Oceanography of the Mexican Pacific Ocean: An interactive region between north and south

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PICES, Nov 2016 San Diego, Ca

1 CICESE

2 CONACYT

3 CIB CENTRO DE INVESTIGACIONES BIOLÓGICAS DEL NOROESTE, S.C.

Objective

To show what are Oceanographic Mexican Institutions working (on PICES interest, i.e., Pacific Ocean!)

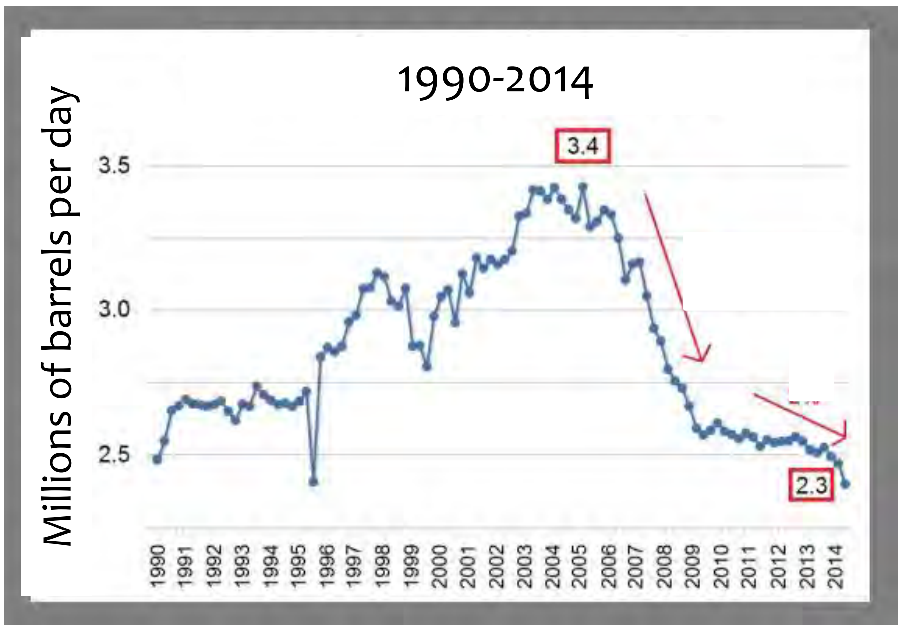
Outline

- Importance of the oceans for Mexico
- The Gulf of Mexico
- The Mexican Pacific: Transition zone
- Some Highlights from the Mexican Pacific
- Forthcoming goal (California Current Ecosystem)

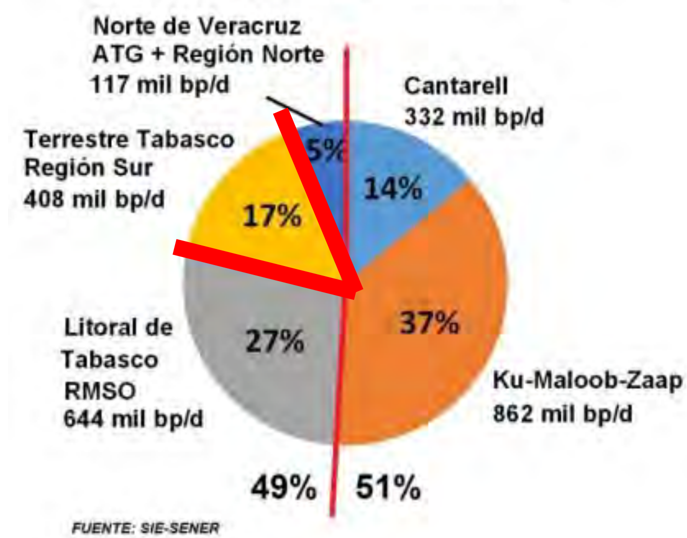
Importance of the Oceans for Mexico

- Oil production

(2015: about 2 x 10^6 barrels per day)



More than 80% fromtheocean



Working on deep waters

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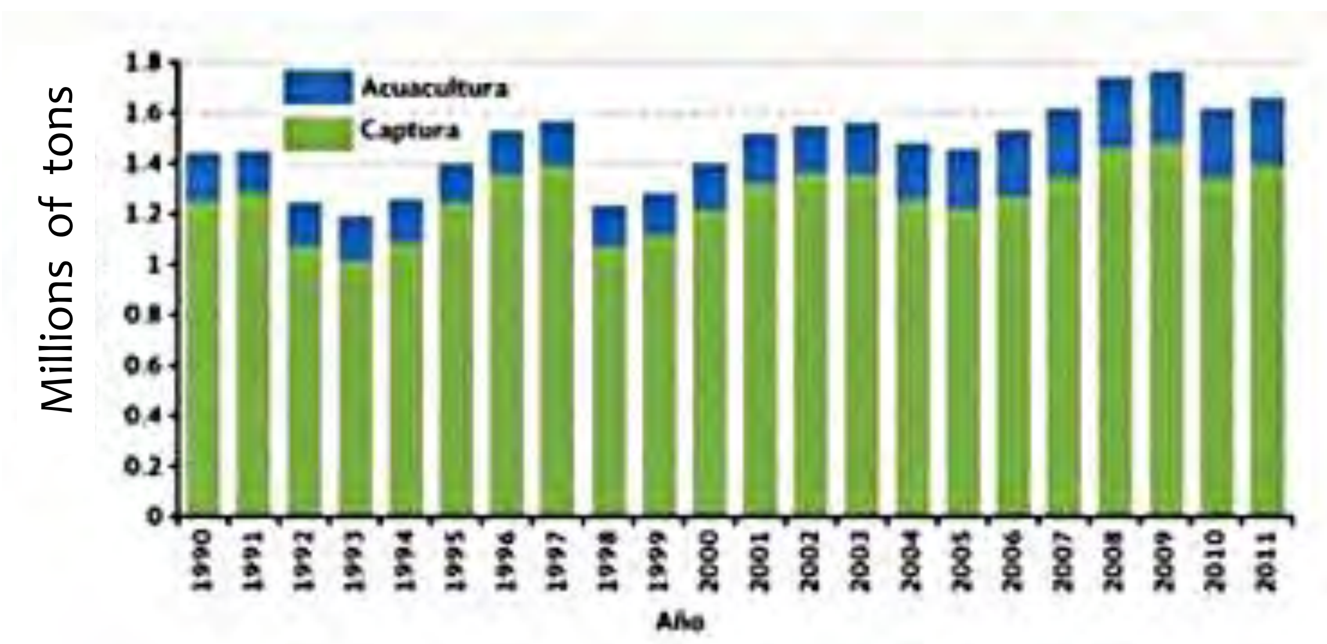
Importance of the Oceans for Mexico

* Fisheries and aquaculture
  (2015: about 2 x 10^6 tons)

1990-2011



Aquaculture

Fisheries

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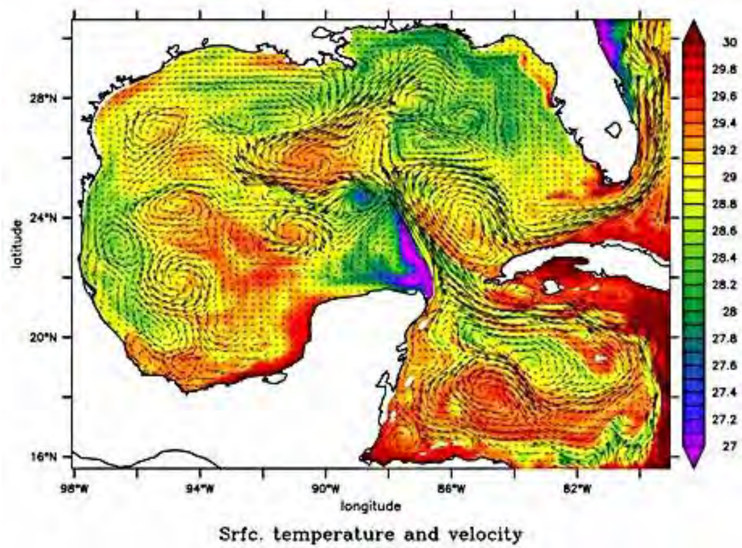
Importance of the Oceans for Mexico

* Registered Vessels
  * Civilian ~172,000
  * Military ~100

The Gulf of Mexico

* CIGoM:

  Oceanographic observational network generating scenarios of possible contingencies related to the exploration and production of hydrocarbons in the Mexican EEZ Gulf of Mexico deep-water region



High-resolution numerical simulations performed with ROMS as part of CIGoM (also operational).

The Gulf of Mexico

* CIGoM: 5 lines of studies

1 System of oceanographic observation platforms (fixed and mobile),

2 base line studies,

3 circulation and biogeochemical numerical models with data assimilation,

4 typify hydrocarbon natural degradation, and

5 analysis of possible different spill scenarios

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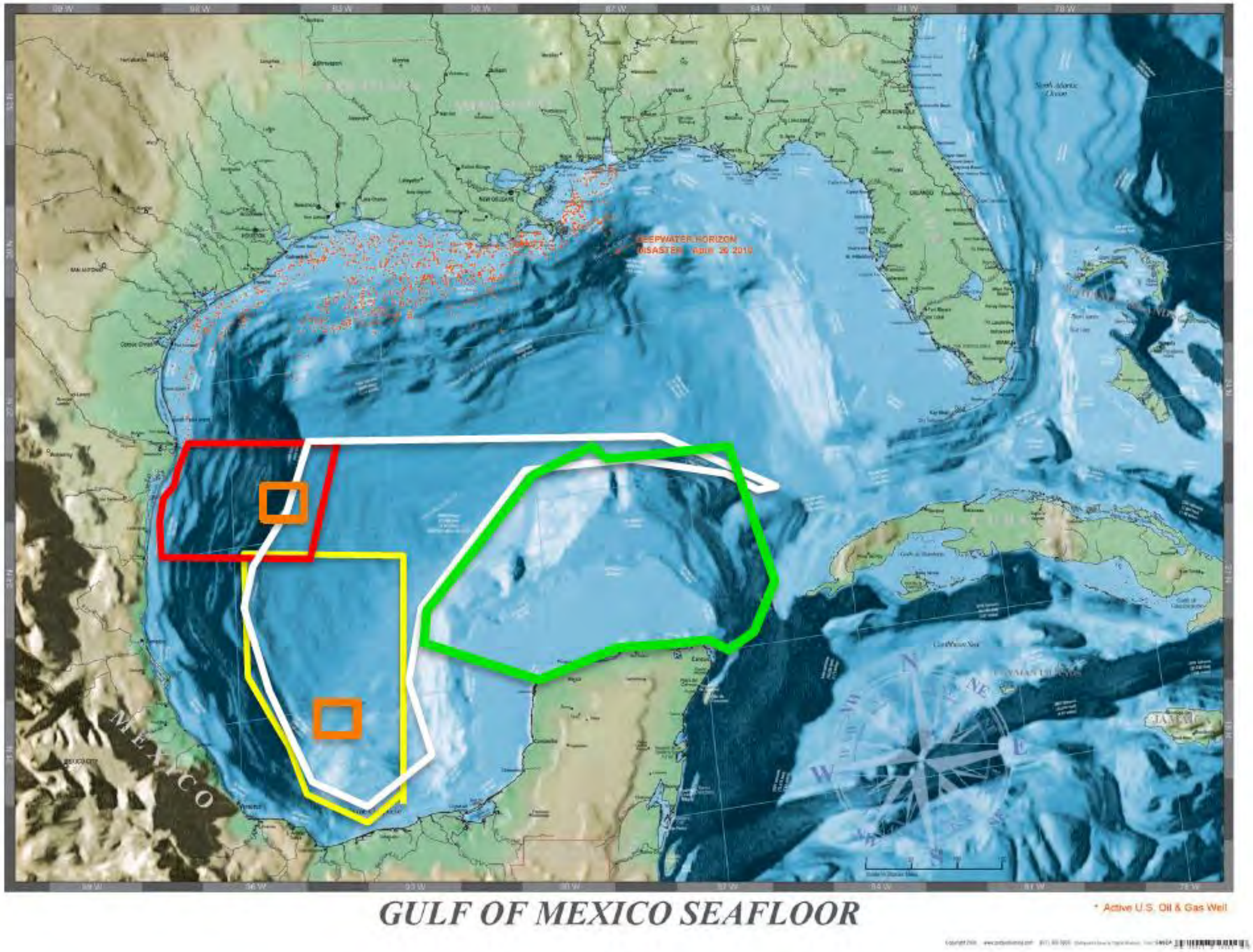
The Gulf of Mexico

