Geo Blue Planet Workshop Series
Session 3: 2 December 2020

Pacific Community
Communauté du Pacifique

Integrating Earth Observation in ocean ecosystem modelling for Improving Sustainable Tuna Management and Biodiversity Conservation

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(On sabbatical year from Collecte Localisation Satellite, CLS, France)

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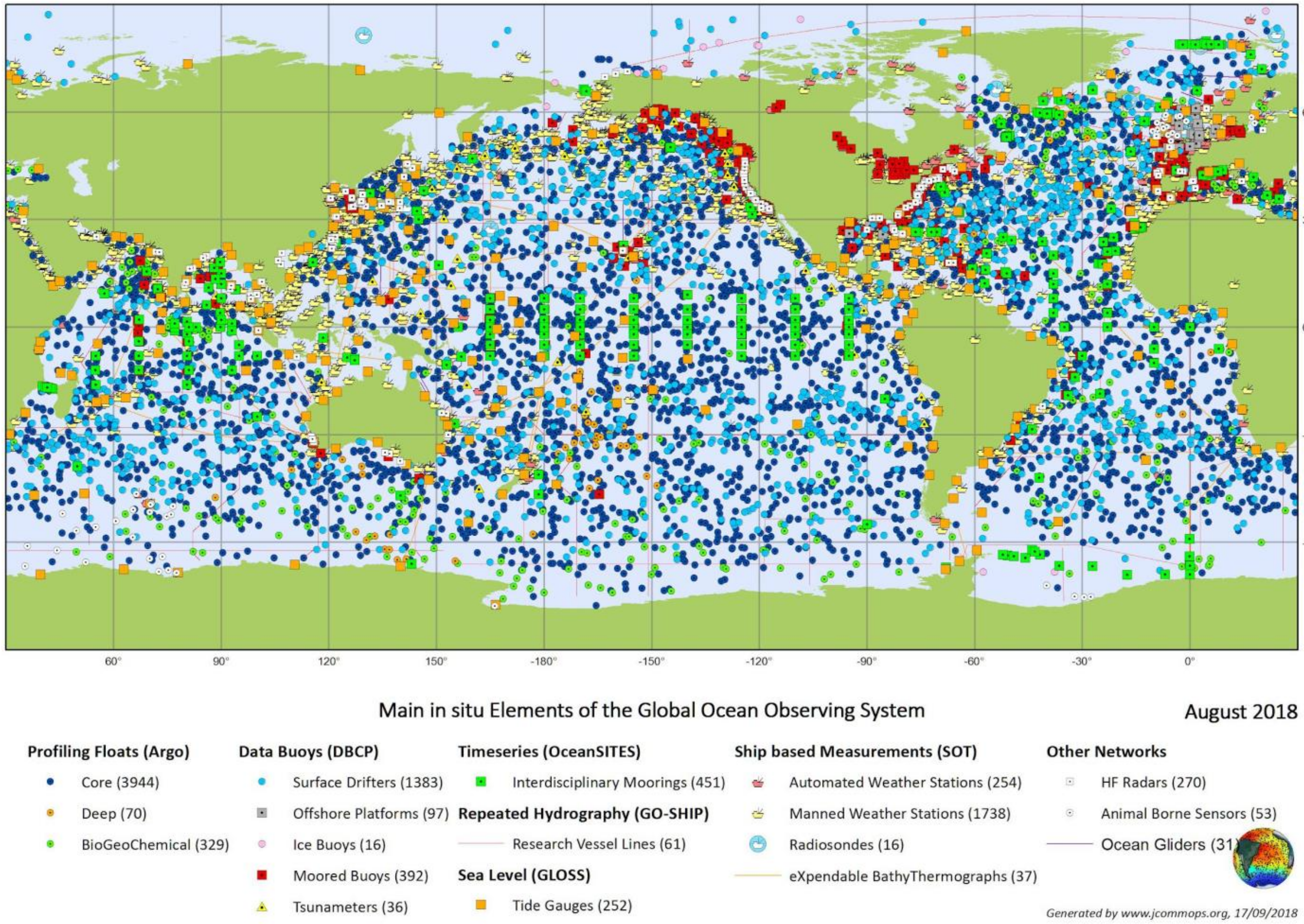
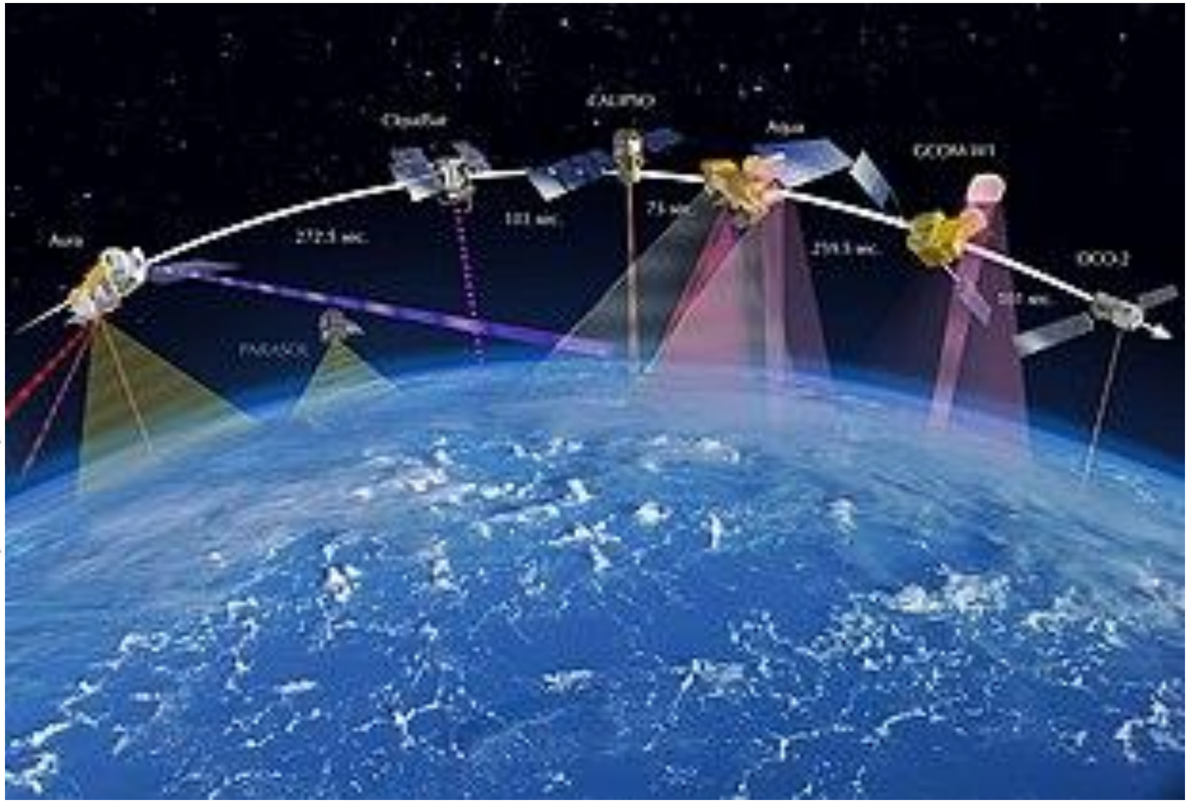
⇒ The last two decades have seen a massive growth in Earth Observation effort both from space and in situ

⇒ It s a great news for marine biologists and fishery scientists, but also rather complicated to navigate in this big data ocean





From EO to Tuna operational forecast system

Marine biologists / fisheries scientists are mostly looking for accurate ocean fields of a few key variables:

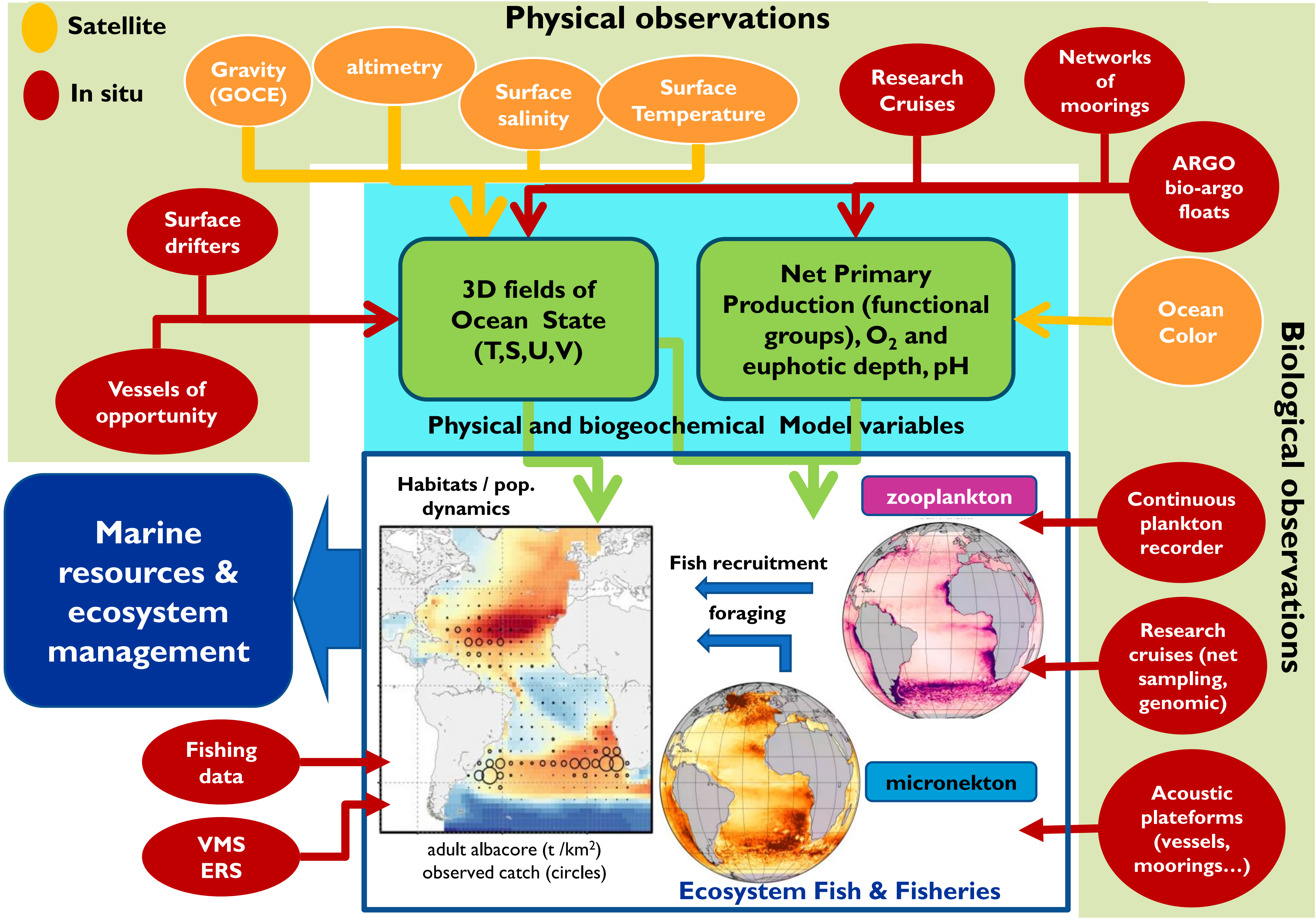
- T, S, U, V, W (3D)
- NPP
- Dissolved O_2
- pH

