SWORDFISH CATCH VARIATION IN RELATION TO MESOSCALE EDDIES IN THE NORTHWESTERN PACIFIC

Xiphias gladius

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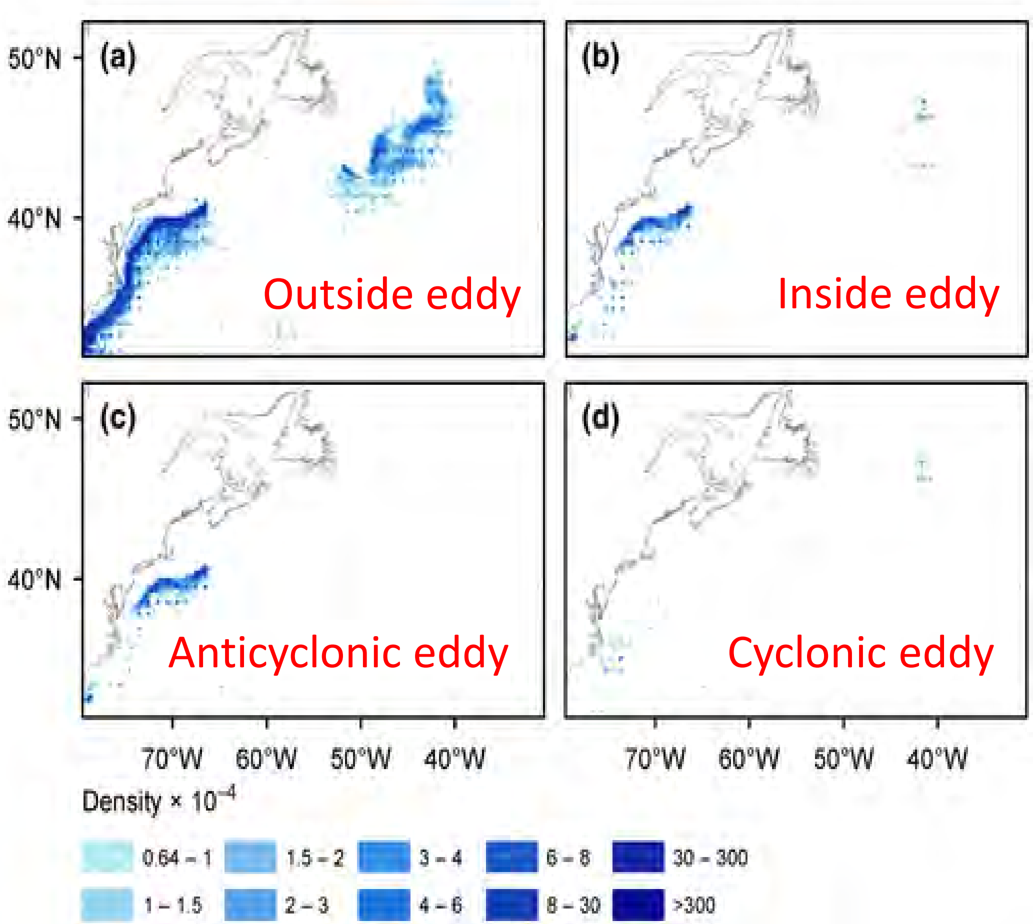
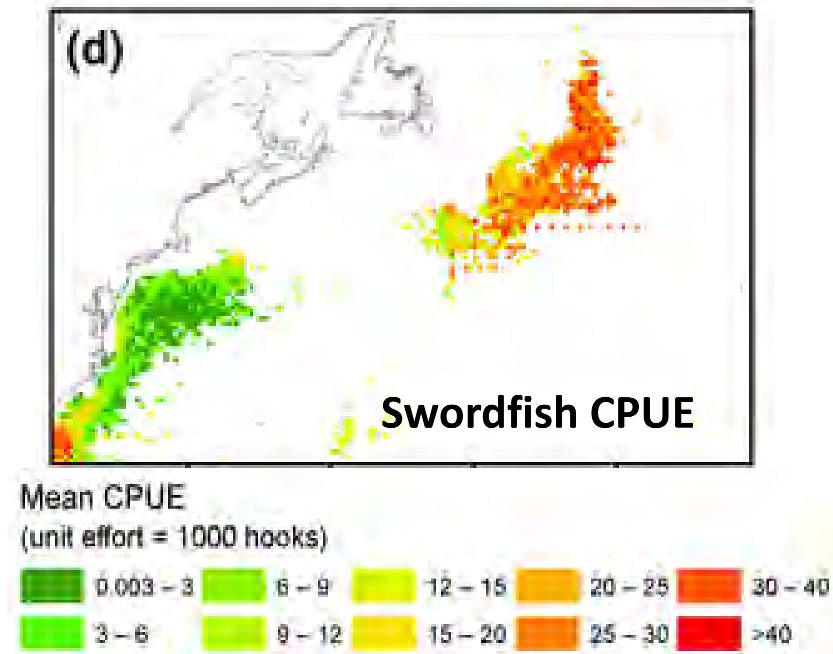
PREVIOUS STUDIES

Hsu et al. (2015) reported that swordfish catch is found preferentially outside of eddies.

