Vertical distribution of larval fish habitats and dissolved oxygen gradients in the Tropical-Subtropical Convergence region in the Pacific off Mexico

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Oxygen Minimum Zones (OMZ)

(Díaz & Rosenberg, 2008; Karstensen et al., 2008; Stramma et al., 2008, 2010)
OMZ: ETP off Mexico
Cepeda-Morales et al., 2013

Vertical distribution of DO along P1 to P4 transect from 0-500m
~ 45 µmol L⁻¹ = ~ 1mL/L [O₂]
~ 9 µmol L⁻¹ = ~ 0.2 mL/L[O₂]

(150 m - north) and (70 m - south)
(400 m - north) and (80 m - south)
Hypoxia and Zooplankton

Longhurst, 1967
(5 - 0.5 mL/L): zooplankton
(0.2 mL/L): limiting concentration

Tremblay et al., 2010
Oxidative stress in Euphausids

Hendrickx & Serrano, 2010
OMZ as a barrier for shrimps

Fernandez-Alamos & Farber-Lorda, 2006; Farber-Lorda et al., 2010:
Hypothesis of habitat compression
Low oxygen restricts distribution of zooplankton to shallower waters
(< 100m)

What happens within the OMZ related to fish larvae?
In this context the intuitive hypothesis was the following:

1. In the well-oxygenated zone is expected to find the highest specific richness probably defining a larval fish habitat between the mixed layer and the thermocline.

CONTRARY:
2. The hypoxic zone should present a decreasing in specific richness and larval fish abundance defining a larval fish habitat below the thermocline.

Hypoxia zone = empty?? or Presence of Adapted Species to low oxygen??
Main Objective

To analyze the vertical distribution of larval fish habitats and dissolved oxygen gradients in the Tropical-Subtropical Convergence region in the Pacific off Mexico during February and June 2010
Methods

Field and Lab Work

- Physical and Chemical samples (CTD, Niskin Bottles)
- Biological samples (zooplankton hauls)
- Open-Closing Net (60 cm diameter and 505 μm)
- Strata (based on the water column structure)
- Zooplankton samples (fixed with formaldehyde at 4%)
- Volume displacement Method (Kramer et al., 1972; Beers, 1976)
- Samples separation and fish larvae identification (Moser, 1996)

Biological data

- Fish larvae abundance (no. indiv/10m²) (Smith & Richardson, 1979)
- Bray-Curtis Dissimilarity Index (Bray & Curtis 1957): LARVAL FISH HABITATS
  - ANOSIM (r=0.55)
- Olmstead-Tukey Test (Sokal & Rohlf, 1985): Characterized species (D, C, O, R) based on abundances (>= 2%) and frequency (>= 2%)
  - SIMPER (% species contribution)

Statistical Analysis

Environmental data

- Temperature, Salinity, Dissolved Oxygen and Chlorophyll a
- Vertical distribution graphs with environmental data and fish larvae habitat
- (CCA) Canonical Correspondence Analysis: allows to obtain the environmental variable that influences on the biological groups formed by the dendogram analysis
45 sampled stations with 20 multilevel biological stations

3 sampled strata (mixed layer, thermocline, oxygen minimum)
Entrance of GC to Cabo Corrientes Area

Defined 3 significantly different larval fish habitats:
Vertical distribution of larval fish habitats and dissolved oxygen (mL/L)

Gulf of California Habitat
Pacific Mixed Layer Habitat
Pacific Oxygen Minimum Habitat

Larval Fish Abundance (larvae/10 m²)
- 1 - 30
- 31 - 60
- > 60
### Gulf of California Habitat (GC)

**Anchoa sp.**

### Pacific Mixed Layer Habitat (PML)

**Vinciguerria lucetia**
Larval fish habitats in the northern boundary of the shallow oxygen minimum zone in the eastern tropical Pacific Ocean off Mexico. S.M. Davies, L. Sánchez-Velasco and E. Beier, in prep.
Canonical Correspondence Analysis (CCA) – Larval Fish Habitats

GC – associated to higher values of salinity

PML – associated to higher values of T°C, DO, ZB

POM – Associated to lower values of dissolved oxygen

Pearson Correlation (0.90 axis 1) (0.74 axis 3)
Water Masses related to each larval fish habitat

- Gulf of California
- Pacific Mixed Layer
- Pacific Oxygen Minimum
Southwestern Coast of Baja California – June 2010

88 sampled station, 46 multilevel biological stations

Sampled Strata (0-15m, 15-30m, 30-50 m, 50-100m, 100-150 m, 150-200m)

Frontal System Region of Southern Baja California
Southwestern coast of Baja California – June 2010

Defined 4 significantly different larval fish habitats:

- California Current Habitat a) Transitional
- California Current Habitat b) North
- Pacific Mixed Layer Habitat (StSsW)
- Pacific Oxygen Minimum Habitat (StSsW)
Larval fish habitats vertical distribution and dissolved oxygen (mL/L)

- Pacific Mixed Layer Habitat (StSsW)
- Pacific Oxygen Minimum Habitat (StSsW)
- California Current Habitat (a) Transitional
- California Current Habitat (b) North

(Larvae/10 m²)
- 0-30
- 30-60
- > 60
California Current Habitat

Mexican Lampfish

*Triphoturus mexicanus*
Pacific Mixed Layer and Oxygen Minimum Habitats

Panama Lightfish

Vinciguerra lucetia

- 0 – 30 (Larvae/10m²)
- 30 – 60
- > 60

Diogenes lanternfish

Diogenichthys laternatus
Conclusions

The results showed that the highest specific richness was located in the larval fish habitats located in the mixed layer and thermocline through the entire studied region, decreasing across the hypoxic zone (< 1mL/L), in the Pacific oxygen minimum larval fish habitat.

In addition, it was observed the highest total larval fish abundance in the hypoxic zone through the entire studied region, mainly by the contribution of two species: i) *Bregmaceros bathymaster* in front of Cabo Corrientes, and  ii) *Diogenichthys laternatus* in front of Cabo San Lucas.

We can concluded that the habitat over the thermocline might be compressed increasing the competence pressure between the fish larvae that coexist within this shallow area of the water column, while the hypoxic zone might not caused a dramatic effect over the total larval abundance.
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