with no gap, on standard grids & format, quality info, regular updates, over several past decades and present / forecast.

Such products are now provided by ocean models assimilating all EO data.

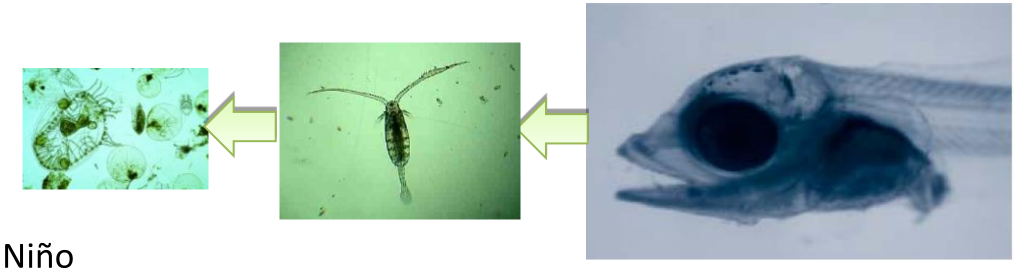
But still, two other key variables are needed:

- **Zooplankton**
- **Micronekton**



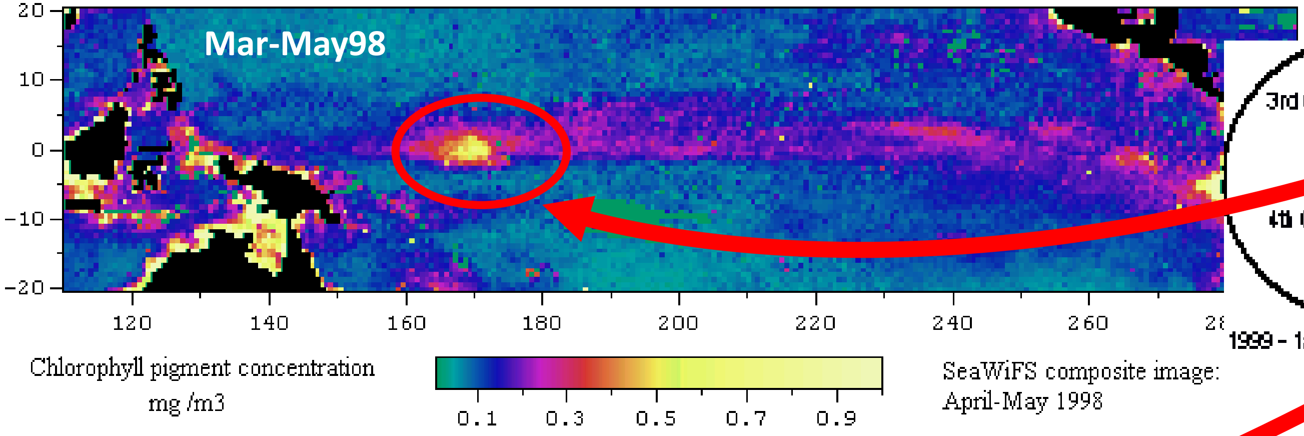
Zooplankton

Fish larvae feed on zooplankton
that feed on phytoplankton



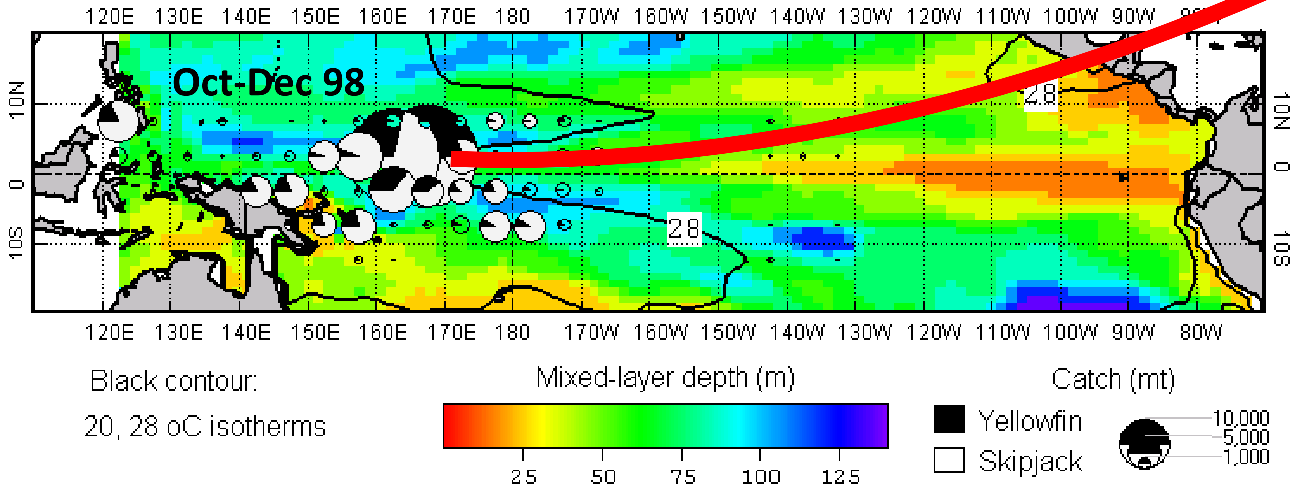
Bloom of phytoplankton at the end of 1997-98 El Niño