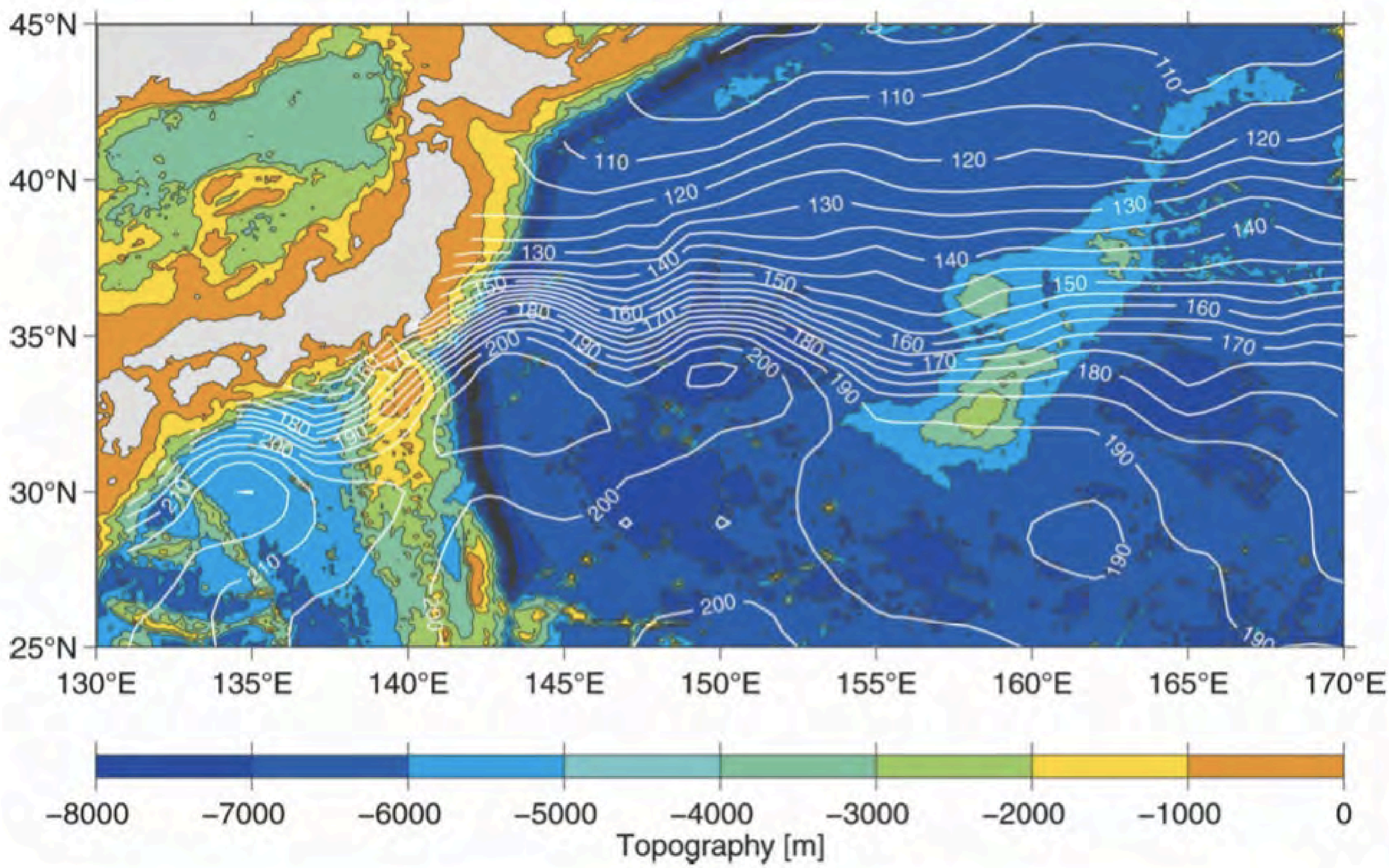
Density of longline hauls



However, Hsu et al. study was limited to the northwestern Atlantic, and the relation with temporal variabilities of the mesoscale flows was not discussed.



KUROSHIO EXTENSION SYSTEM



Qiu and Chen 2005

The **OBJECTIVES** of this study are:

- **To reveal** where a better swordfish catch is expected regarding the mesoscale parameters.

- **To understand** how the swordfish catch varies in relation the mesoscale flows in the Kuroshio Extension region.

DATA

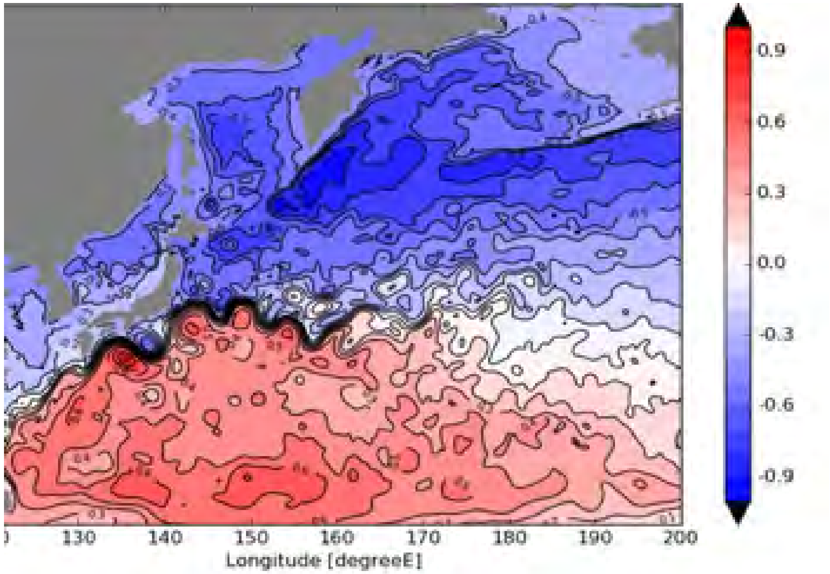
Ocean Reanalysis data

Four-dimensional Variational Ocean Re-Analysis for the Western North Pacific over 30 years (FORA-WNP30).

Area: 117°E – 160°W, 15°N – 65°N.

-Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

-Japan Meteorological Agency (JMA)



Fishery data

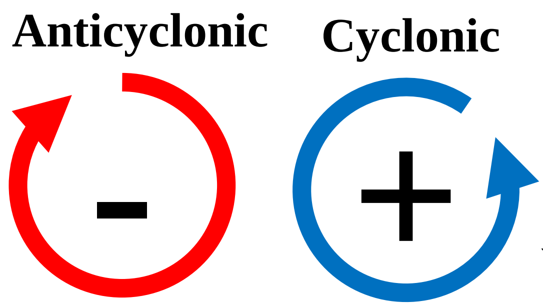
Data collected by commercial longline vessels of **Kesennuma port** in the region **25° N – 45° N, 138° E – 160° W** from 2004 through 2010.

TOTAL DATA: 27398 Registered data

-Fisheries Research Agency, FRA.

