Collecte Localisation
Satellites (CLS)

CLS
COLLECTE LOCALISATION SATELLITES

Developing Operational Products for Ocean Ecosystem and Fishery Management

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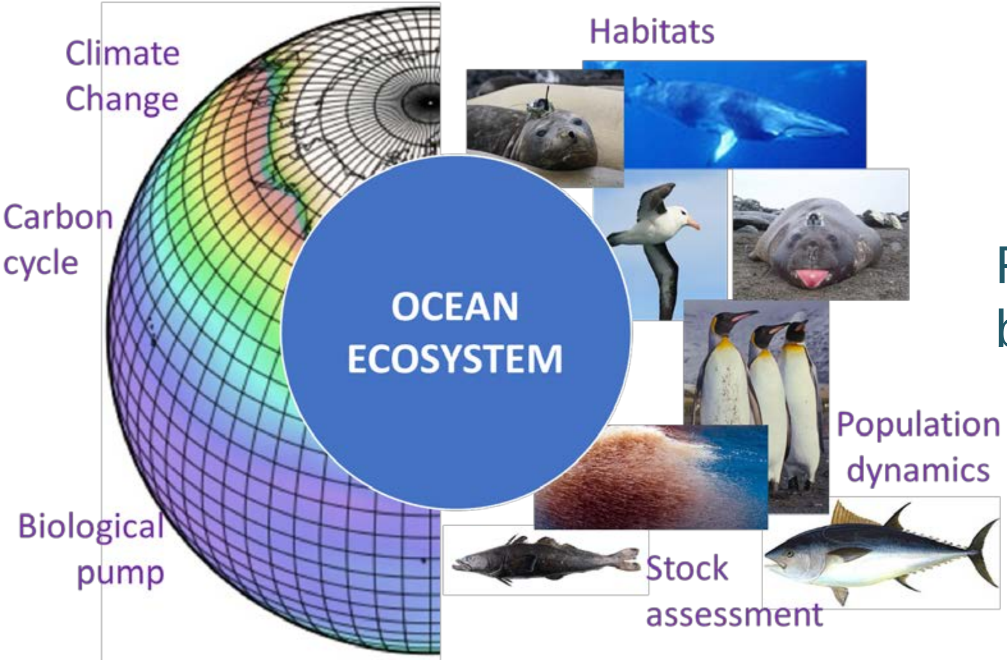
Outlines

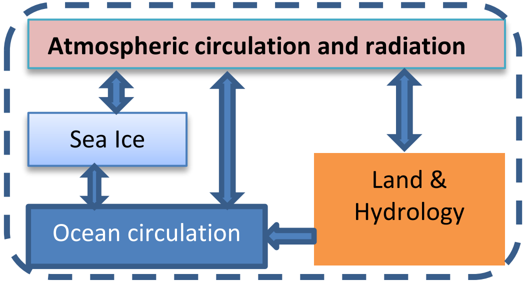
Earth System & Climate



Resource & biodiversity

Ocean Ecosystem & Climate

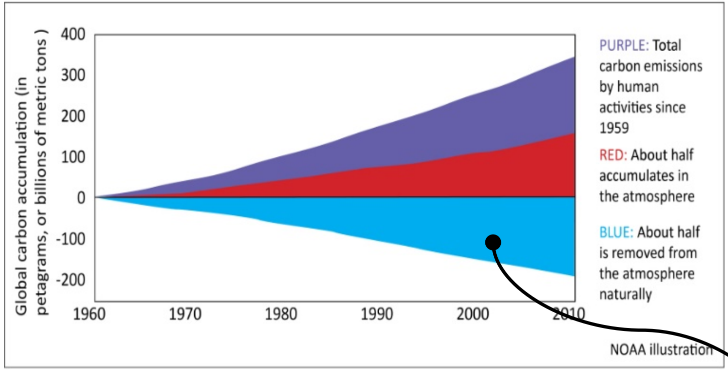
Climate model



A Climate model simulate changes in temperature, salinity, winds, currents, moisture and atmospheric pressure.

What is the fate of stored C? Where, when it reappears in the atmosphere? How much?

Observations

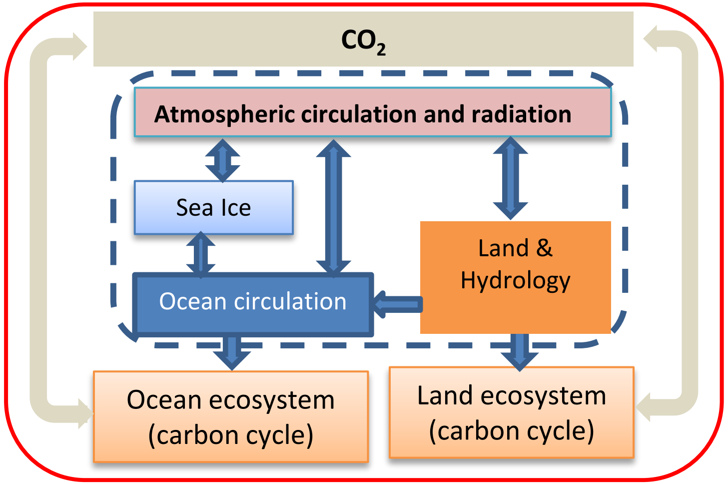


Without Ocean Physics AND biology, CO_2 concentration in the atmosphere would be the double (e.g., CO_2 is incorporated into land and ocean reservoirs by organisms during photosynthesis).