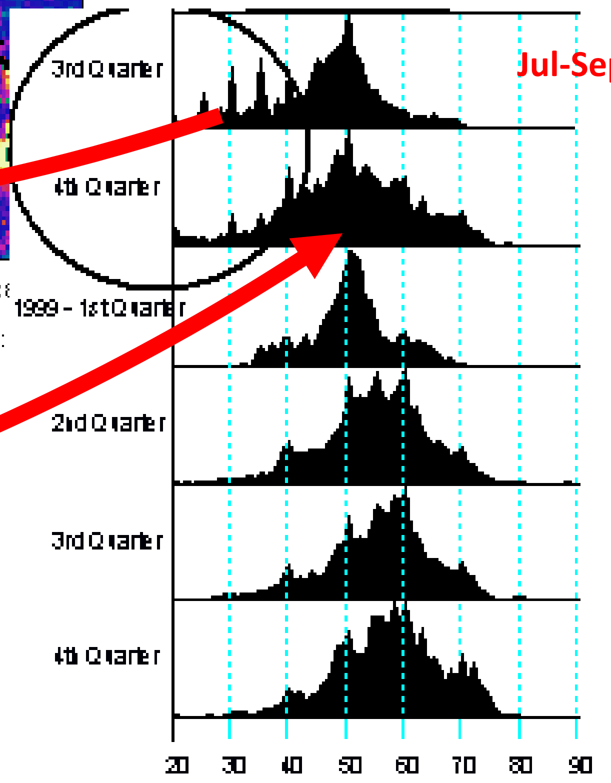
Satellite
Chlorophyll



+ 7 months

Tuna catch by purse seiners



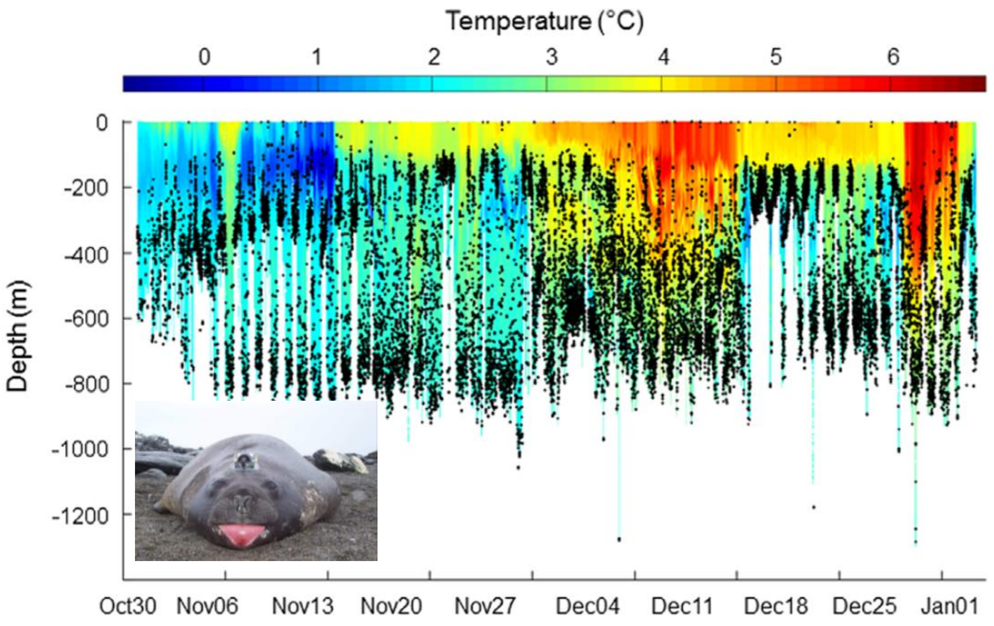


Size Frequencies
of skipjack
caught by purse
seiners

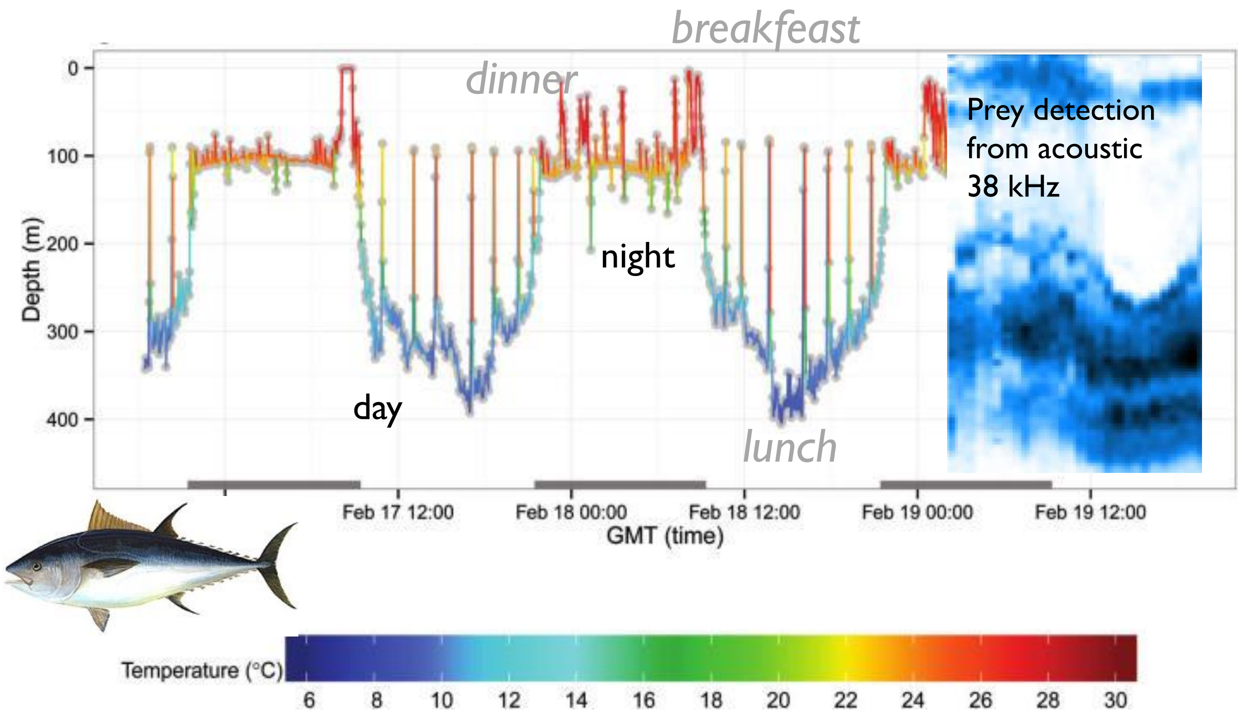
Lehodey et al. (2011)

Micronekton

Behaviour and distributions of large oceanic species are linked to the distribution of their prey (micronekton).



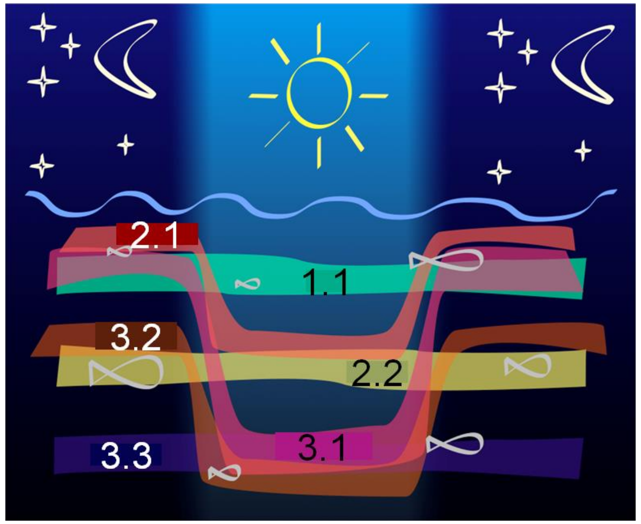
Temperature profiles obtained for a two-month foraging trip of one Elephant Seal. Each black dot corresponds to a prey capture attempt (Vacquié-Garcia et al. 2015).

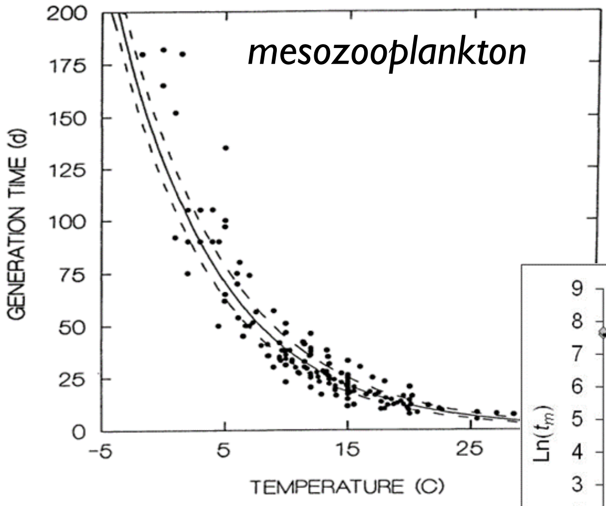


Time series of depth and temperature for one bigeye tuna tagged in the N-W Atlantic (C. H. Lam et al. 2014)

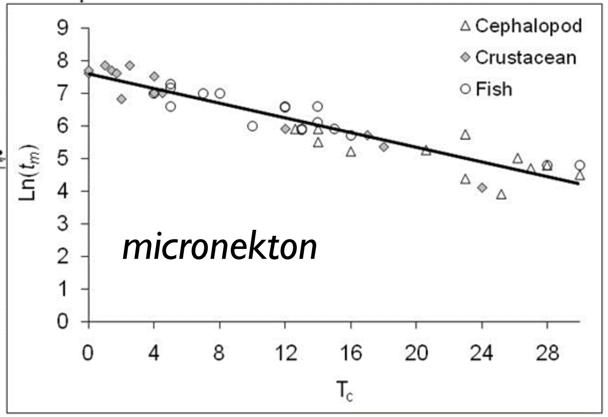
A model of zooplankton and micronekton

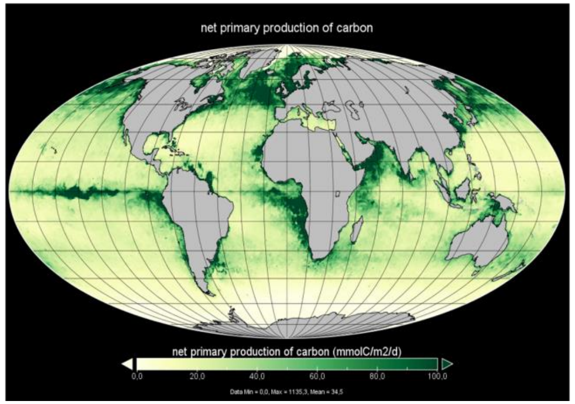
Using **temperature**, oceanic **currents and primary production** (sat. or mod.), the model SEAPODYM-LMTL simulates spatio-temporal dynamics of one zooplankton and 6 micronekton functional groups, according to their diel vertical migration behavior in 3 vertical layers (epi-, upper meso- and lower meso-pelagic).

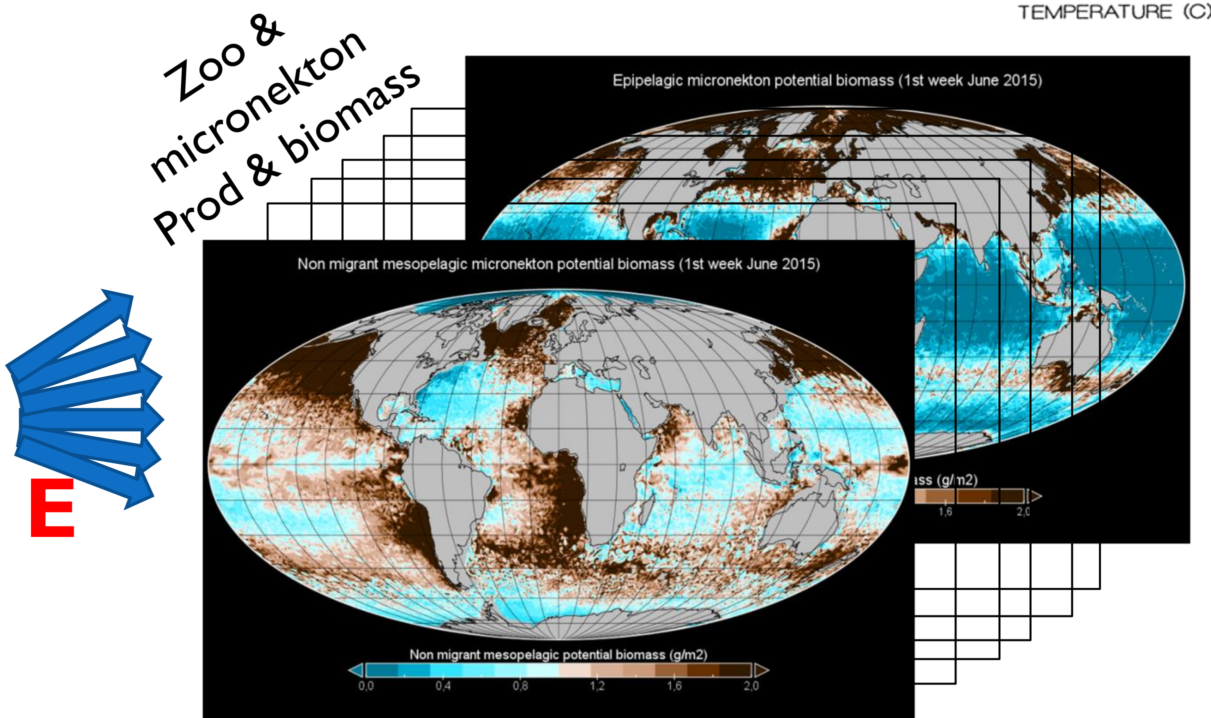




Time of development until maturity vs temperature







A parsimonious approach (11 param.)