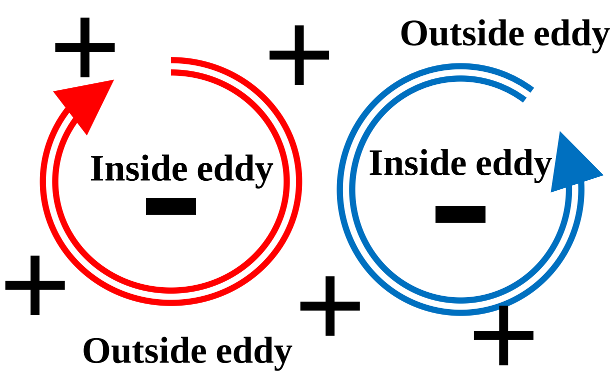
Vorticity

$$\zeta = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y},$$



Okubo-Weiss parameter

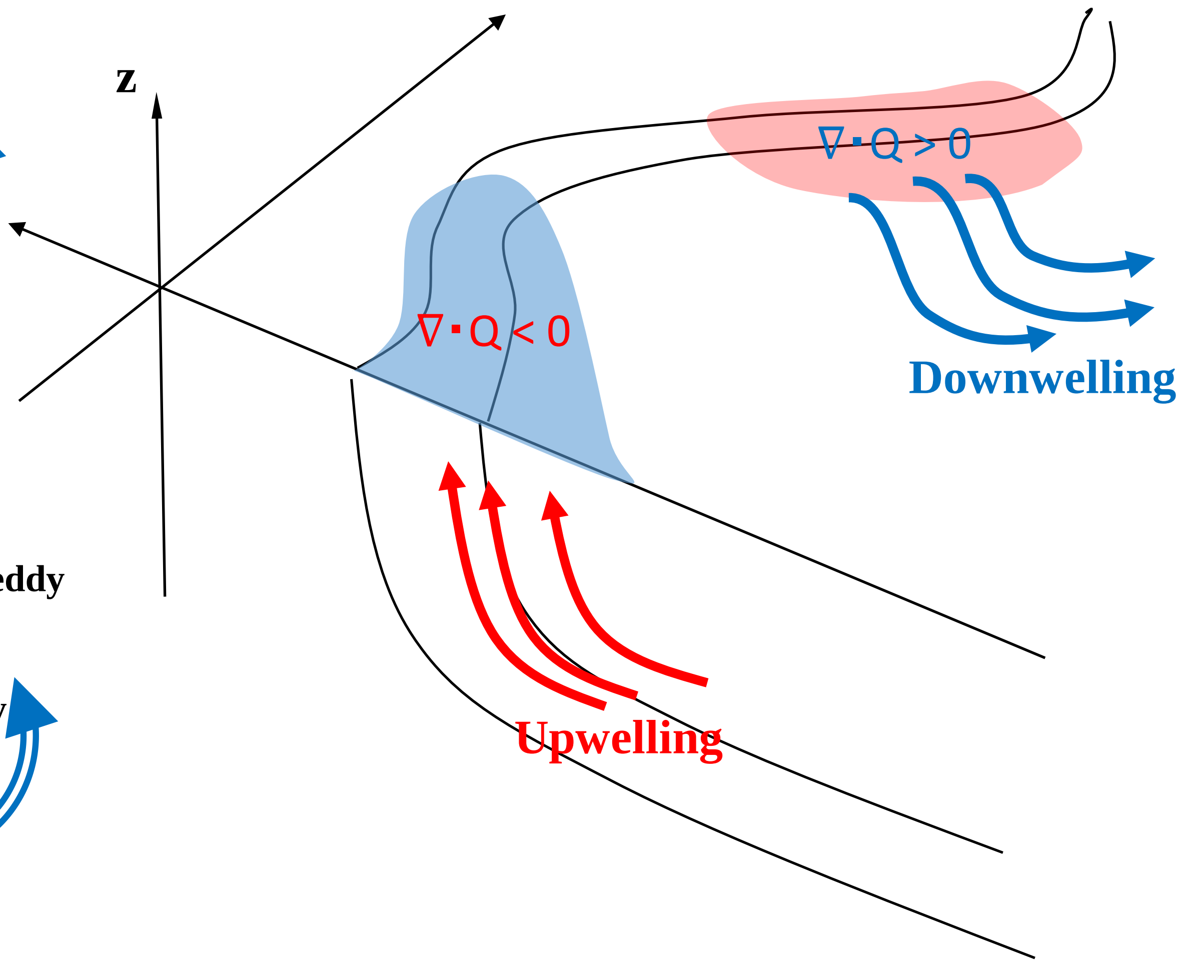
$$\mathrm{OW} = 4\left[\left(\frac{\partial u}{\partial x}\right)^2 + \frac{\partial v}{\partial x}\frac{\partial u}{\partial y}\right]$$



Divergence of Q-vector

$b = -g\rho/\rho_o$ Buoyancy

$$\nabla_h \cdot \mathbf{Q} = -\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}\frac{\partial b}{\partial x} + \frac{\partial v}{\partial x}\frac{\partial b}{\partial y}\right) - \frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}\frac{\partial b}{\partial x} + \frac{\partial v}{\partial y}\frac{\partial b}{\partial y}\right),$$

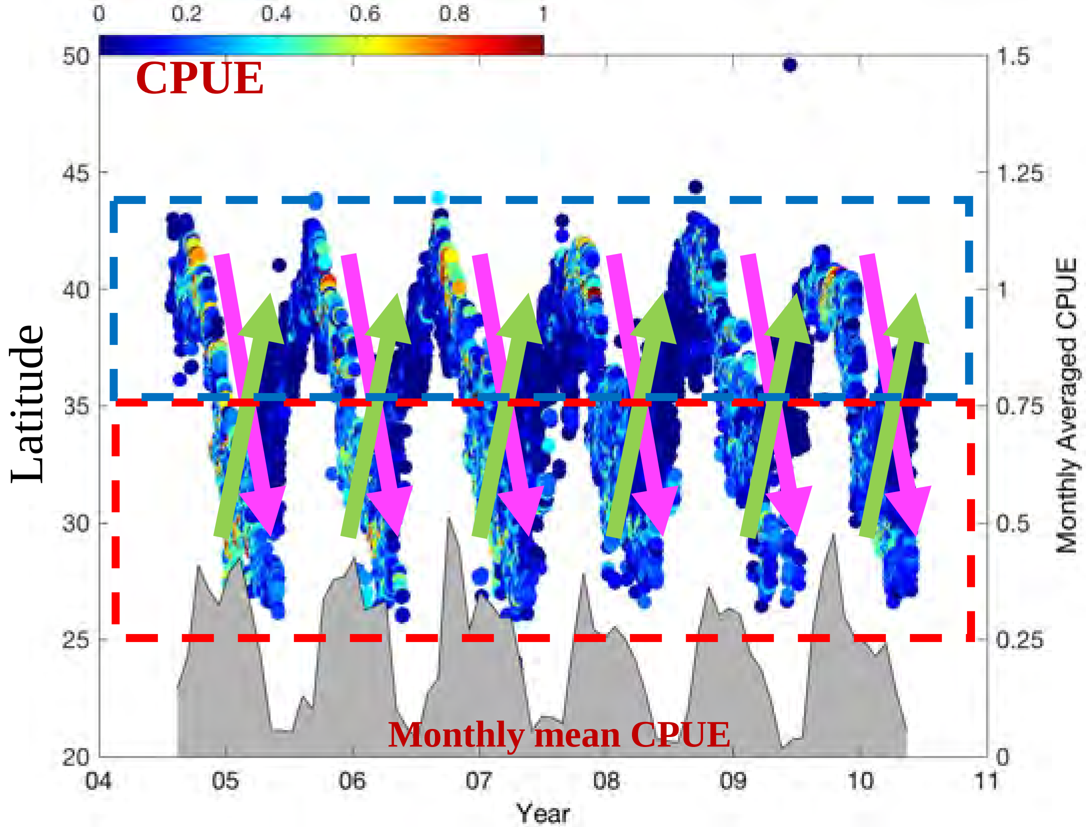


RELATIVE ABUNDANCE OF SWORDFISH

↔ *Proportional* ↔

$$\text{CPUE} = 1000\frac{\text{Total \# of fish catch}}{\text{Total \# of hooks}}.$$

