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# Views from top predator fishes: Do top predator fishes decide their distribution by environment or forage species

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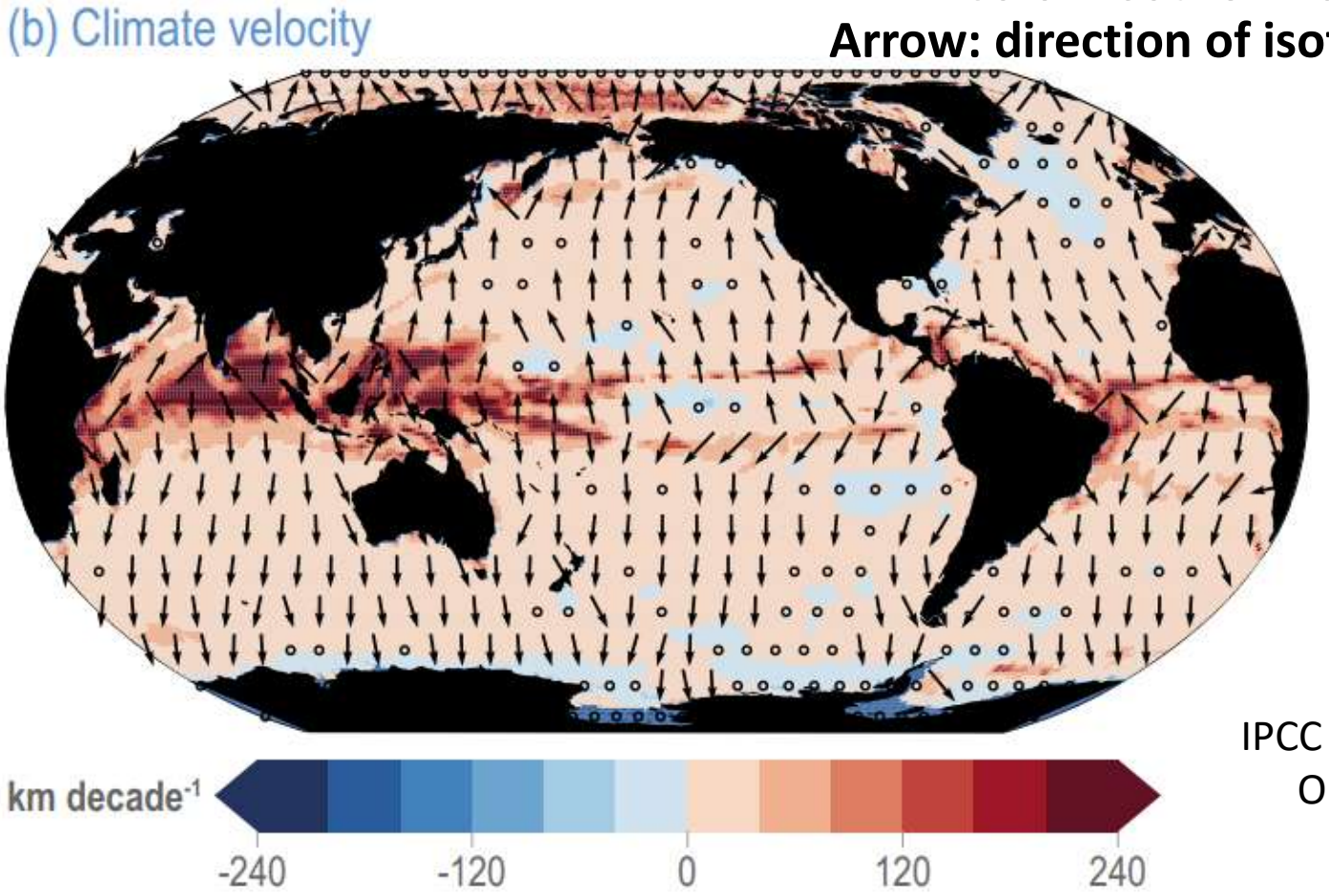
**Today's contents**

