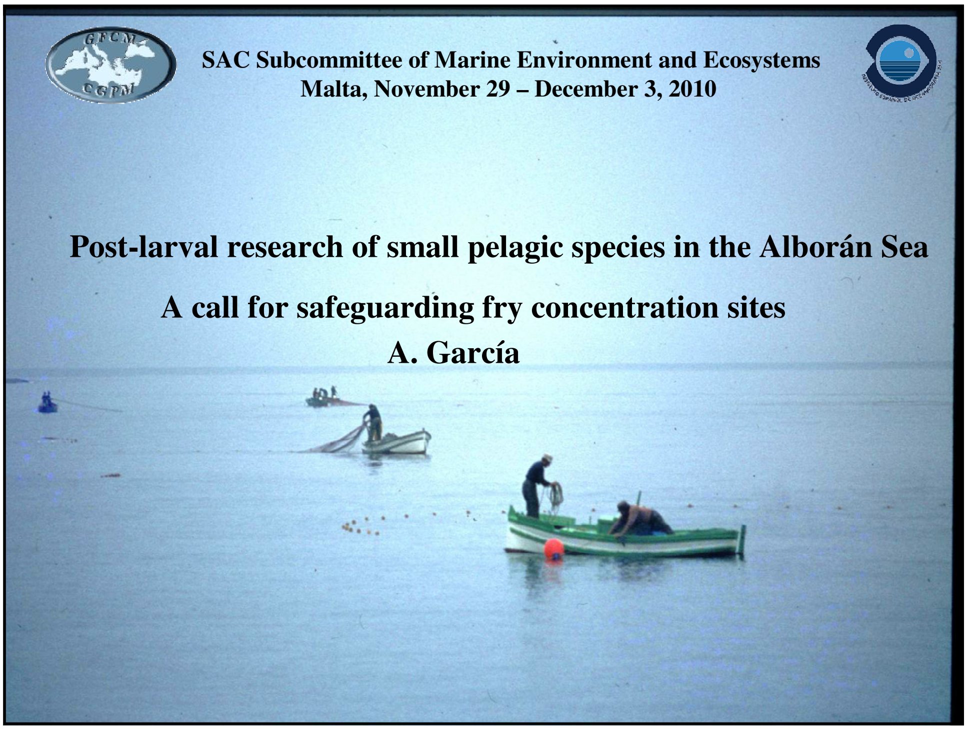
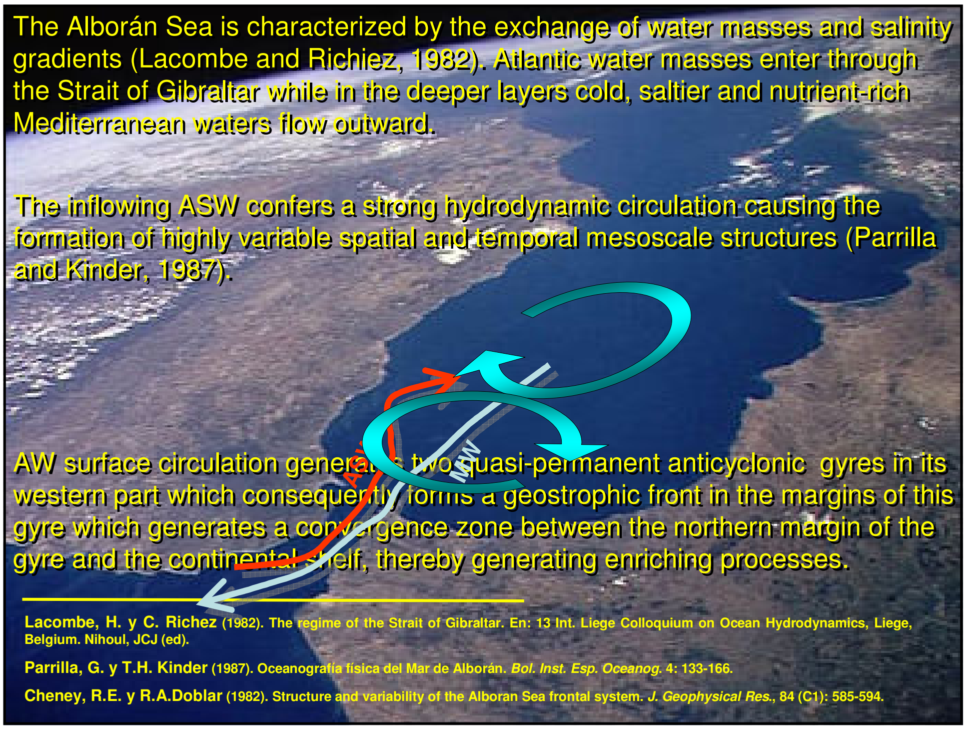
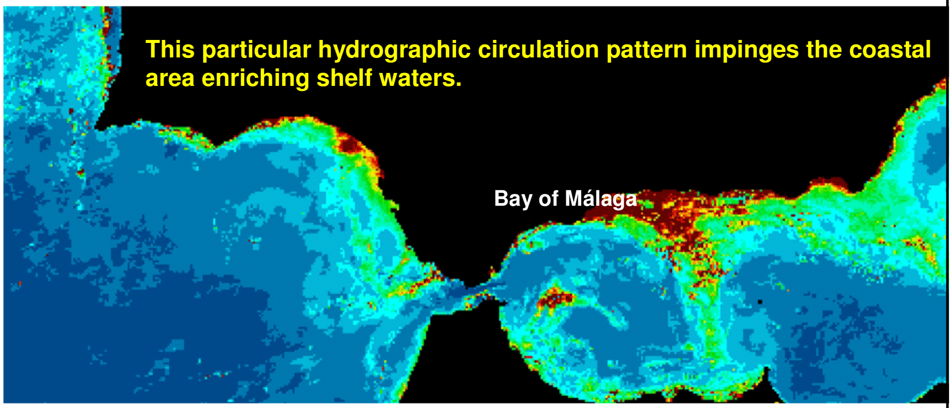
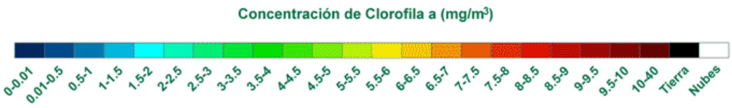