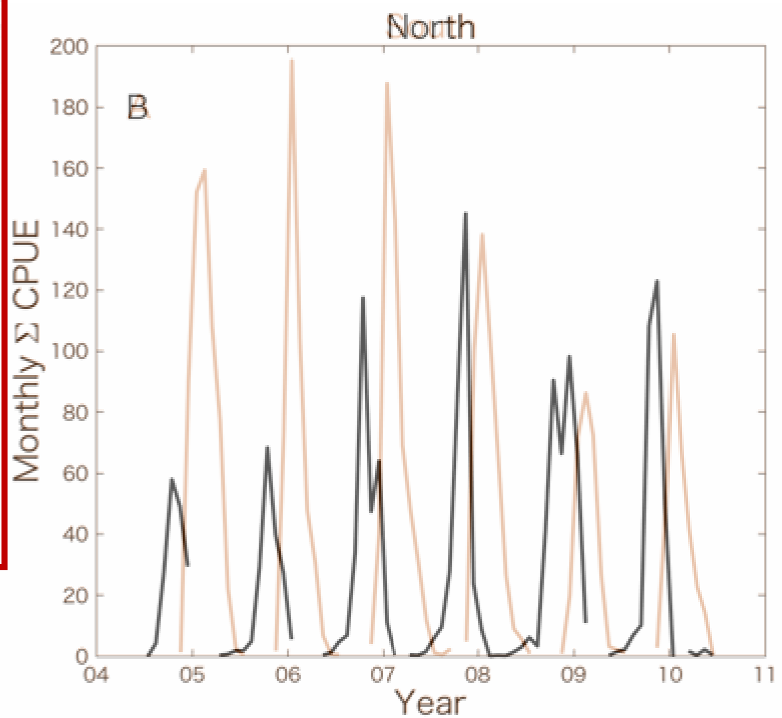
RESULTS



Meridional migration patterns - monthly integrated CPUE

From autumn to winter: swordfish fishing activities migrate southward from **43° N → 26°N**.

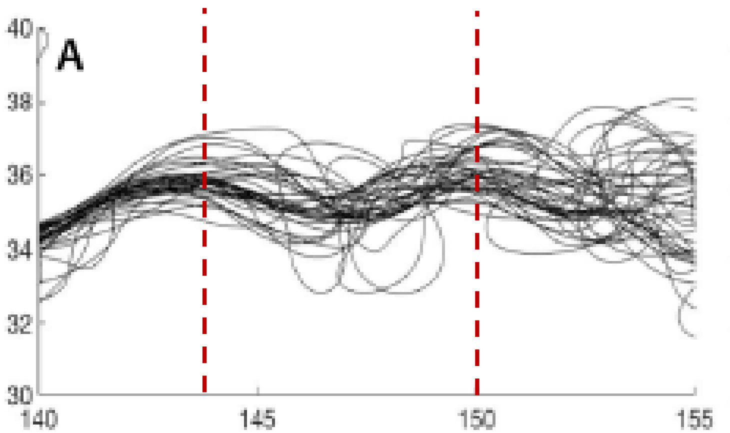
From spring to summer: swordfish fishing activities go from **26°N → 43°N**.