1. Introduction (thermal vs prey)
2. Eddies and top predator (tunas)
3. Environments vs forage
    1) squids
    2) Spanish mackerel
    3) Chub mackerel
4. Conclusion and future perspectives

# Thermal restriction

**Color: isotherm shift speed during 2016 – 1925**
**Arrow: direction of isotherm shift during 2016 - 1925**

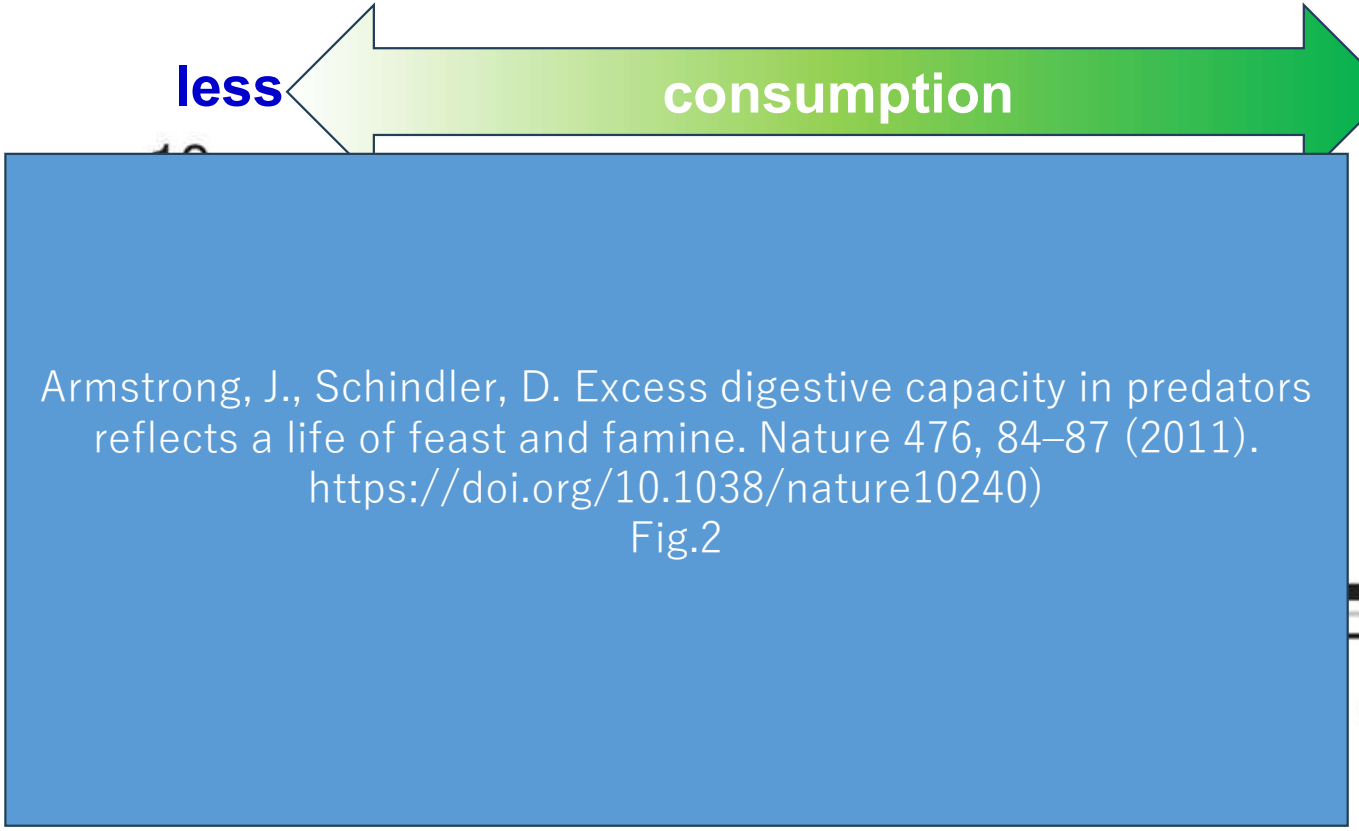



- **Fish are basically ectotherms that cannot maintain their body temperature.**
- **As the optimum temperature zone shifts, fish must shift poleward**