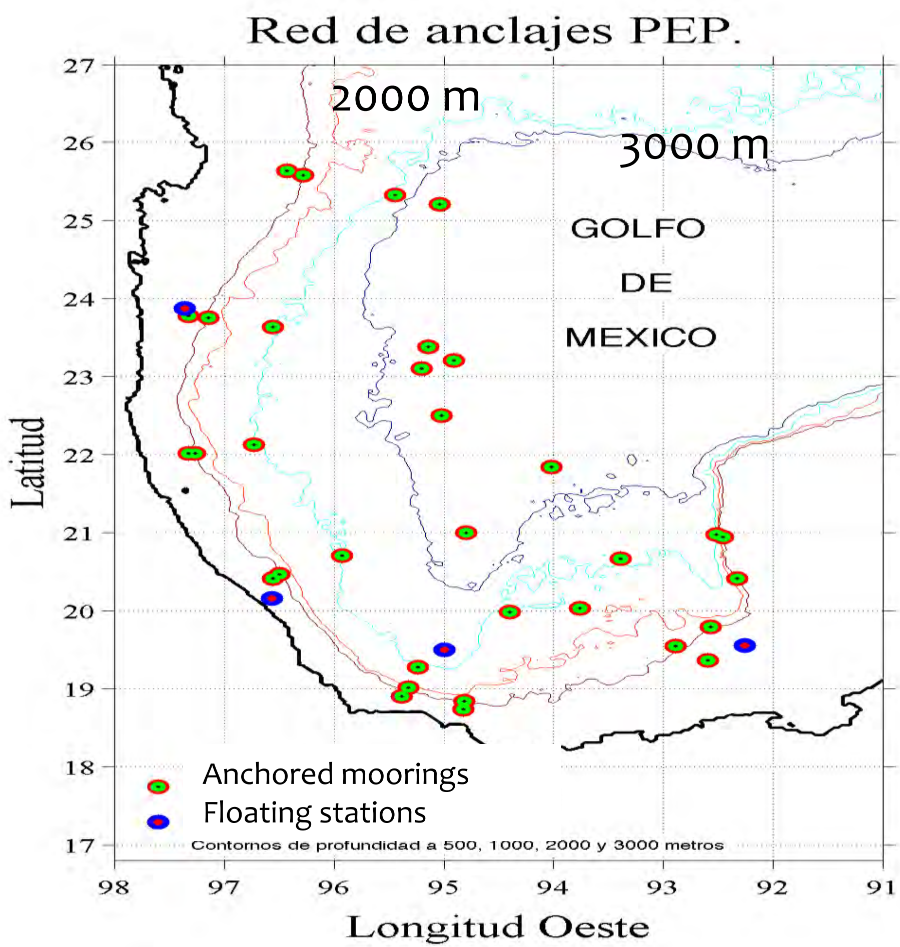
- CIGoM: polygons for hydrographic stations



The Gulf of Mexico

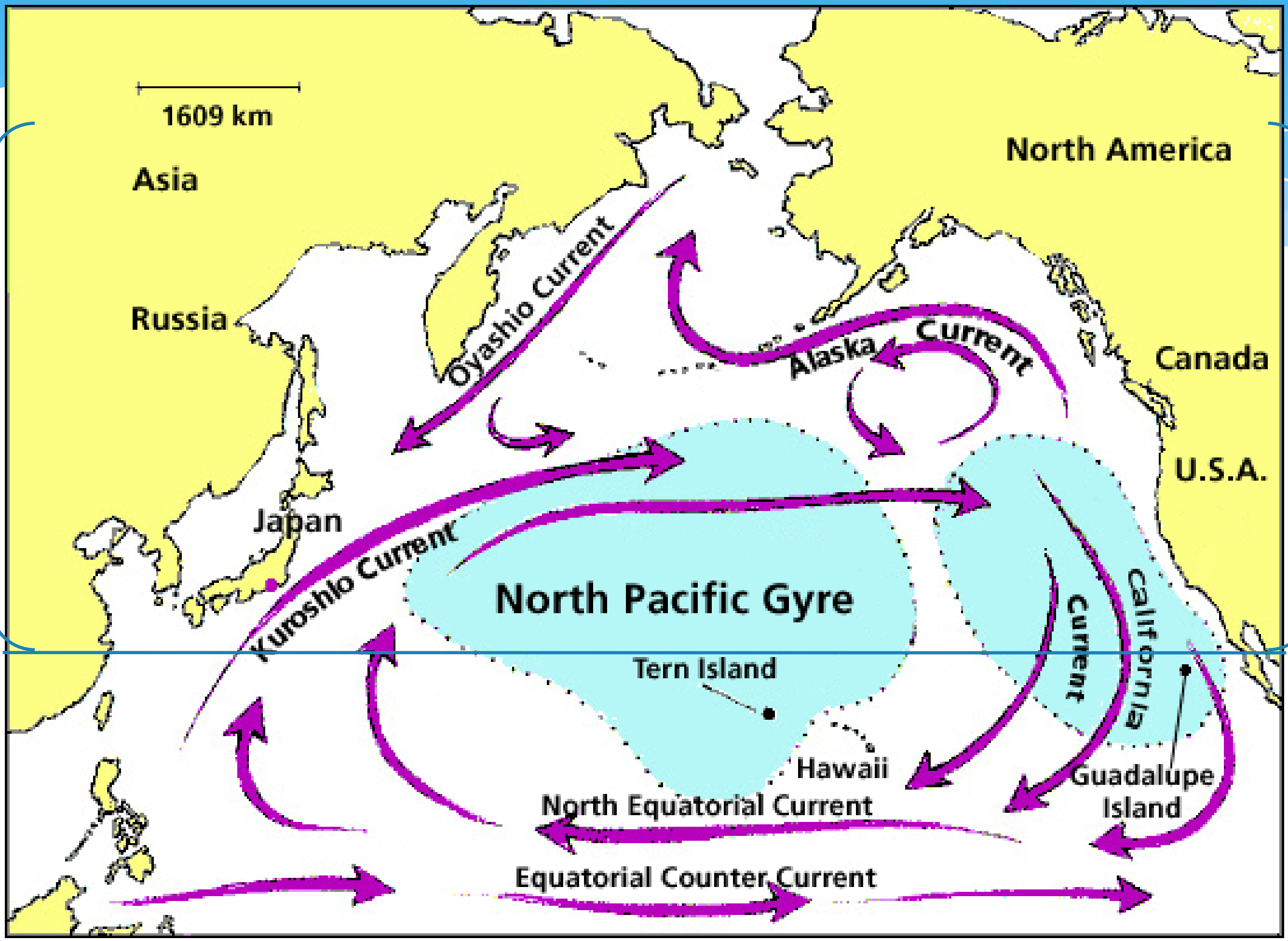
CICESE with PEMEX: Measurements and analysis in deep water

Project duration 2007-2015



The Mexican Pacific: Transition Zone

P I C E S



P I C E S

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The Mexican Pacific: Transition Zone (PICES-Equator)

Some Highlights from the Mexican Pacific

1. Research centers
2. Research Vessels
3. Transitional zones: Circulation and Water Masses
4. Transboundary fisheries and biological migrations
5. Marginal Sea and MPA (Gulf of California)
6. Boundary Upwelling Systems and BACs
7. Numerical modeling
8. Monitoring program IMECOCAL

Highlights of the Mexican Pacific

1 Research centers

CICESE
IIO-UABC
CIBnor
CICIMAR-IPN
UNAM-Mazatlán
UdG

Highlights of the Mexican Pacific

2 Research Vessels

Alpha Helix 40m
CICESE

El Puma 49 m
UNAM

BIPO 59 m
INAPESCA

Highlights of the Mexican Pacific

3 Transitional zones: circulation and water masses

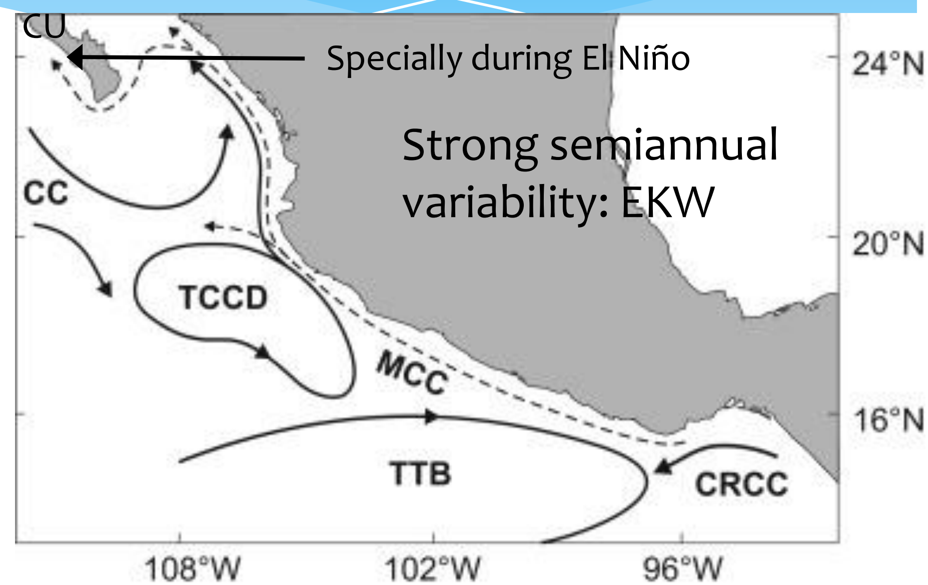
Transitionalzones:

a) Mid latitude-Tropical-subtropical interactions

b) Climate signals multi-scale interactions (seasonal, El Niño, decadal, …)

c) Biogeographic boundaries dynamics (dominated by currents)

d) Marine diversity responses to Climate Change (N-S migrations)

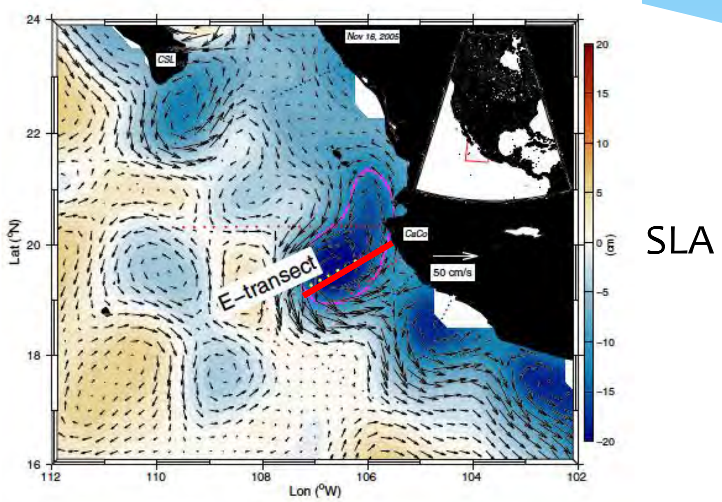


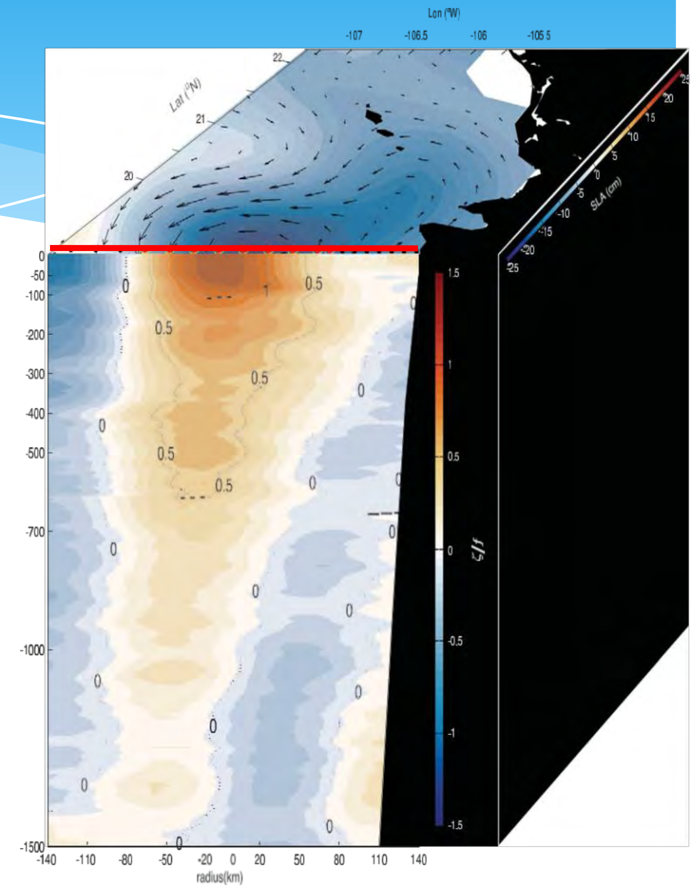
Squematic mean circulation off SW Mexico. Continuous lines indicate near-surface currents, and dashed line indicates the subsurface component of the Mexican Coastal Current. Gómez-Valdivia *et al.*, CSR, 2015.

TTB: Thermocline Tehuantepec Bowl, CRCC: Costa Rica Coastal Current, TCCD: ThermoclineCabo Corrientes Dome, CU: California Undercurrent MCC: Mexican Coastal Current, , CC: California Current

Highlights of the Mexican Pacific

3 Transitional zones: circulation and water masses





A cyclonic mesoscale eddy observed in the northeastern Pacific tropical-subtropical transition zone.

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Formed at the coast, generated by coastal upwelling event with an equatoward flow. Traveled W ~ 1000 km in ~8 months.

