Swordfish population dynamics in the Pacific Ocean

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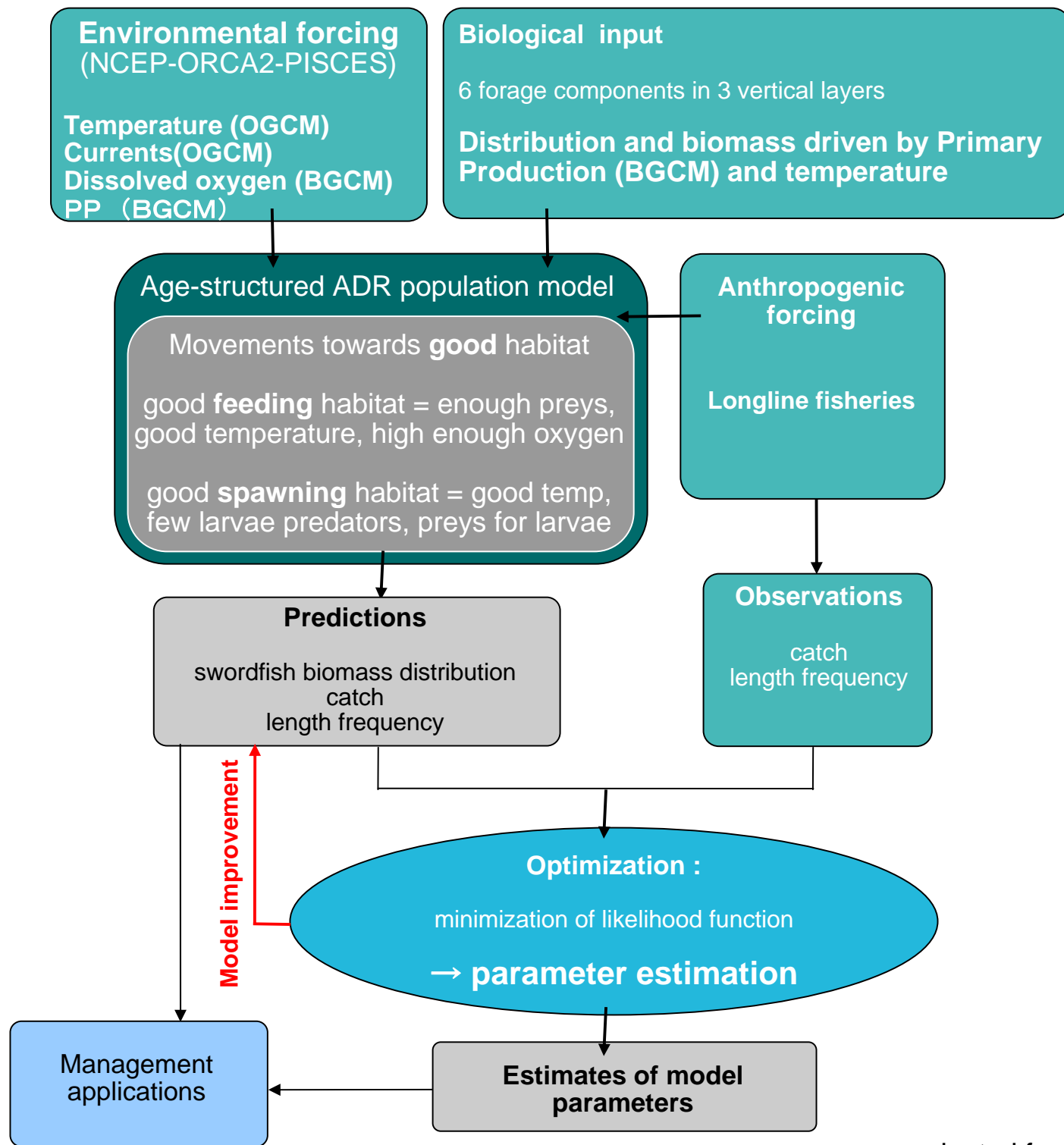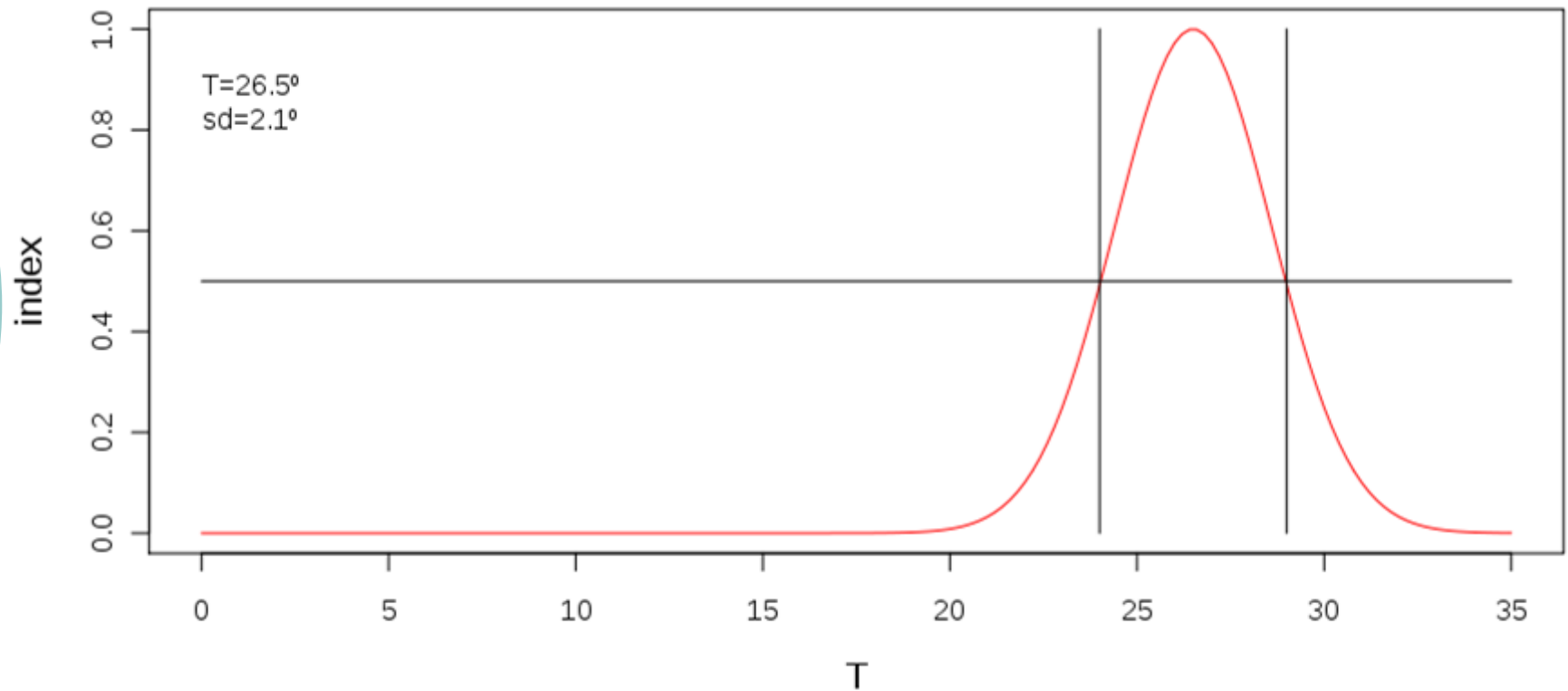[3] PIFSC, NOAA, Hawaii

