Aggregative behaviour in shallow habitats

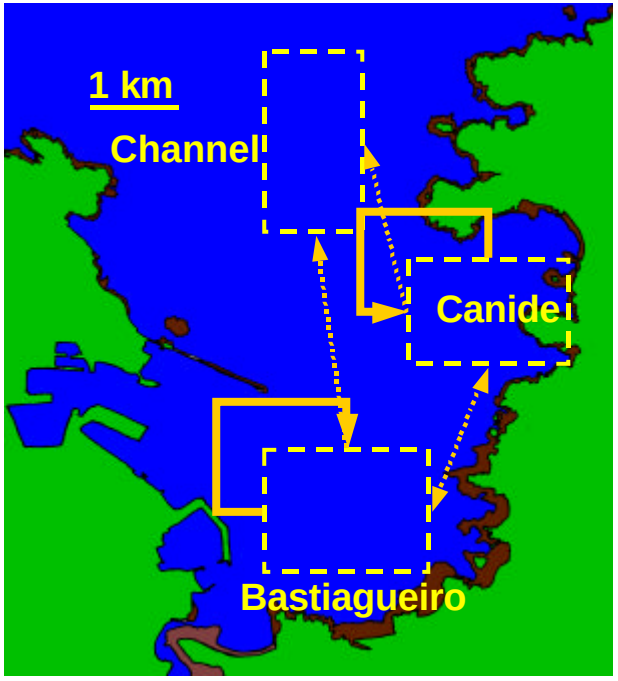




# Spatial distribution in local populations

- Mark-recapture: transfer among local populations

| *% RECAPTURES* | | | Shallow | | Deep |
|---|---|---|---|---|---|
| | Nm | Nr | Bast. | Canide | Channel |
| Bast. | 6752 | 417 | 99.0% | 0.5% | 0.5% |
| Canide | 1743 | 63 | 3.2% | 87.3% | 9.5% |




Nm = no. of juveniles marked
Nr = no. recaptured as juveniles

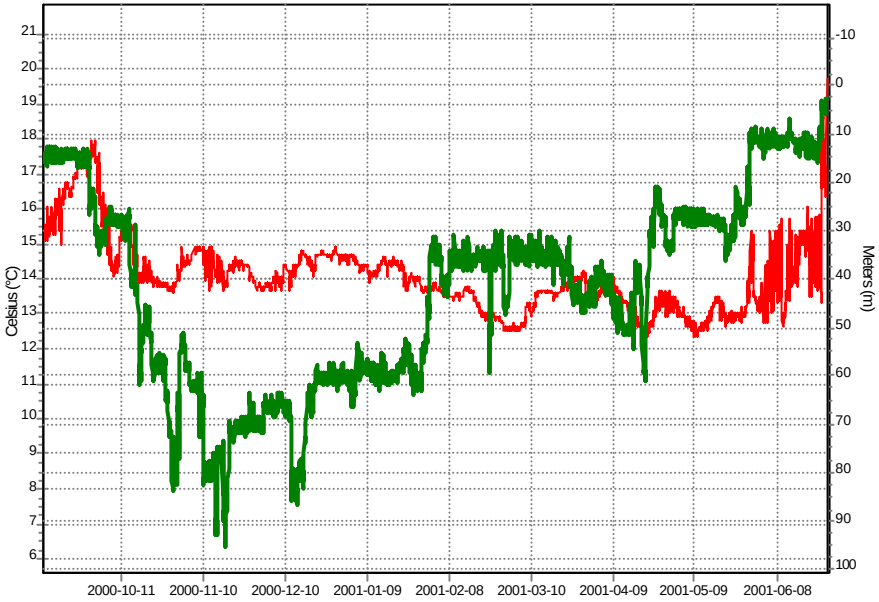
# Individual behaviour

- Reproductive migrations of adults to deep habitats

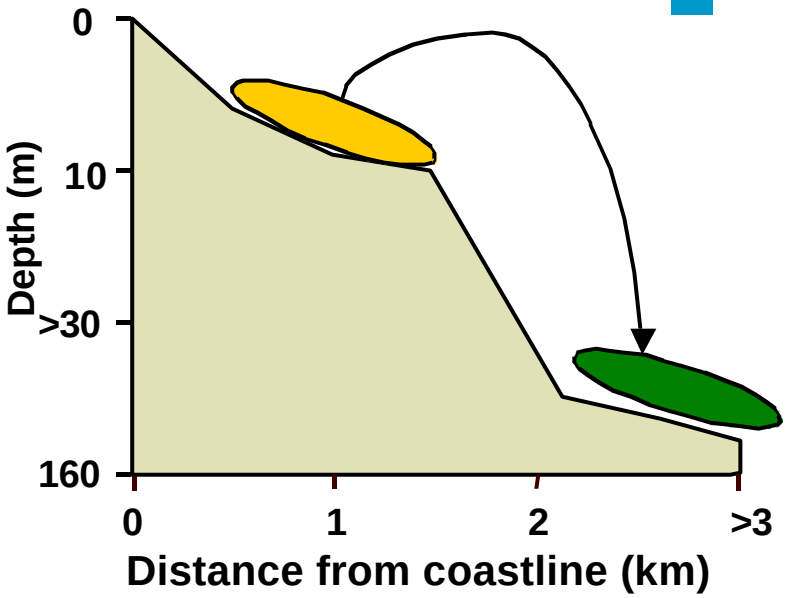
Adult female migrating up to 95 m deep and returning to shallow waters