Kurczynet *al.*, *JGR-Oceans*, 2013

Highlights of the Mexican Pacific

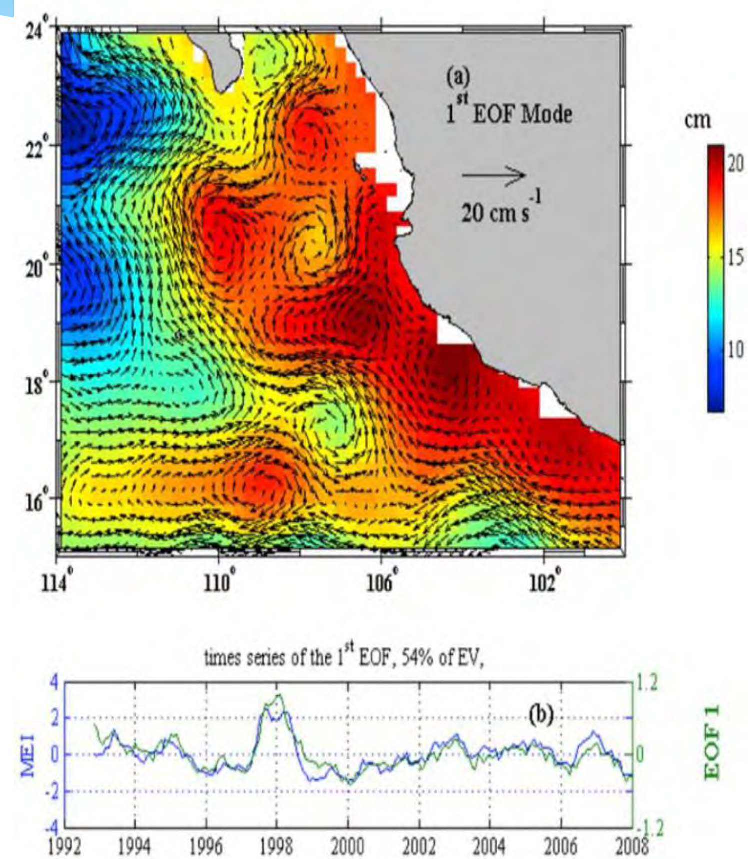
3 Transitional zones: circulation and water masses

Surface variance split in mesoscale, seasonal, and interannual scales.

Interannualcomponent dominated by the ENSO, which induces in the gulf entrance an anticyclonic (cyclonic) circulation during El Niño (La Niña);
this circulation includes a poleward flowing branch (during El Niño) parallel to the Pacific coast of the Baja California peninsula.

Seasonal:coastal (~300 km) connection MCC and equatoward CC.

The mesoscale variability is caused by intense eddy activity.



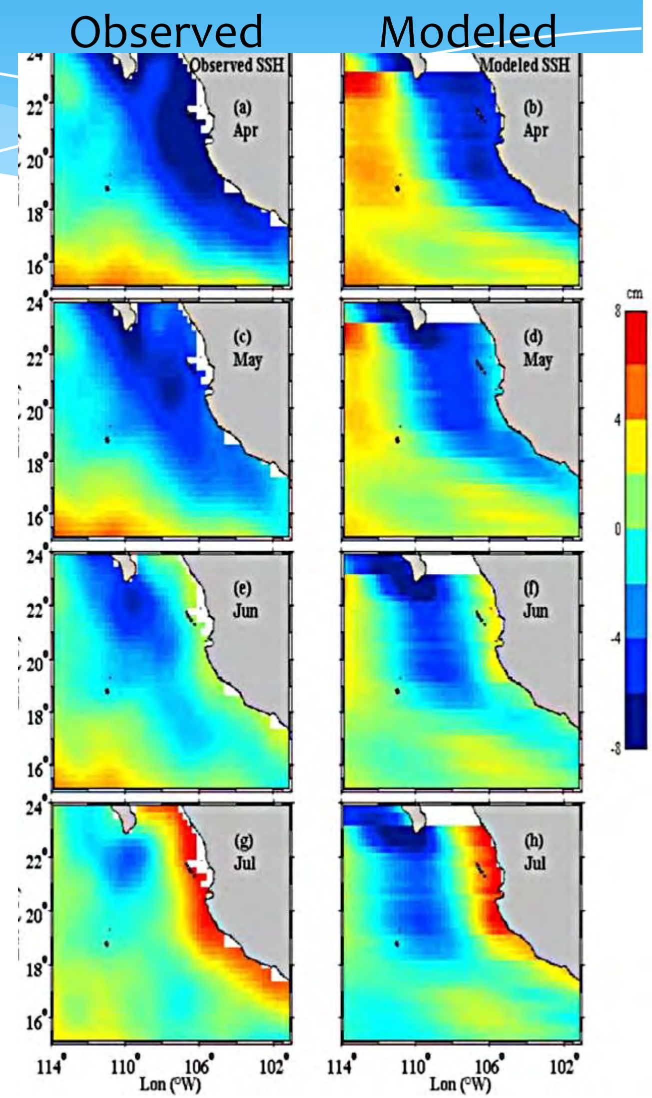
Godinez *et al.*, *JGR-Oceans*, 2010

1992-2008 altimeter & CTD

Highlights of the Mexican Pacific

3 Transitional zones: circulation and water masses

The seasonal signal of the sea level, which shows the interplay of the poleward Mexican Coastal Current and the equatorward branch of the California Current, can be explained by a long Rossby wave model forced by the annual wind and by radiation from the coast



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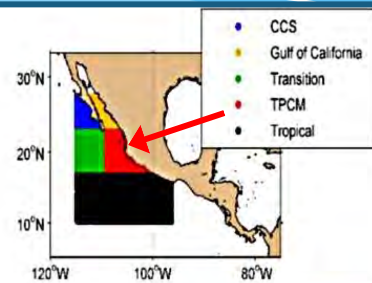
Godinez *et al.*, *JGR-Oceans*, 2010

Highlights of the Mexican Pacific

3 Transitional zones: circulation and water masses

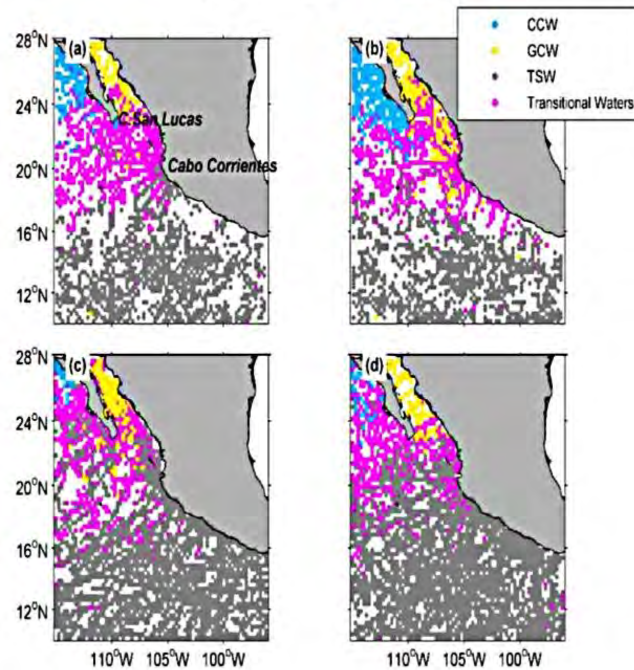
Surface Water Masses



areas

winter

spring



summer

fall

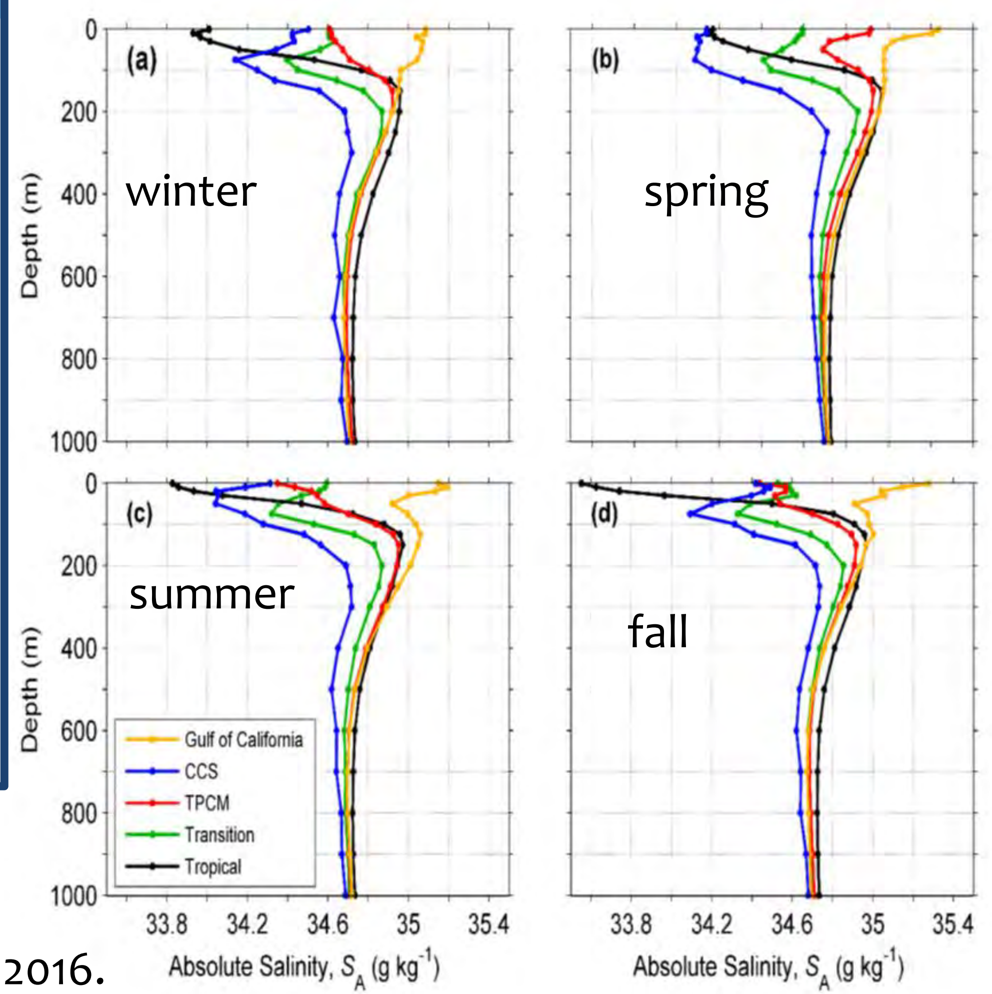
Portelaet *al.*, *JPO*, 2016.

Highlights of the Mexican Pacific

3 Transitional zones: circulation and water masses

The shallow (50–100 m) salinity minimum originates with the California Current System andbecomes saltier as it extends southeastward and mixes with tropical subsurface waters.

The surface salinity minimum extends farther north in the TPCM in summer and fall because of the northward advection of tropicalsurface waters



Portelaet *al.*, *JPO*, 2016.

Highlights of the Mexican Pacific

4Transboundary fisheries and biological migrations

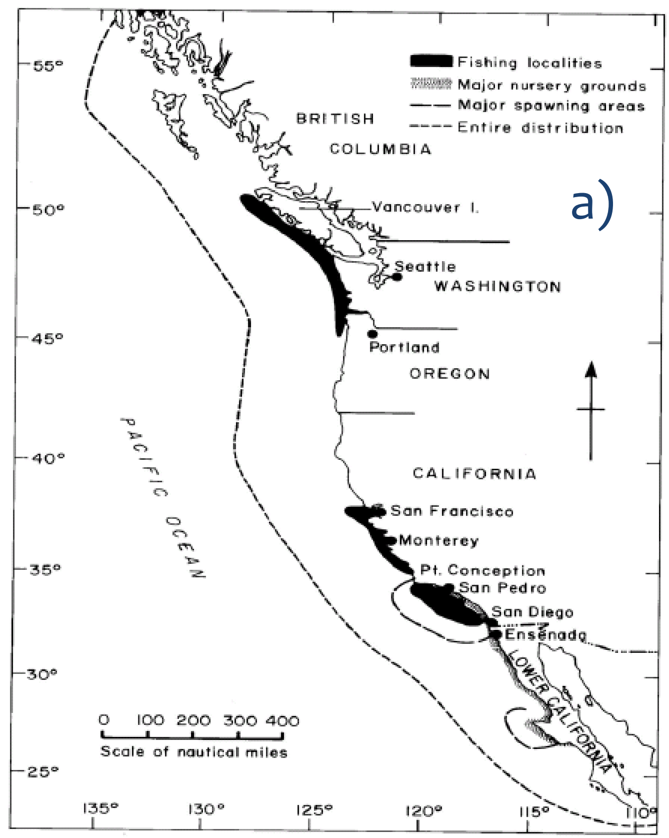
Transboundaryfisheries:

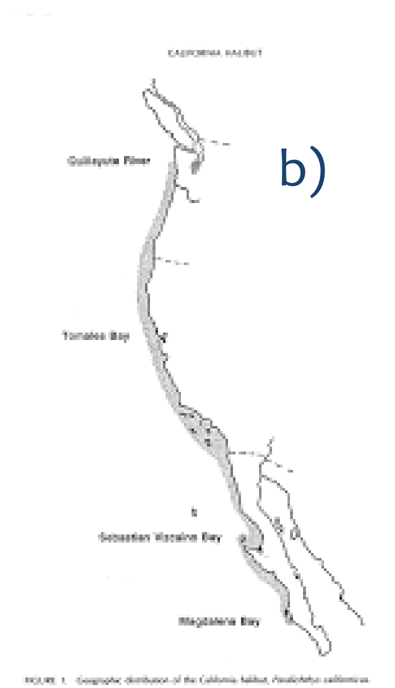
e.g.

a) Pacificsardine, *Sardinopssagax*

b) California Halibut, *Paralichthyscalifornicus*

Large migrations of different species





Schweigert, COSEWIC, 2002.

Haugen, DFG, 1990.