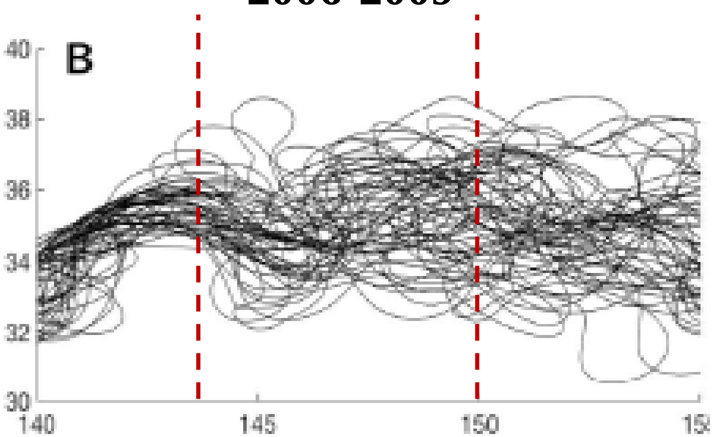
Southern region: 25° N - 35ºN

Northern region: 35° N - 45ºN

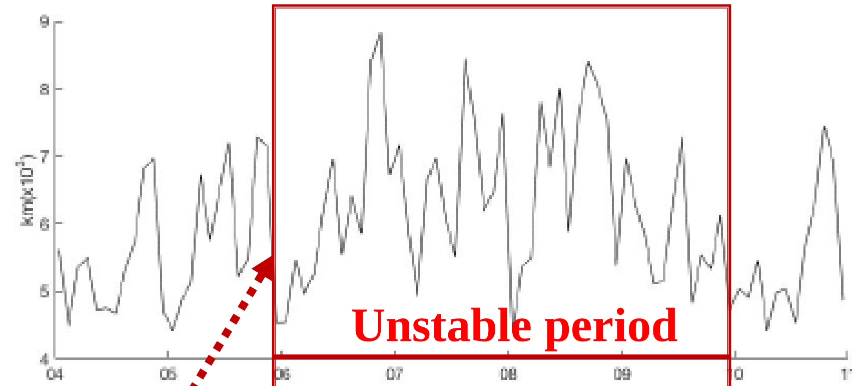
Stable KE path
2004-2005, 2010



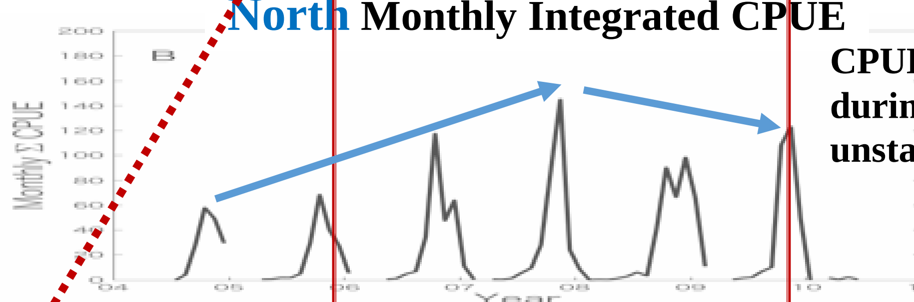
Unstable KE path
2006-2009



KE path length



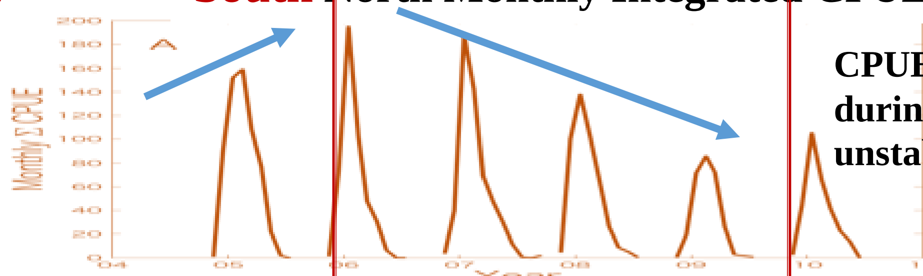
North Monthly Integrated CPUE



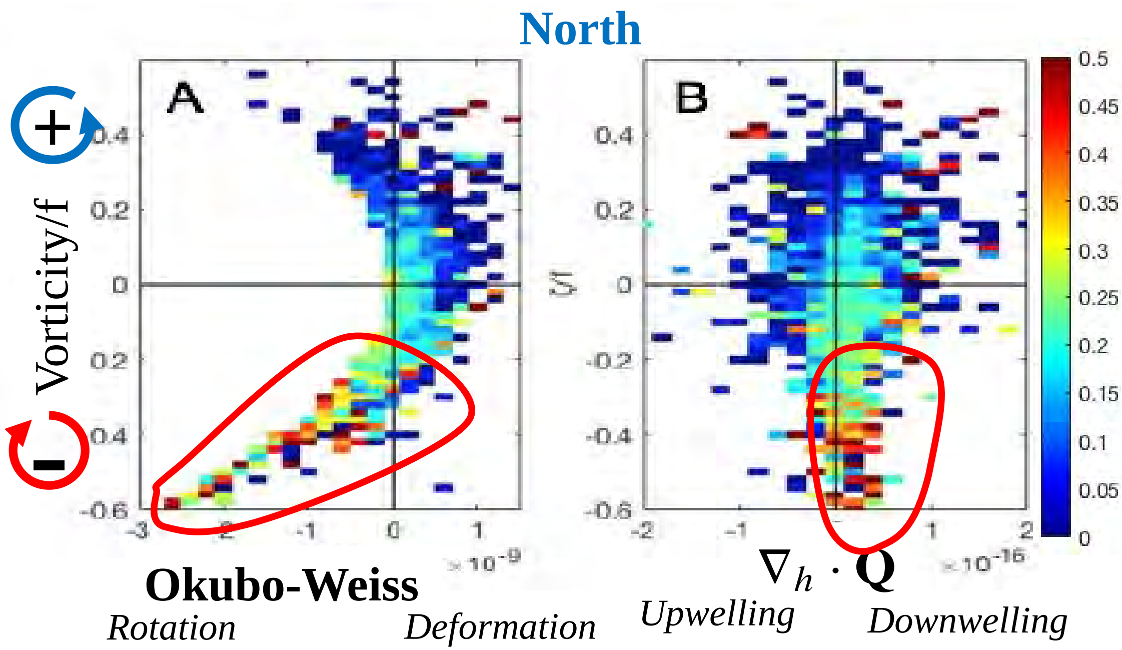
CPUE increase during unstable phase

Unstable period

South North Monthly Integrated CPUE



CPUE decrease during unstable phase

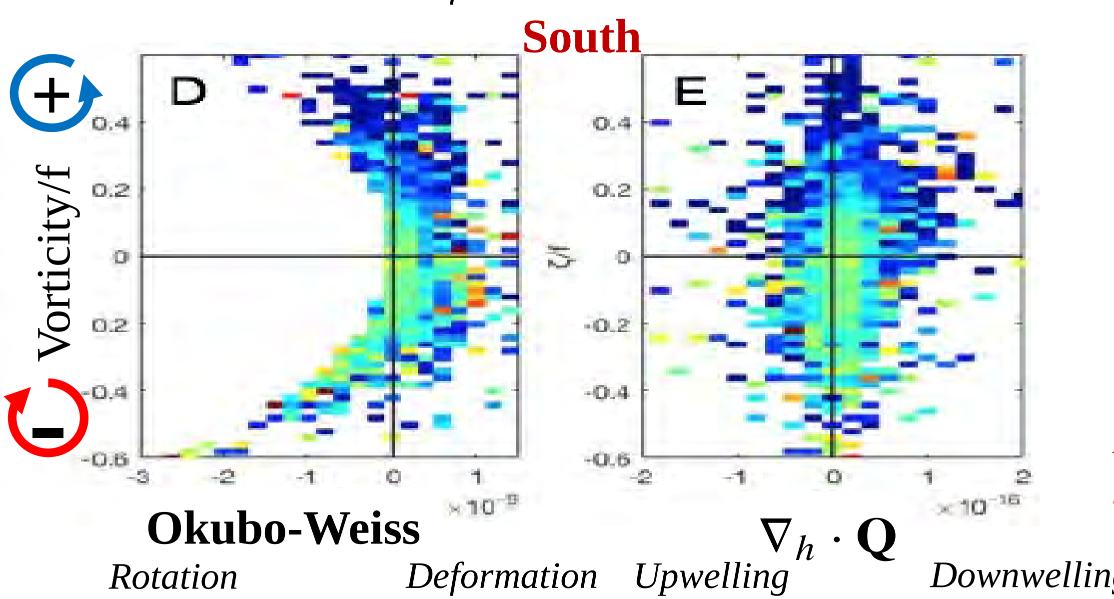


In Northern region,

- Higher CPUE values are mostly associated with negative vorticity **ζ < 0** in rotating regime with **negative OW.**