SAC Subcommittee of Marine Environment and Ecosystems
Malta, November 29 – December 3, 2010
Post-larval research of small pelagic species in the Alborán Sea
A call for safeguarding fry concentration sites
A. García

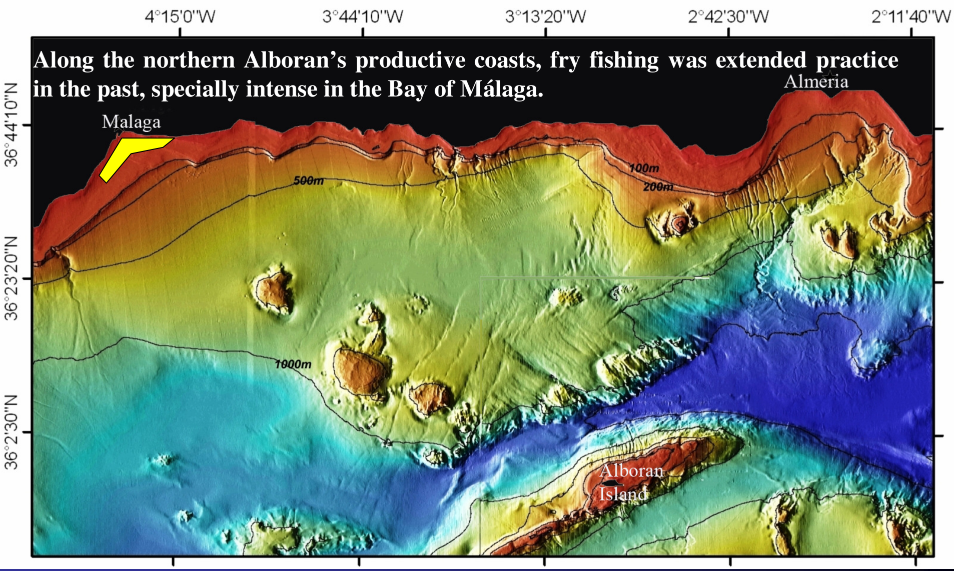

The Alborán Sea is characterized by the exchange of water masses and salinity gradients (Lacombe and Richiez, 1982). Atlantic water masses enter through the Strait of Gibraltar while in the deeper layers cold, saltier and nutrient-rich Mediterranean waters flow outward.
The inflowing ASW confers a strong hydrodynamic circulation causing the formation of highly variable spatial and temporal mesoscale structures (Parrilla and Kinder, 1987).
MW
AW surface circulation generates two quasi-permanent anticyclonic gyres in its western part which consequently forms a geostrophic front in the margins of this gyre which generates a convergence zone between the northern margin of the gyre and the continental shelf, thereby generating enriching processes.
Lacombe, H. y C. Richez (1982). The regime of the Strait of Gibraltar. En: 13 Int. Liege Colloquium on Ocean Hydrodynamics, Liege, Belgium. Nihoul, JCJ (ed).
Parrilla, G. y T.H. Kinder (1987). Oceanografía física del Mar de Alborán. Bol. Inst. Esp. Oceanog. 4: 133-166.
Cheney, R.E. y R.A.Doblar (1982). Structure and variability of the Alboran Sea frontal system. J. Geophysical Res., 84 (C1): 585-594.