Depth (m)

Temp (ºC)



# Spatial distribution in local populations

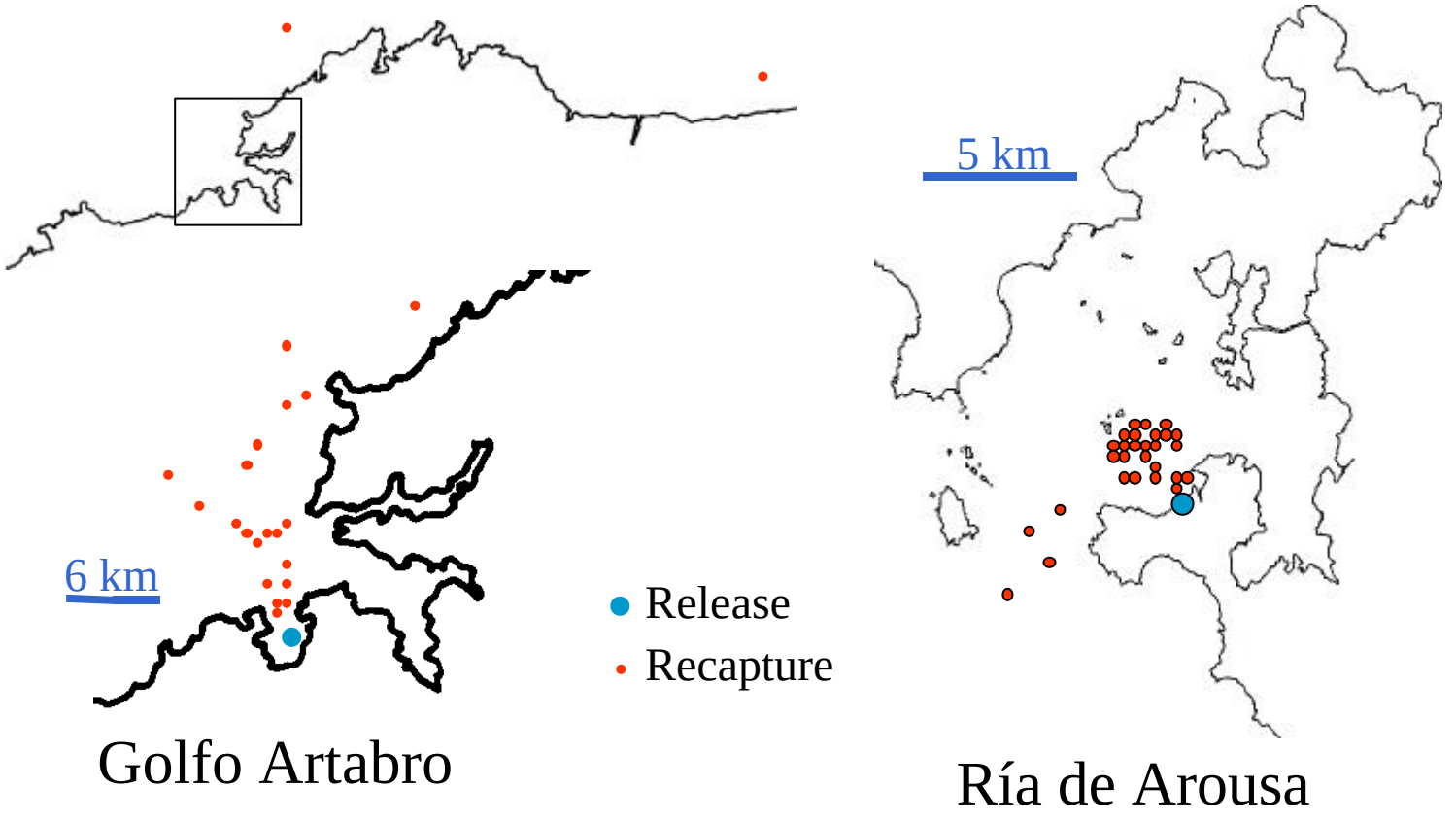



| Phase | CL (mm) |
|---|---|
| Juv. 1+ | 67 – 120 |
| Adults | >120 |

- Connectivity juveniles-adults

# Spatial distribution in local populations

- Recaptures from the fishery of adults in deep waters (scale of adult populations in mating habitats)