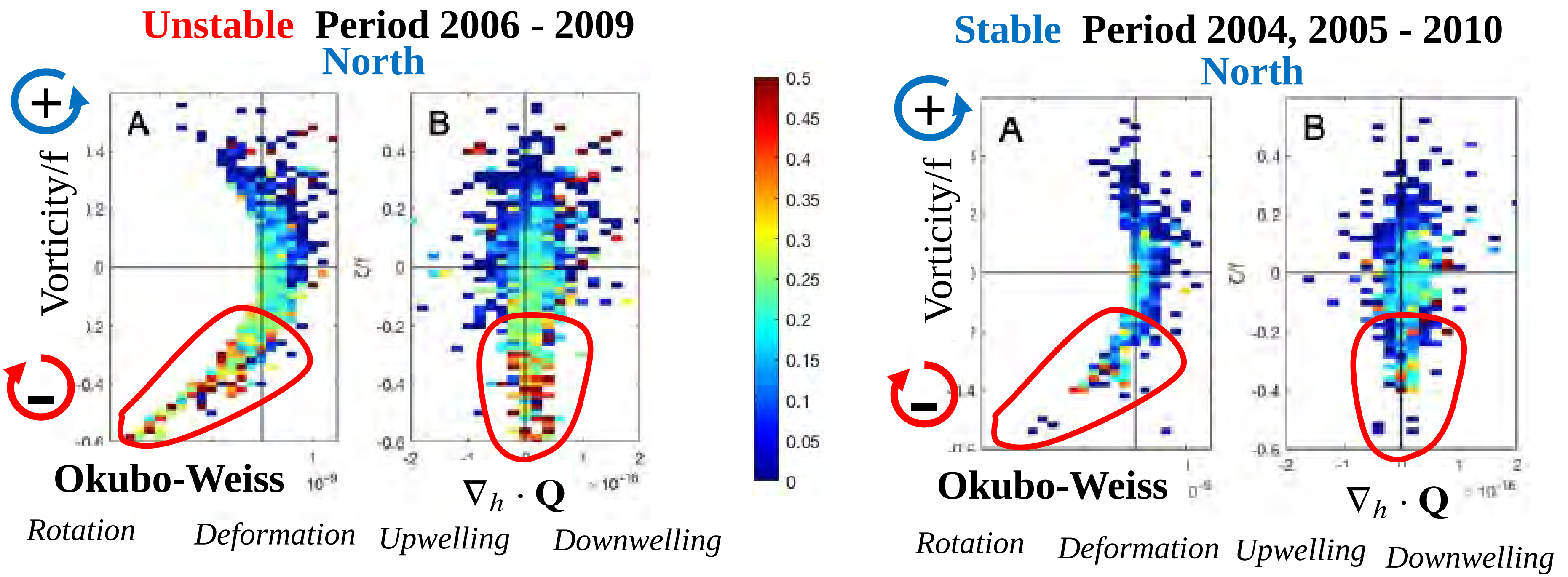
→ Anticyclonic eddies.

- Bin-averaged CPUE as a function of $\nabla_h.Q$ suggests slightly positive value: **DOWNWELLING TENDENCY**



This implies that **better fishing ground** for swordfish is formed within **anticylonic eddies** (warm core rings) in **downwelling** motion.

However, in Southern region, there is no such clear tendency.



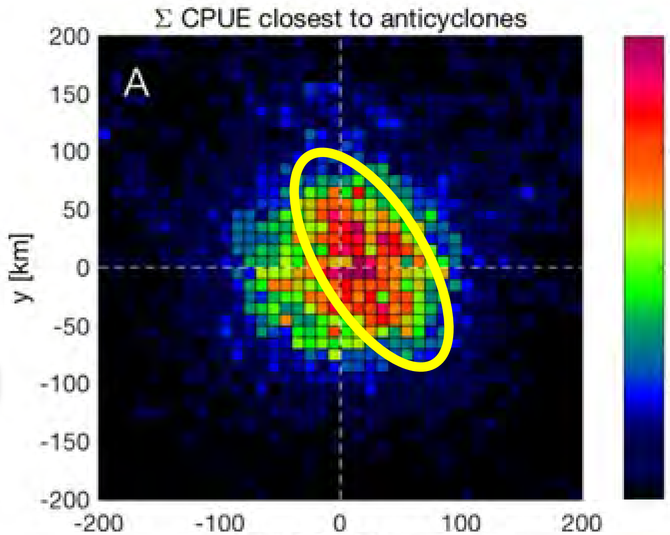
- Separated analyses for unstable and stable periods show that the tendency of high CPUE within **warm core rings** with downwelling motion **is only found in unstable period in northern region.**

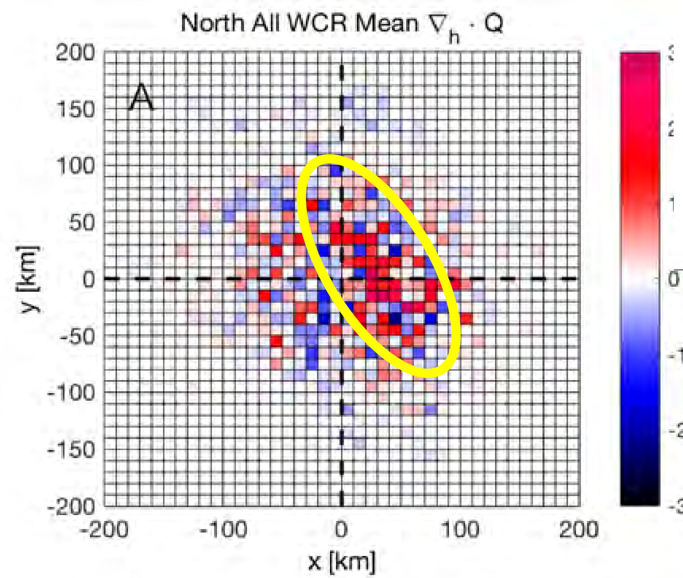
RESULTS

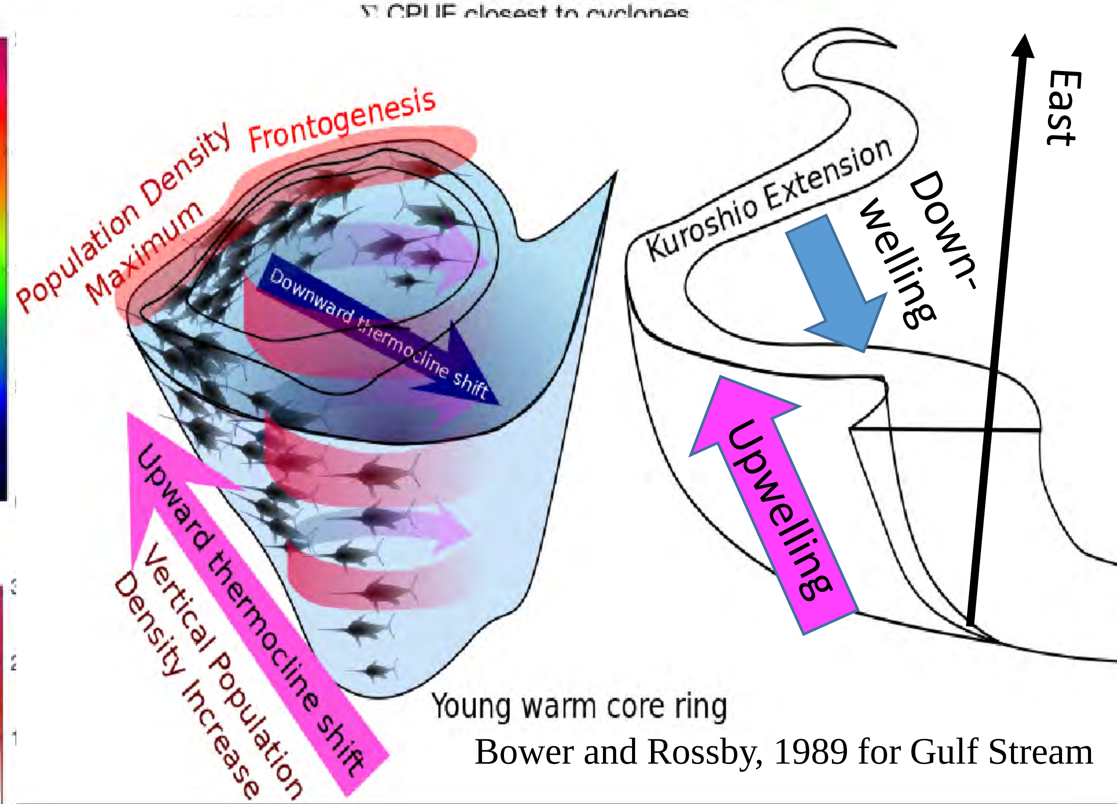
EDDY DETECTION ANALYSIS: ALL DETECTED EDDIES