Clorofila-a. Marzo 2006





In conclusion, the Alboran Sea coasts constitutes a highly productive ecosystem but within the context of a very narrow continental shelf, subject to human pressure resulting from increasing activities of its populated coasts.



Past historical artisanal fisheries exploiting post-larval stages and fry of sardines and anchovy along the inshore waters of the Malaga bay beach fronts may represent the example of a sensitive habitat according to GFCM SAC11/2008/Inf.20

Sensitive habitat is defined as:

- **-Essential to the ecological and biological requirements of at least one of the life stages of the species;**
- **-Crucial for the recovery and/or the long term sustainability of the marine biological resources and the assemblages to which the priority species belongs;**
- **-Any other habitat of high biodiversity importance potentially impacted by fisheries activities;**
- **- Any other habitat of high biodiversity importance potentially impacted by climate change**

This definition also applies to EFH, as defined by law in USA

Essential Fish Habitat

"Those **waters** and **substrate necessary** to fish for **spawning, breeding, feeding,** or **growth** to maturity."

"**Waters**" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish.

"**Substrate**" includes sediment, hard bottom, structures underlying the waters, and associated biological communities.

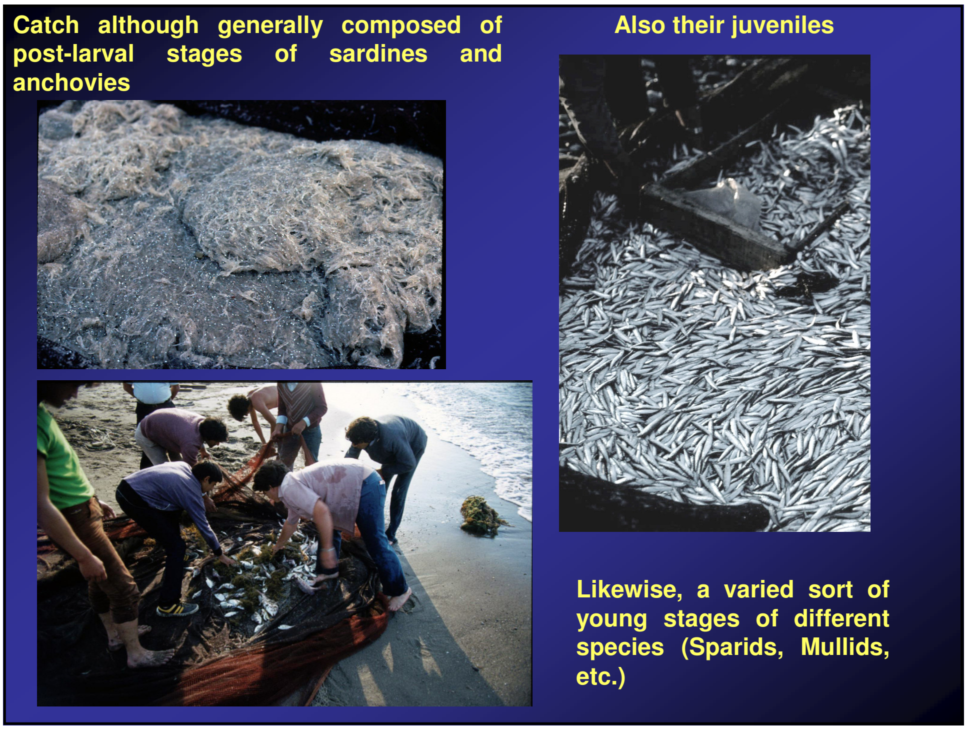
"**Necessary**" means the habitat required **to support a sustainable fishery and the managed species' contribution to a healthy ecosystem**; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