Highlights of the Mexican Pacific

4Transboundary fisheries and biological migrations

Large biological migrations:

a) Loggerheadturtles

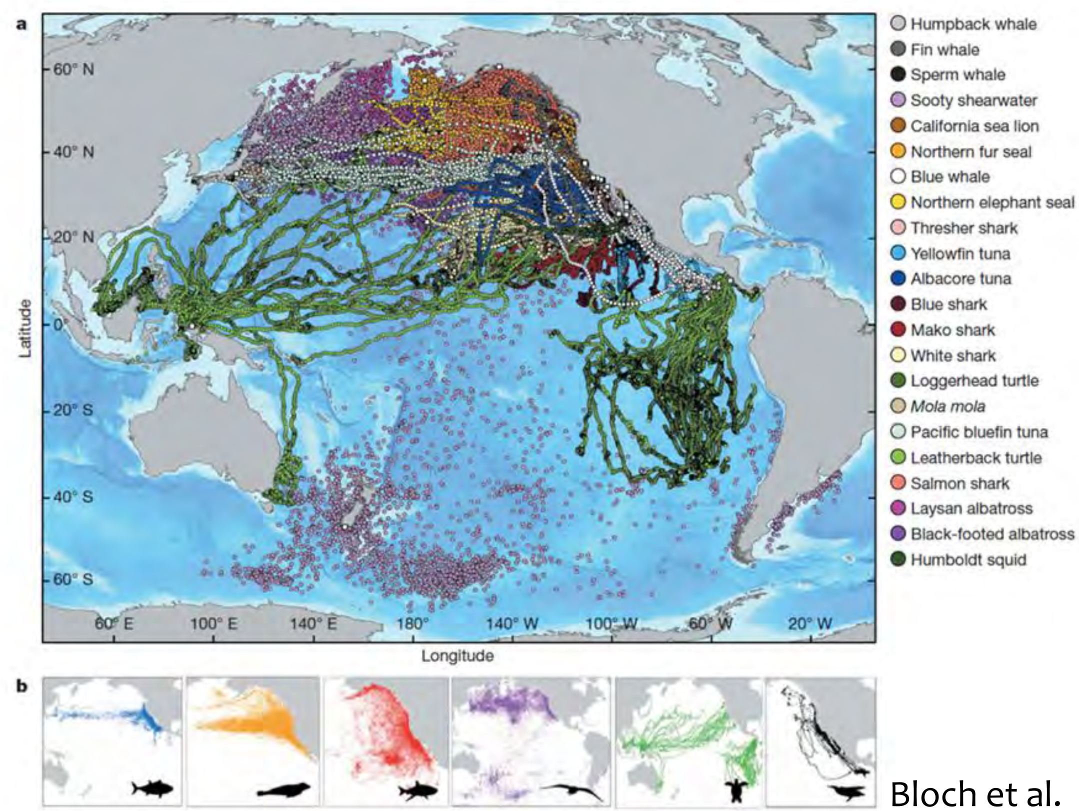
b) Gray whale

c) Humpackwhale

d) Jumbo squid

e) Pacificsardine

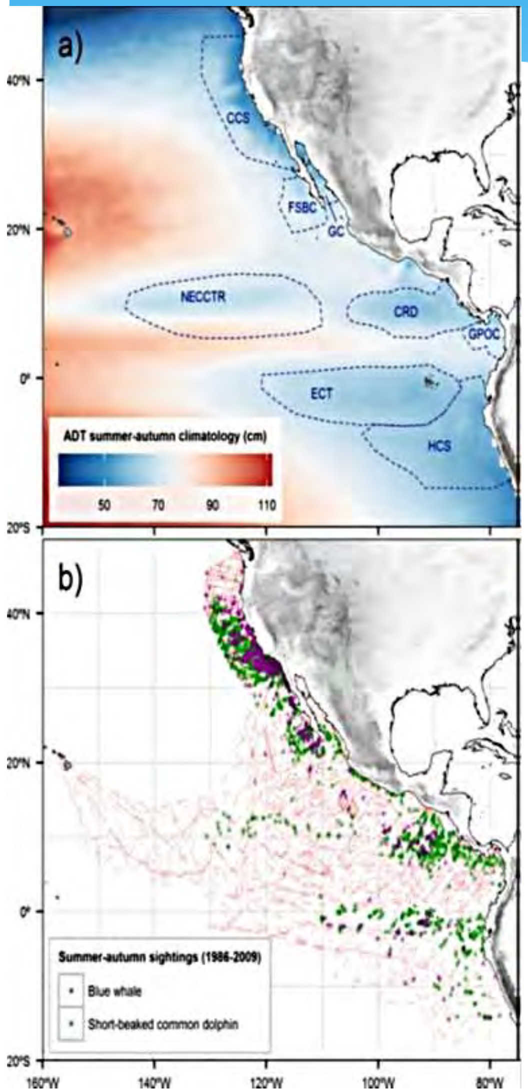
f) White shark



Bloch et al.

Highlights of the Mexican Pacific

4Transboundary fisheries and biological migrations



Cetacean population densities. (Bayesian models)

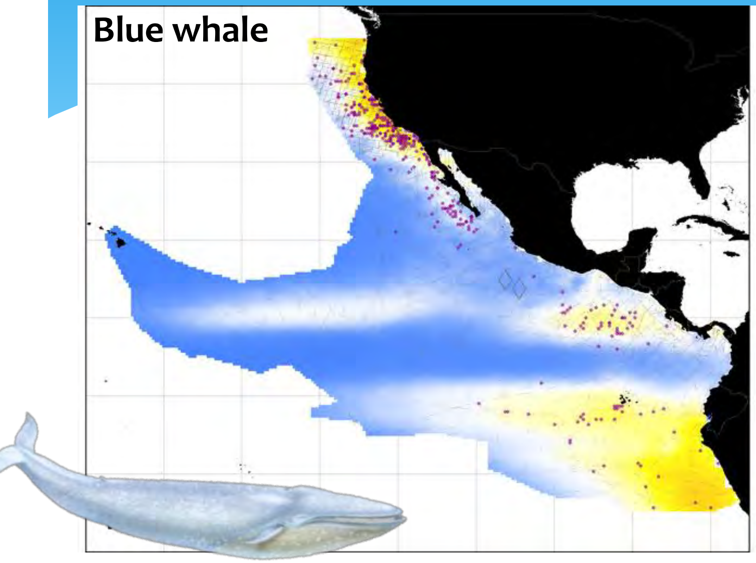
a) Main features of **lowAbsolute Dynamic Topography** (ADT⇐pycnocline shoaling) in the California Current System (CCS), the Frontal System off Baja California (FSBC), the Gulf of California (GC), the North Equatorial Countercurrent thermocline ridge (NECCTR), the Costa Rica Dome (CRD), the Gulf of Panama and off Colombia (GPOC), the Equatorial Cold Tongue (ECT), and the Humboldt Current System (HCS).

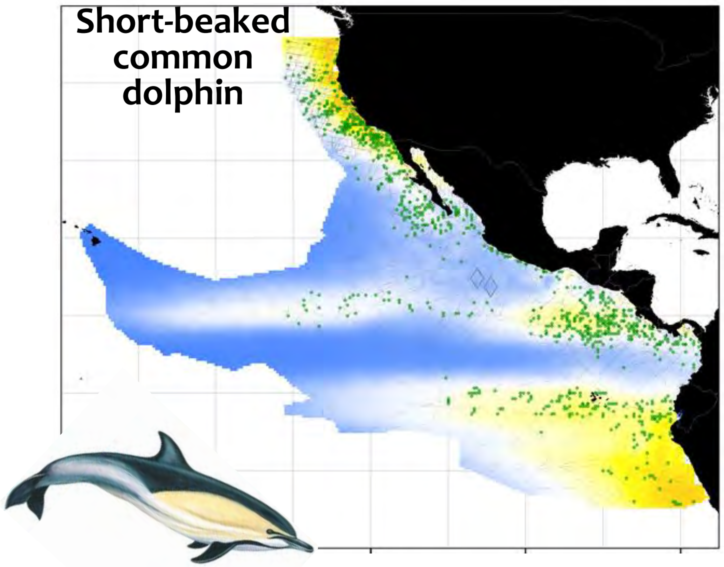
a) Blue whale and short-beaked common dolphin **sightings** (dots colored), and survey effort (thin red lines), collected during July-December at from 1986–2009. Follow more productive physical structures.

Pardo *et al.*, *PLoSONE*,2015.

Highlights of the Pacific off Mexico

4Transboundary fisheries and biological migrations





Cetacean population densities.

(Hierarchical Bayesian models)

From Main features of low Absolute Dynamic Topography (ADT⇐pycnocline shoaling) in the California Current System (CCS), the Frontal System off Baja California (FSBC), the Gulf of California (GC), the North Equatorial Countercurrent thermocline ridge (NECCTR), the Costa Rica Dome (CRD), the Gulf of Panama and off Colombia (GPOC), the Equatorial Cold Tongue (ECT), and the Humboldt Current System (HCS).

Is possible to predict:

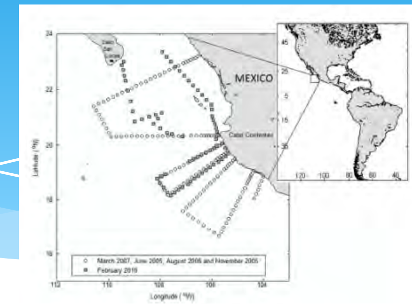
Blue whale and short-beaked common dolphin population density distributions (colorimetric scale) **and interannual redistributions**

Sightings (colored dots) and survey effort (thin gray lines), collected during July-December spanning 1986–2009.
Follow more productive physical structures.

Pardo *et al.*, *PLoS ONE*, 2015.

Highlights of the Mexican Pacific

4Transboundary fisheries and biological migrations

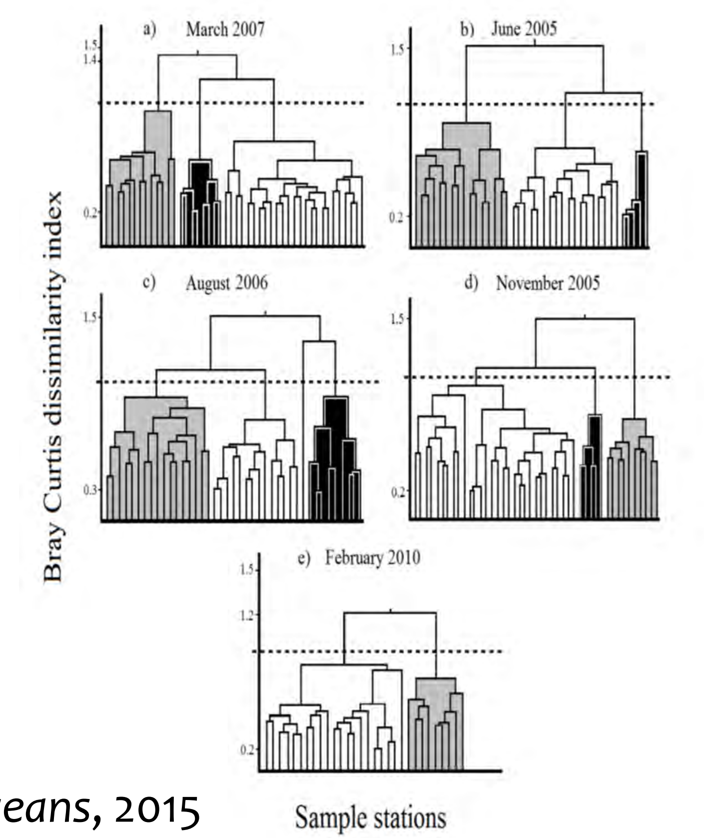


Larval composition and abundance of species

Dendrograms of groups of sampling stations defined by the Bray-Curtis dissimilarity index.

Shaded
White: Tropical
Gray: Coastal-and-Upwelling
Black: Transitional-CC

larval fish habitats



Leon-Chavez *et al*., *JGR-Oceans*, 2015

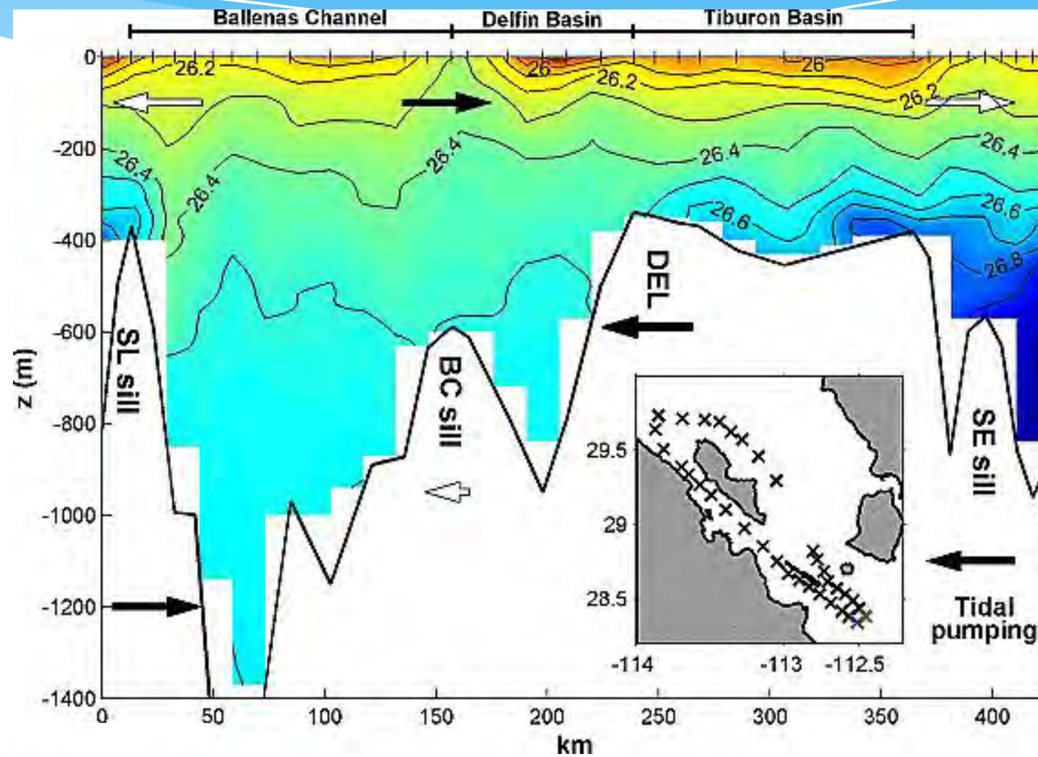
Highlights of the Mexican Pacific

5 Marginal seas and Marine Protected Areas

Marginal seas (Gulf of California):

a) Basin scale interactions

b) Semi-enclosed sea dynamics



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Solid arrows denote flow or transport toward the head of the gulf, and open arrows denote flow toward the mouth of the gulf. Lópezet *al*., *GRL*, 2006.