Ocean Ecosystem & Climate

Climate model

Earth System model

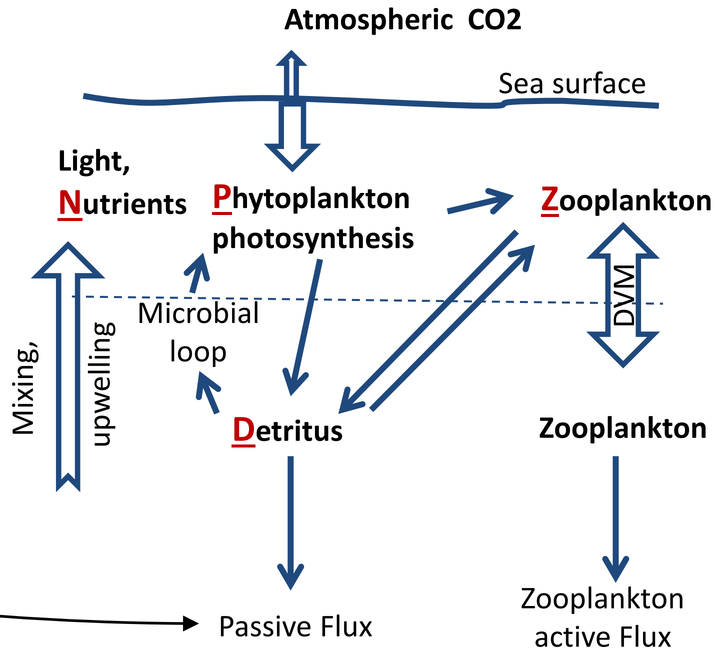


The Global **Earth Ecosystem** is represented by its carbon cycle that plays a key role in the sequestration or release of greenhouse gas (CO_2) in the atmosphere.

In an Earth System Model (ESM) additional "ecosystem" components allow to close the carbon cycle.

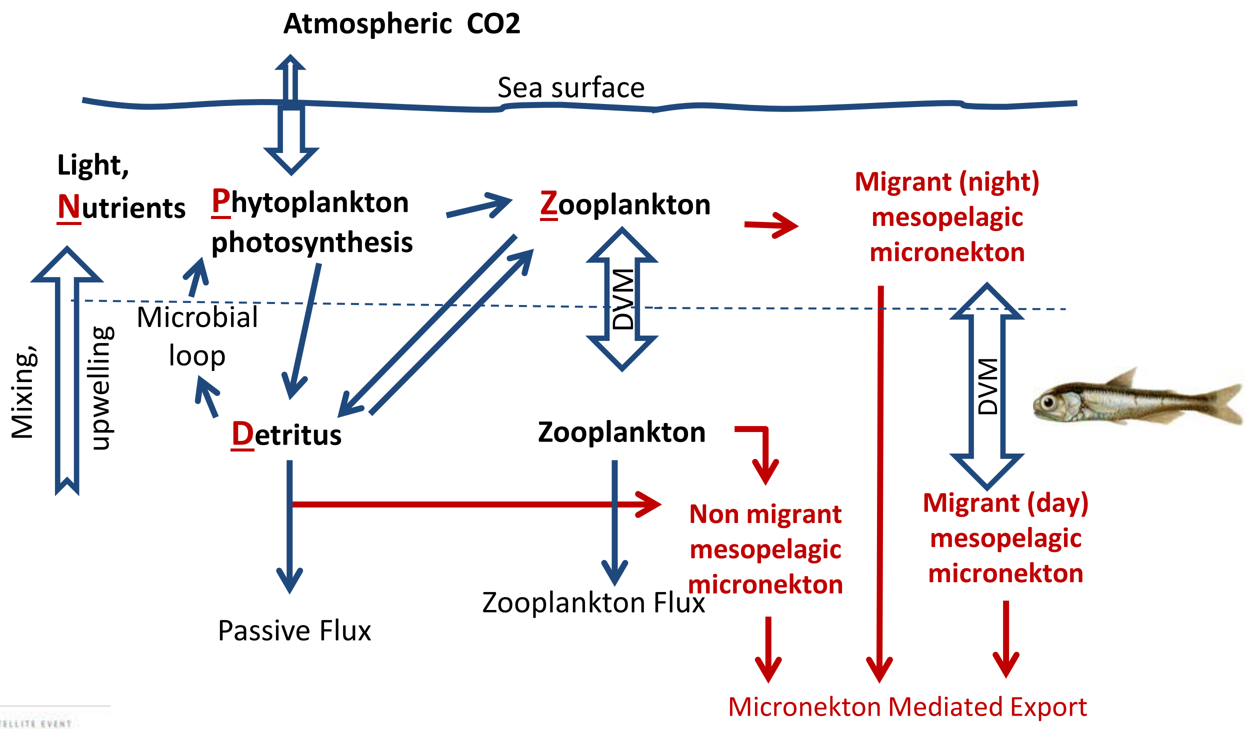
Ocean Ecosystem &Climate

Observation vs Model:
C exported from surface layer by passive transport (measured with sediment traps) is lower than estimations by other methods (models and radionuclides), sometimes by 70%! (Usbeck et al 2003; Buesseler et al 2007)