IPCC AR6 WGII (2022)
Oliver et al. (2018)

# Food restriction

less consumption enough

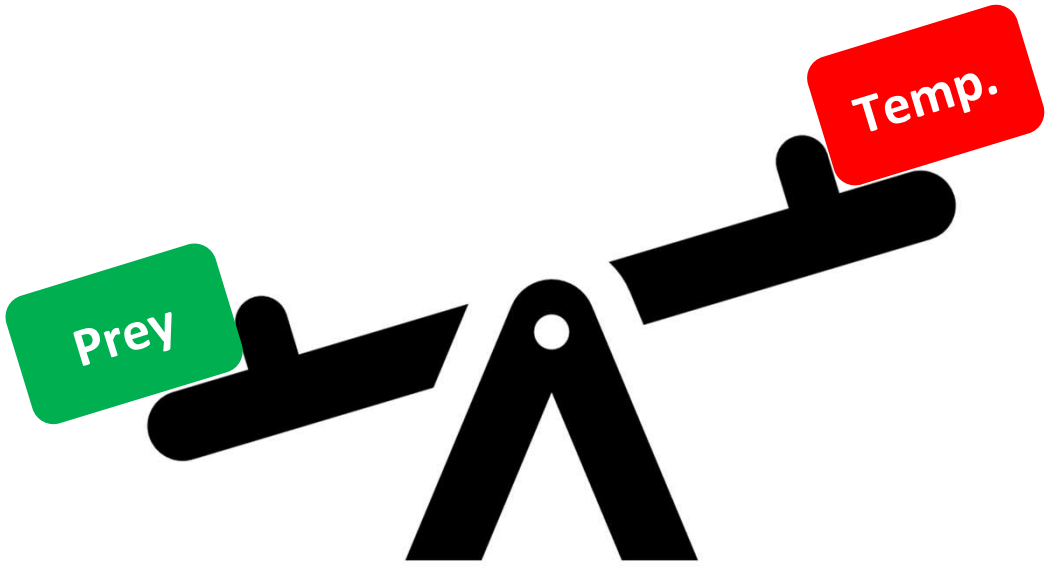



Armstrong and Schindler (2011, Nature)


**For predator fishes, it is challenging to achieve positive energy balance. Predator fishes maintain a capacity for food-processing that exceeds average levels of consumption. But, …**