Highlights of the Mexican Pacific

5 Marginal seas and Marine Protected Areas

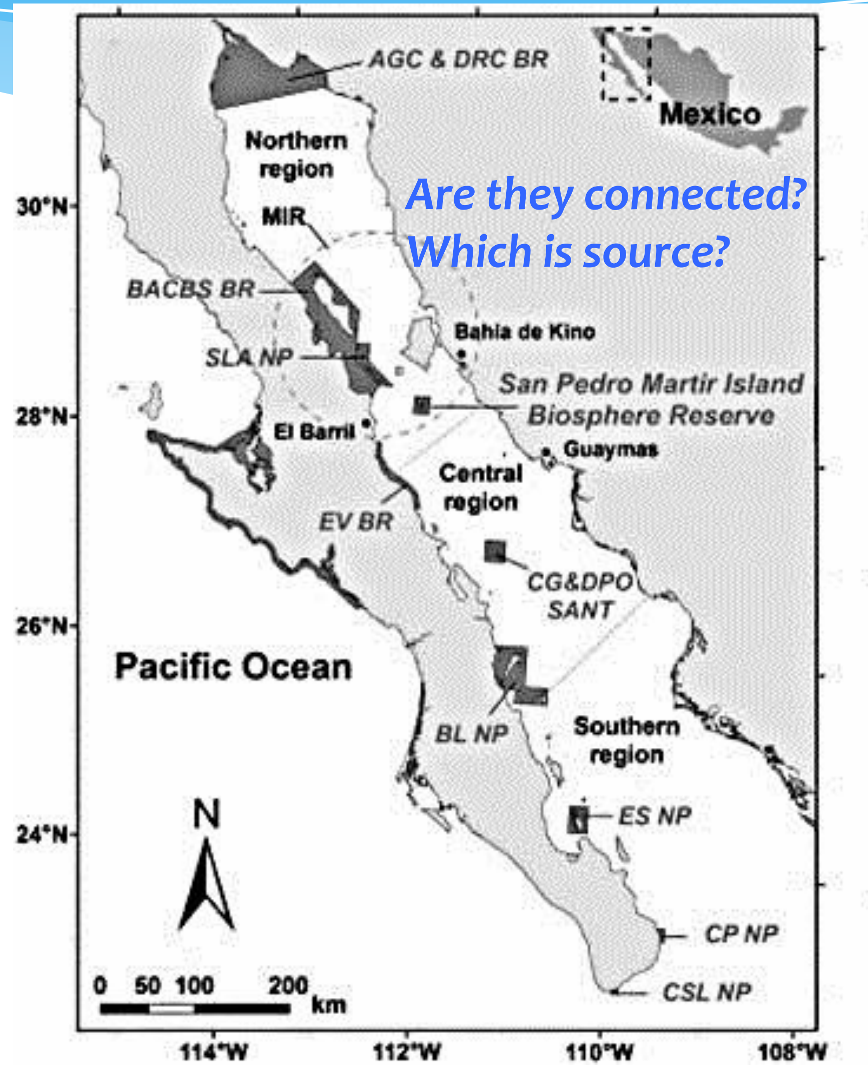
Effects of Marine ProtectedAreas:

a) Fish stocks

b) Preserves genetic diversity

c) Larvaetransport and dispersal

d) Human dimensions



Soria *et al.*, *JMS*, 2014.

Highlights of the Mexican Pacific

6 Boundary upwelling systems and BACs

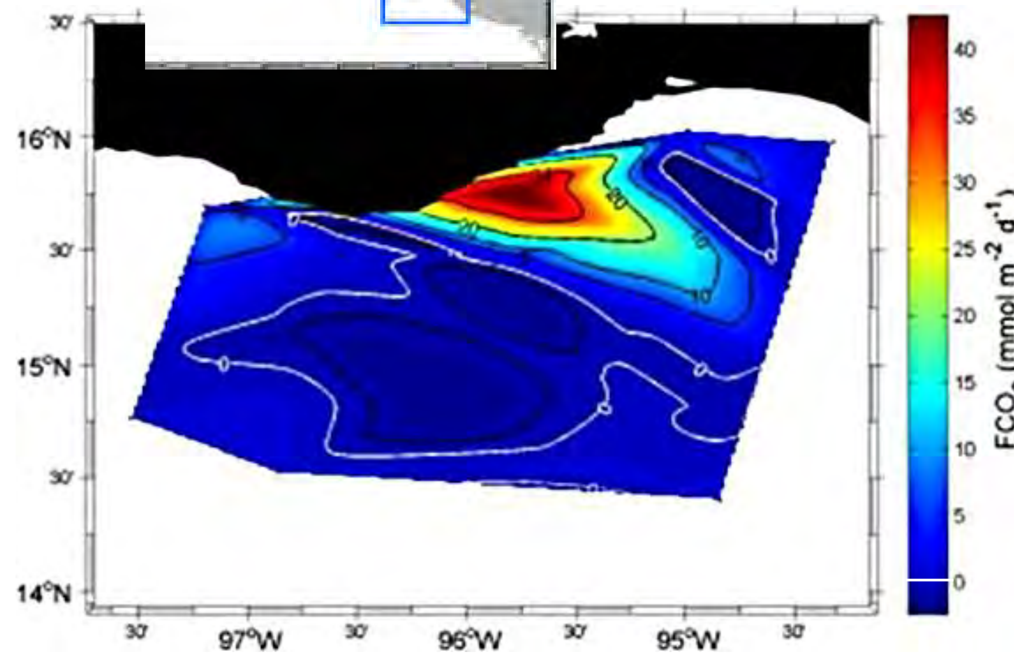
Boundaryupwellingsystems and Biological Active Centers:

a) Primaryproductivity

b) Ocean-atmosphereinteractions

c) Biogeochemicalcycles

d) Long-termpatterns



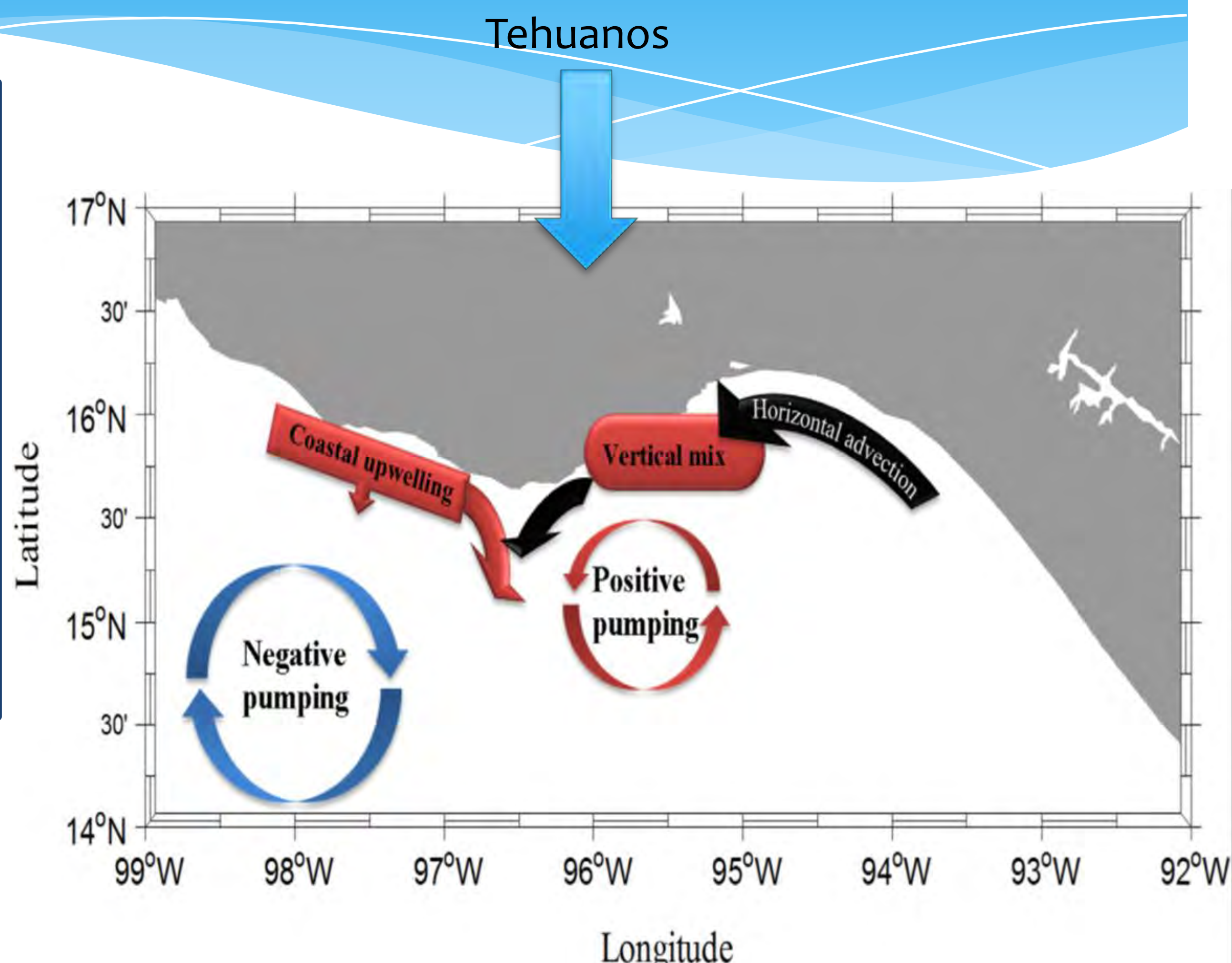
Air-sea CO2 flux. Positive values indicate fluxes toward the atmosphere. (Chapa-Balcorta, *et al.*, *JGR-Oceans*, 2015). GoT source of CO2

Highlights of the Mexican Pacific

6 Boundary upwelling systems and BACs

Processes involved in the variability of the CO2 system at the Gulf of Tehuantepec during Post-Tehuano conditions.

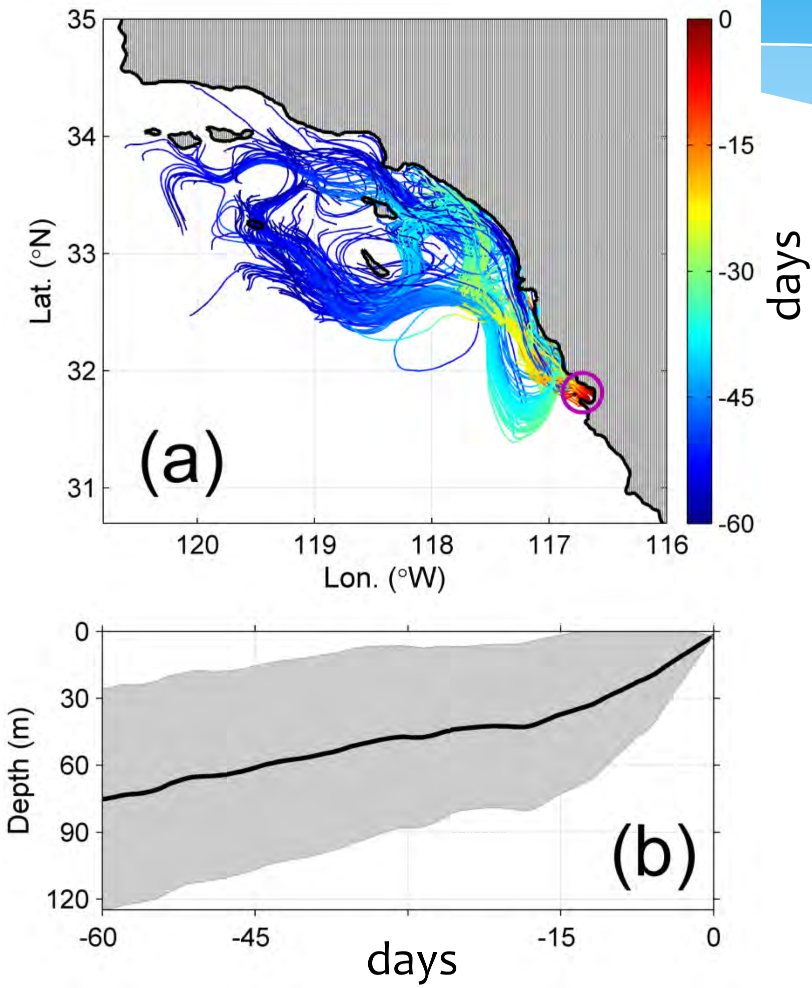
Red source
Blue sinks
of CO2.



Chapa-Balcorta, *et al.*, *JGR-Oceans*, 2015

Highlights of the Mexican Pacific

7 Numerical modeling



3-D numerical simulation (seeRivas &Samelson, JPO, 2011)

Particle-tracking experiment.
(a) Color indicates time along the trajectory.
(b) Mean depth. Gray indicates one standard deviation.