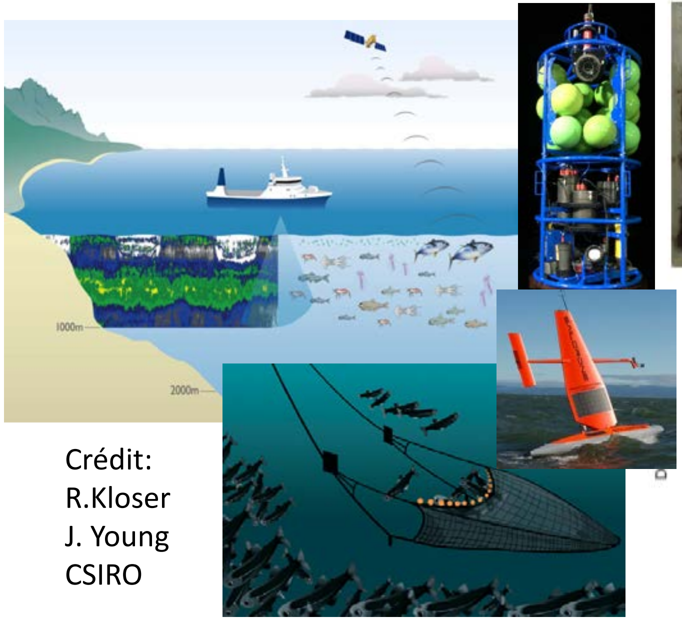
Ocean Ecosystem & Climate

Migrant **micronekton** could contribute between <10% (mesotrophic) and >40 % (oligotrophic) export (Davison et al. 2013)



Ocean Mid-trophic Levels

Micronekton: the mid-trophic level of ocean ecosystem



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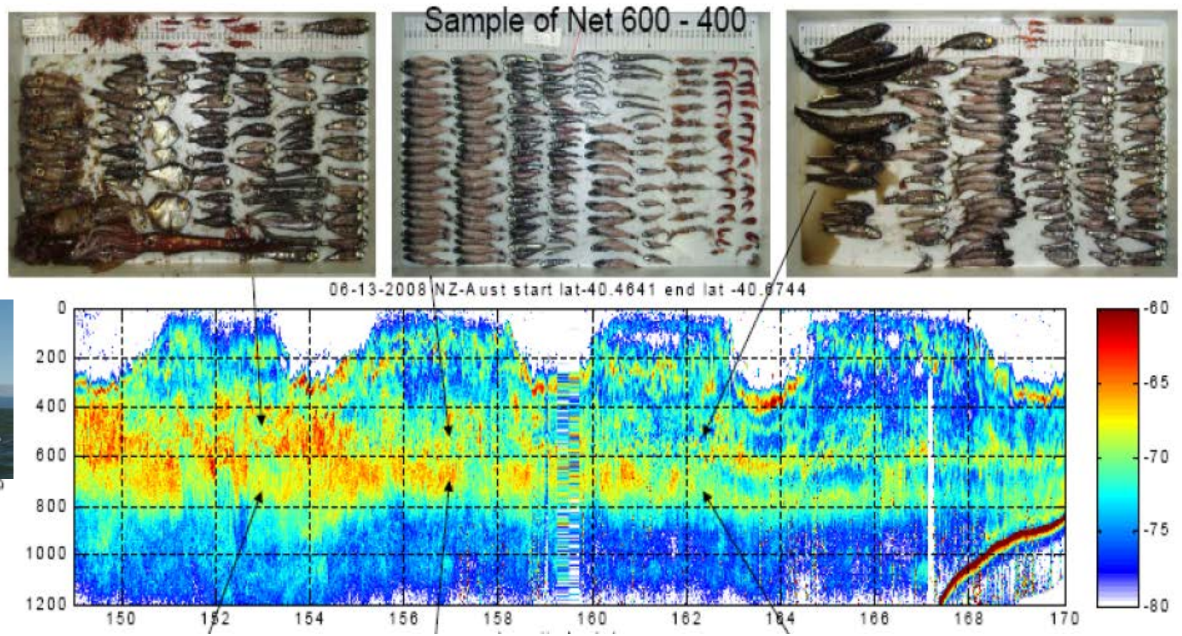
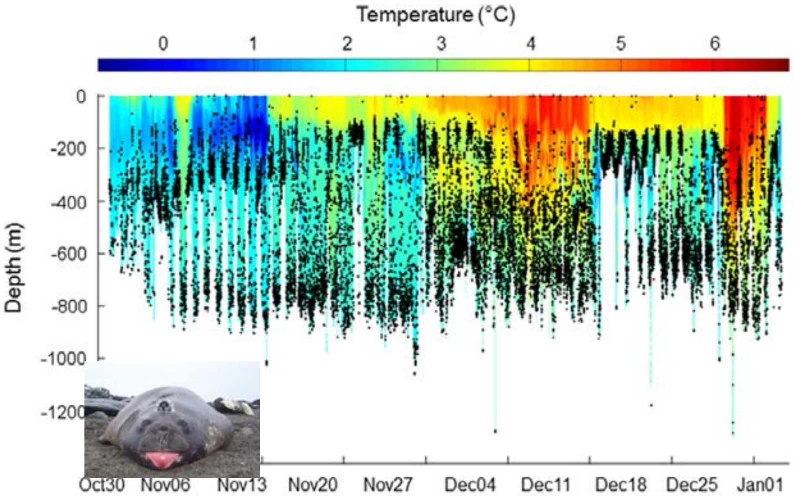
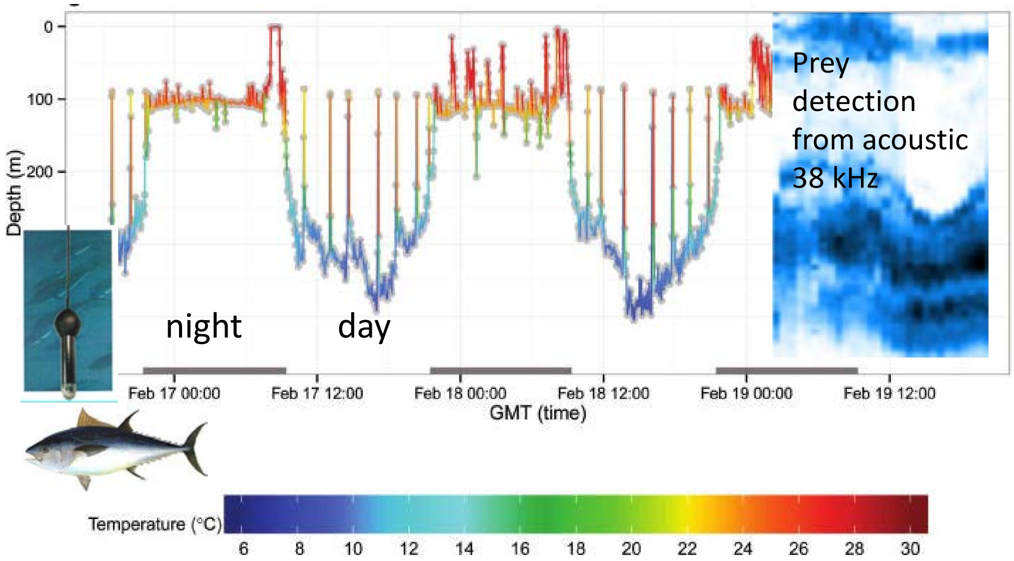