Ref: Lehodey et al. 1998; *Fish. Oceanog.*; 2010, *Progr. Oceanog.*; 2015, *ICES J Mar Sci*; CMEMS: QUID document

A model of zooplankton and micronekton

A first product is available: global (60°N-60°S) 1998-2019 0.25° x week

Next release: 1st quarter of 2021 (80°N-80°S) 1998-2019; 1/12° (9 km) x day

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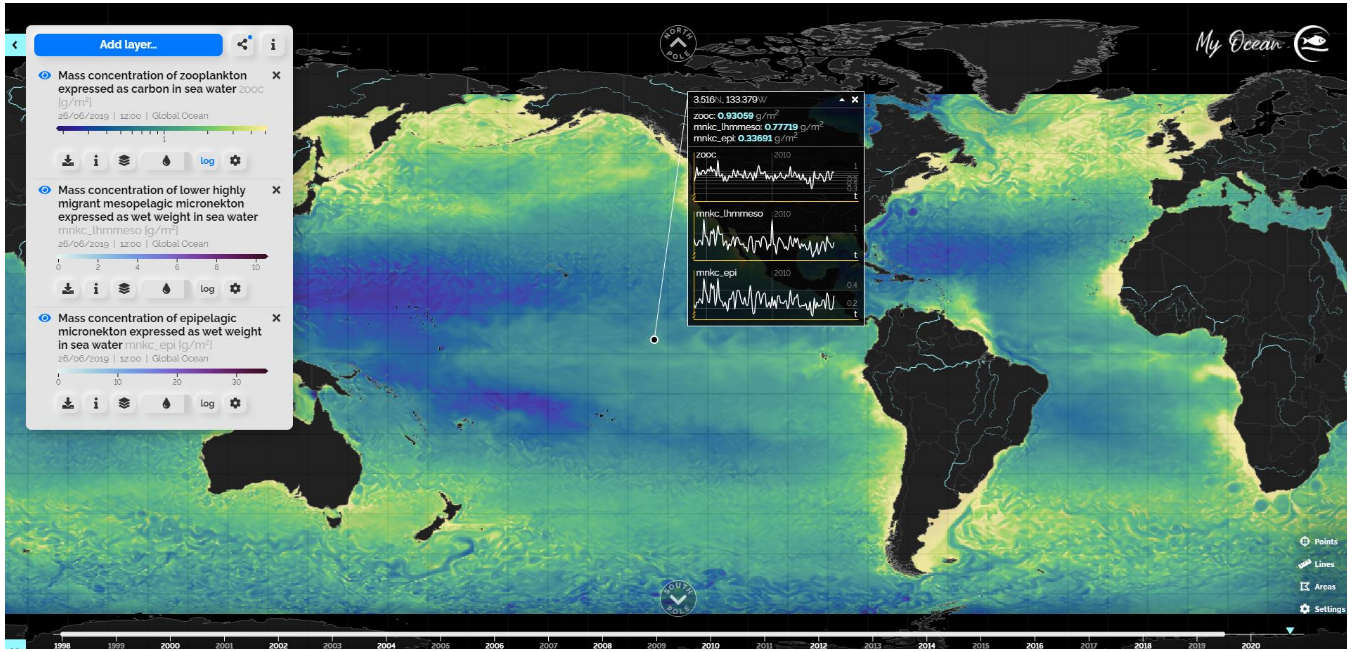
https://marine.copernicus.eu/



Case studies on large marine species habitat/behaviour using Zpk and Mnk:

- Pérez-Jorge et al. (2020). Environmental drivers of large-scale movements of baleen **whales** in the mid-North Atlantic Ocean. Diversity and Distributions, 26(6): 683-698.
- Green et al. (2020). Modelled mid-trophic pelagic prey fields improve understanding of marine **predator foraging behaviour.** *Ecography, 43(7): 1014- 1026.*
- Romagosa et al. (2020). Differences in regional oceanography and prey biomass influence the presence of foraging odontocetes at two Atlantic seamounts. ***Marine Mammal** Science,* 36(1): 158-179.
- Lambert et al. (2014) Predicting **Cetacean** Habitats from Their Energetic Needs and the distribution of Their Prey in Two Contrasted Tropical Regions. PLoS ONE 9(8): e105958.
- Abecassis et al. (2013) A Model of Loggerhead Sea **Turtle** (*Caretta caretta*) Habitat and Movement in the Oceanic North Pacific. PLoS ONE 8(9): e73274. doi:10.1371/journal.pone.0073274

Operational modeling of tuna

Bio-physical environment:
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- Currents
- Dissolved oxygen
- Euphotic depth
- Primary production
- Zooplankton (1 group)
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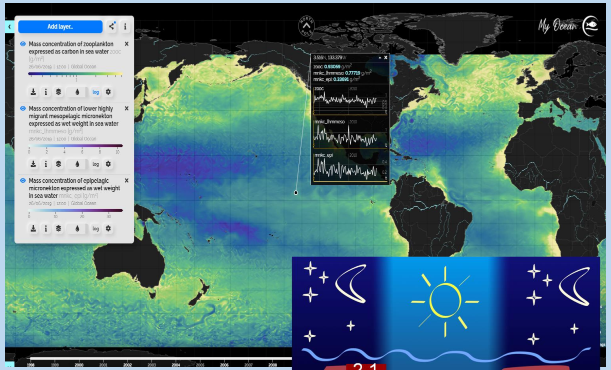

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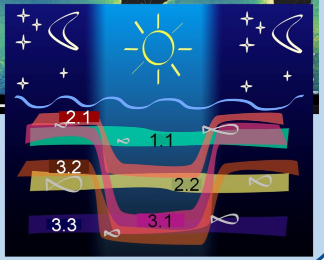
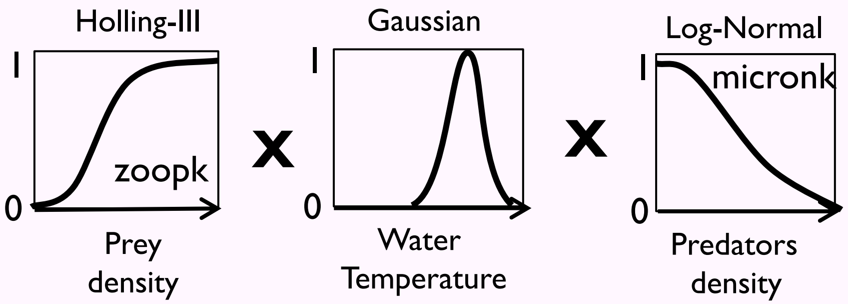
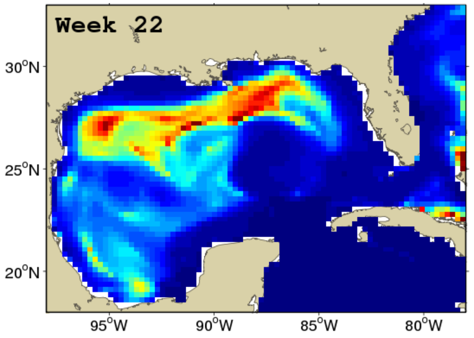


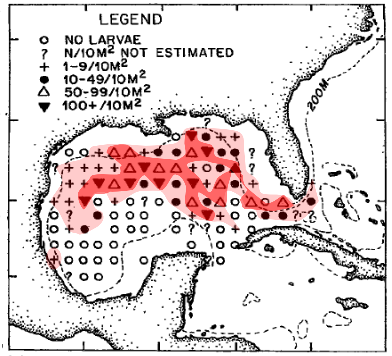
Spawning habitat H_s



$$H_s = f_1(prey)\ f_2(T^{\circ})\ f_3(predator)$$



Predicted bluefin larvae density



Observed bluefin larvae density

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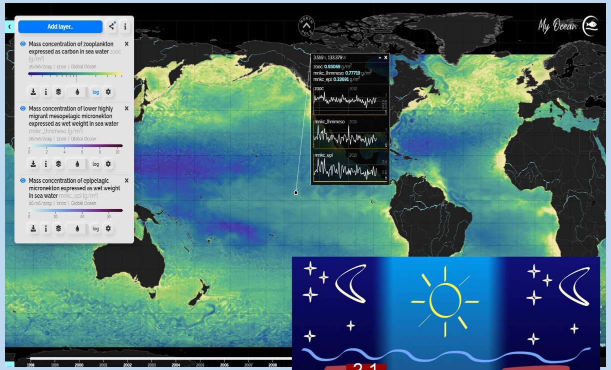

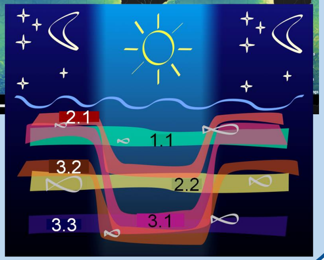

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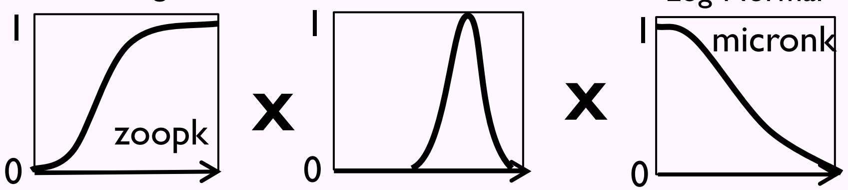