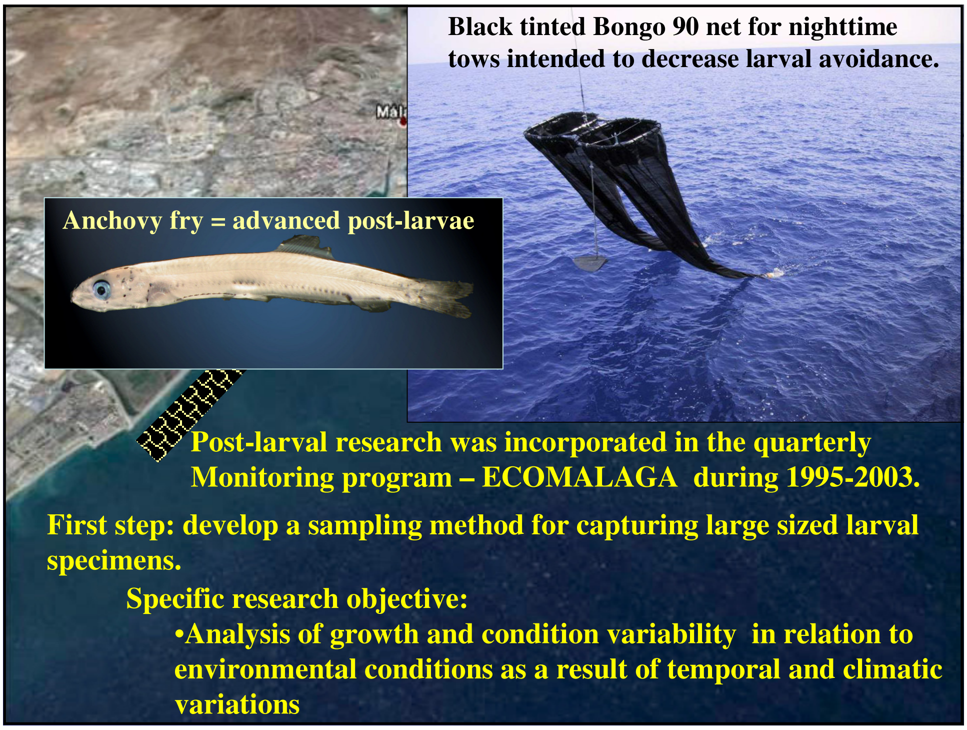
Magnuson-Stevens Act Provisions. Essential Fish Habitat. Dpt. of Commerce, NOAA (USA). Federal Register, vol 67, nº 12, January 2002.

Fry fisheries artisanal fishing gears

•Beach seines

• Specifically designed type of purse seines


Catch although generally composed of post-larval stages of sardines and anchovies
Also their juveniles
Likewise, a varied sort of young stages of different species (Sparids, Mullids, etc.)


Black tinted Bongo 90 net for nighttime tows intended to decrease larval avoidance.
Anchovy fry = advanced post-larvae
Post-larval research was incorporated in the quarterly Monitoring program – ECOMALAGA during 1995-2003.
First step: develop a sampling method for capturing large sized larval specimens.
Specific research objective:
•Analysis of growth and condition variability in relation to environmental conditions as a result of temporal and climatic variations

Rationale for post-larval research is based on the statements of Peterman et al. (1988) after examining 30 years of CALCOFI data on anchovy egg and larval abundance:

"*Interannual variability in recruitment in this species (E. mordax) and perhaps many other marine fish species may have to rely not only on data on eggs and larvae, but especially on data on abundances estimated after 20 days, closer to the age at recruitment*" (Peterman et al., 1988).

As the interval between recruitment and early life stages is decreased, the predictive capability of recruitment is increased (Bradford, 1992).

This assertion is justified by the biological implications of growth.....

Growth-Mortality hypothesis (Anderson, 1988)

Growth selective predation hypothesis (Takasuka, 2003)

Bigger is better hypothesis (Meekan et al, 2006)

Stage duration hypothesis (Hare and Cowen, 1997)
Deficient growth rates cause longer time exposure in larval sizes vulnerable to predation (Folkvord and Hunter, 1986).

Actually, there is compelling evidence relating growth variability with recruitment variability