Ocean Mid-trophic Levels

Behaviour and distributions of large oceanic species are linked to the distribution of 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)

Ocean Mid-trophic Levels

Statistical Species Habitat modelling is based on 2 hypotheses:

1- the animals spend more time in favorable habitat due to **foraging activity**

2- the favorable habitat results of a combination of environmental factors, e.g.:

SST; SSH; EKE
Sea Ice; Distance to.. (Ice, land)
Bathymetry, Slope
Chlorophyll-a
Gradients
Wind, …

Proxies…

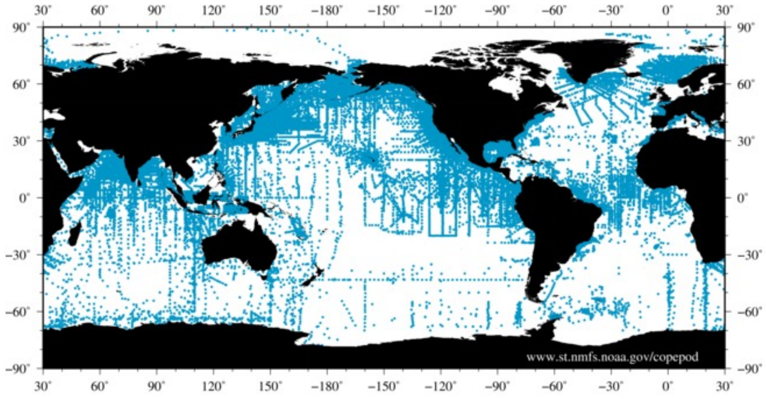
The main explanatory variables (micronekton) is missing!