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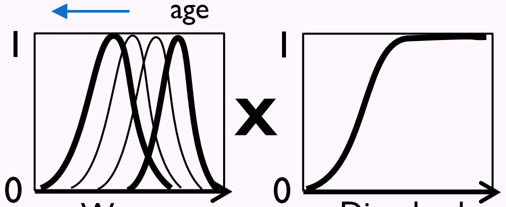

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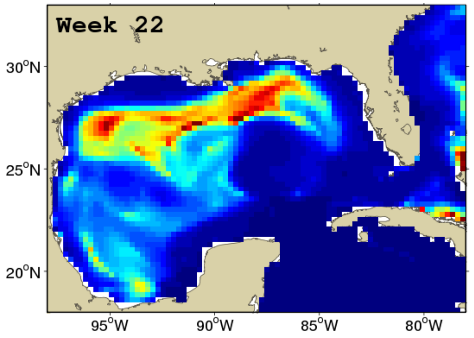

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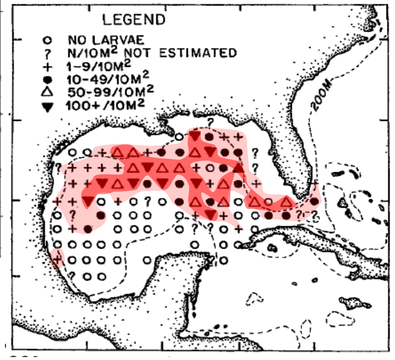

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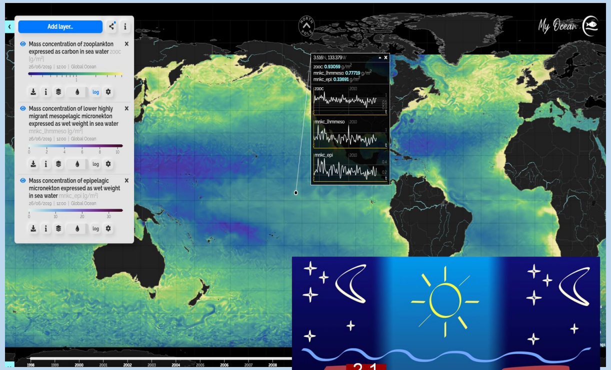

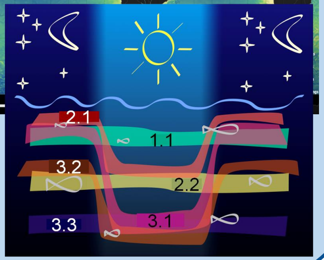

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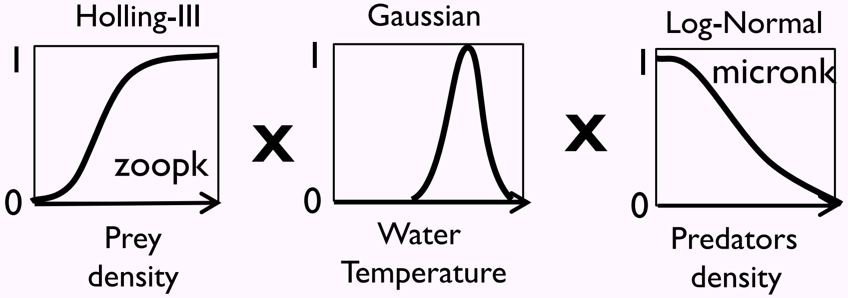

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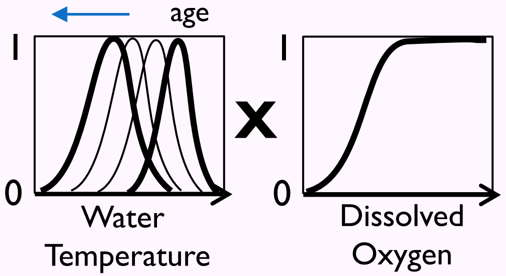

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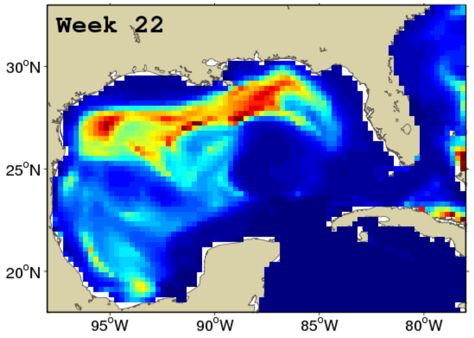

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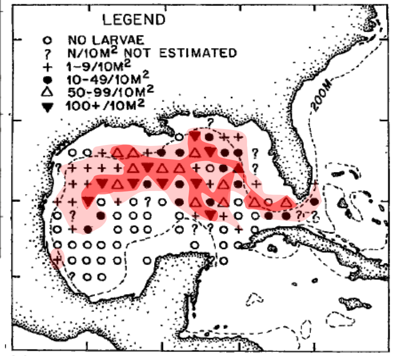
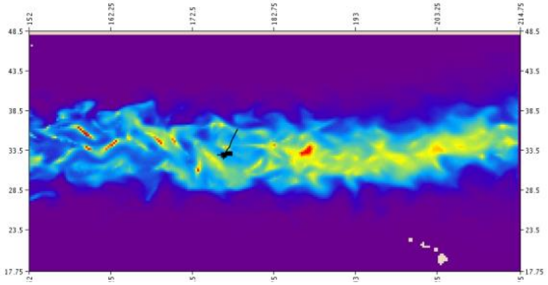
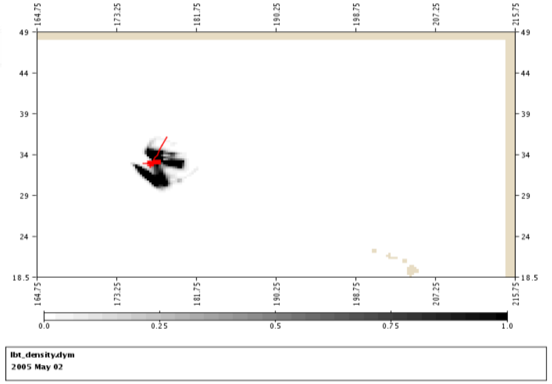


Observed bluefin larvae density



<= Predicted habitat and observed tracks



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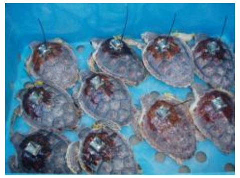

Loggerhead turtle (Abecassis et al 2012)

Operational modeling of tuna

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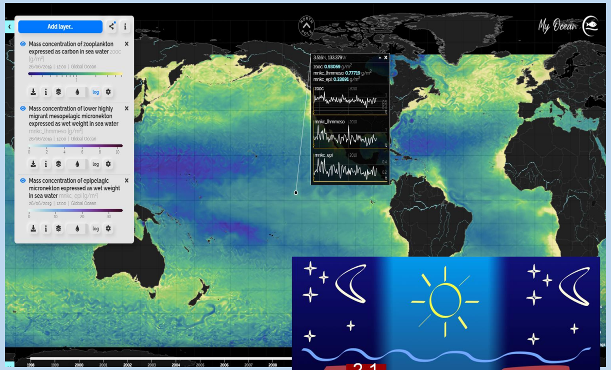

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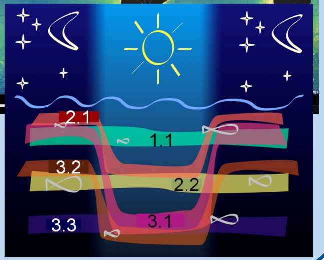

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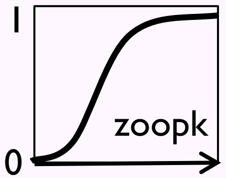
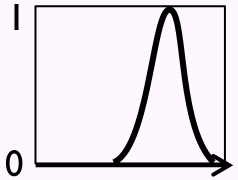


x



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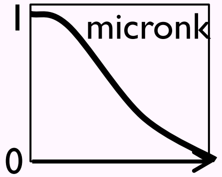

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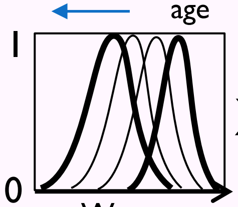

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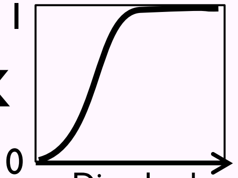

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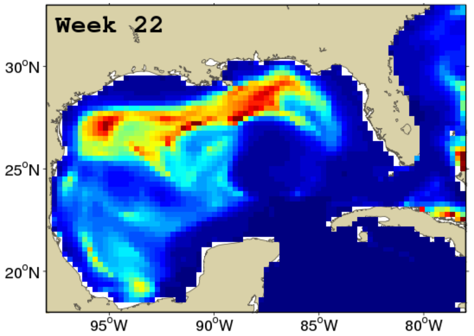

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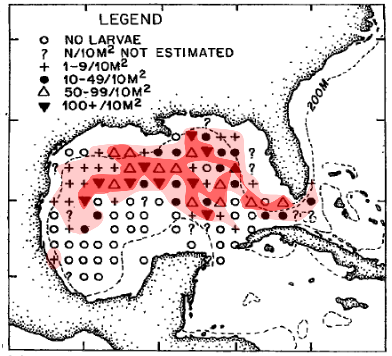

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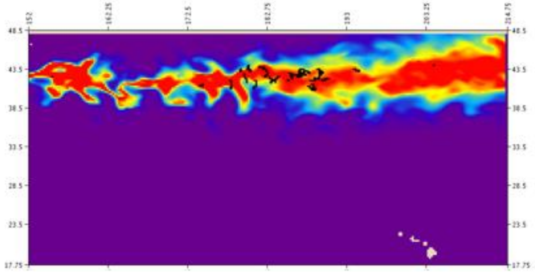