Integrated CPUE closest to Anticyclonic Eddy

Integrated CPUE closest to Cyclonic Eddy





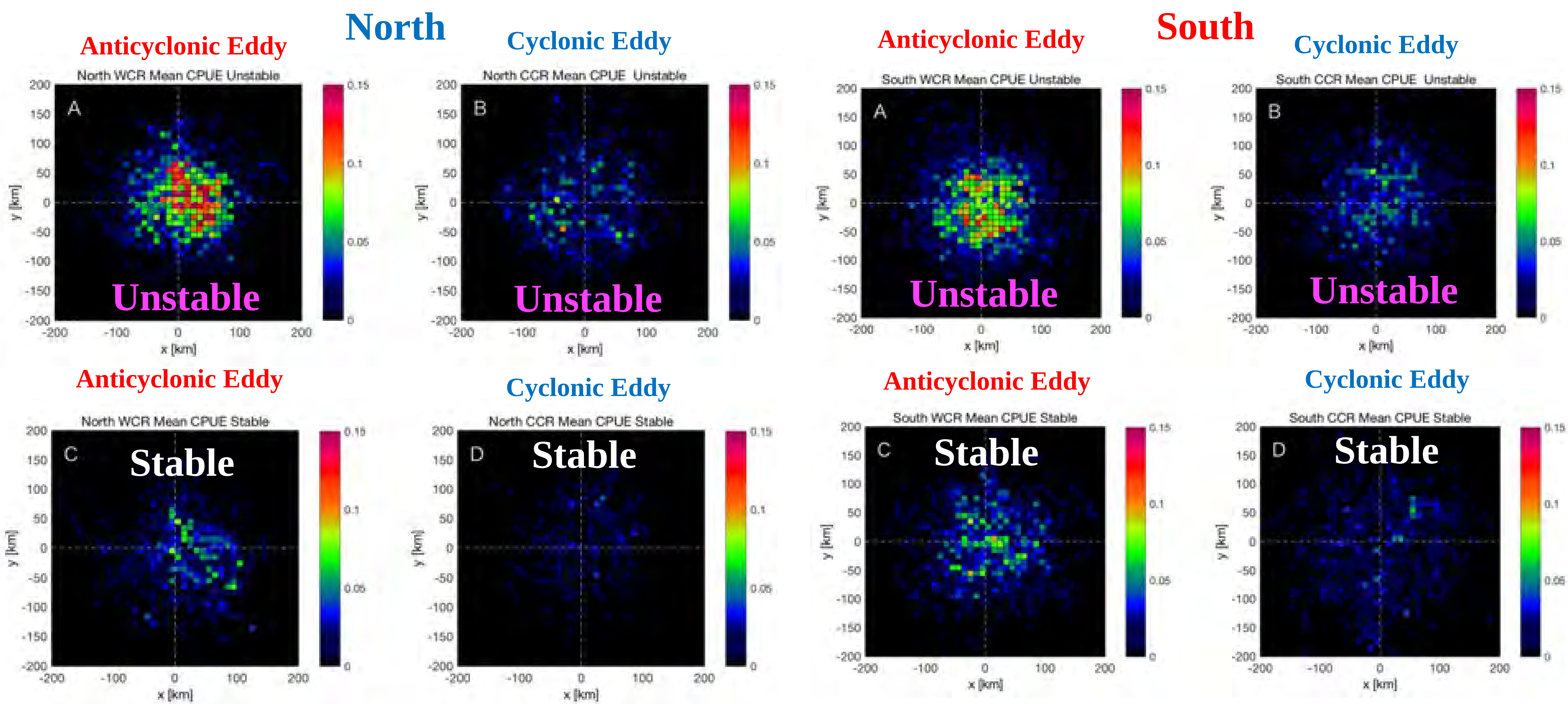


Bower and Rossby, 1989 for Gulf Stream

Divergence of Q-vector in anticyclonic eddies: **Downwelling tendency** on the **northeastern** side of the eddies.

Eddy Detection Analysis: Stable, Unstable, Northern-Southern

Integrated CPUE with respect to the closest to eddies



The anticyclonic eddies in the northern region are dominantly causing the tendency of high CPUE.

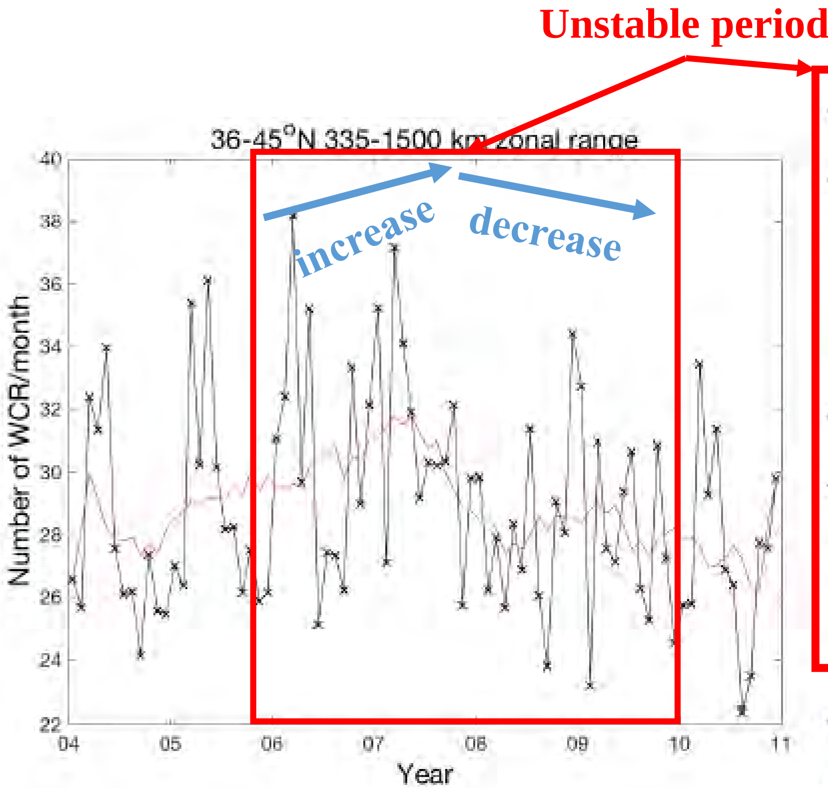
Also this tendency is caused by anticyclonic eddies in the northern region during unstable KE period.