The Holly graal of fishery science is to predict fish recruitment

- Johan Hjort (1914): *"the renewal of the (fish) stock…must depend upon highly variable natural conditions"*… mainly in the availability of planktonic food for fish larvae, and the influence of wind and current on the potential drift of fish eggs and larvae.
- David Cushing (1969): the Match-Mismatch hypothesis, i.e., variability in timing of zooplankton production leads to variability in larval mortality and hence year class strength

Operational realistic and validated distributions of zooplankton abundance are still missing

(COPEPOD database)

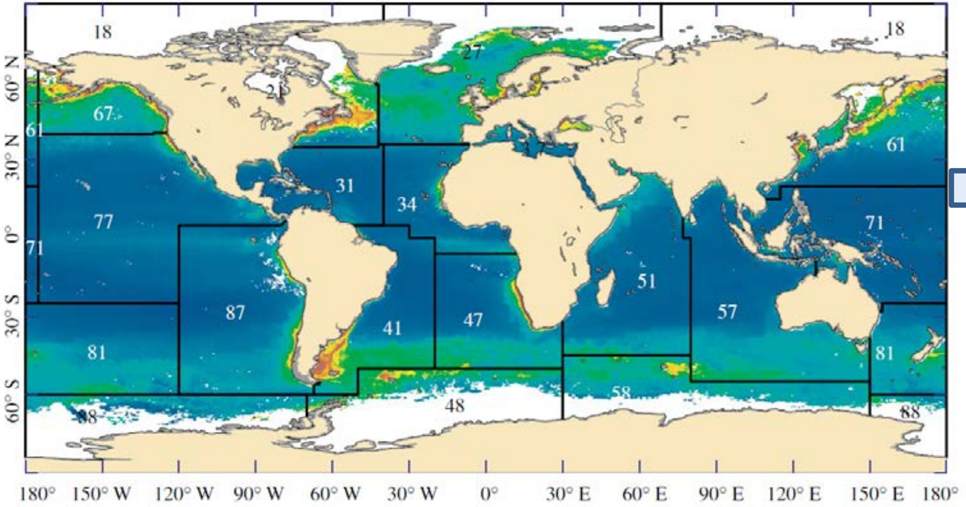


Distribution of Total Biomass (all types) observations within the COPEPOD database.

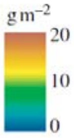
www.st.nmfs.noaa.gov/copepod/

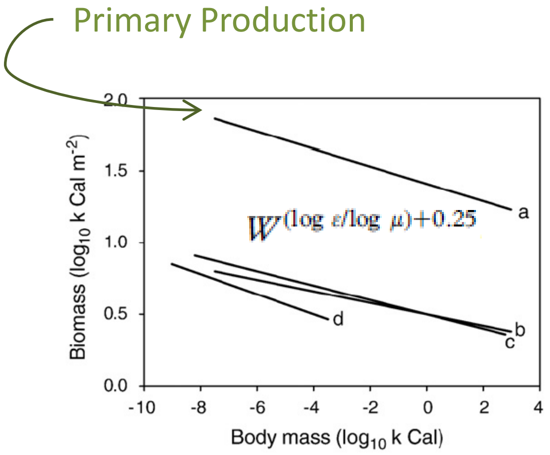
Towards Realistic L&MTL products

Size-based modelling approach



body mass	biomass (B)	
g	10^6 t	g m^{-2}
10^{-5}–10^{-4}	400.67	1.25
10^{-4}–10^{-3}	356.25	1.11
10^{-3}–10^{-2}	316.76	0.99
10^{-2}–10^{-1}	281.64	0.88
10^{-1}–10^{0}	250.42	0.78
10^{0}–10^{1}	222.66	0.69
10^{1}–10^{2}	197.97	0.62
10^{2}–10^{3}	176.03	0.55
10^{3}–10^{4}	156.51	0.49
10^{4}–10^{5}	139.16	0.43
10^{5}–10^{6}	123.73	0.38
totals	2621.81	8.16



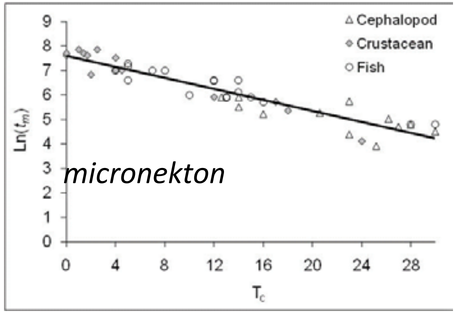


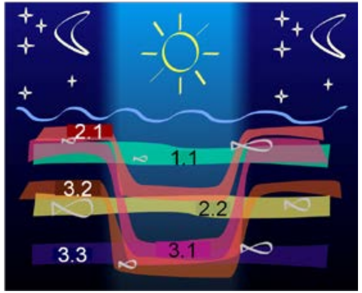
Distribution of teleost biomass (gWW). Jennings et al (2008) Global-scale predictions of community and ecosystem properties from simple ecological theory. Proc. R. Soc. B, 275, 1375–1383

Size-spectra for four marine ecosystems. Slopes are comparable but differences in intercept reflect differences in primary production.

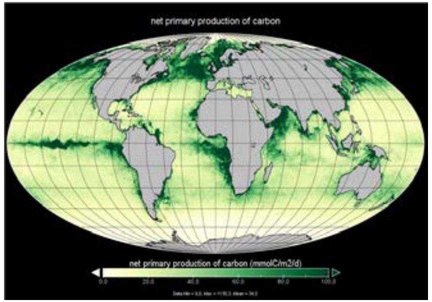
Towards Realistic L&MTL products

SEAPODYM-LMTL simulates biomass distributions of 1 zooplankton and 6 micronekton **functional groups**, according to their diel vertical migration behavior. Their spatio-temporal **dynamics** are driven by **temperature** and oceanic **currents**.