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The Seapodym model

an age-structured
HABITAT-based
spatial population dynamics model

Environmental forcing
(NCEP-ORCA2-PISCES)

Temperature (OGCM)
Currents(OGCM)
Dissolved oxygen (BGCM)
PP （BGCM）

Biological input

6 forage components in 3 vertical layers

Distribution and biomass driven by Primary Production (BGCM) and temperature

Age-structured ADR population model

Movements towards **good** habitat

good **feeding** habitat = enough preys, good temperature, high enough oxygen

good **spawning** habitat = good temp, few larvae predators, preys for larvae

Anthropogenic forcing

Longline fisheries

Predictions

swordfish biomass distribution
catch
length frequency

Observations

catch
length frequency

Model improvement

Optimization :

minimization of likelihood function

→ parameter estimation

Management applications

**Estimates of model parameters**
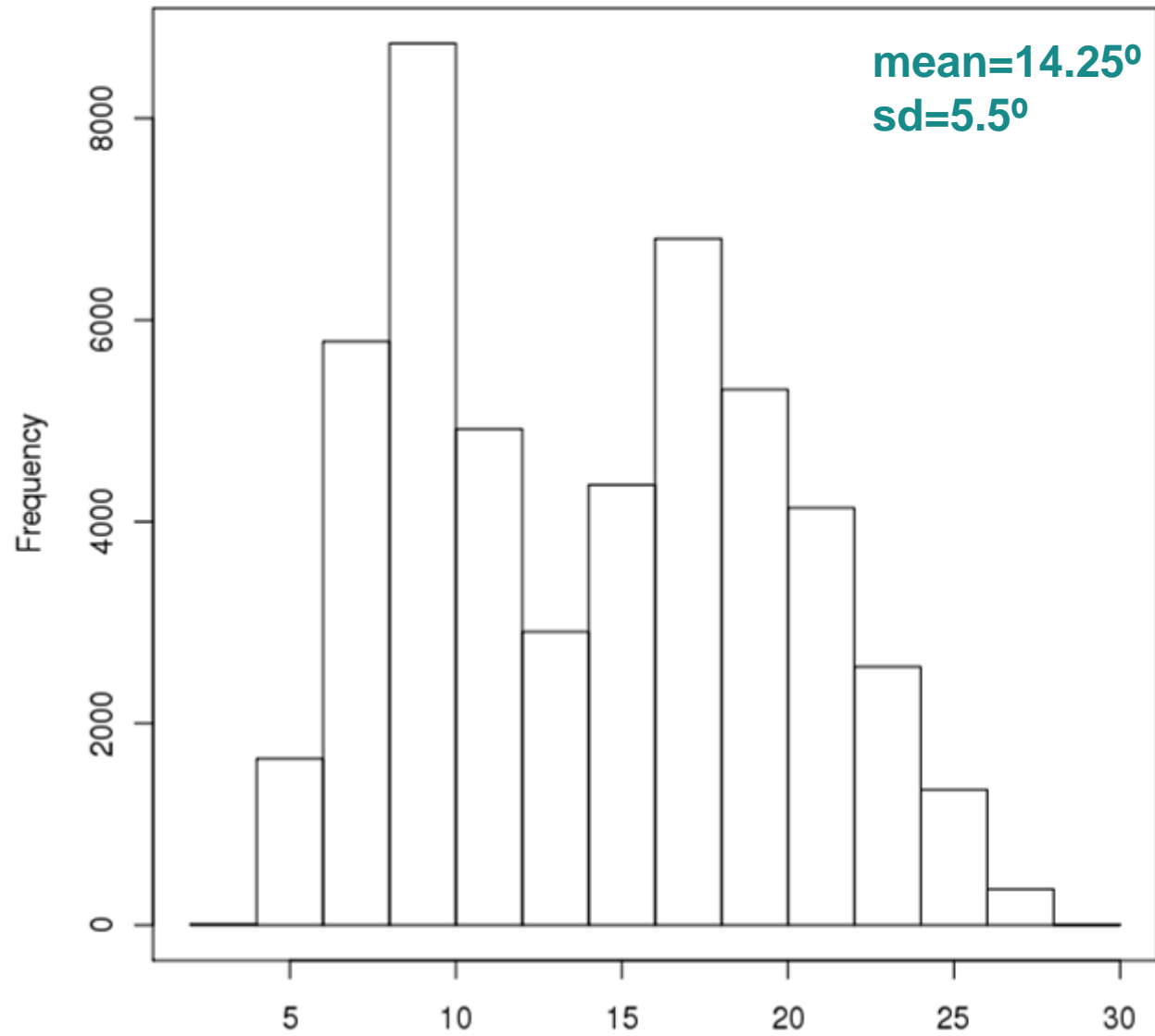
adapted from Senina et al., 2008

Spawning index

Some degree of spawning seems to take place year round in circumtropical waters, between 20ºN. and 20ºS. latitudes, with the distribution of larvae associated with SST between 24 and 29ºC