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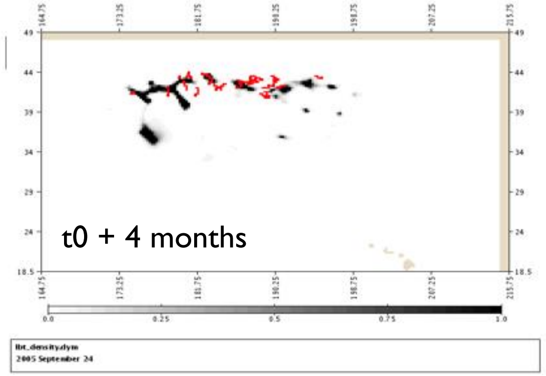

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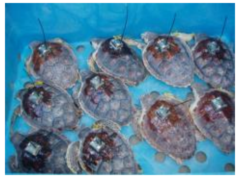

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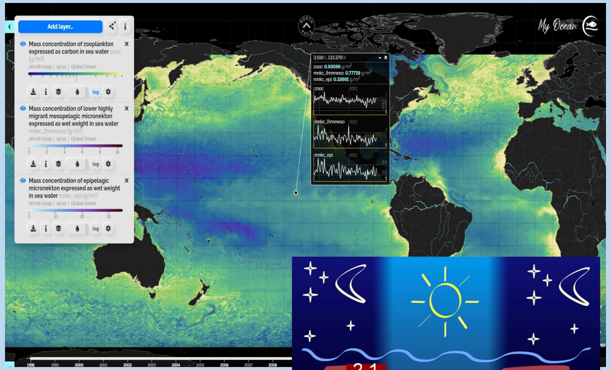

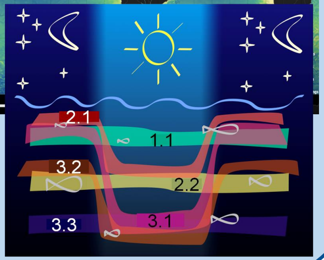

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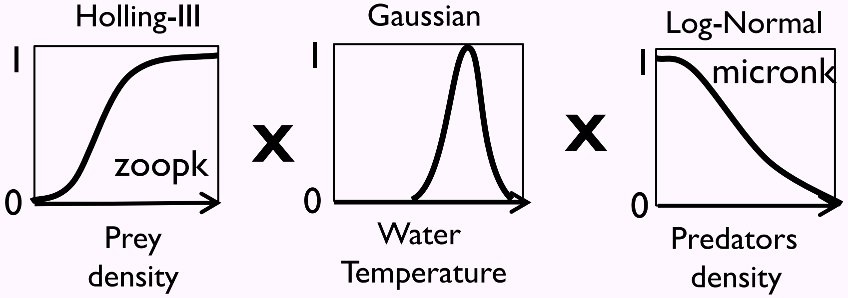

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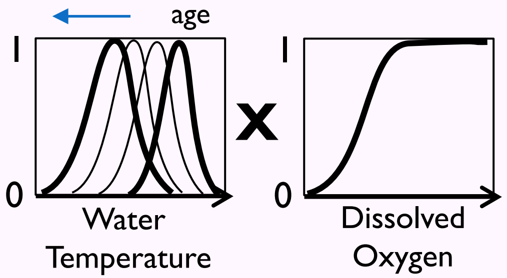

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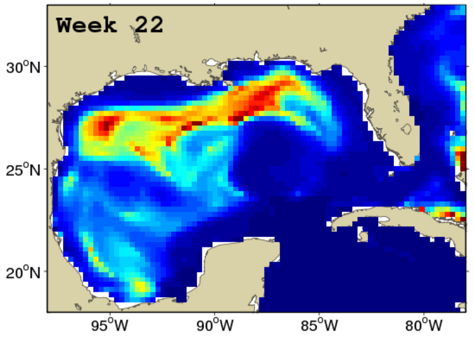
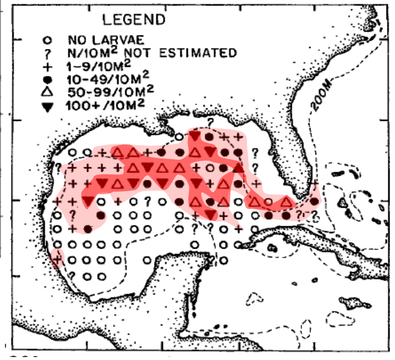
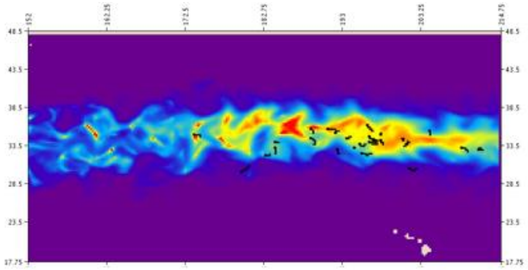


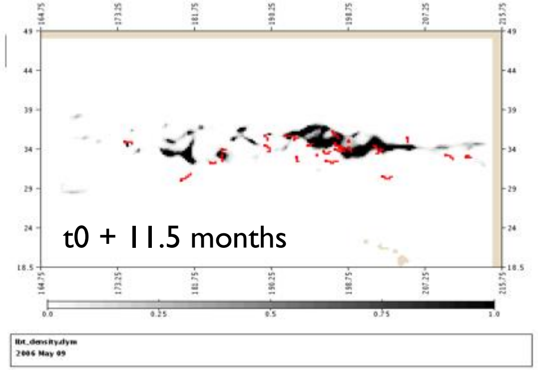
Predicted bluefin larvae density

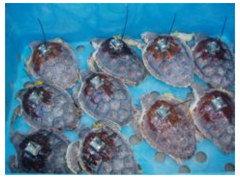


Observed bluefin larvae density



<= Predicted habitat and observed tracks

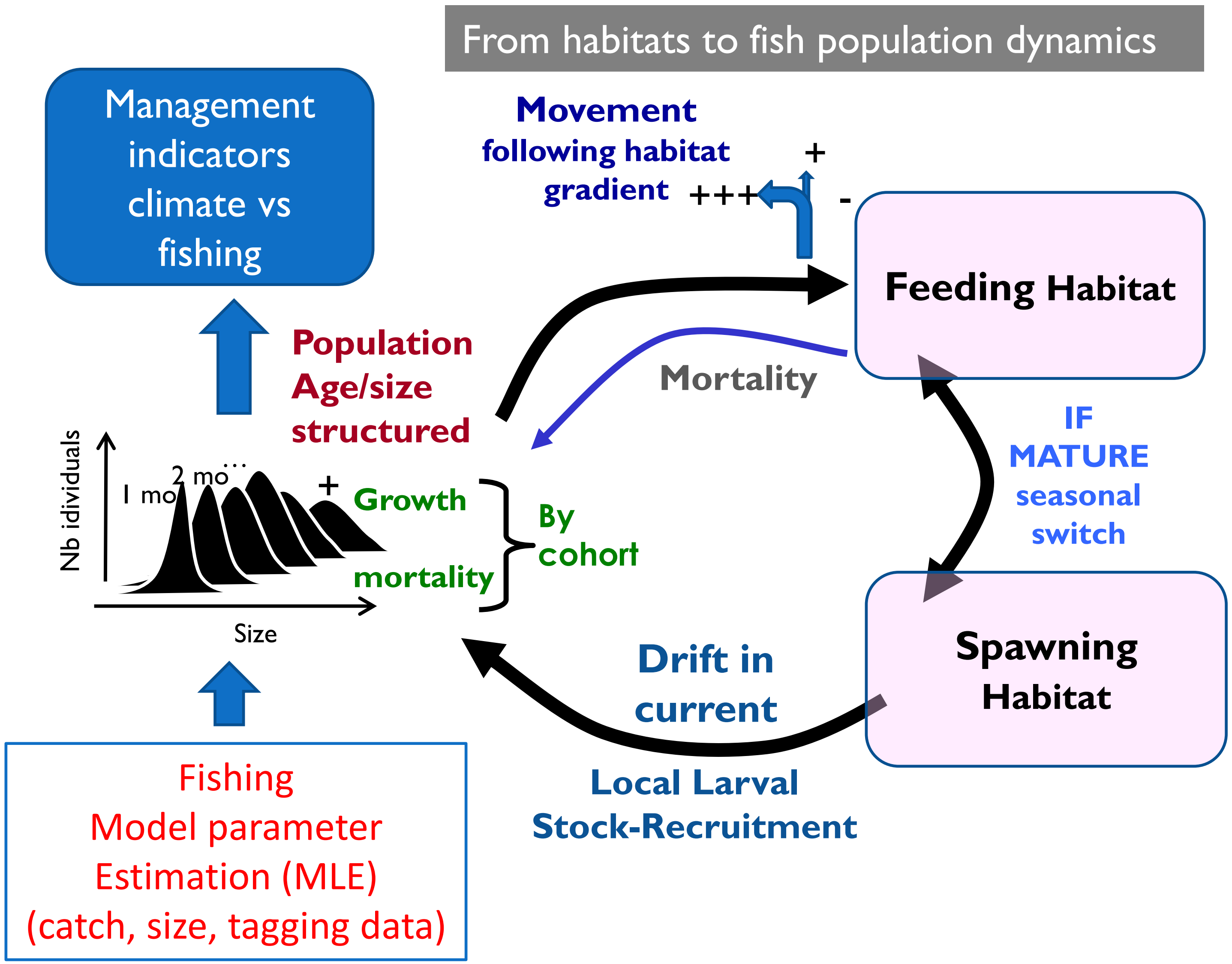




Loggerhead turtle (Abecassis et al 2012)

<= Predicted movement and observed tracks

Operational modeling of tuna



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Operational modeling of tuna