Connectivity study between SC Bight and TS Bay with relation to harmful algal blooms.

Nitratos-Fitoplancton-Zooplancton-Detritus (NPZD; Powell et al., 2006),

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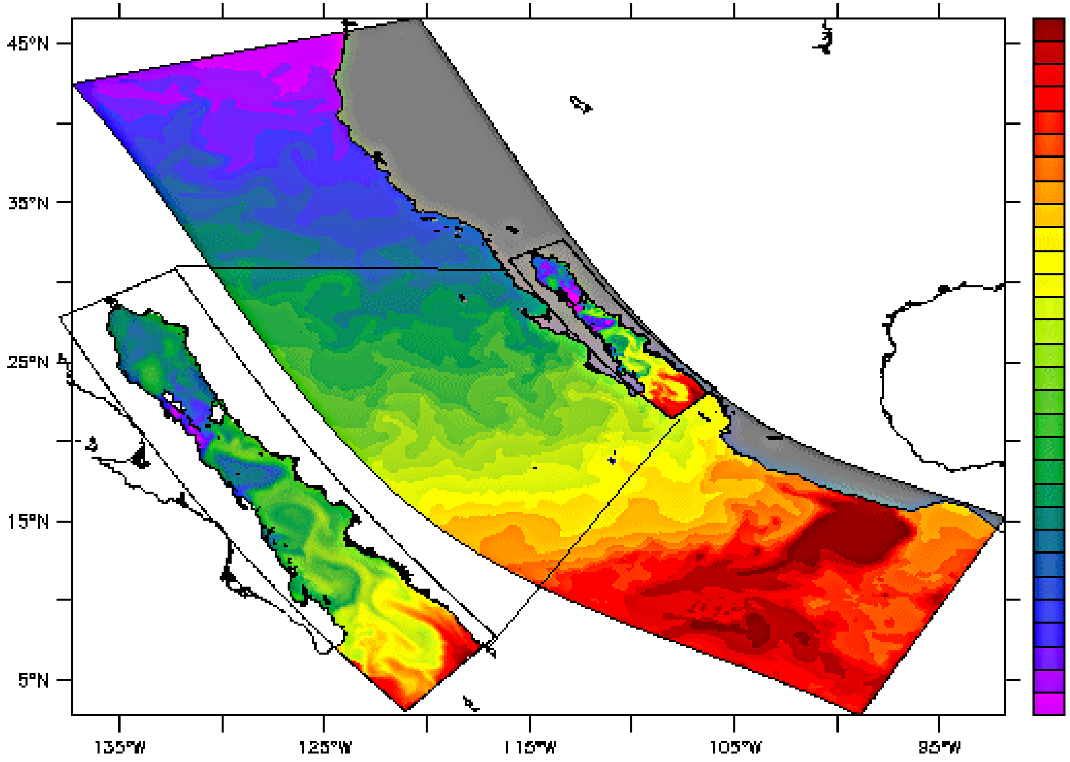
Highlights of the Mexican Pacific

7 Numerical modeling



ROMS SST nested simulation (by A. Parés-Sierra)

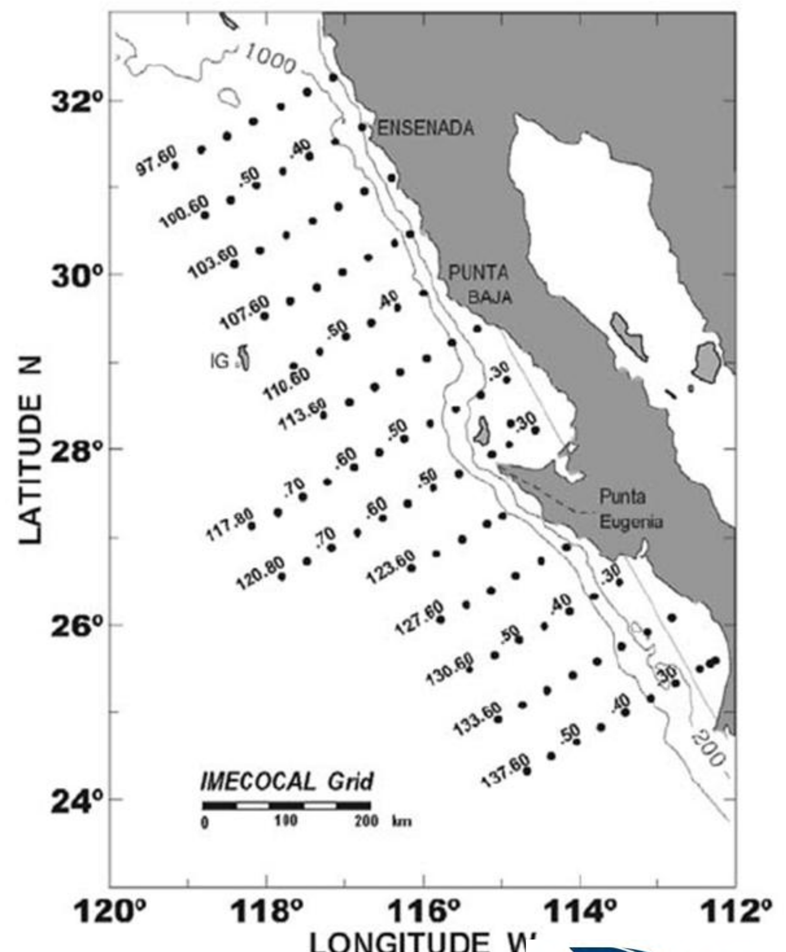
High-resolution numerical modeling is performed at CICESE (almost operational)

Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL

- Since October 1997
- 66 cruises (including one in February 2016)
- Data partially online :

http://imecocal.cicese.mx/



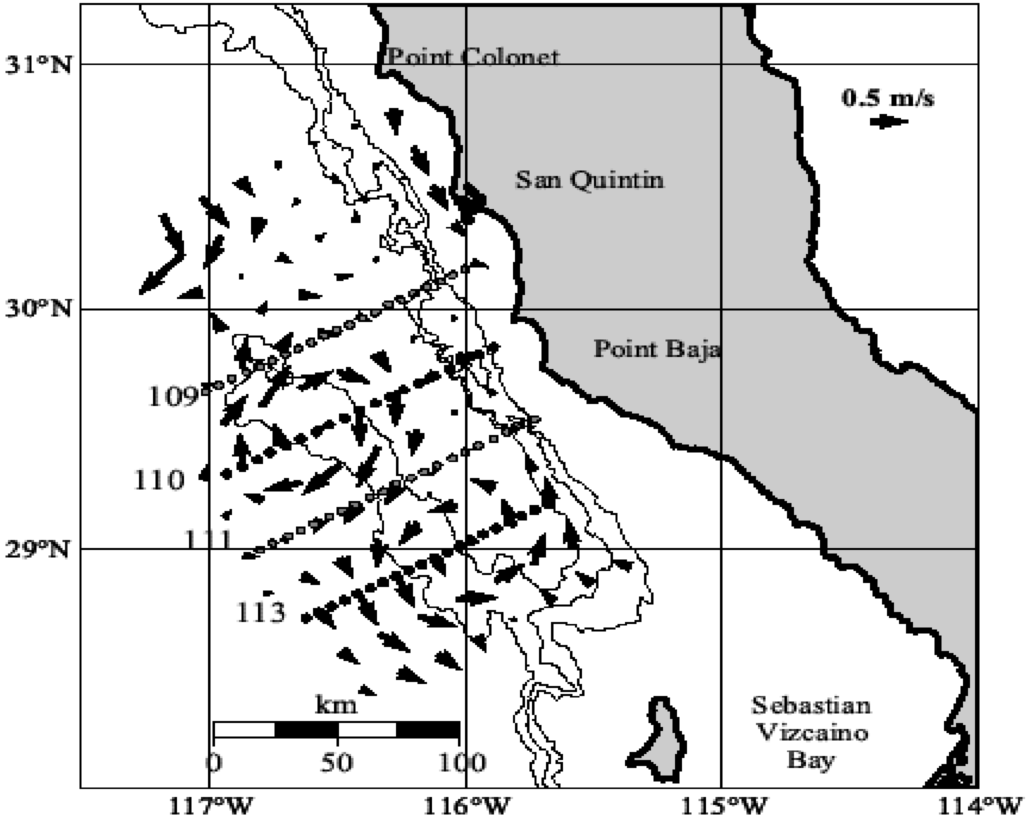
Hydrographic data with CTD casts down to 1000 m.
Biological sampling includes primary productivity, zooplankton, icthyoplankton and continuous sampling of fish eggs

Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL

Subsurface anticyclone October 2009

Geostrophic Velocity from ADCP at 40 m



- Observed in summer and autumn off San Quintin
- Diameter ~70 km
- Center with California subsurface counter current.
- Formation related to separation of counter current from continental slope
- Eroded after passing submarine mount Mariano Matamores

Gomez-Valdes, Torres, and Wang (2016), JGR

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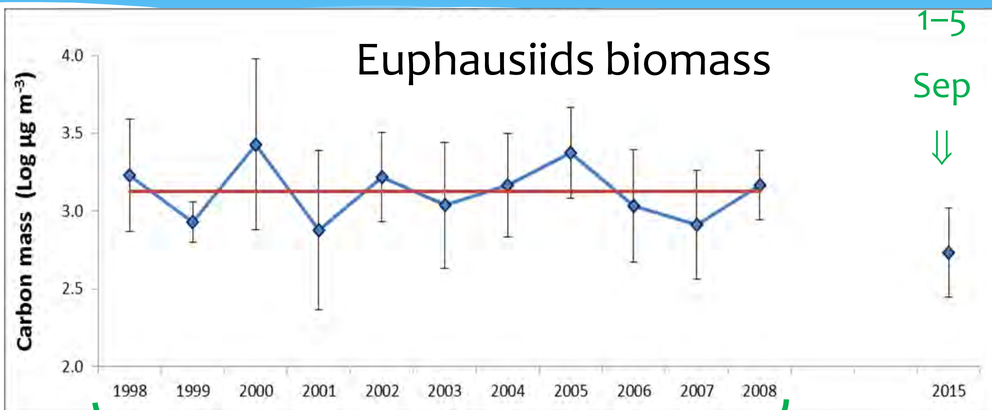
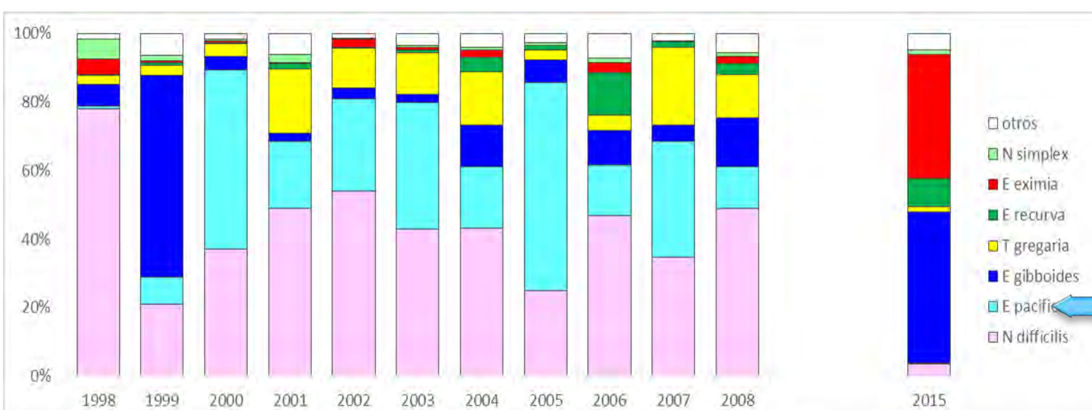
Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL