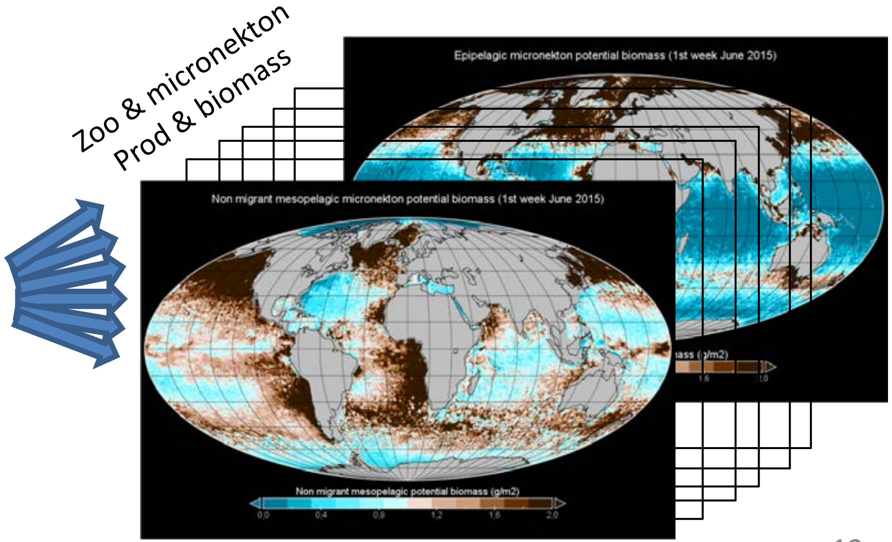


Primary production



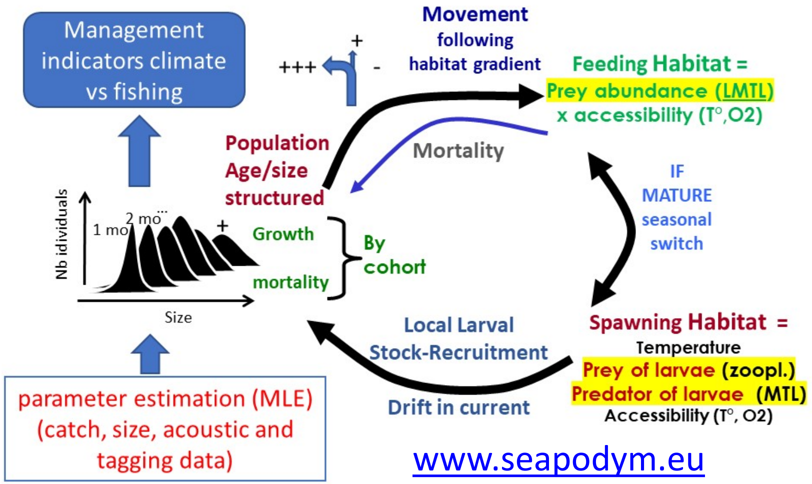
Temperature; currents

A parsimonious approach (11 param.)
A robust Maximum likelihood Estimation approach (Lehodey et al 2015; Conchon et al. in prep.)

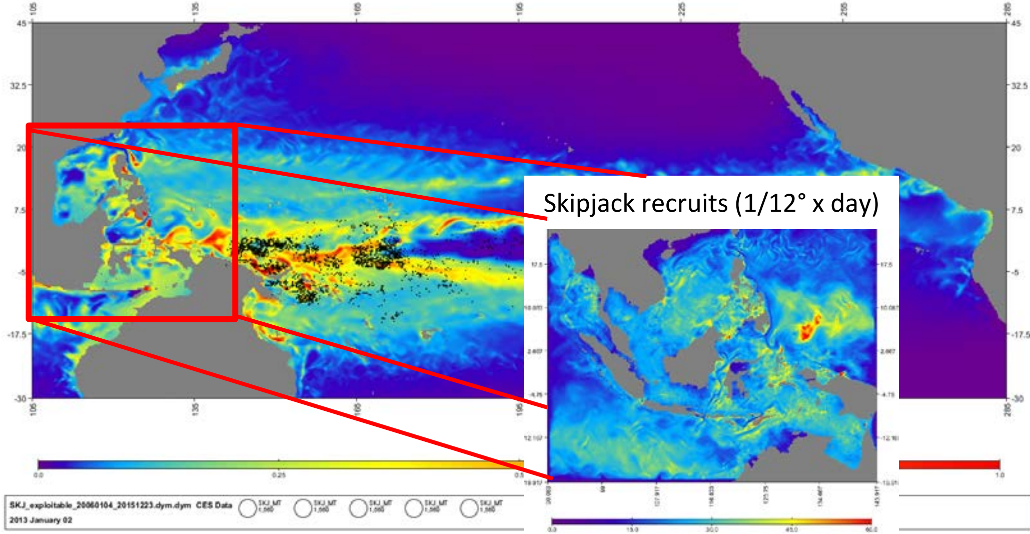


Towards Realistic L&MTL products

Example from a spatially-explicit population dynamics model relying on physical and biological (***Low and mid-trophic levels***) conditions