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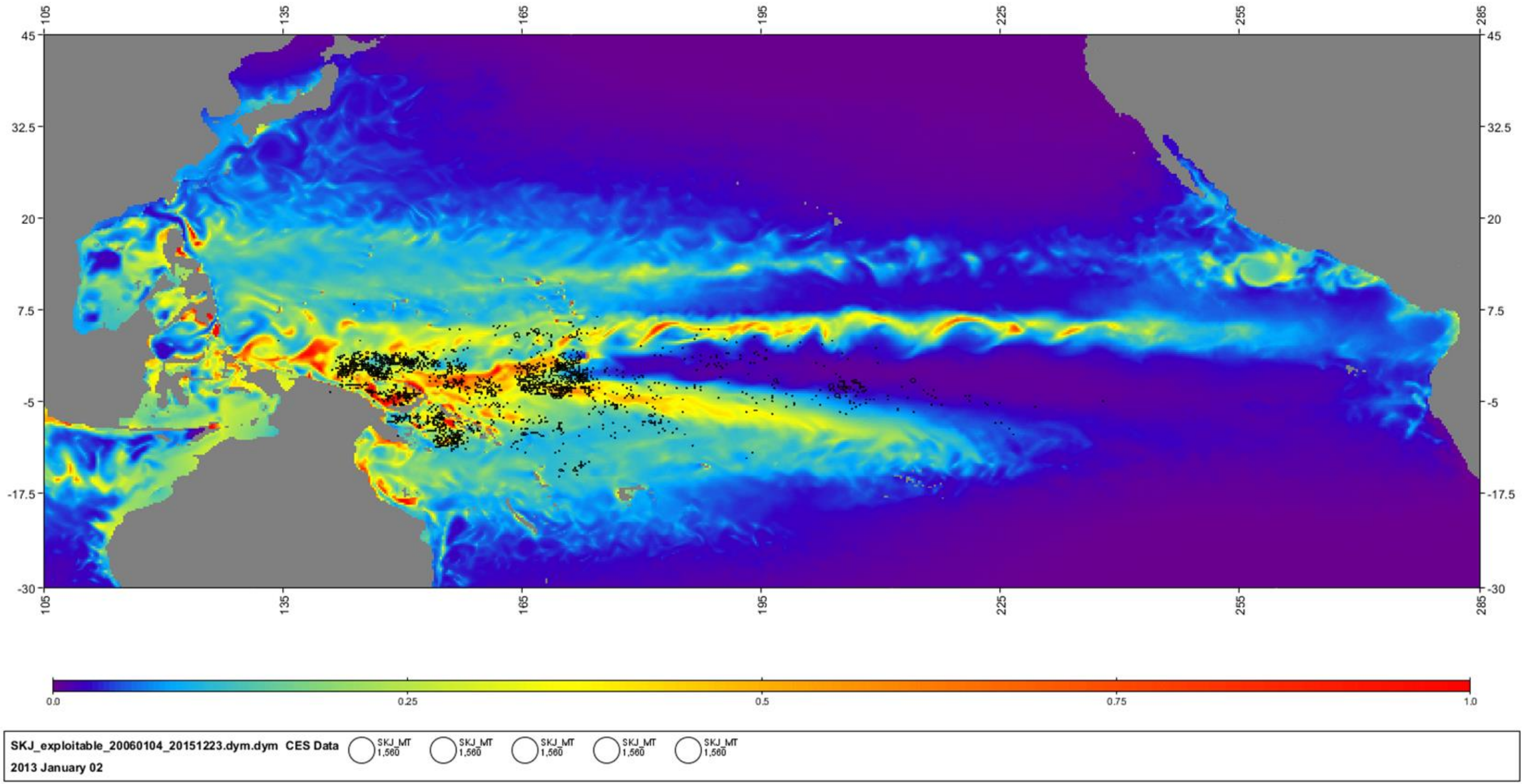

Operational modeling of tuna

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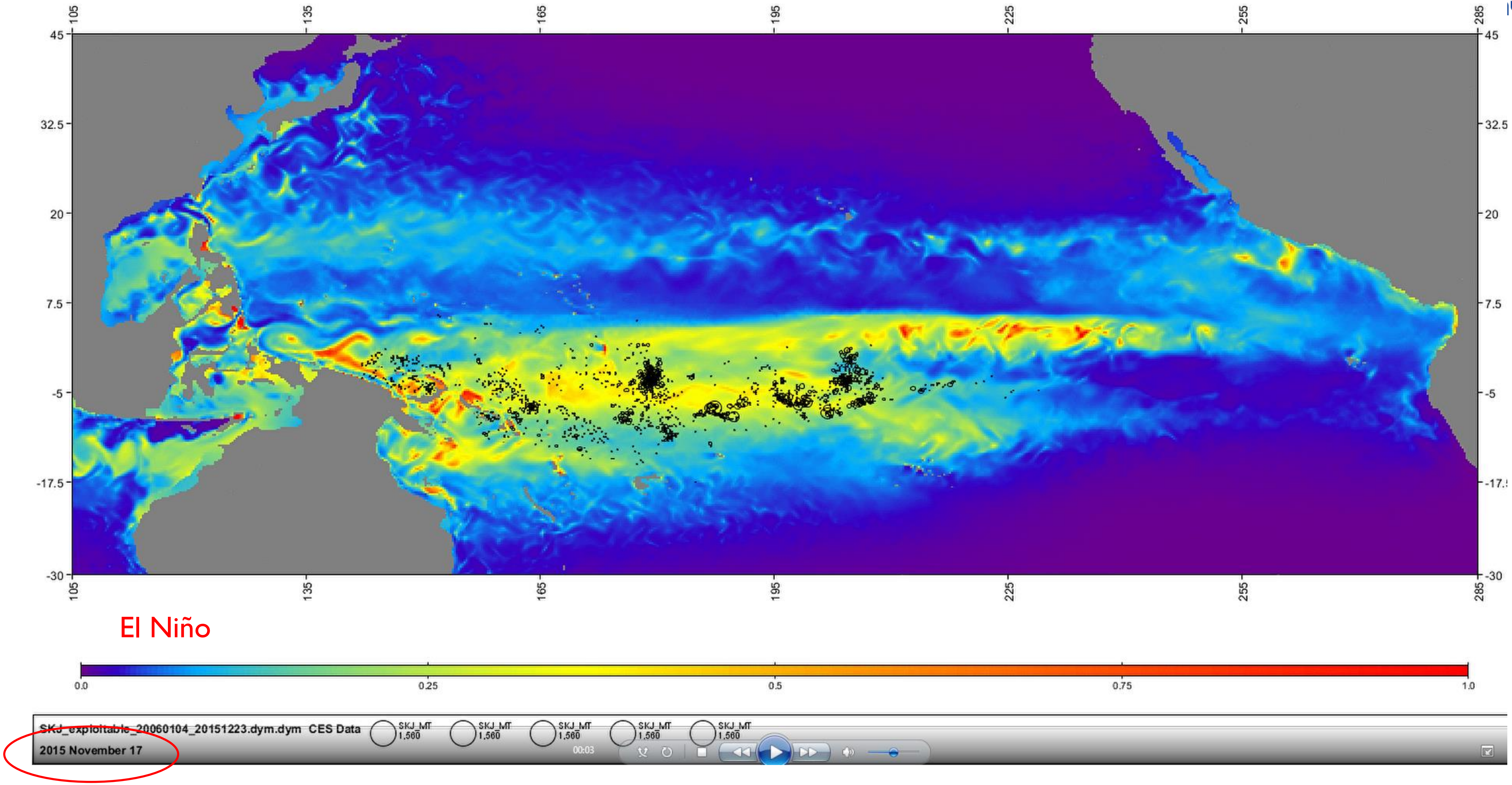
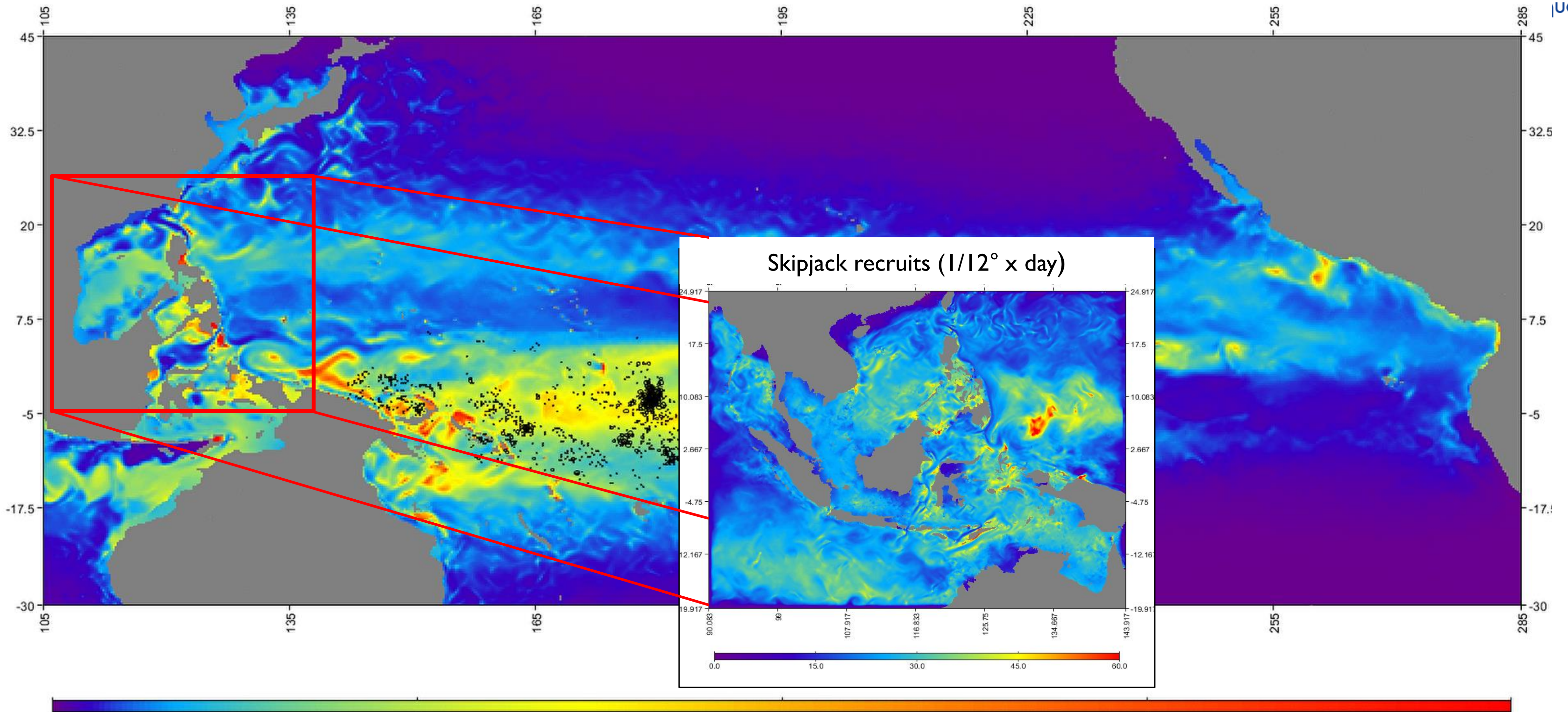