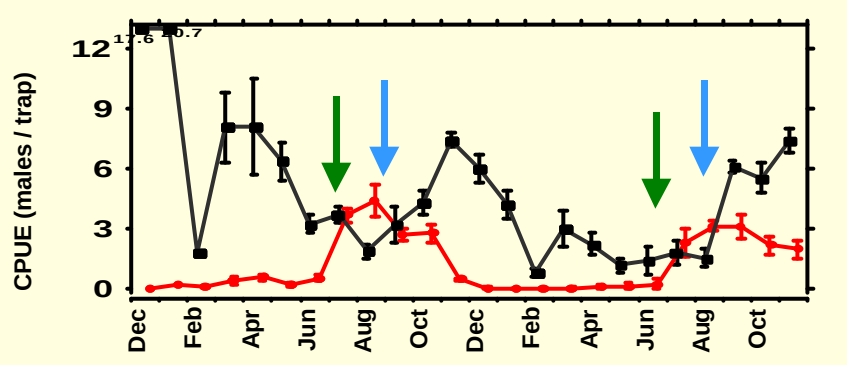



***Telemetry experiments***

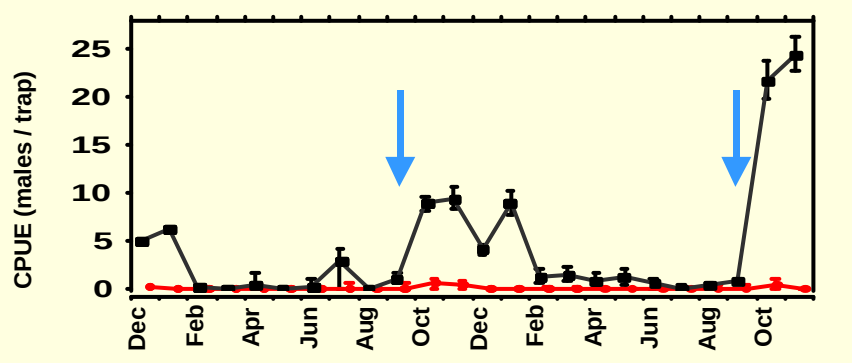
# Dynamics of local populations

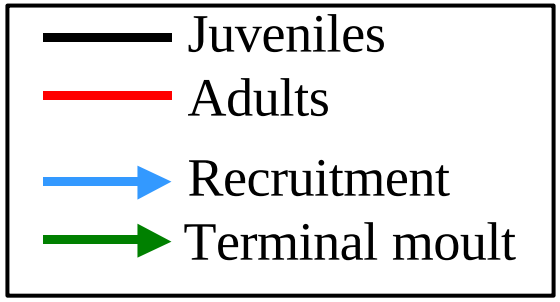
- Time series of abundance in local shallow-water populations: recruitment, mortality, onset of maturity and migration