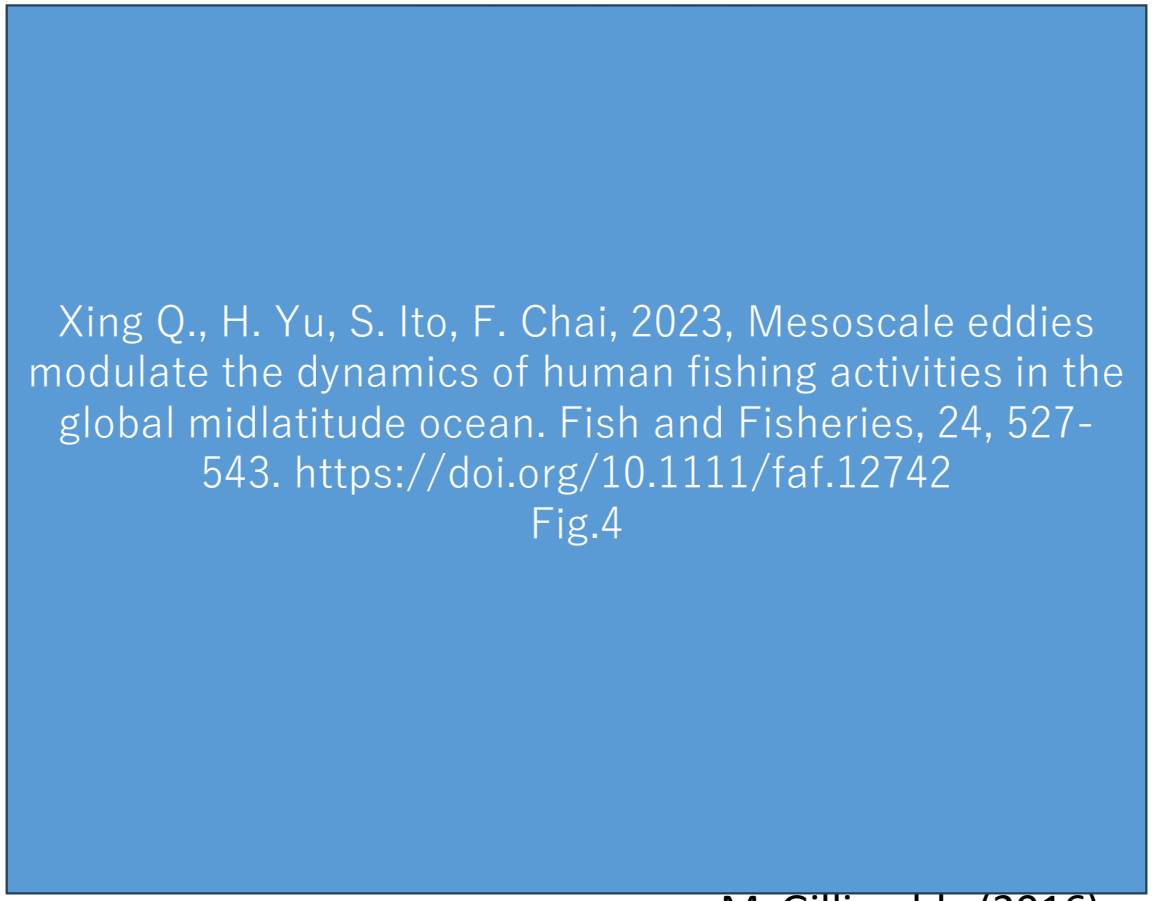
# Big question

**How top predator fishes decide their distribution under a tradeoff between severe thermal restriction and heterogeneous forage availability.**



# Mesoscale eddies & Chl-a

a Gulf Stream **Chl-a in eddies**



Xing Q., H. Yu, S. Ito, F. Chai, 2023, Mesoscale eddies modulate the dynamics of human fishing activities in the global midlatitude ocean. Fish and Fisheries, 24, 527-543. https://doi.org/10.1111/faf.12742
Fig.4

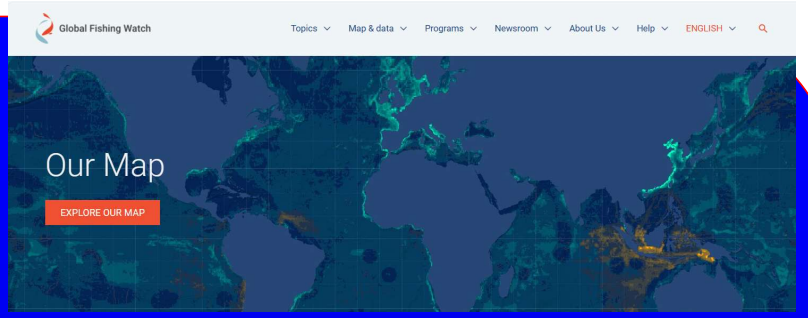
McGillicuddy (2016)

**About 50% of Chl-a is trapped in the mesoscale eddies, while mesoscale eddies occupy only 25% of the world ocean (Zhao et al., 2021)**