Summers in North Baja California (30-32°N)
July– August



Assemblages of euphausiid species

Not present in 1998 and 2015

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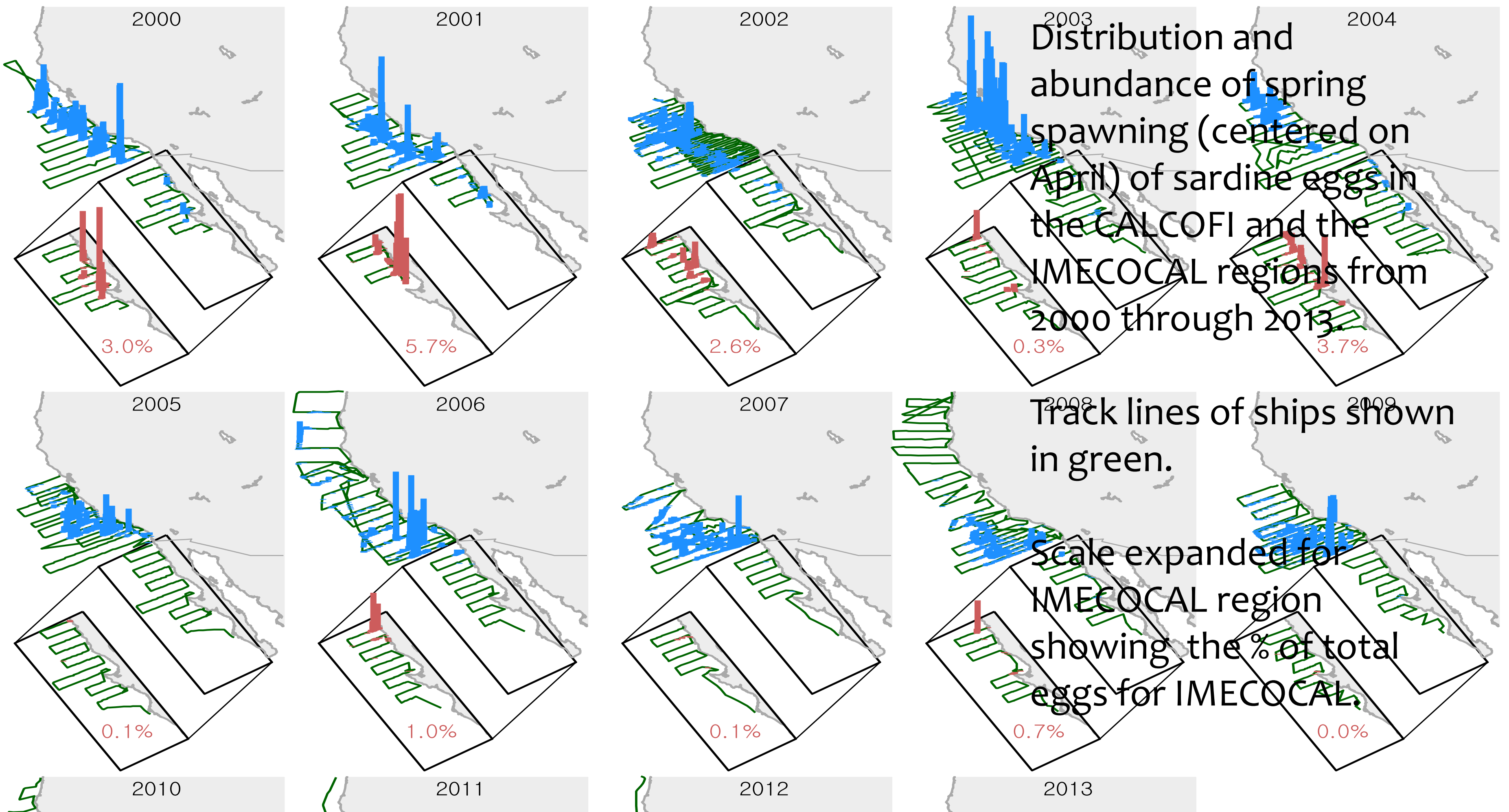
Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL

CalCOFI + IMECOCAL CUFES databases sardine spawning



Distribution and abundance of spring spawning (centered on April) of sardine eggs in the CALCOFI and the IMECOCAL regions from 2000 through 2013.

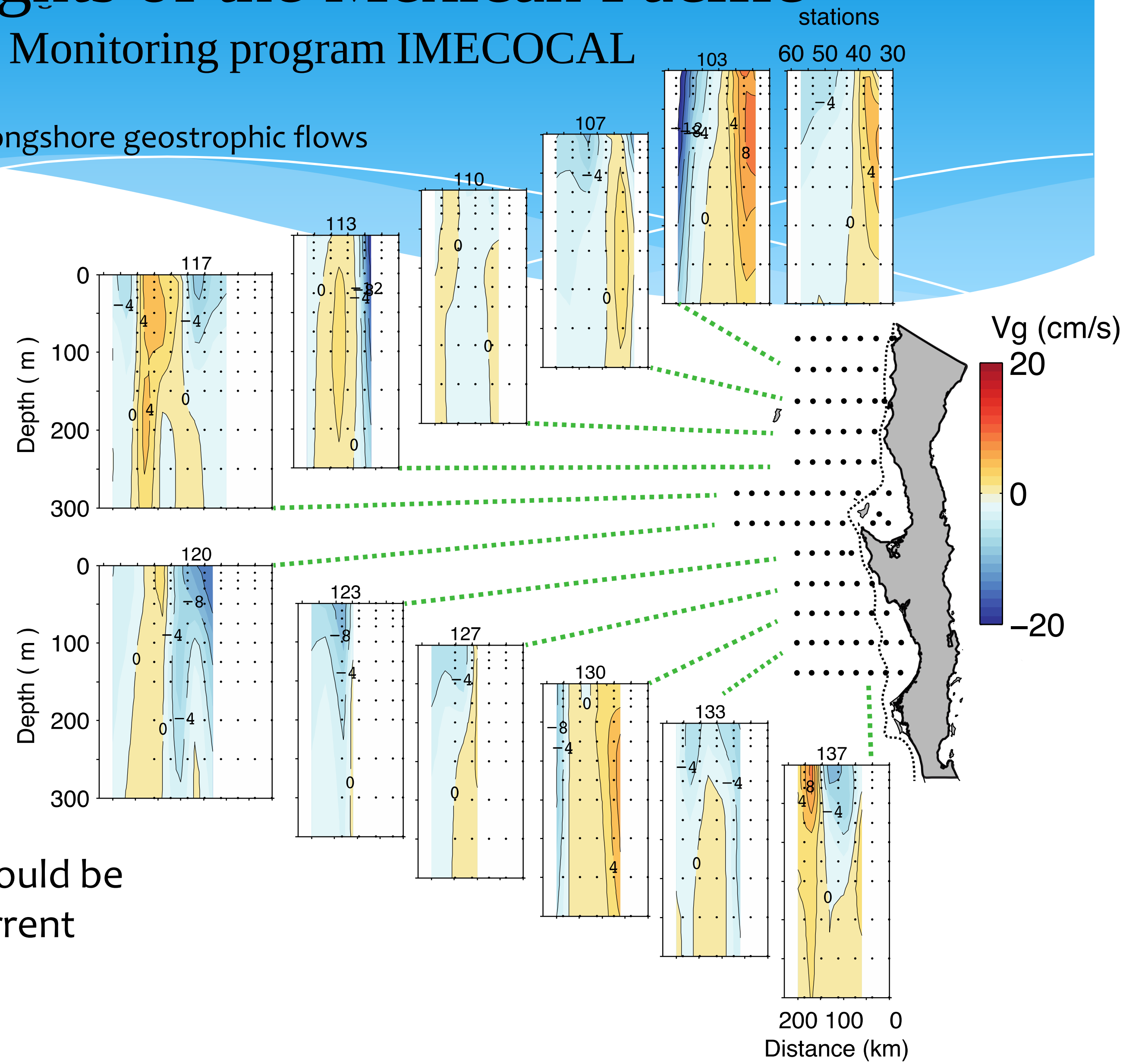
Track lines of ships shown in green.

Scale expanded for IMECOCAL region showing the % of total eggs for IMECOCAL.

Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL

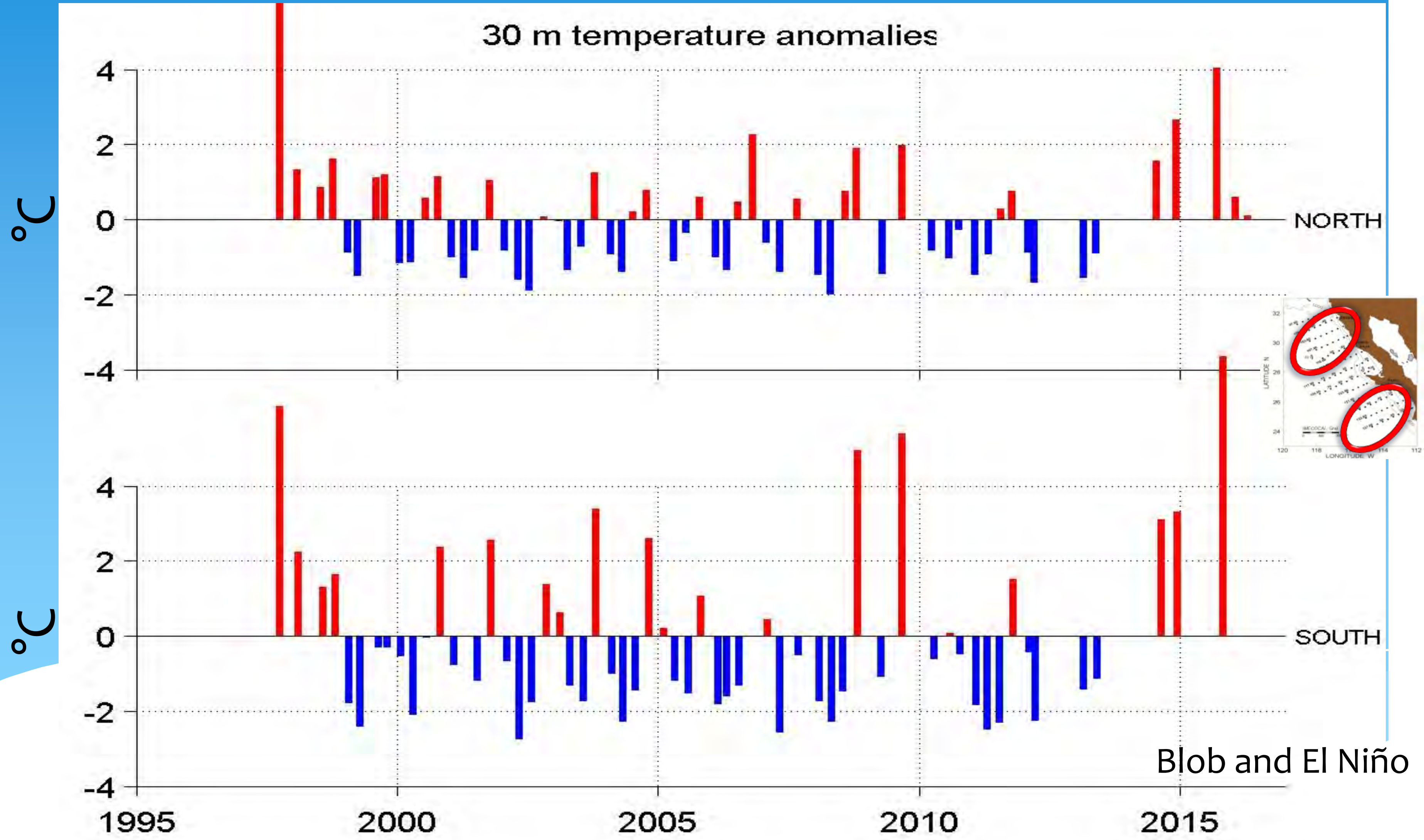
Mean **autumn** alongshore geostrophic flows



Continuospoleward flow could be connected to Davidson current

Highlights of the Mexican Pacific

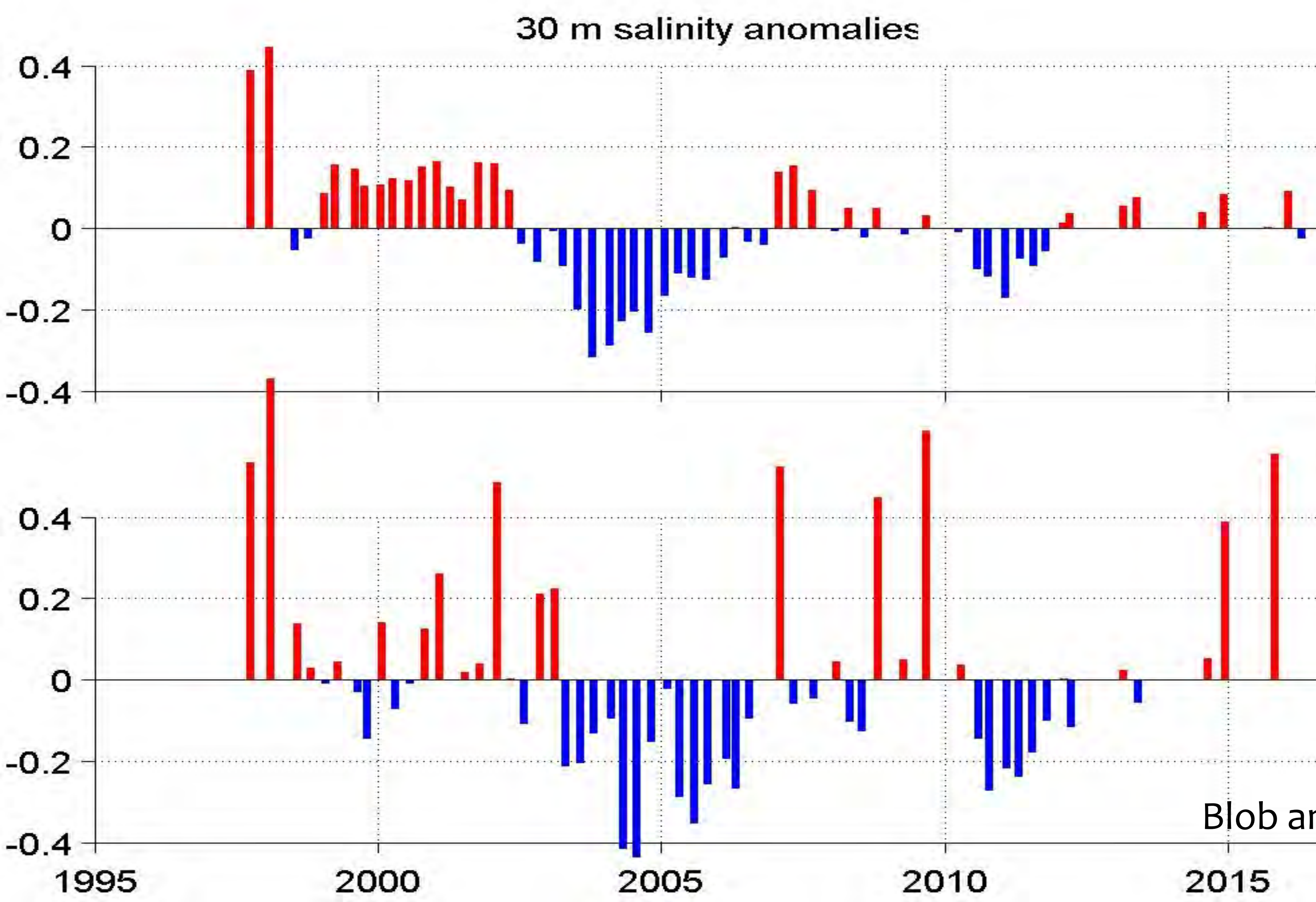
8 Monitoring program IMECOCAL

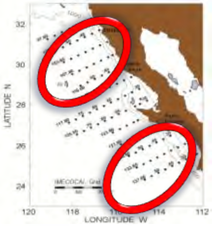


Blob and El Niño

Highlights of the Mexican Pacific

8 Monitoring program IMECOCAL





Blob and El Niño

Finally (almost)

The Mexican Pacific is an area where

- currents with water masses and properties and
- marine life

from the tropical and mid latitude areas meet and interacts.