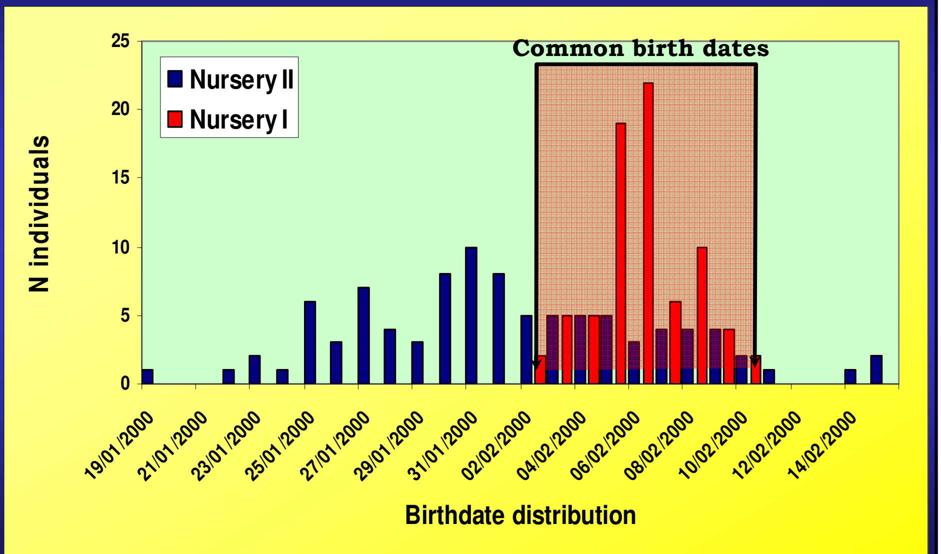
CASE STUDIES

ALBORAN SEA SARDINE AND ANCHOVY

KEY SPECIES OF THE MEDITERRANEAN PELAGIC ENVIRONMENT

1. Case study: Daily growth of the Alboran Sea sardine

Experiment verifying growth mortality hypothesis



1. Case study: Daily growth of the Alboran Sea sardine

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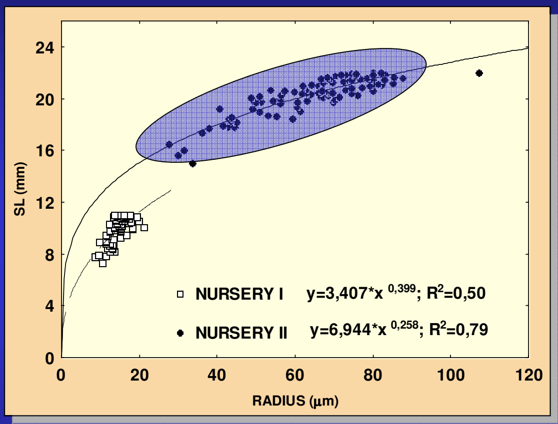


Survivor larvae showed higher growth from the initial stages

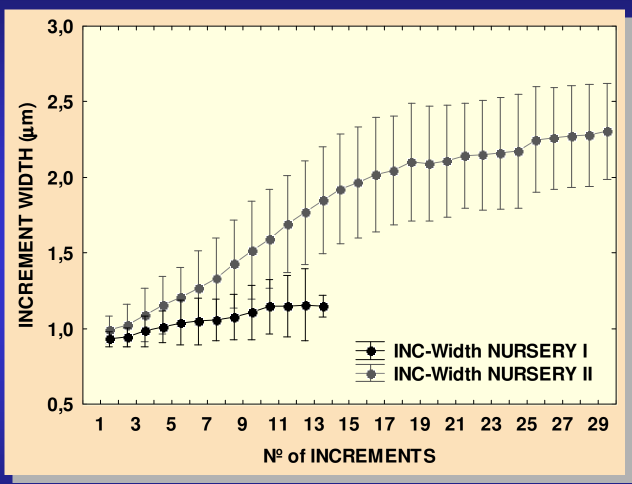
Higher somatic growth of larvae was corresponded with a higher otolith growth

Size (SL) at age (DI) relationship of pre-flexion and post-flexion larval populations.

Fig 5: Size (SL) vs Otolith Radius relationship of pre-flexion and post-flexion larval populations.

1. Case study: Daily growth of the Alboran Sea sardine

Experiment verifying growth mortality hypothesis



Back-calculated growth trajectories of pre-flexion and post-flexion larval populations

Mean increment width of pre-flexion and post-flexion larval populations.

2. Case study: Alboran Sea Anchovy Growth variability and Recruitment

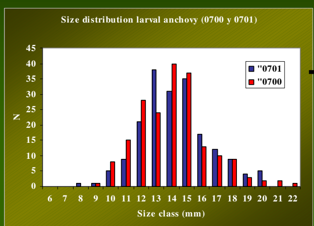
➢Anchovy larval growth interannual variability

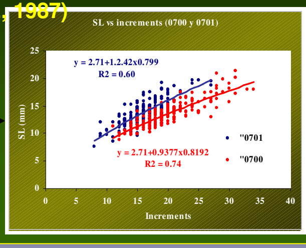
During the spawning peak of anchovy, larvae were sampled in the their area of concentration off the Bay of Malaga.

Larvae were sampled in July 2000 and 2001 in the same site/area.

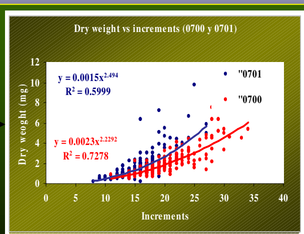
2. Case study: Alboran Sea Anchovy Larval Growth Variability Study

SCIENTIFIC EVIDENCE HAS DEMONSTRATED THAT SMALL VARIATIONS IN THE DAILY GROWTH RATES CAN CAUSE IMPORTANT RECRUITMENT OSCILLATIONS, SPECIALLY IN THE CASE OF ANCHOVY LIKE SPECIES (HOUDE, 1987)