Bastiagueiro




Canide



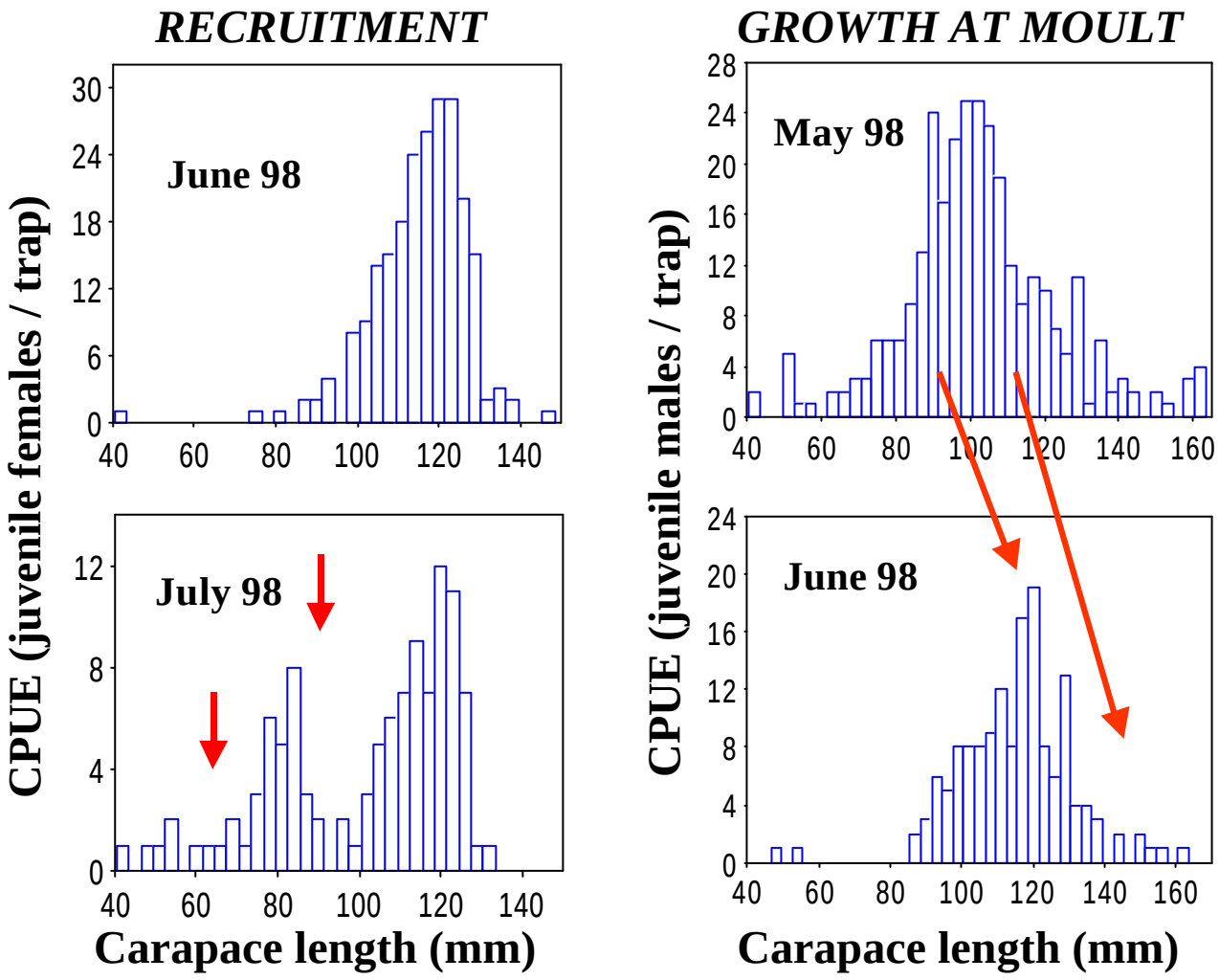




***"Source":***
***net adult production***

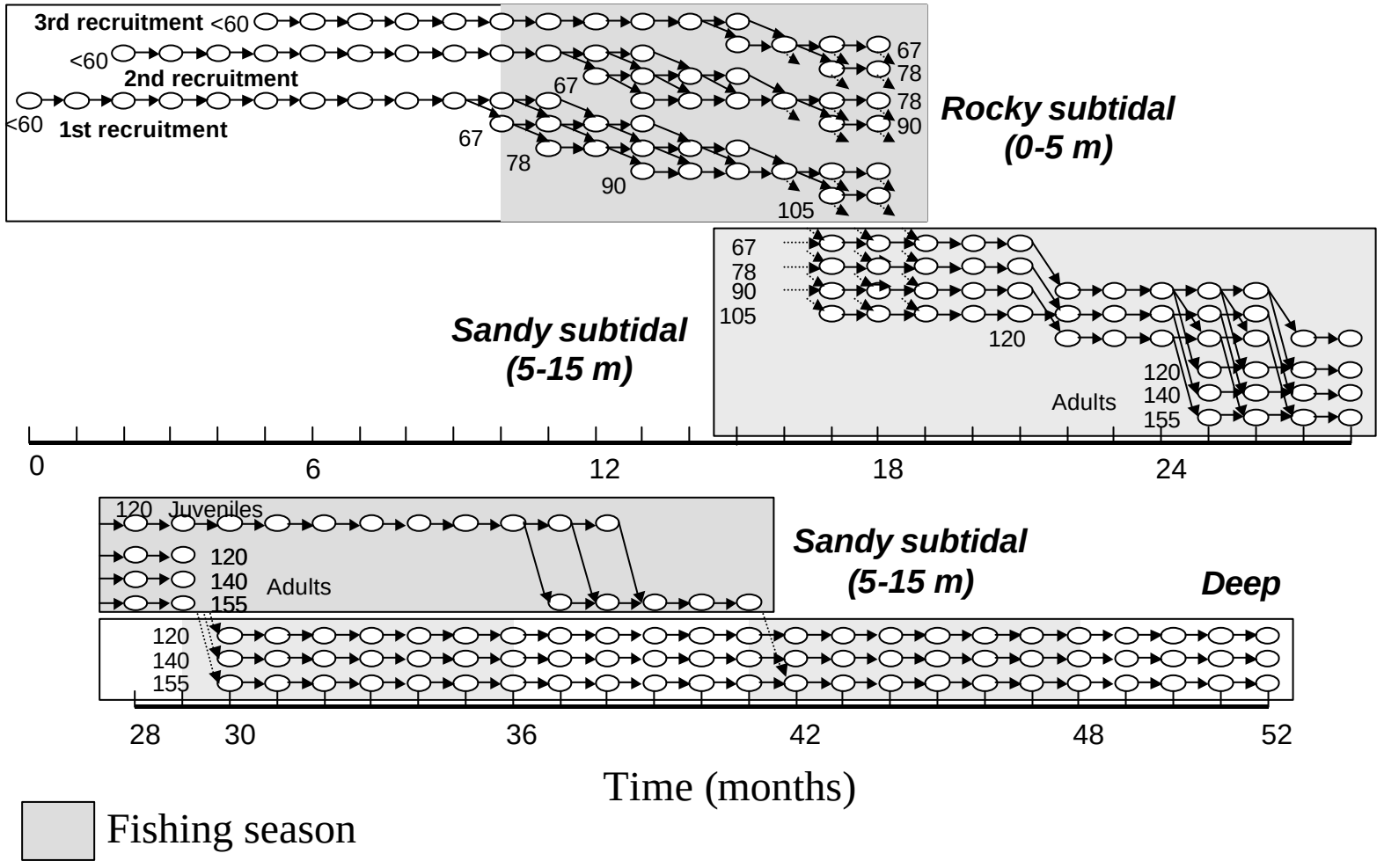