The above gets a local signature also due to local forcing.

Forthcoming Goal
(Nevertheless it requires swift actions)

To establish a tri-national (Canada-USA-Mexico) observational and physical-biological modeling program to study the California Current Ecosystem, in order to provide information for the management and conservation of marine resources.

Forthcoming Goal
(California Current Ecosystem)

* Where diverse environments, communities and species concur.
* Where physical forcing goes from days to decades.
* Where populations (e.g. sardines, anchovies, squid, salmon) respond to this forcing.

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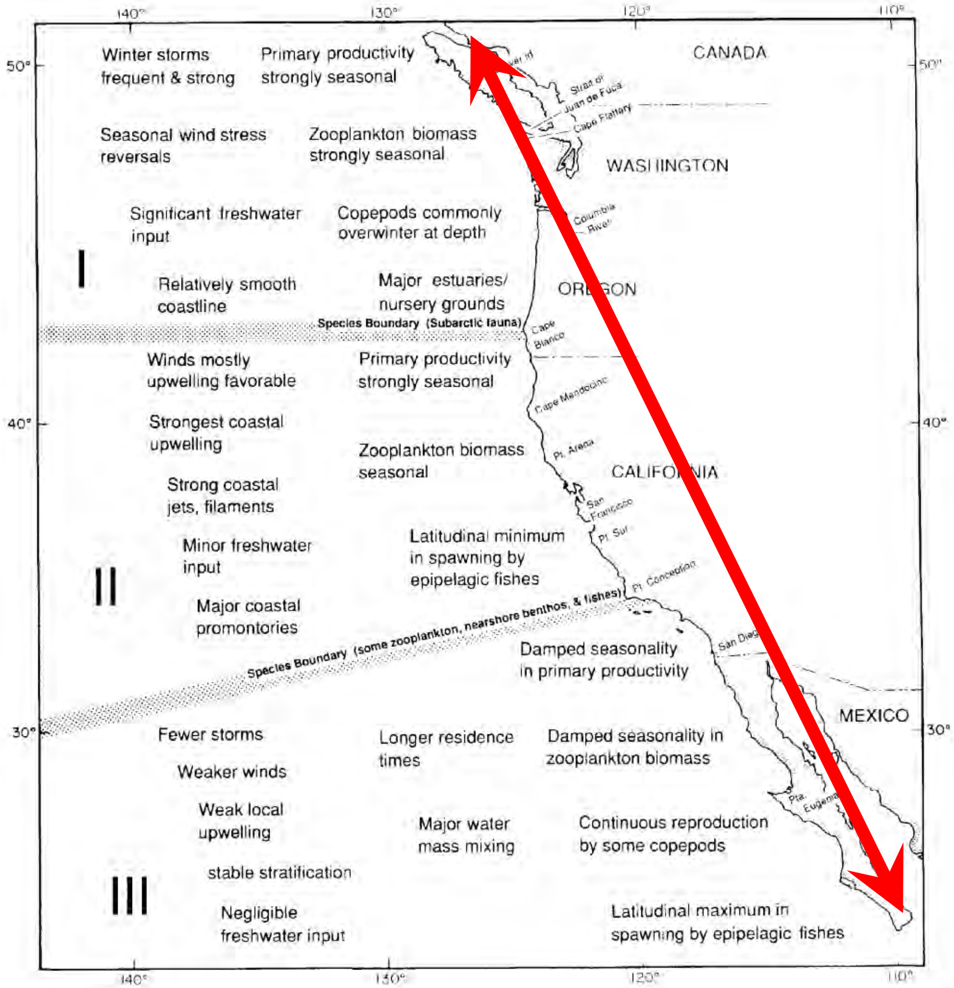
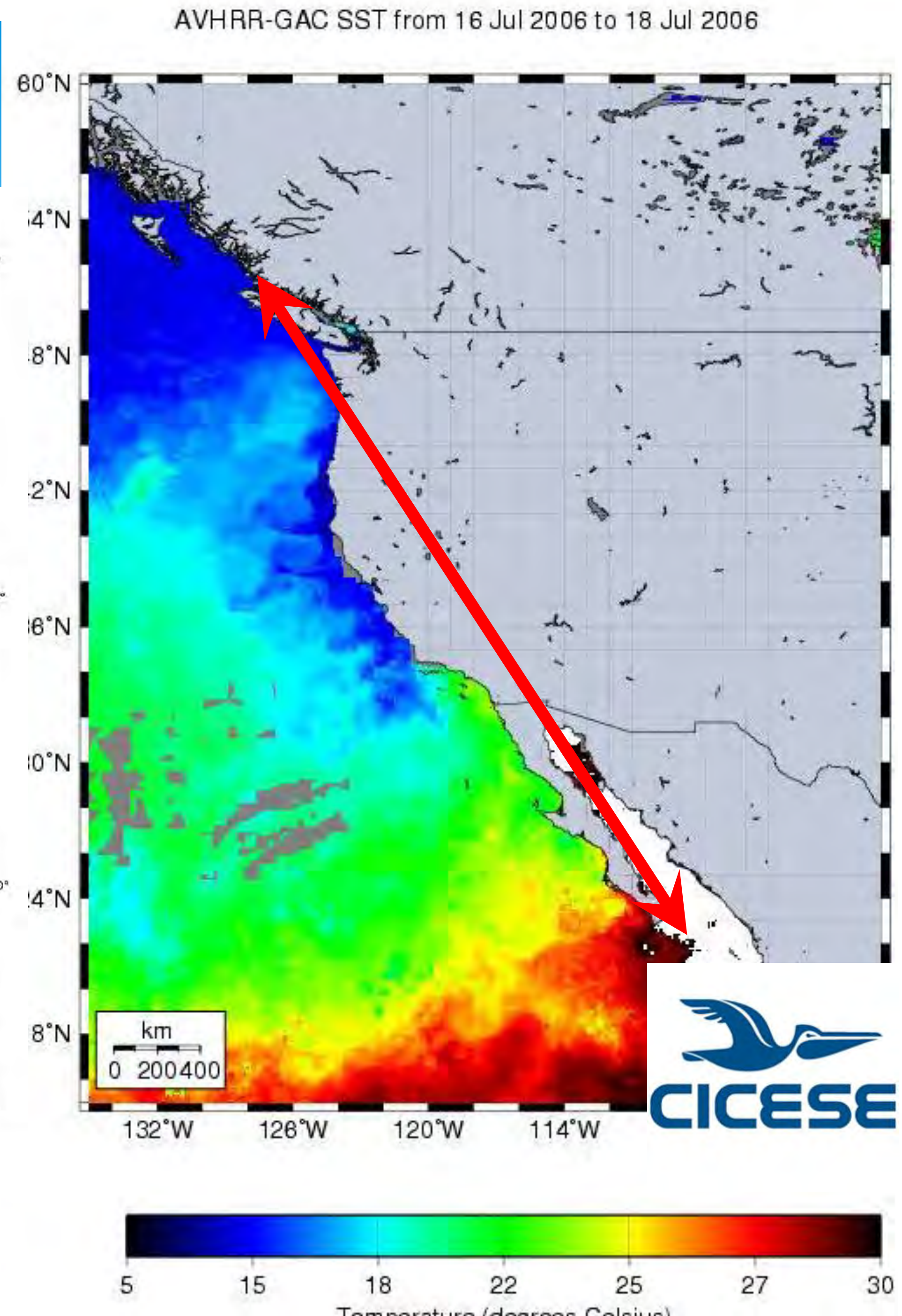
CCE from BC a BC:



(Courtesy of C. Werner)



California Current Ecosystem
(Example of integrated observing system)

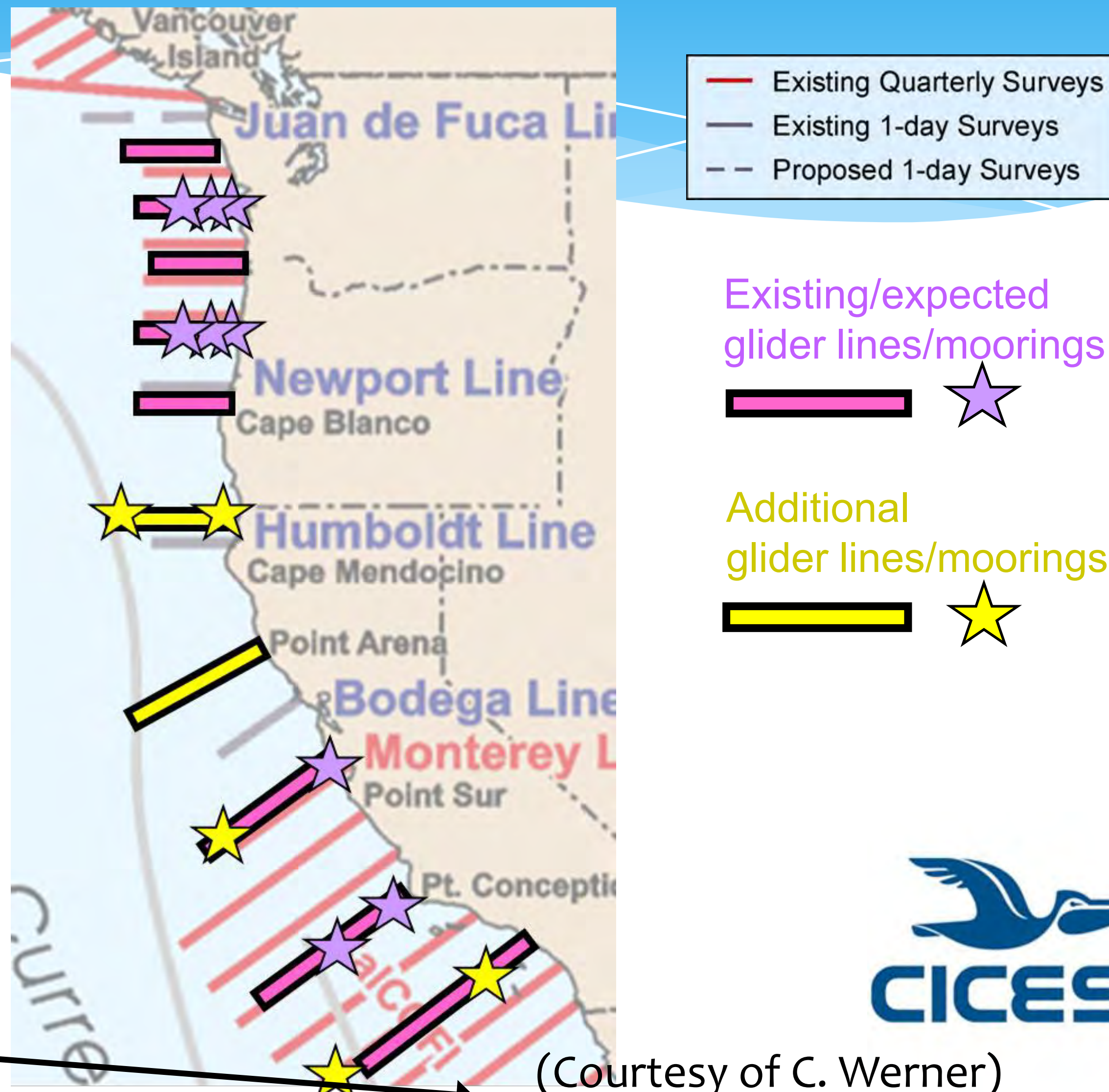
Much is already in place

- ship surveys:
  - regular quarterly surveys
  - regular 1-day surveys
  - NOAA stock assessment surveys
  - NOAA OA surveys
- 3 glider lines:
  - CORC
- 3 ecosystem moorings:
  - CCE-1/2
  - MBARI moorings
- coming OOI glider sections and moorings

Need only small increment to complete a comprehensive system (example in yellow):

- 2-3 glider lines
- 4-5 ecosystem moorings

Plus IMECOCAL



Existing/expected glider lines/moorings

Additional glider lines/moorings

(Courtesy of C. Werner)

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What is next?

- Particularly
  - Establish a tri-national (Canada-USA-Mexico) observational and physical-biological modeling program to study the California Current Ecosystem, in order to provide information for the management and conservation of marine resources
- In general
  - Invest in **human resources** training for the different areas of oceanography
  - Link early and comprehensively the human dimension and development for the country
  - Have oceanographic **infrastructure** and state of the art technology
  - Promote interaction **among science-industry-government sectors**
  - Promote high level research on priority resources and themes of **economical interest,** promoting the development of new technologies and the innovations of tools that allow us to solve the challenges of the different fields
  - Recognise the importance of **long term studies** relevant to predictive models of regional and global scales
  - Generate open **data bases**
  - Promote **collaboration** among the different institutions

CICESE

Thankyou

http://www.cicese.edu.mx