www.seapodym.eu

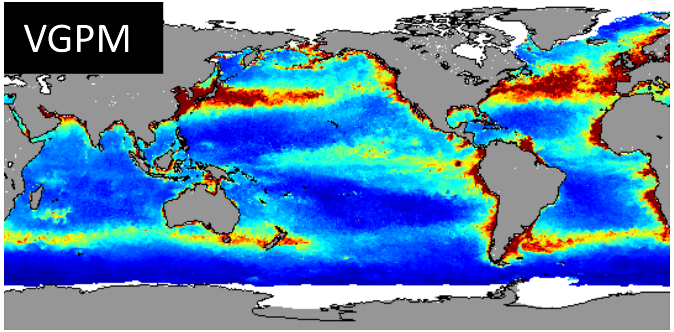


Towards Realistic L&MTL products

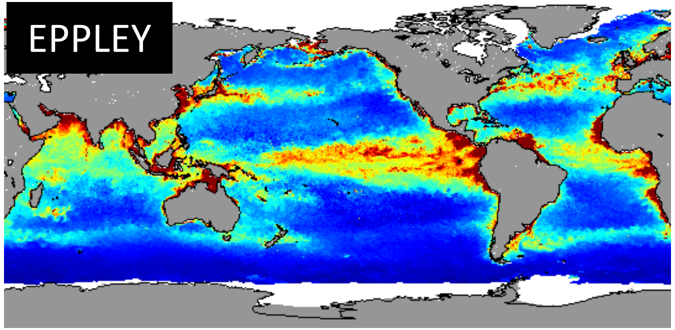
The first essential product is Primary Production:

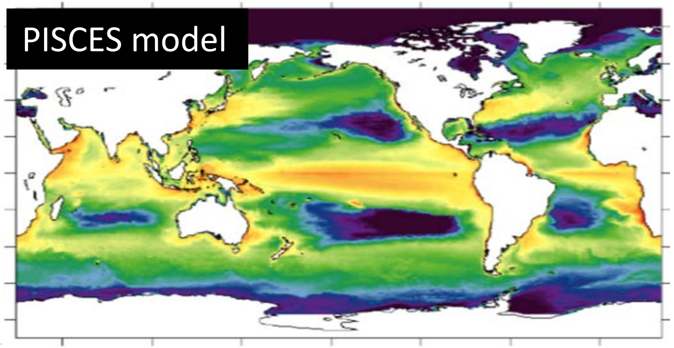
In the few coming years = we can expect convergence between ocean biogeochemical and empirical satellite-derived models together with in situ data.