from Ward & Elscot 2000

Habitat parameters estimated from tracks

23 estimated tracks

tags deployed from 2002 to 2008
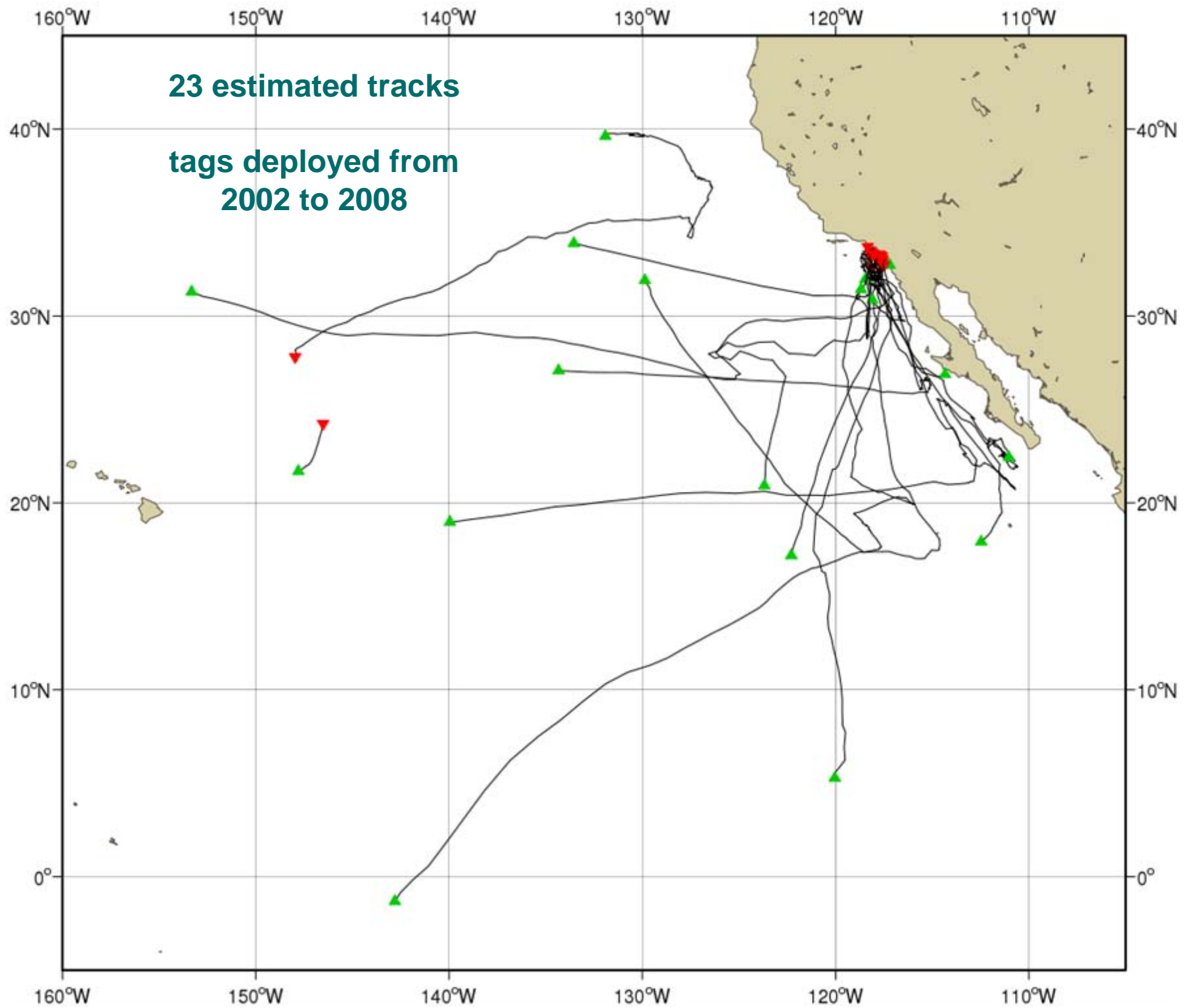
Temperature distribution from tag data

mean=14.25⁰
sd=5.5⁰

tag # 59276
Max dive

Ox
at 150m
in Nov.
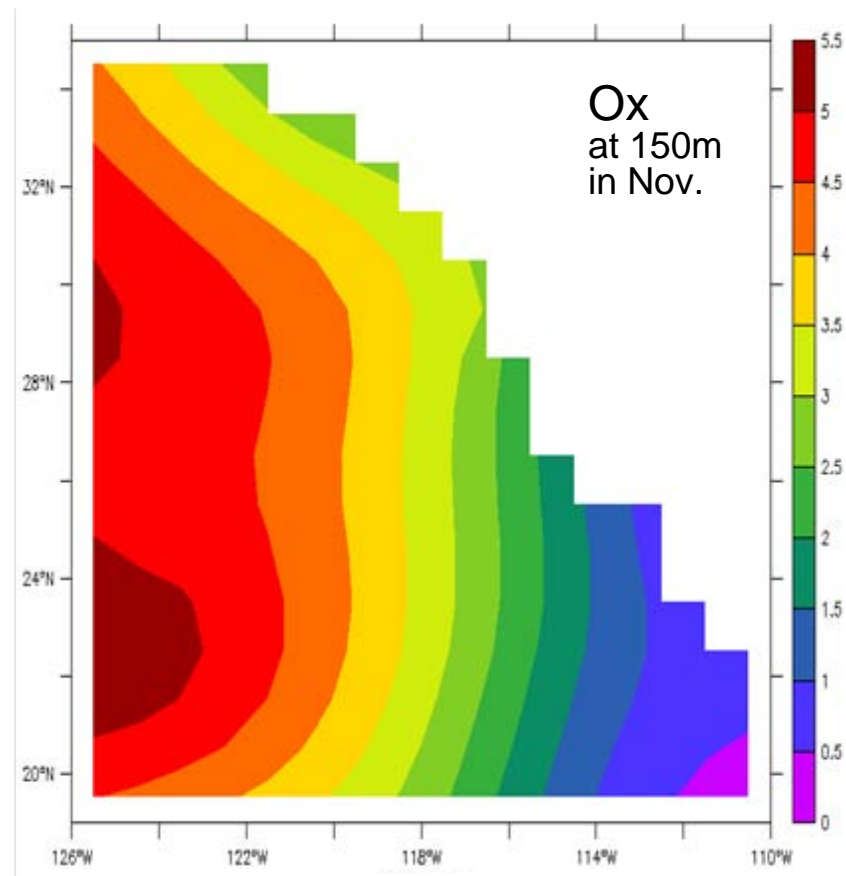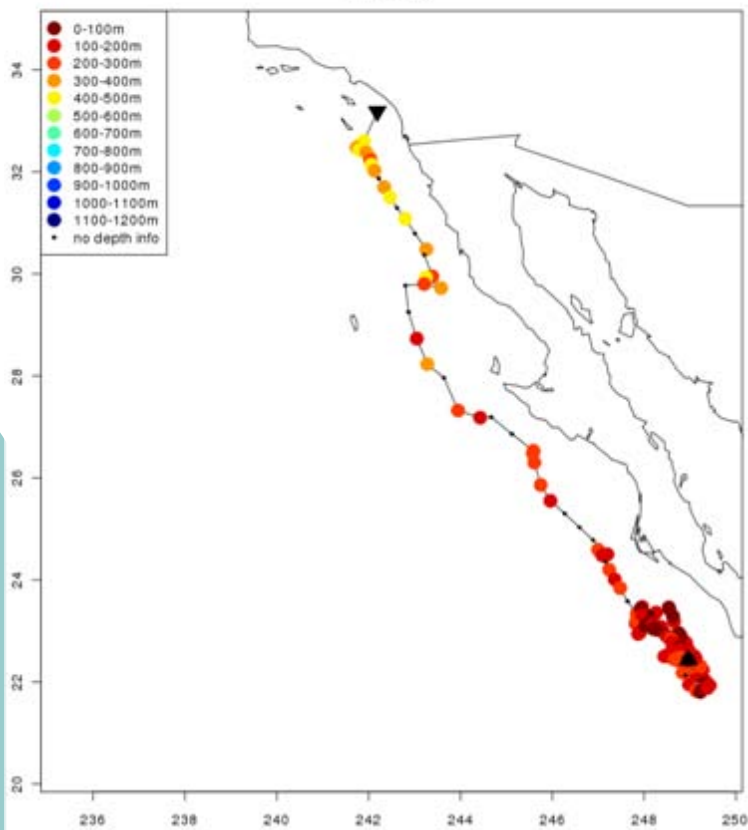
tag #59276
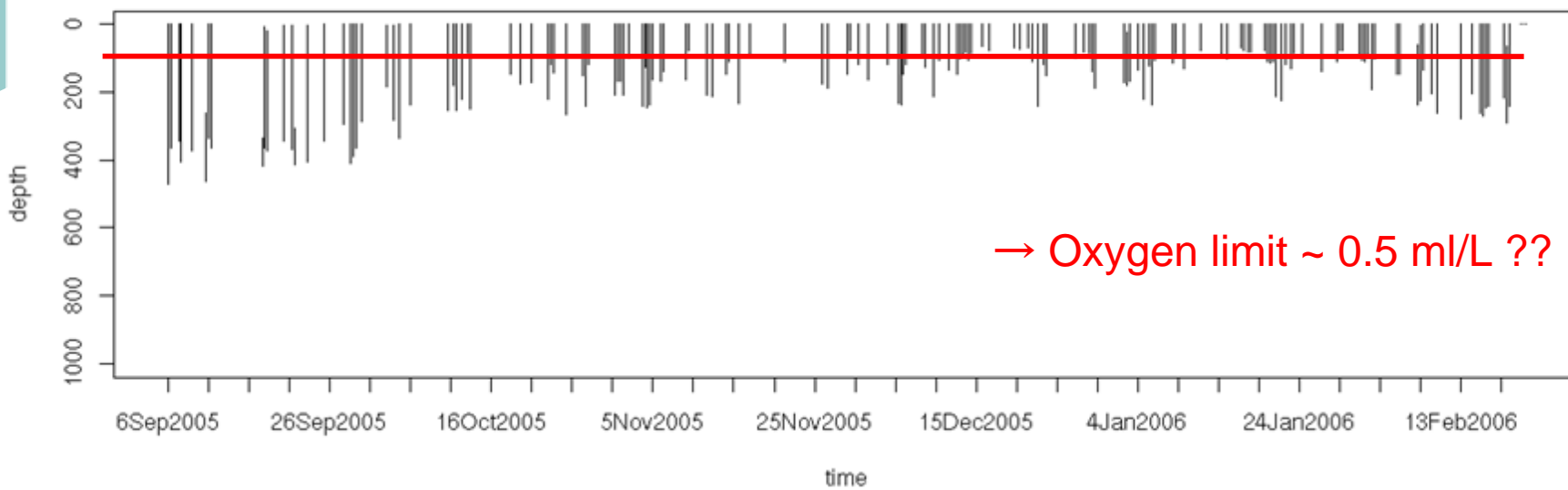
→ Oxygen limit ~ 0.5 ml/L ??