**In the mid-latitude, cyclonic eddy is productive (McGillicuddy, 2016)**

**However, there is no global assessments for the relationship between top predator and eddies**

# Global fishing data & eddy data

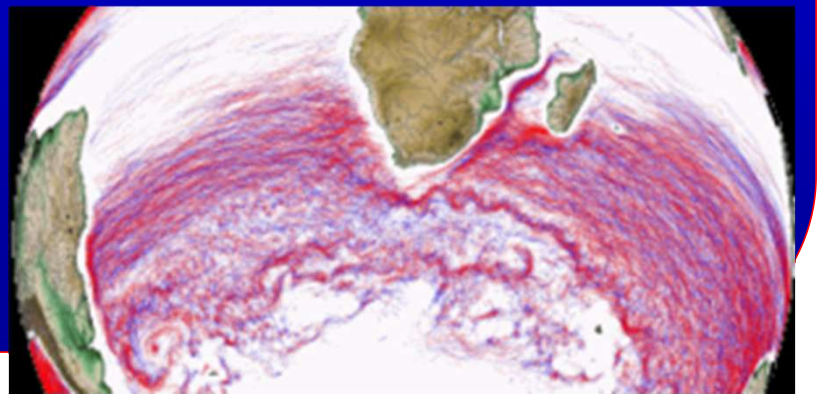



**AIS (Automatic Identification System)**
**https://globalfishingwatch.org**

- **Jan.2012 – Dec.2020**
- **Daily fishing hours (0.1×0.1°) and fishing gears (0.01×0.01°)**
- **114,897,958 records (Kroodsma et al., 2018)**

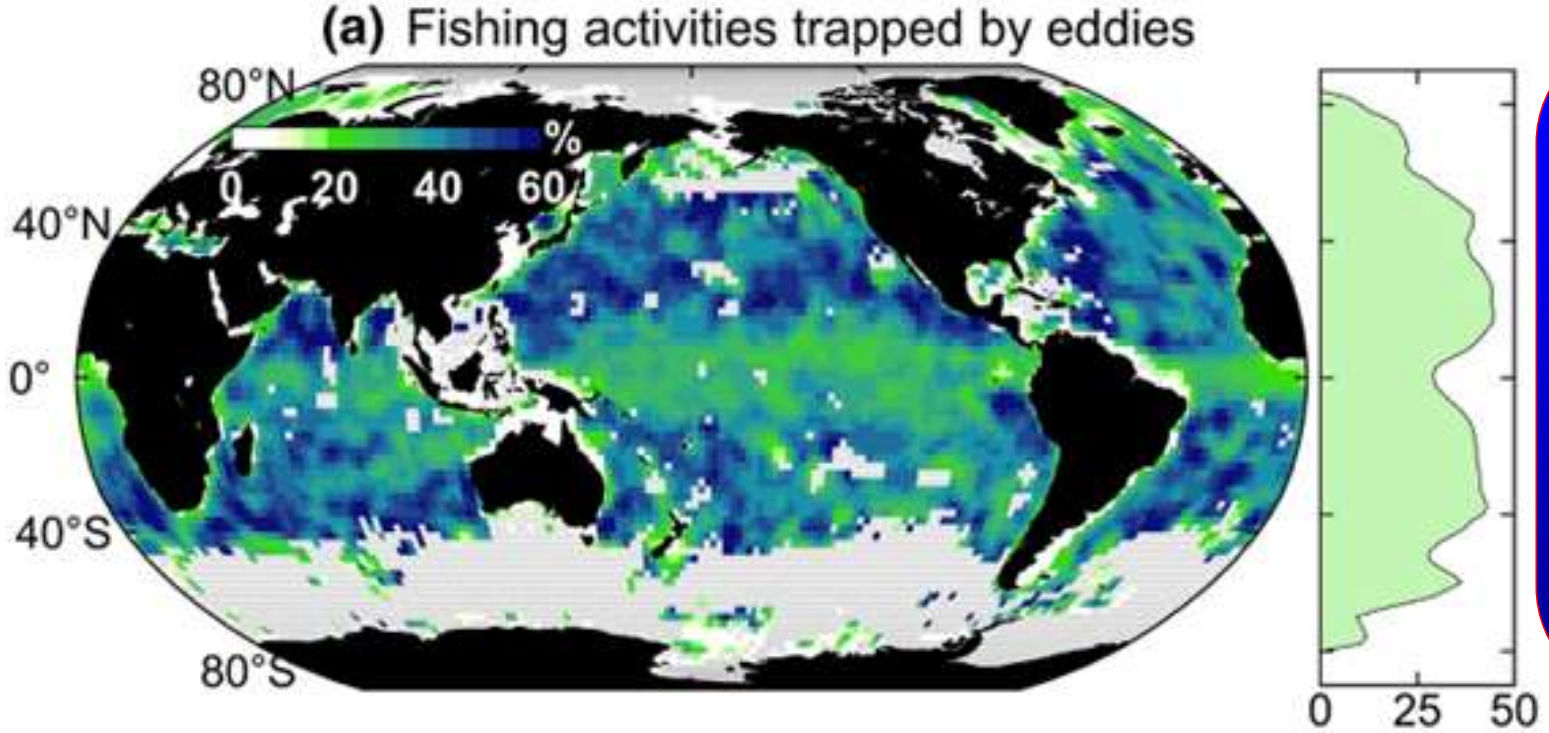
**Mesoscale Eddy Tracking Atlas (META) 3.1exp DT all-satellites**
**https://aviso.altimetry.fr**