Somatic growth models



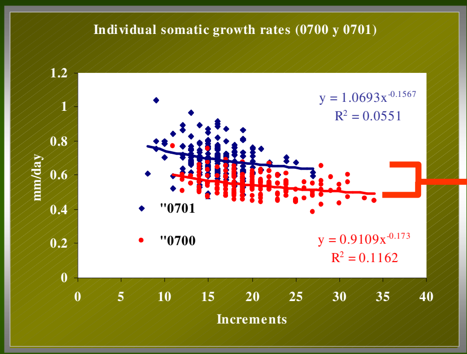
Two anchovy larval cohorts were sampled in the Bay of Málaga in July 2000 and 2001

Significant growth differences were observed in the size vs age and weight vs age relationships

García, A., D. Cortés, T. Ramírez, A. Giráldez and A. Carpena. 2003. Contribution of larval growth rate variability to the recruitment of the Bay of Málaga anchovy (SW Mediterranean) during 2000-2001 spawning seasons. Sci. Mar., 67(4): 477-490.

2. Case study: Alboran Sea Anchovy Growth and Recruitment

➢ As a result of faster growth during 2001, GAIN IN SIZE AND WEIGHT PER TIME UNIT IS GREATER DURING JULY 2001



➢INDIVIDUAL SOMATIC GROWTH RATES SHOWED AN OVERALL INCREASE OF 20%

2. Case study: Alboran Sea Anchovy Growth variability and Recruitment

➢MORTALITY IN THE EARLY LIFE STAGES OF ANCHOVY IS GROWTH AND STAGE DURATION DEPENDENT

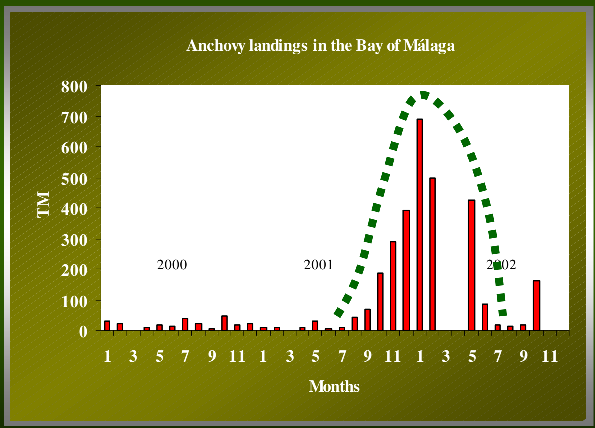
DAILY GROWTH RATES OF THE BAY OF MALAGA ANCHOVY DURING YEARS 2000 AND 2001

To attain a size:	Year	Growth rate	Duration	Difference
10 mm larva	2000	0.49 mm/day	12.2 days	2.8 days
	2001	0.62 mm/day	9.4 days	
15mm larva	2000	0.43 mm/day	23 days	5 days
	2001	0.54 mm/day	18 days	
20mm larva	2000	0.40 mm/day	35 days	7.4 days
	2001	0.50 mm/day	27.7days	
7 cm recruit	2000	0.30 mm/day	184 days	33 days
	2001	0.35 mm/day	151 days	

➢ HIGHER GROWTH RATES REDUCE EARLY LIFE STAGES DURATION, AND THEREBY, LESSENING SENSITIVE STAGES TO MORTALITY, ie. PREDATION.

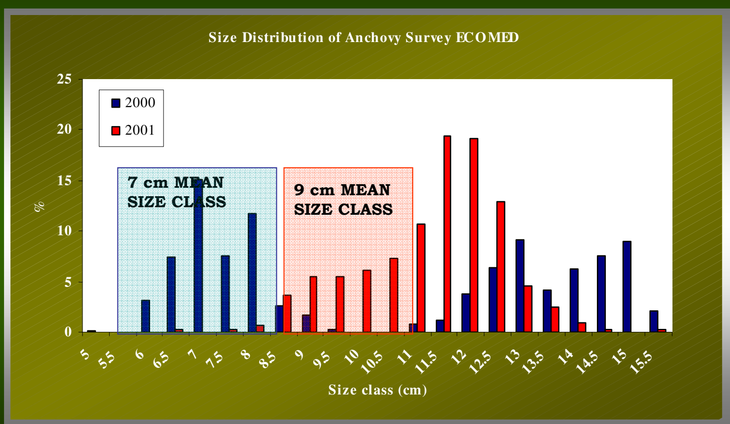
2. Case study: Alboran Sea Anchovy Growth variability and Recruitment

CONSEQUENTLY, ANCHOVY RECRUITMENT DURING 2001 WAS THE MOST SUCCESFUL SINCE ITS DECLINE IN MID-EIGHTIES AS SHOWN IN THE LANDINGS OF THE PORT OF MALAGA WHICH LANDS OVER 85% OF THE TOTAL ALBORAN SEA ANCHOVY CATCH MOSTLY COMPOSED OF -0 AGE CLASS.