***"Sink":***
***no adult production***

# Dynamics of local populations

- Size structure of local populations: recruitment and growth dynamics

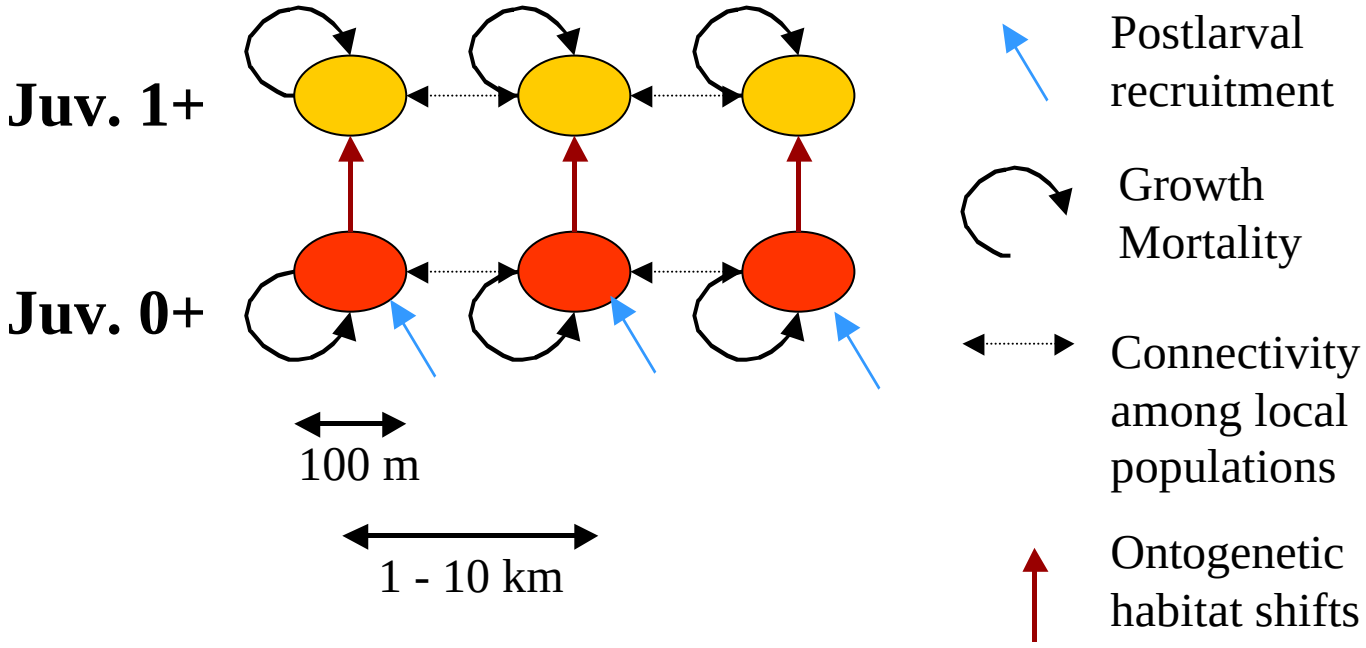


# Stage-dependent population dynamics



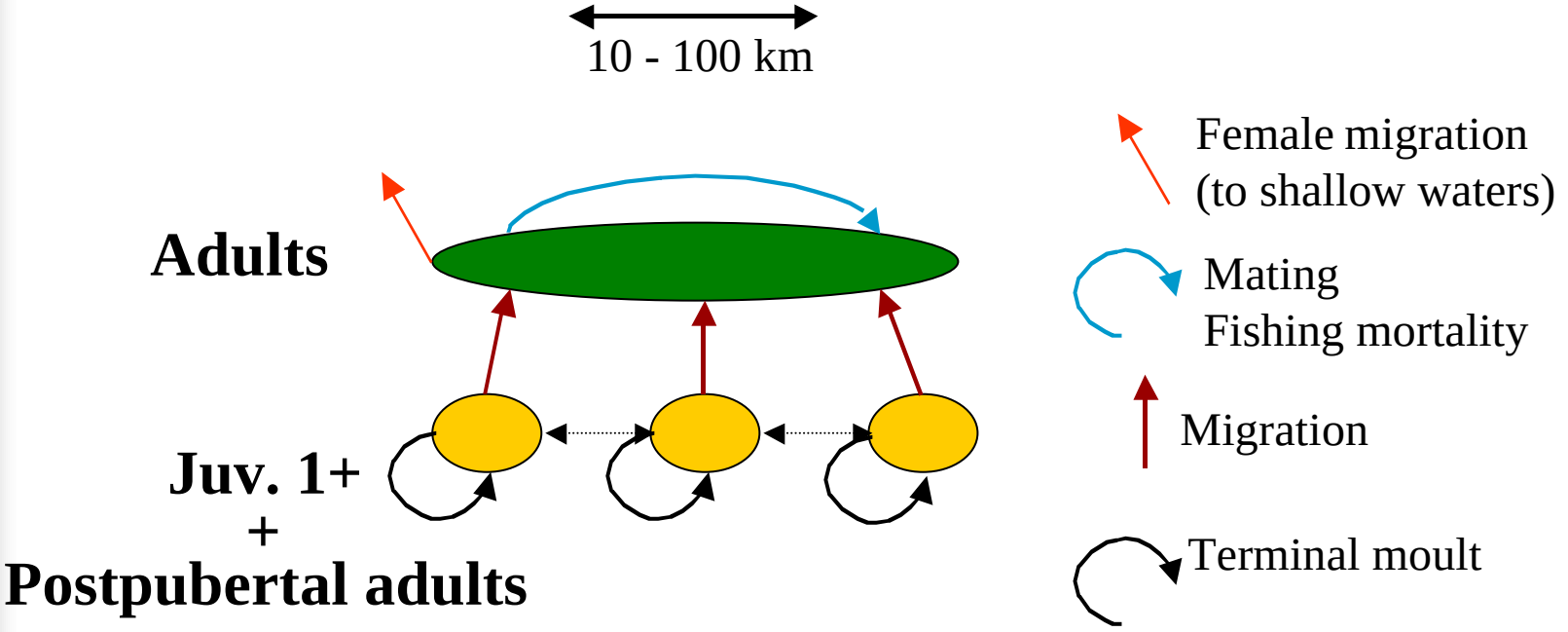
# CONCLUSSIONS: Metapopulation structure