Habitat

Temperature functions for different ages

age 1
age 9
oldest
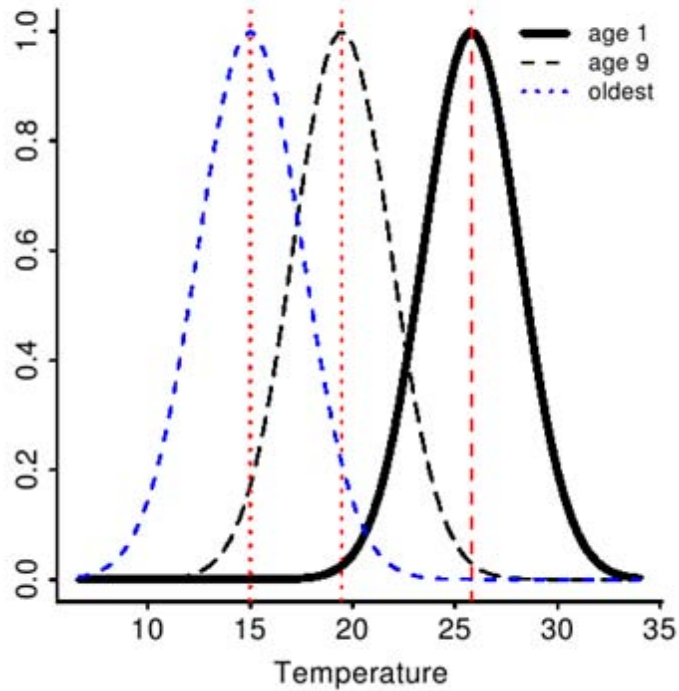
Vertical distribution constraint = oxygen limit

swordfish
bigeye
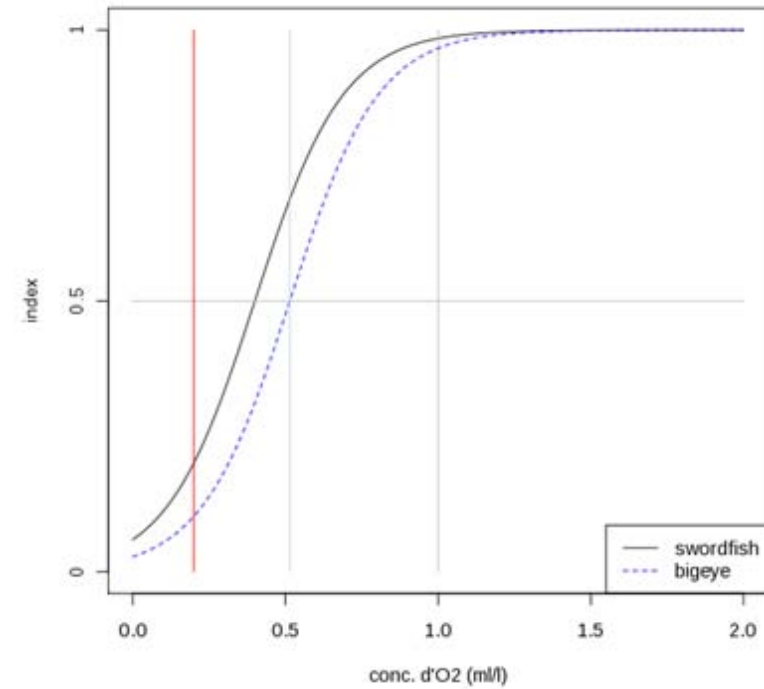
-> parameters to estimate :
$T_{opt\ larvae}$, $sd(T_{larvae})$,
$T_{opt\ adults}$, $sd(T_{adults})$, $Ox_{threshold}$, Ox_{slope}