Operational modeling of tuna



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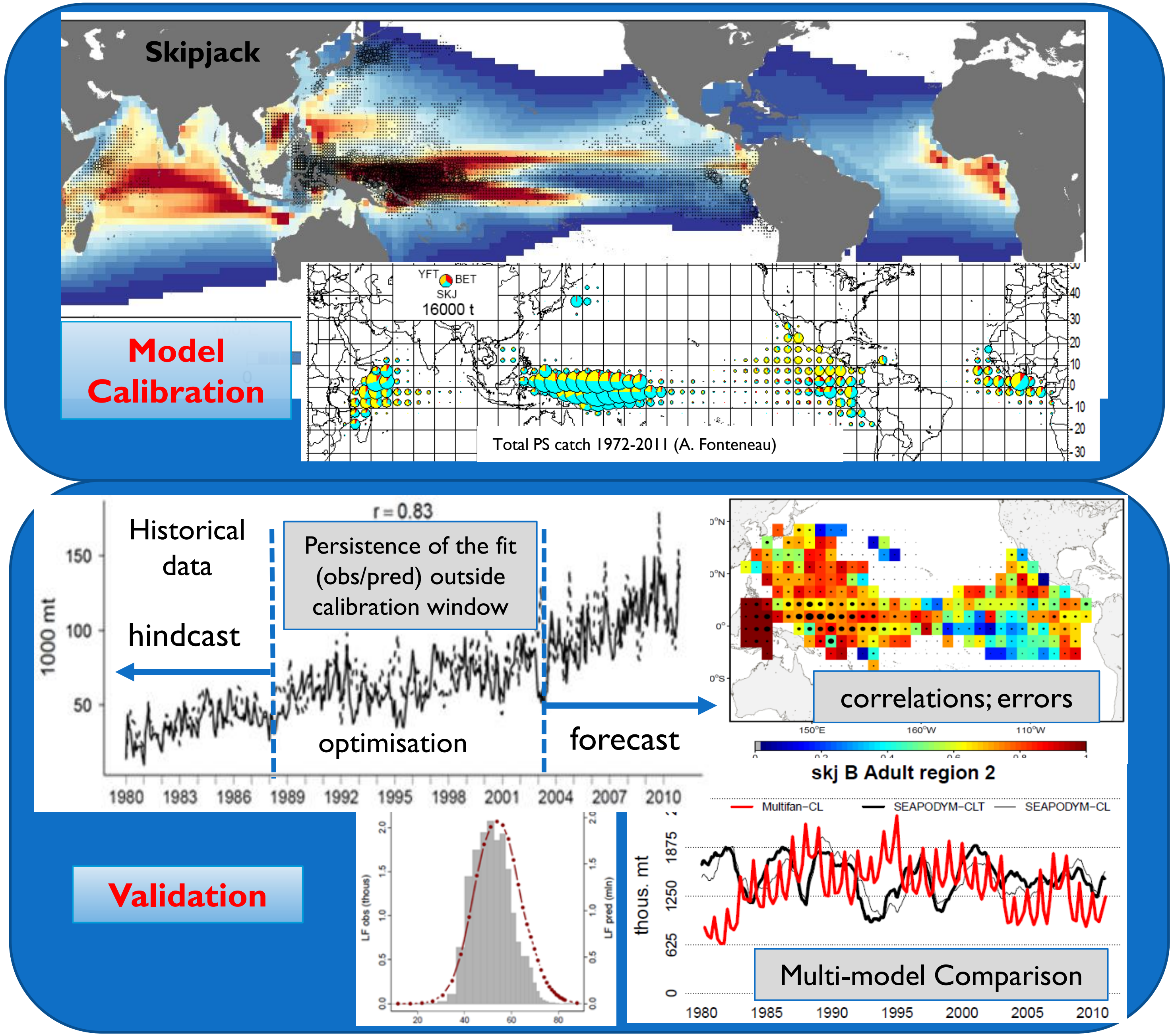
Stock assessment and management scenarios

- Stock estimates (recruits, spawning biomass, …)
- Fishing mortality
- Fishing Impact vs environmental variability
- Management Scenarios : (fishing effort, fishing areas and periods,…)
- Spatial planning



Operational Monitoring (real-time)

- Support to monitoring of fishing
- Support to detection of IUU
- Pollution impacts

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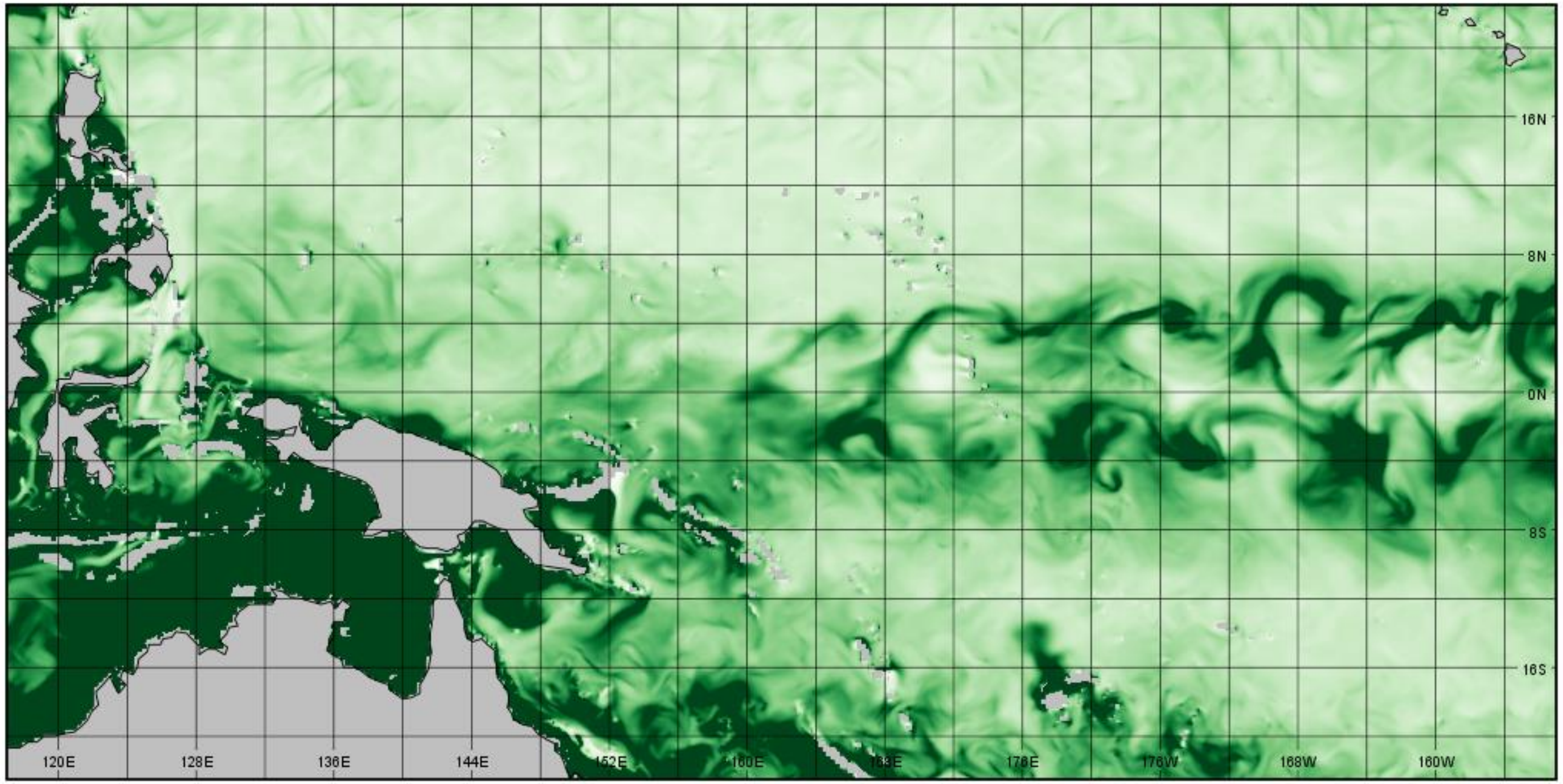
COLLECTE LOCALISATION SATELLITES
Copernicus Marine Service

Conclusions

- Integrated systems (OBS + MOD) for ocean modelling makes the forecast of fish stocks a true possibility
- Two essential Ecosystem variables (Zooplankton and Micronekton) are becoming available in addition to key physical and biogeochemical ones
- Models (habitats & spatial dynamics) will provide new management tools with additional features for spatial management
- Fishing impact can be discriminated from natural variability
- Support to monitoring of fisheries (eg IUU, pollution)
- Provide rapid feedback on quality and gaps to address in priority

Next release to come…

mass content of epipelagic micronekton expressed as wet weight in sea water



Thanks!

Questions?