- Characteristics of the juvenile segment of metapopulation



# CONCLUSSIONS: Metapopulation structure

- Characteristics of the adult segment of metapopulation

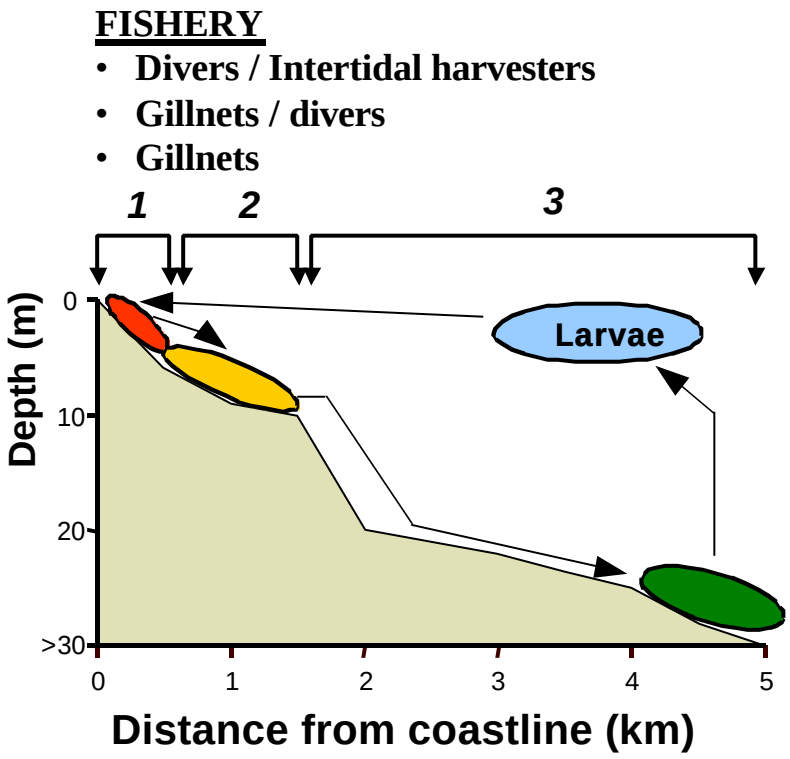


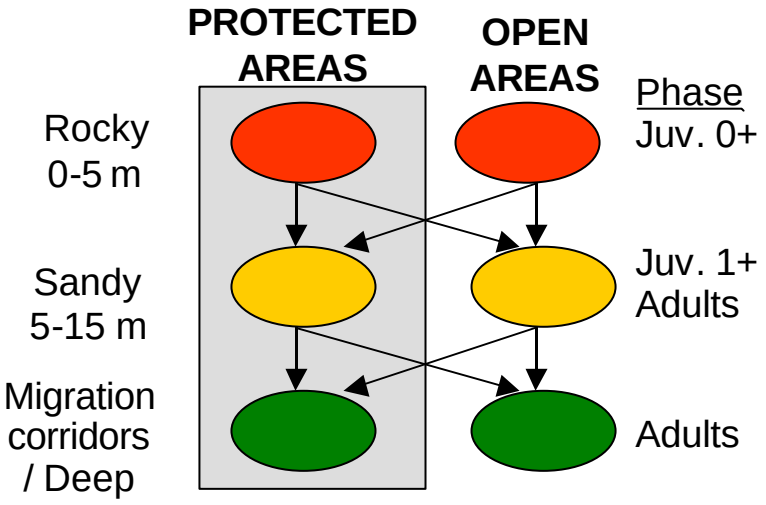
# MODELLING POPULATION DYNAMICS:
## Spatially-explicit yield- and egg-per-recruit models

- Stage structure:

  size, age, maturity and habitat

- Spatial structure

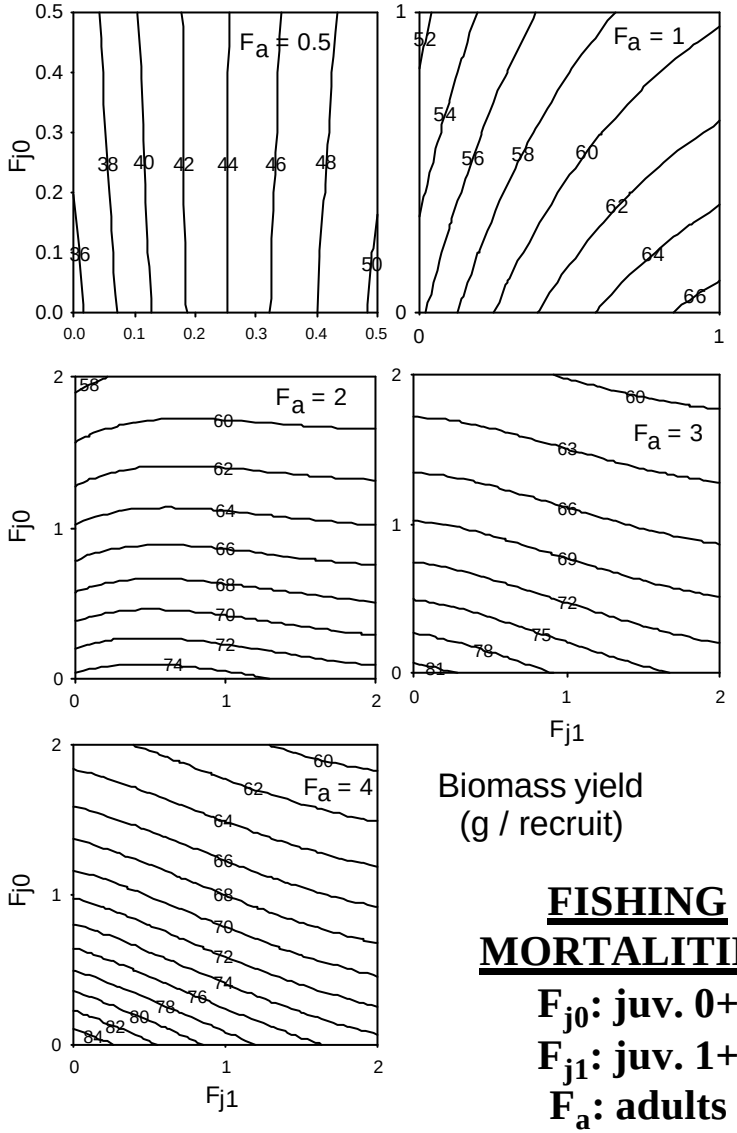


# Yield- and egg-per-recruit analyses: Results without MPAs

- Control of fishing mortality to maximize yield and egg production: HOW?

•Artisanal small-scale fisheries
•Multi-fleet and multi-gear
•No effort data
•No catchability information