Fisheries
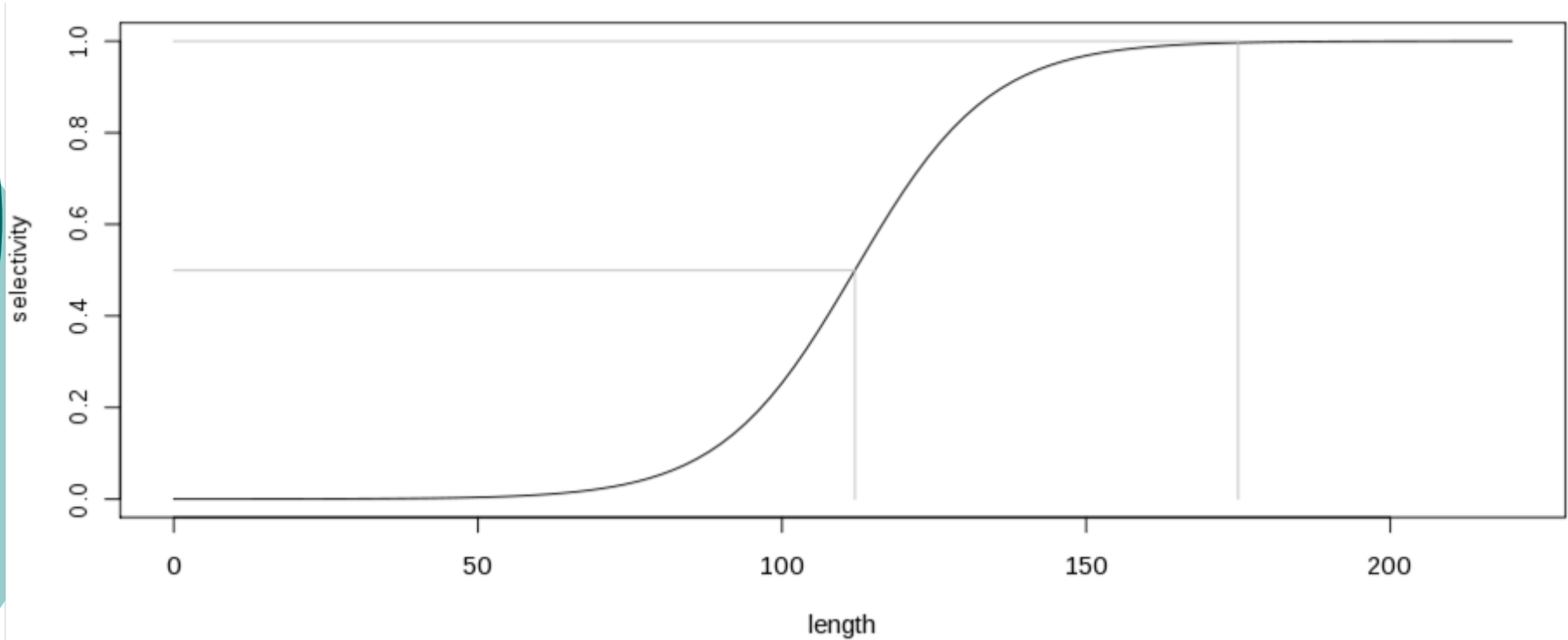
→ one selectivity function and one catchability coefficient per fishery
→ need to define homogeneous fisheries with ~ similar cpue !!
→ for swordfish : need to separate deep sets (usually targeting tuna)
from shallow sets (usually targeting swordfish)

First outputs vs known distributions
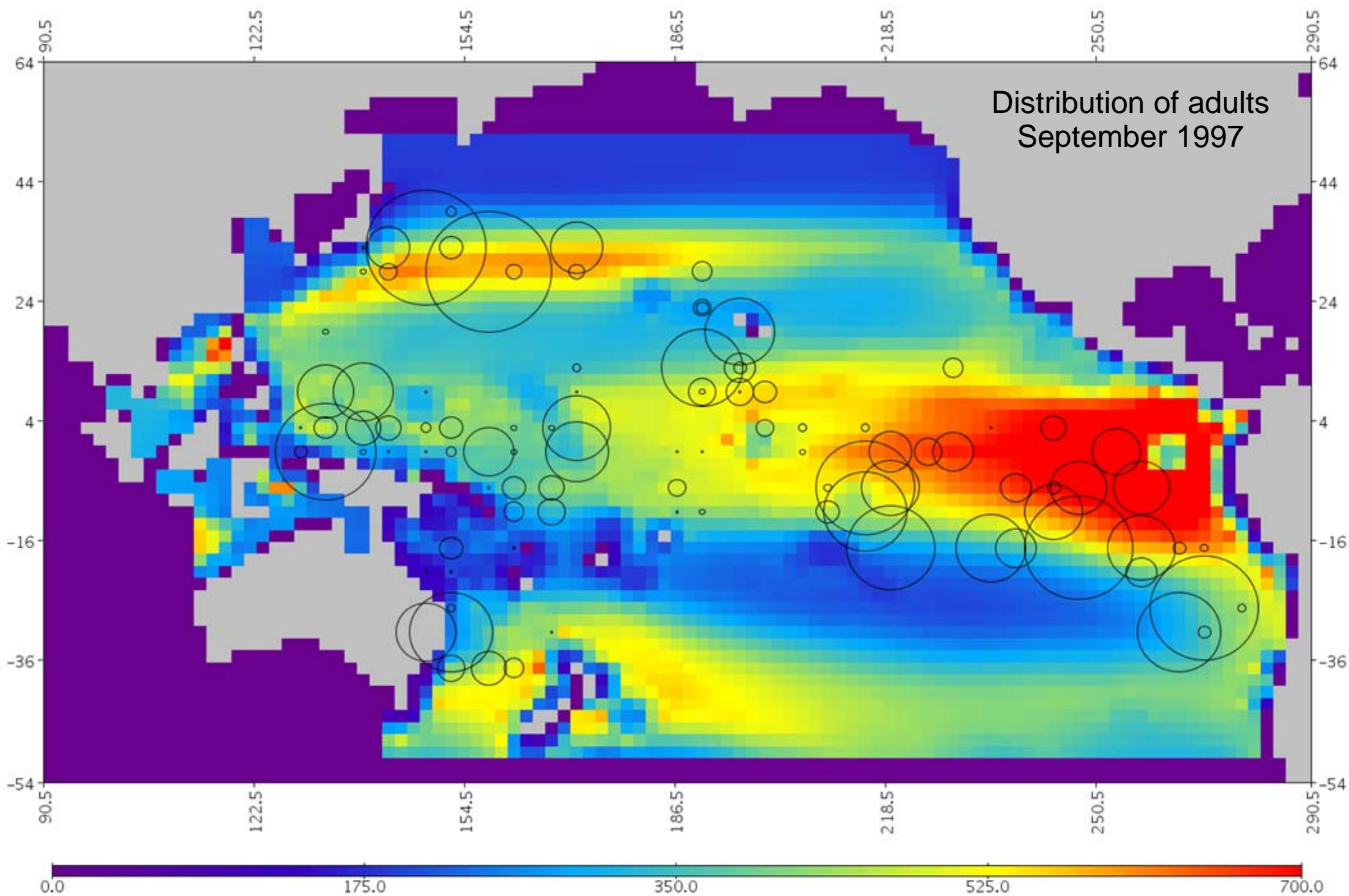
Distribution of adults
September 1997