- **improve Py-Eddy-Tracker algorithm is applied for 0.25×0.25°dynamic height data (Pegliasco et al., 2021)**



**Chl-a: https://resources.marine. copernicus.eu/**
**Temperature, DO: BGC-Argo**

# Ratio of fishing hours trapped in eddies







**Global mean:**
**Eddy area: 31.05%**
**Fishing in eddy: 37.29%**

**Mid-latitudes:**
**Fishing in eddy: 41.62%**

Xing et al. (2023, Fish & Fisheries)

**Ratio of fishing hours in eddies (zonal average, %)**

# Anticyclonic eddy－Cyclonic eddy (ratio of fishing hour)

Xing Q., H. Yu, S. Ito, F. Chai, 2023, Mesoscale eddies modulate the dynamics of human fishing activities in the global midlatitude ocean. Fish and Fisheries, 24, 527-543. https://doi.org/10.1111/faf.12742
Fig.1

**Global mean:**
**Cyclones: 17.46%**
**Anticyclones: 19.83%**

**Mid-latitude:**
**Cyclones: 17.38%**
**Anticyclones: 24.24%**
**CE<AE（p < .01）**

Xing et al. (2023 , Fish & Fisheries)

**AE-CE ratio of fishing hours (zonal average, %)**

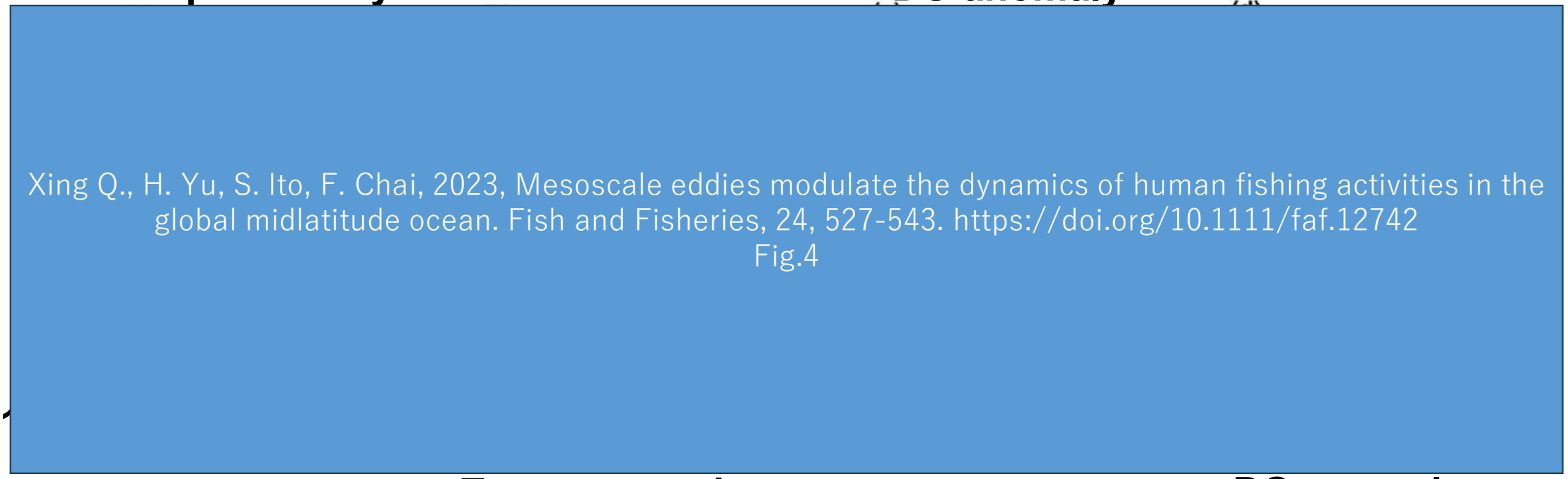