polynomial function of SST

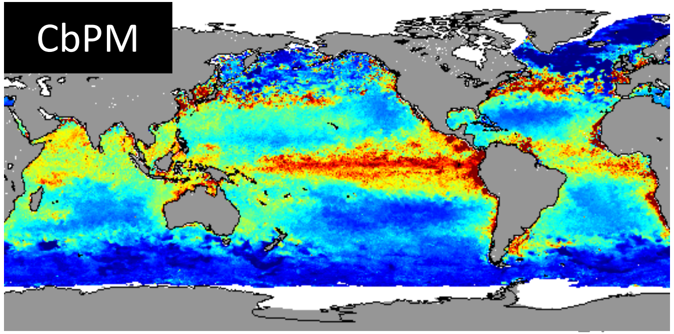


exponential function of SST



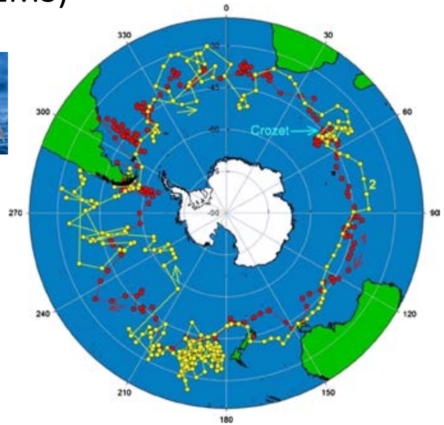


carbon * growth rate * f(par) * z_eu

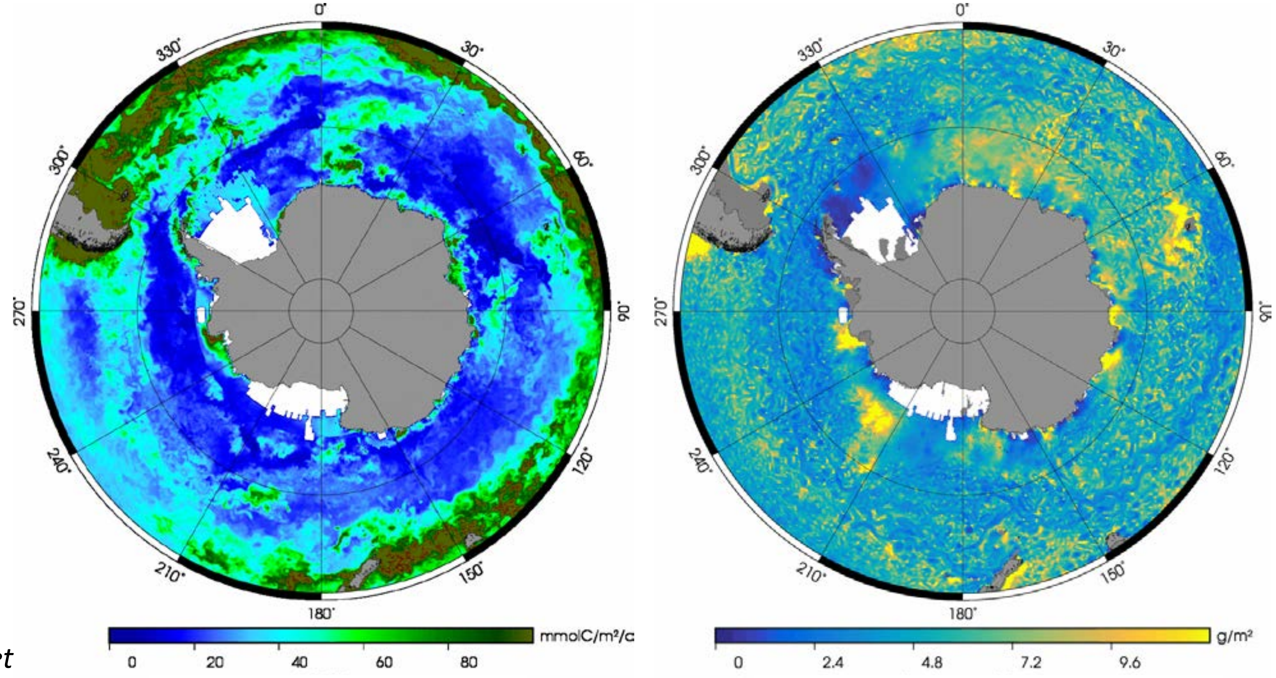


Towards Realistic L&MTL products

One year (2016) simulation of mesopelagic biomass at ¼°x week, using satellite derived PP, and temperature and currents from operational ocean model (CMEMS)



Double circumpolar movements of a male Crozet wandering albatross (Weirmerskirch et al. 2014)



Primary production

All mesopelagic groups

www.mesopp.eu

Ongoing progress

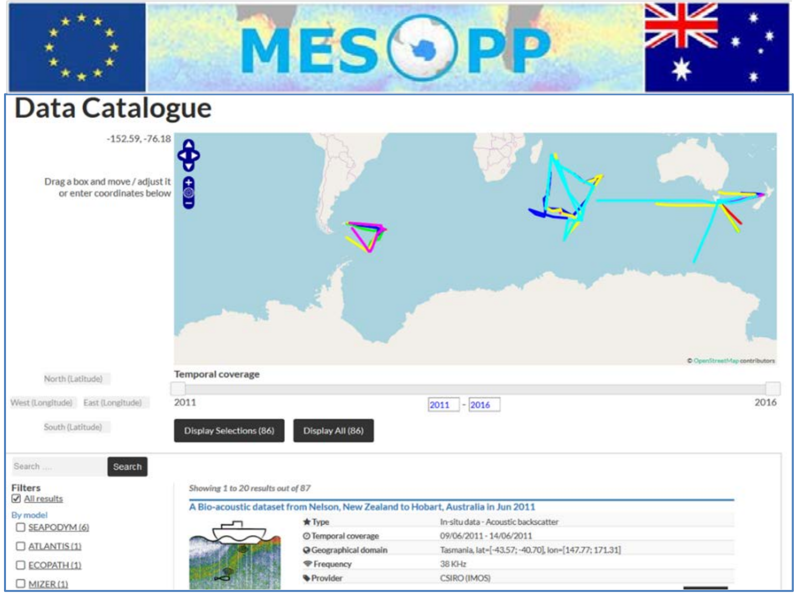
Copernicus Service Evolution

EU Horizon 2020

- **GREENUP: Green matrix Uploaded; 2016-2018**
- **LMTL: Marine Ecosystem Low to Mid-Trophic Levels; 2018-2020**

⇒ improving, optimising and validating the model with acoustic data

1- Optimal Design of Acoustic sampling for LMTL
2- Operational demonstration for Atlantic albacore tuna



3rd MESOPP Workshop: Falmouth, Cape Cod, USA, 9-11 Oct 2018

“Designing the needs for the implementation of a global coupled acoustic-based observation-modelling system”

Conclusions

- Modelling of Ocean Ecosystems has several facets (climate, biodiversity or resources), sharing the same bottleneck: low (primary production and zooplankton) and mid-trophic (micronekton) levels.
- There is a diversity of modeling approaches that can be directly driven by operational products of ocean circulation models and satellite derived observations and provide useful tools for monitoring and management of marine resources and conservation of biodiversity.
- Following the example of physical oceanography, pushing the models to the operational side (real time + data assimilation + high resolution) provides the most efficient ground testing with rapid feedback and improvement.
- Archived and new data are needed to provide the ground truth for these new products.

Support welcome!