Longline swordfish catch from 1990-2005

LL SWO catches 1990-2005

ISC

WCPFC

IATTC
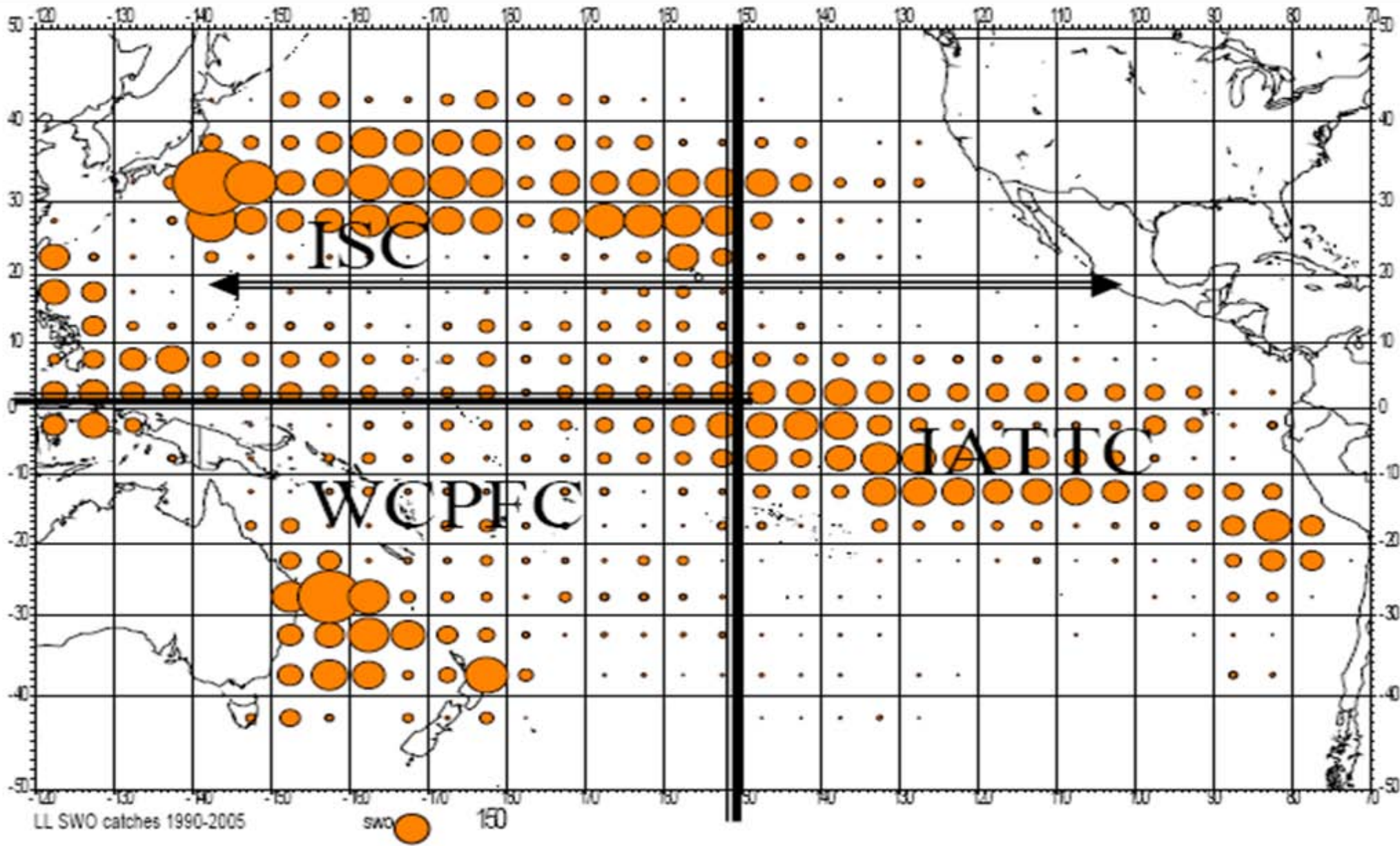
Climate applications

Forecast under IPCC A2 scenario

IPSL Earth Climate Model
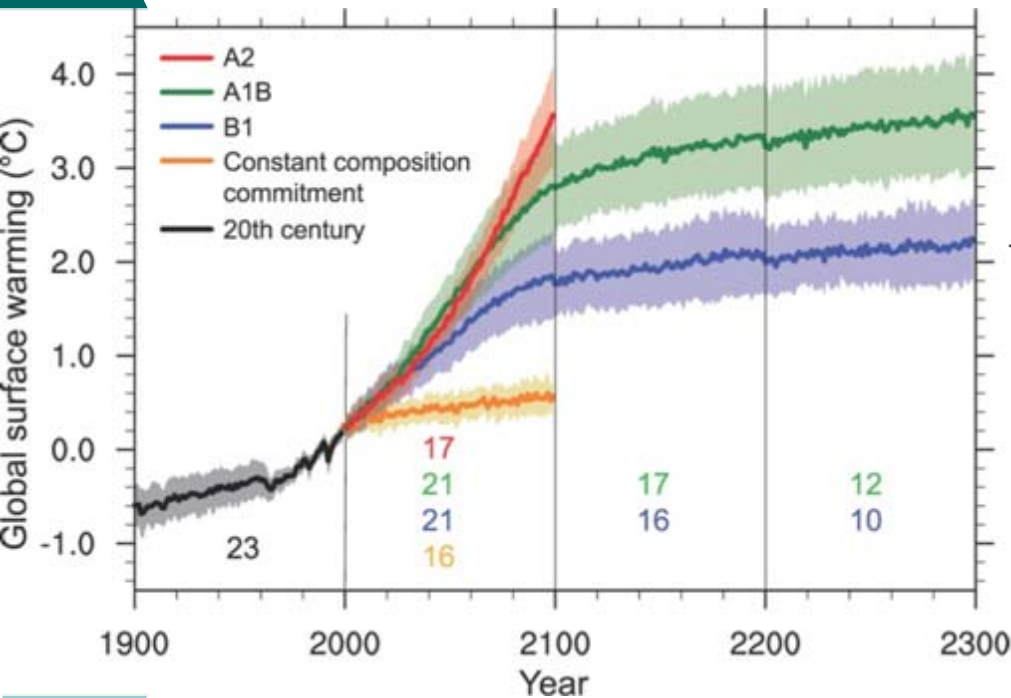
**Atmospheric CO2 concentration
1860-2000 : Measured
2000-2100 : IPCC A2 scenario**

Atmospheric model (*LMDZ*)

Land surface Model (*ORCHIDEE*)

Coupler (OASIS)

Ocean General circulation Model (*OPA*)

Sea-ice model (*LIM*)