2. Case study: Alboran Sea Anchovy Growth variability and Recruitment

EVIDENCE OF FASTER GROWTH WAS OBSERVED IN THE INCREASE OF IN THE AVERAGE SIZES OF ANCHOVY RECRUITS DURING 2001..



CONCLUSIONS

Fry concentration sites are KEY ECOSYSTEMS in the life and growth strategy of small pelagic species offering excellent research opportunities at relatively low spatial scales (mesoscale).

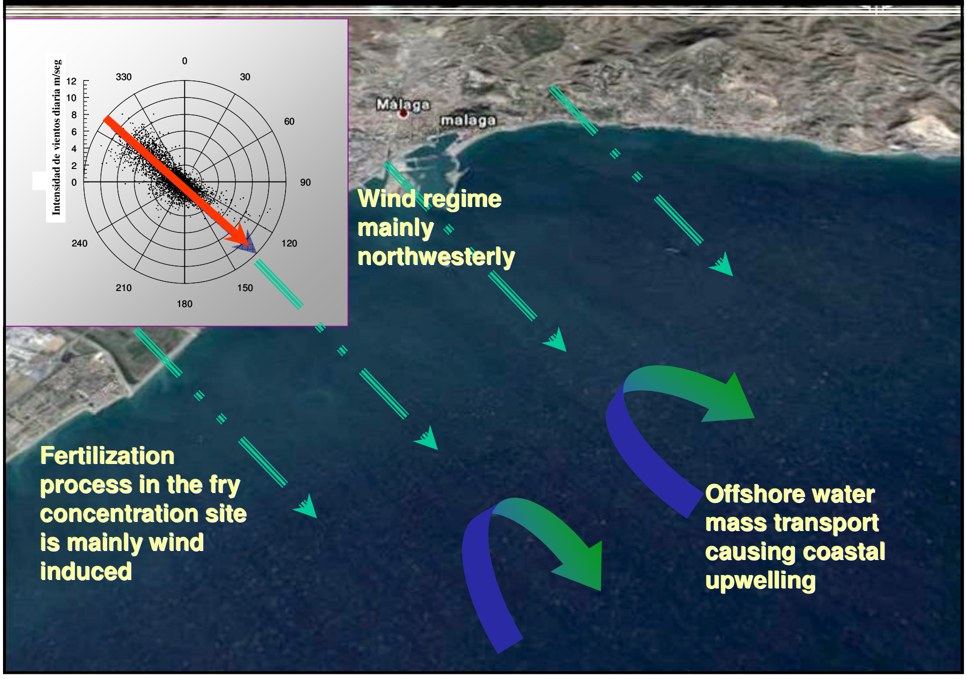
Larval survival expectancy of early life stages is increased in these privileged spots.

Therefore, fry concentration sites as the inshore waters of the Bay of Málaga meet the essential ecological and biological requirements of these key pelagic species.

Moreover, this site is crucial for the recovery and long term sustainability of these resources.

IN AGREEMENT WITH THE CGPM DEFINITION OF
SENSITIVE HABITAT.