## Big contradiction

**Fishing efforts are aggregated in less productive warm eddies.**

**Mid-latitude large fishery boats are dominated long line fishery for tuna species.**

# Environmental differences (Argo float composites)

**Temp. anomaly** **DO anomaly**




**Eddy coordinates** **Temp. anomaly** **Eddy coordinates** **DO anomaly**

**3D composites in eddies**
**High temp. & DO in the intermediate layers**

Xing et al. (2023, Fish & Fisheries)

# Main target of large fishing boats: tunas

Xing et al. (2023)

Xing Q., H. Yu, S. Ito, F. Chai, 2023, Mesoscale eddies modulate the dynamics of human fishing activities in the global midlatitude ocean. Fish and Fisheries, 24, 527-543. https://doi.org/10.1111/faf.12742
Fig.5

**Higher temp. & DO enable tunas to feed on mesopelagic species longer time.**

## How about for different species

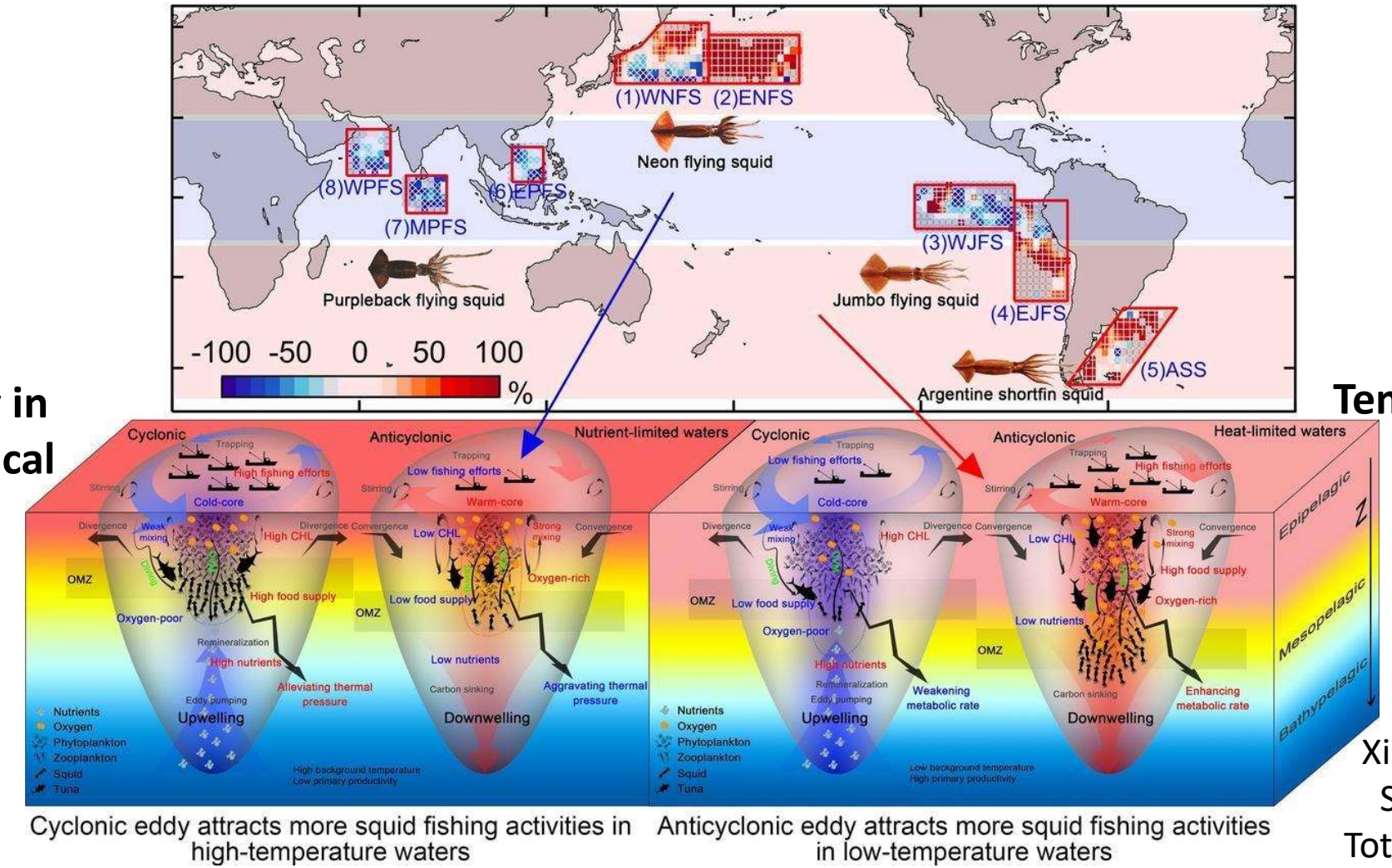
**Squids (Xing et al., 2024, Sci. Total Env.)**
**Prey in low lat. & temp in high lat.**