Ocean Biogeochemical (NPZD) Model

A2 scenario : PCO$_2$ reaches 850 ppm in 2100
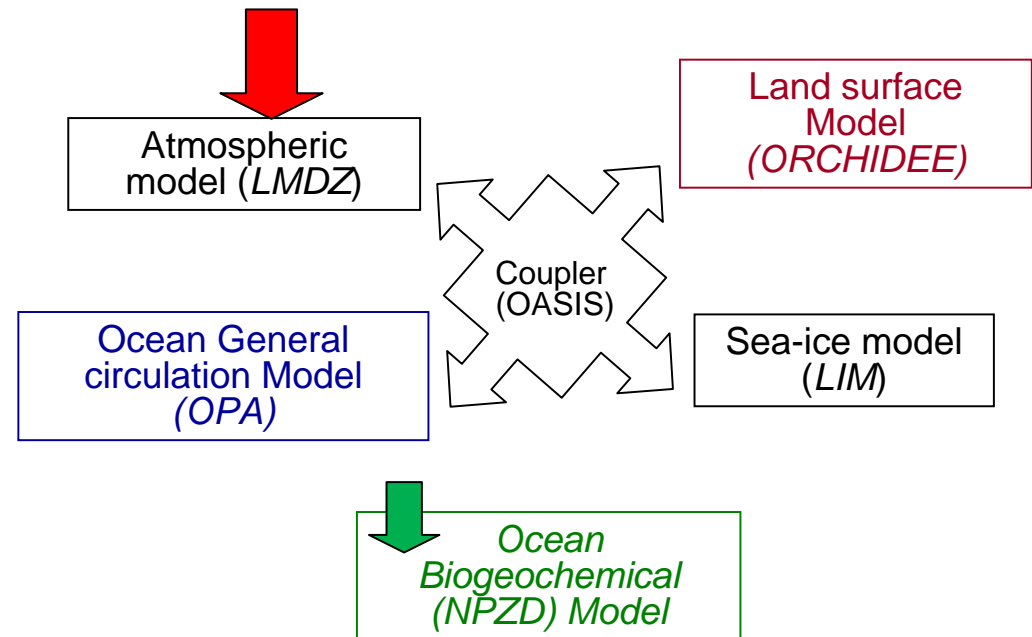
This model simulates realistic seasonal, interannual and decadal variability in a **statistical sense**

Effects of Climate Change
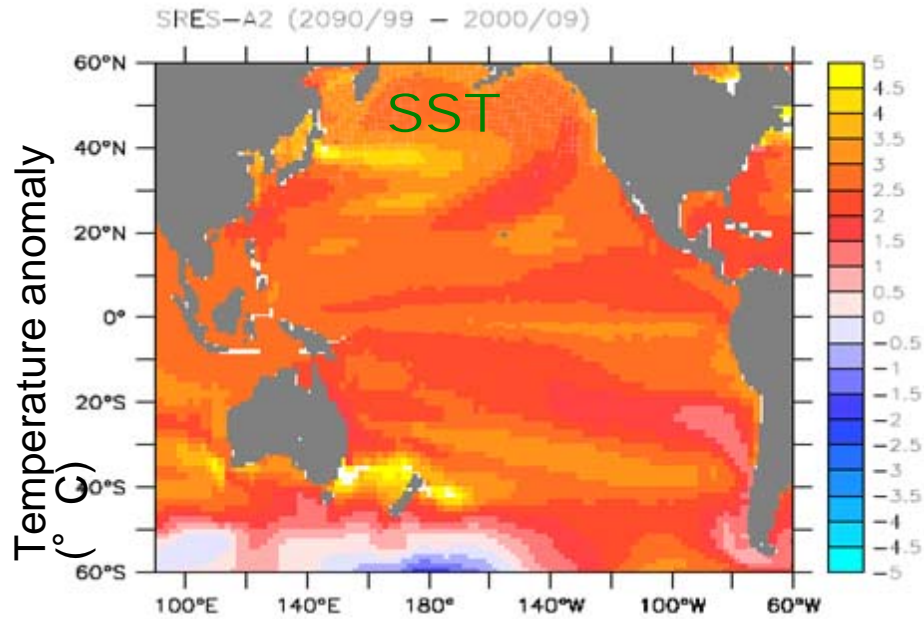
Simulated change in
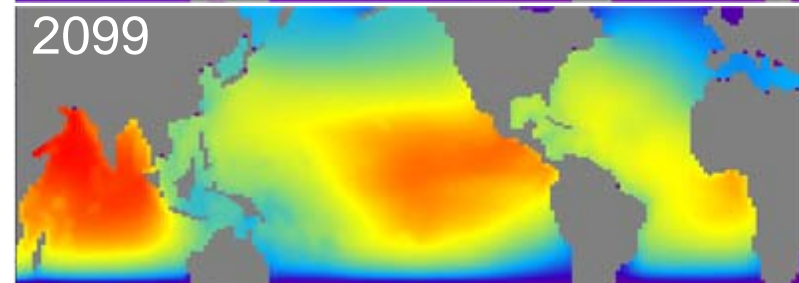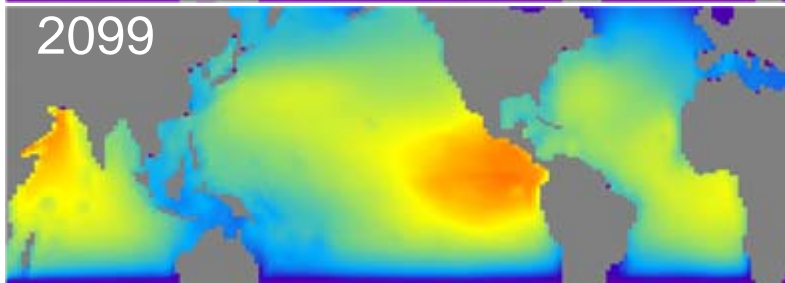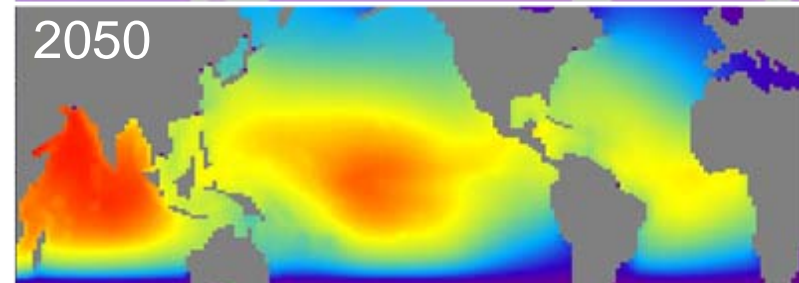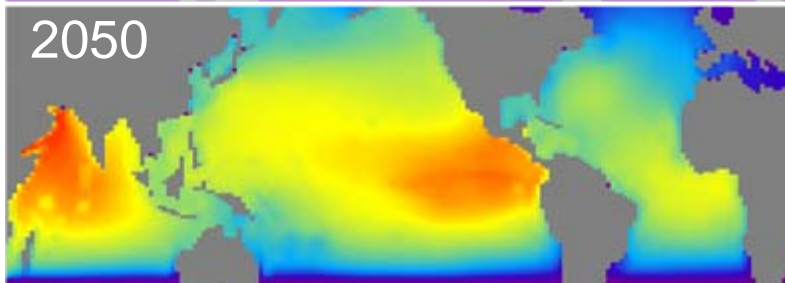
SST, PP & DO

[2090/99] - [2000/09]