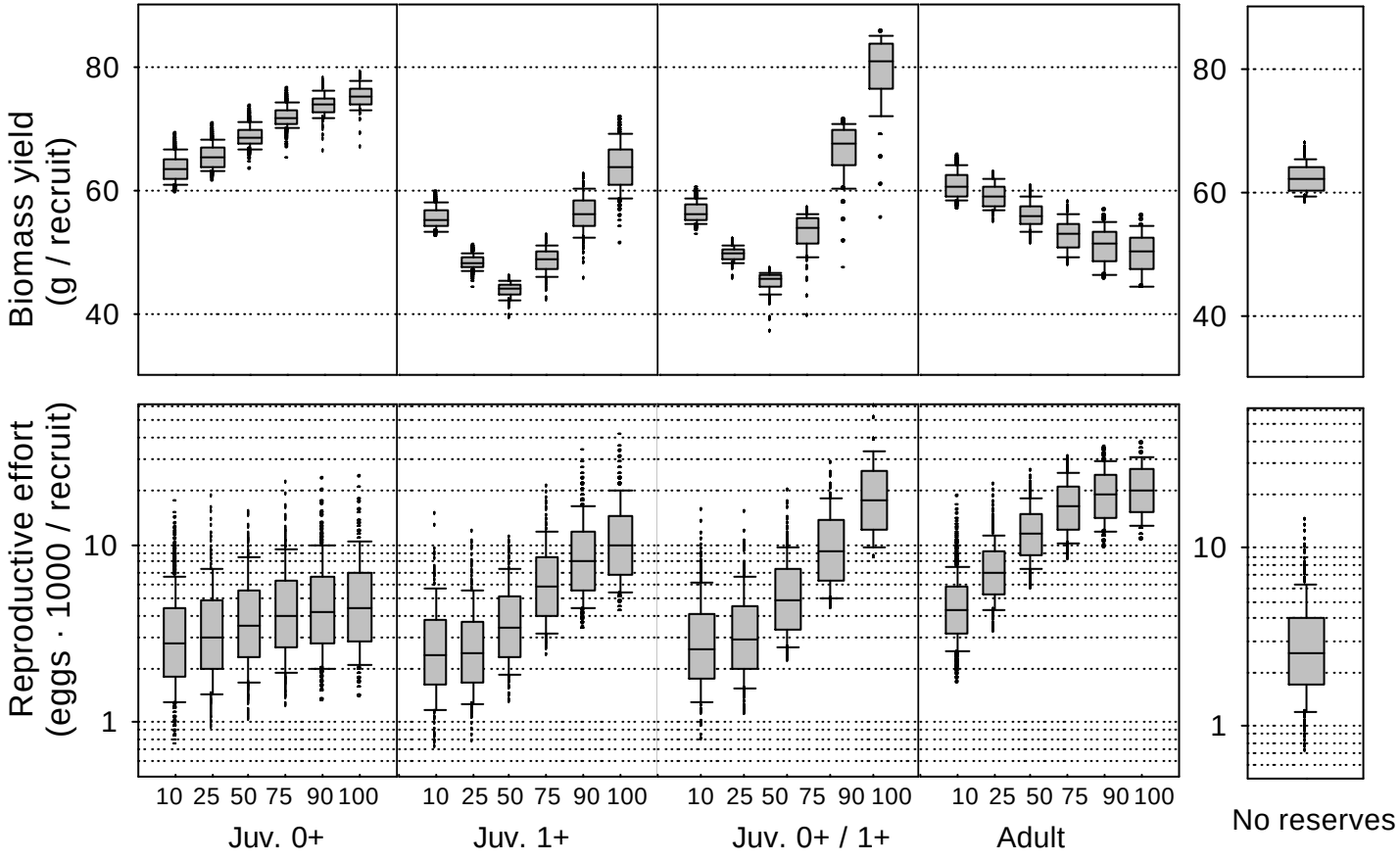

Biomass yield
(g / recruit)

**FISHING MORTALITIES:**

**$F_{j0}$: juv. 0+**
**$F_{j1}$: juv. 1+**
**$F_a$: adults**

# Yield- and egg-per-recruit analyses: Results with MPAs

- Lets allow fishing mortality to be an uncontrolled variable (in open areas)



# CONCLUSSIONS: Modelling population dynamics

**CONSIDERATIONS**

- Regulations based in direct control of fishing effort are difficult to implement
- MPAs are easier and cheaper to implement in coastal areas
- MPAs and minimum sizes are understood and well accepted by fishers

**RESULTS OF ANALYSES**

- MPA performance is robust to uncertainties in Fs in open areas
- Performance of regulations based on MPAs is similar or higher than others based in direct control of effort
- The best MPA designs should implement closures in most of the juvenile habitat in shallow waters

**REGULATION IMPLICATIONS**

- Direct efforts to implement MPAs and minimum landing sizes
- Do no invest too much effort trying to control fishing effort in areas open to the fishery

# A new management policy is needed: Community-based co-management systems are working for other resources

| CHARACTERISTICS | CENTRALIZED MODEL (bureaucreatic / government) | COMMUNITY CO-MANAGEMENT MODELS |
|---|---|---|
| **Property rights** | State<br>No access limitation | Community (TURFs)<br>Access limitation |
| **Decission-making**<br>· Flows<br>· Institutions involved | <br>Top-down<br>Autonomous goverment | <br>Bottom-up<br>Fishers' organizations |
| **Knowledge sources** | Scientific | Traditional<br>Scientific |
| **Regulations** | • Inputs: gears, seasonal closures, minimum sizes<br>• Outputs: daily quotas per vessel or fisher | • Inputs: minimum sizes, seasonal closures<br>• Outputs: daily quotas per vessel or fisher<br>• MPAs and rotations |
| **Compliance systems**<br>· Surveillance<br>· Punishments | <br>State<br>Legal | <br>Fishers organizations<br>Social (+ legal) |