**Spanish mackerel (Liu et al., 2022, Deep-Sea Res. II)**
**Influenced by anchovy**

**Chub mackerel (Yu et al., 2023, Front. Mar. Sci.)**
**Anchovy dependent**

# Squid responses are different between tropical & mid-latitude

Mesoscale eddies exert inverse latitudinal effects on global industrial squid fisheries




Cyclonic eddy attracts more squid fishing activities in high-temperature waters

Anticyclonic eddy attracts more squid fishing activities in low-temperature waters

Xing et al. (2024, Science of The Total Environment)

# Conclusion and Future perspectives

1. **Predators are always facing to shortage of foods.**
   **Their distribution is highly restricted by food availability.**

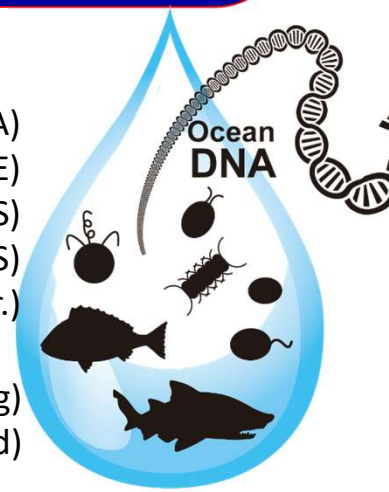
2. **Aggregation to less productive warm eddies**
   **Warm temp. and high oxygen enable predators elongate feeding activity.**

1. **Fishing efforts are influenced by economical factors.**
   **Need fishery independent data (e.g. eDNA)**

Wong, Ito et al. (2022, Env. DNA)
Yu, Ito, et al. (2022, PLOS ONE)
Yu, et al. (2023, Frontiers MS)
Ahmet at al. (2025, RSMS)
Ahmed et al. (J. Oceanogr.)

2. **Fronts and fish distribution**
   **Developed a new front detection algorithm**
   **Need to test fish distribution across fronts**

Xing et al. (2023, Remote Sensing)
Xing et al. (submitted)



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