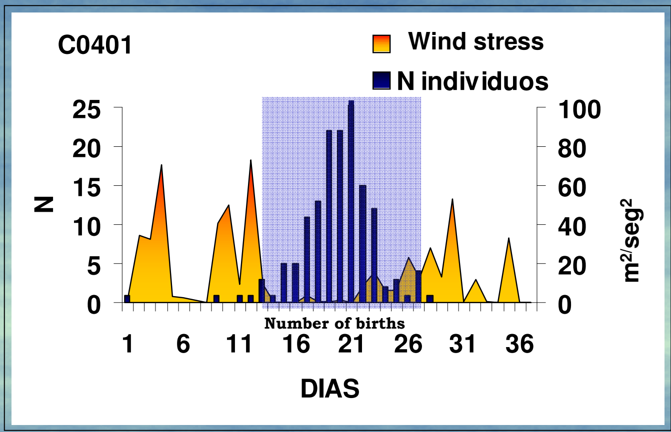
CLIMATIC INFLUENCE ON GROWTH VARIABILITY



CLIMATIC INFLUENCE ON GROWTH VARIABILITY

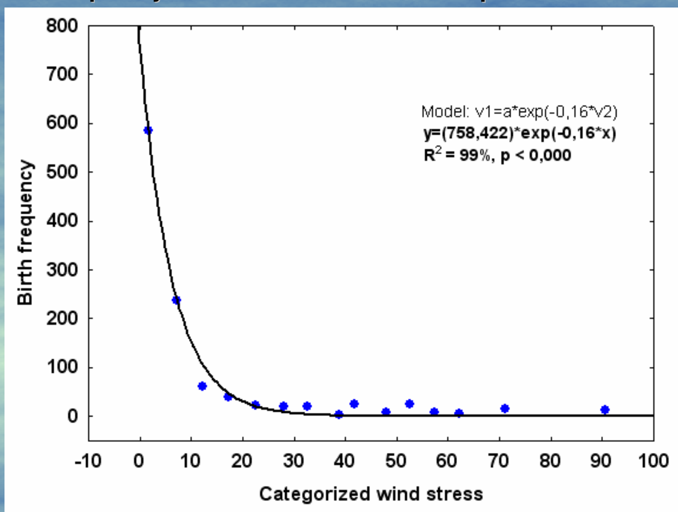
Life strategy of sardine is intimately linked to wind regime.

Birth frequencies match with calm wind periods.



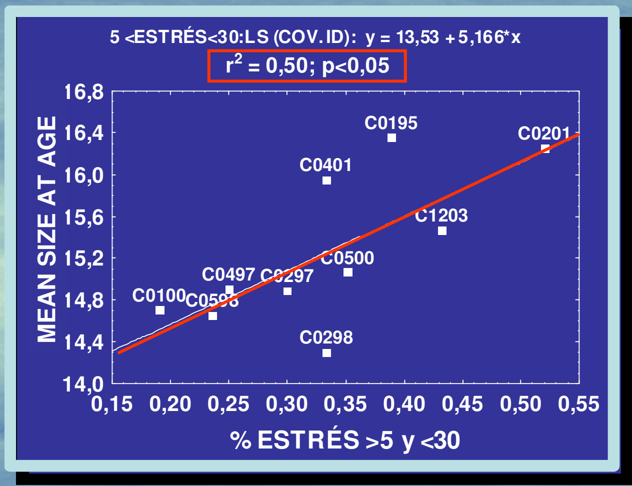
CLIMATIC INFLUENCE ON GROWTH VARIABILITY

The data set of birth dates of winter spawned sardine from 1995-2003 clearly shows birth frequency associated with calm wind periods.



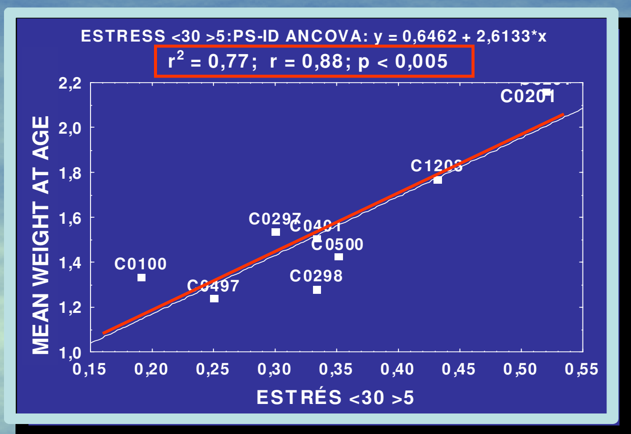
CLIMATIC INFLUENCE ON GROWTH VARIABILITY

However, wind shows significant linear relationship with growth potential (mean size at age) of each sampled larval cohort considering the % of days in which larvae were under the influence of an optimal environmental window of wind stress (5-30 m^2/s^2).



CLIMATIC INFLUENCE ON GROWTH VARIABILITY

Larval weight at age seems to be an even better predictor of wind stress relationship with growth potential.



CONCLUSIONS

FURTHERMORE, it may be assumed that:

The Bay of Málaga fry concentration site is

highly influenced by its **wind regime**

and therefore, potentially impacted by climate change dynamics.

Life and growth strategy are intimately linked to a **match/mismatch** of wind events that drive **enrichment** and **stability** periods.

PAST AND ACTUAL STATUS OF BAY OF MALAGA FRY FISHING GROUNDS

Past threat from fry fishing is bygone.

However, this fry concentration site is under strong anthropogenic forces that may result in degradation of this sensitive habitat.

Human pressure derives from:

- Urban development and population increase
- Waste disposal (of industrial and human source)
- Leisure activities (beach and associated activities)
- Coastline modification (beach sanding)
- Recreational fishing
- Aquaculture (expansion of coastal fish cages)

PAST AND ACTUAL STATUS OF BAY OF MALAGA FRY FISHING GROUNDS

AND THEREFORE, FRY CONCENTRATION SITES MAY BE IN NEED EXAMINING CONSERVATION MEASURES TO SAFEGUARD THE SUSTAINABILITY OF SMALL PELAGIC RESOURCES.