From Lehodey 2010
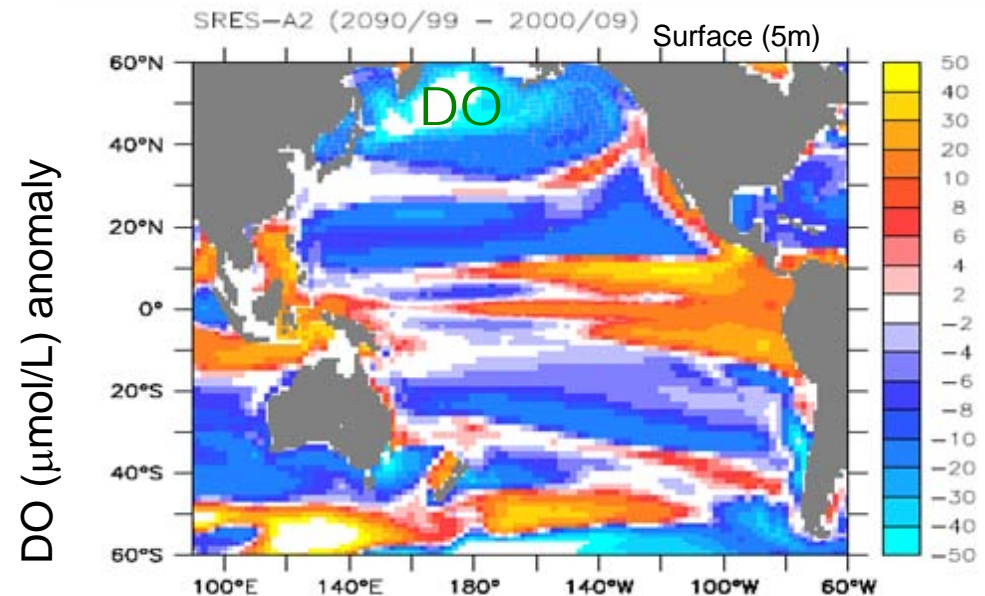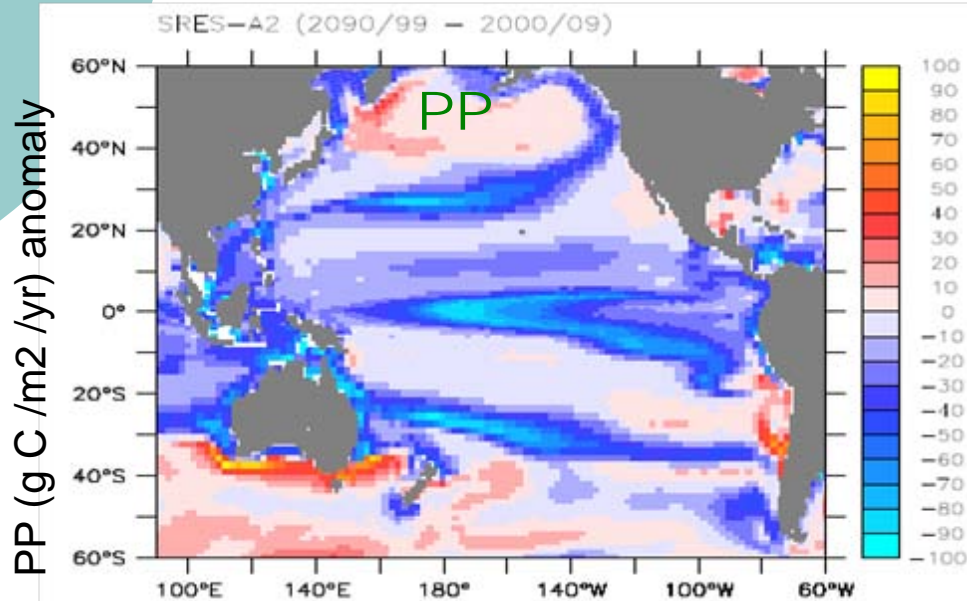
Forecast using IPSL forcing

From Lehodey 2010
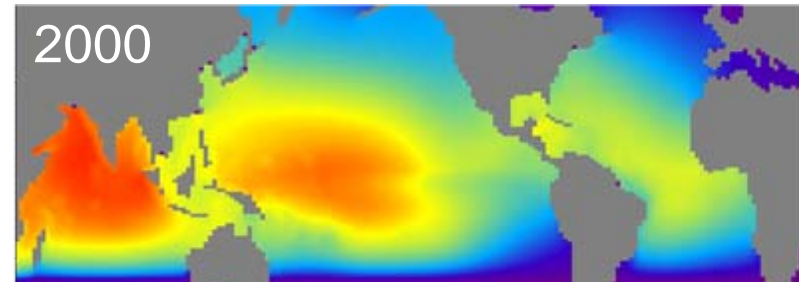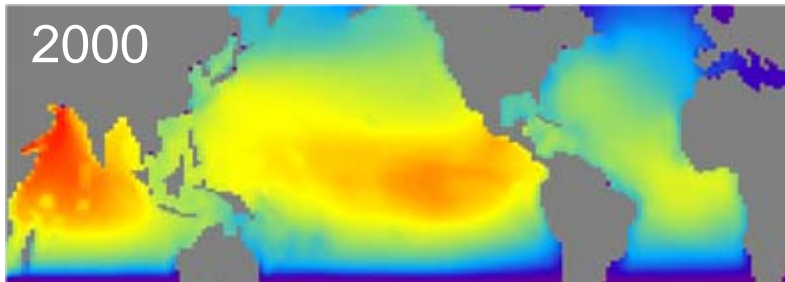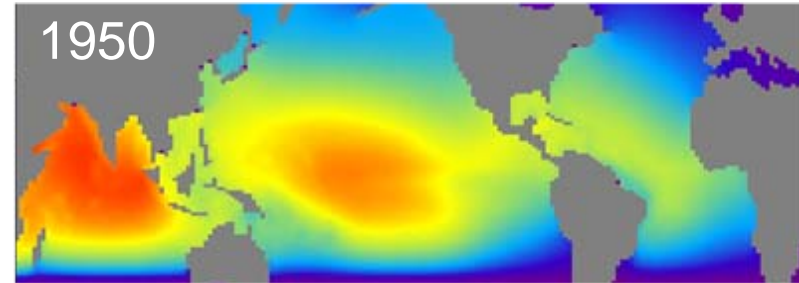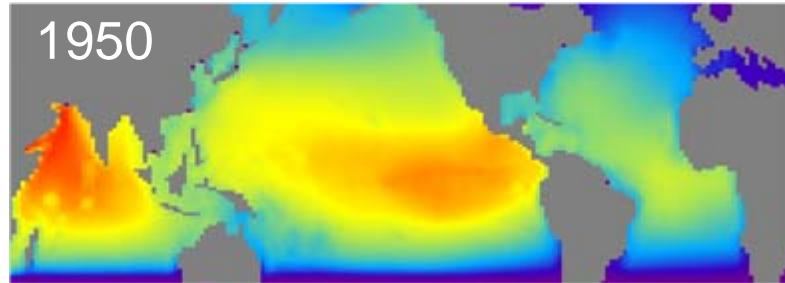
Summary

→ Seapodym is a HABITAT based population dynamics model

→ it can be forced by different coupled physical-biogeochemical models

→ depending on model used as forcing, Seapodym can be used either for :

    - hindcast : test agreement between model predictions and fishing data, refine habitat parameters

    - forecast : test different climate scenarios to forecast changes in fishing grounds, biomass, ...