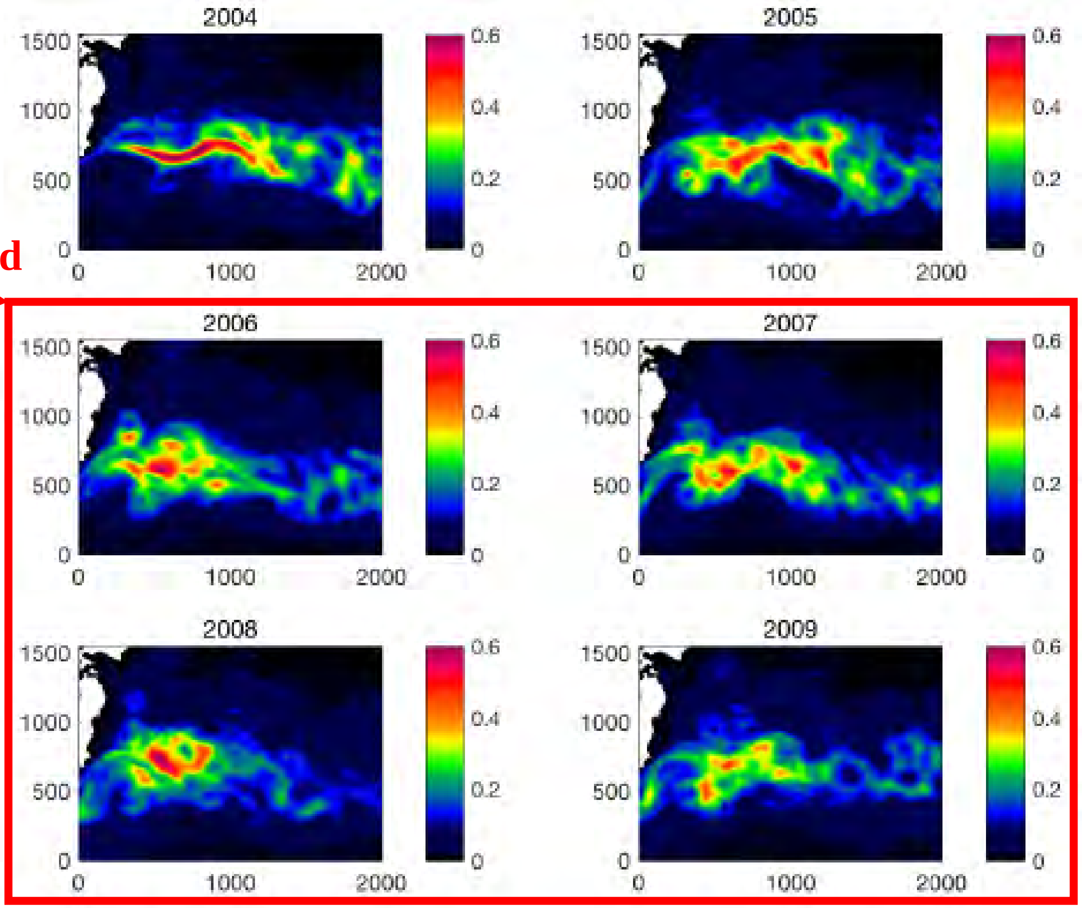
However, the amplitudes are much smaller by several factors in the southern region.

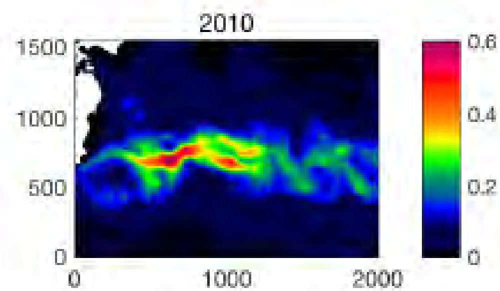
RESULTS

Interannual variations in Number of Anticyclonic Eddy and Eddy Kinetic Energy

Wider meridional width of higher **Eddy Kinetic Energy** → consistent with more **anticyclonic warm core rings** in the **unstable period.**

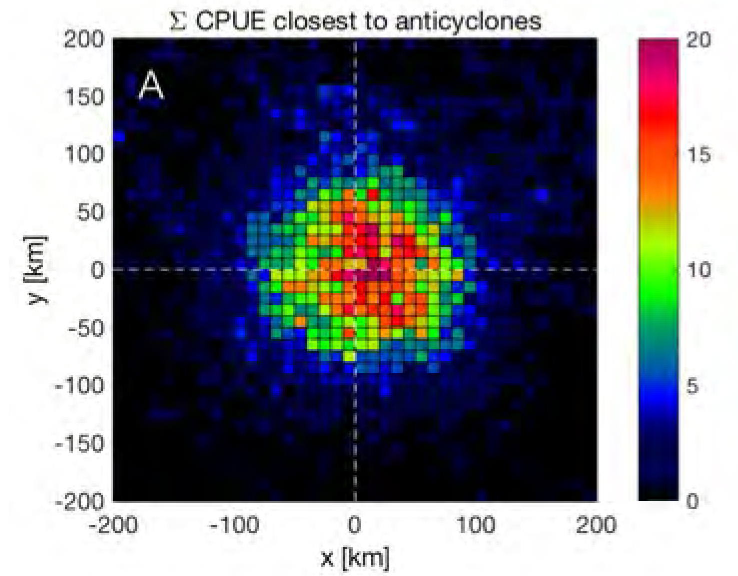






Top 100 m annual mean eddy kinetic energy [m^2s^2] from 2004 through 2010 obtained from FORA-WNP30 data.

CONCLUSIONS AND IMPLICATIONS



- Higher CPUE can be found more efficiently in the **anticyclonic eddies**, during the **unstable period of the KE** (2006 – 2009).

- Higher CPUE values are found in the **northeastern side of anticyclonic eddies.**

Hypothesis: These warm core eddy's physical structures may concentrate swordfish on this side of the anticylones.

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