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

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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

TOTAL DATA: 27398 Registered data

-Fisheries Research Agency, FRA.
Vorticity

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

Okubo-Weiss parameter

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

Divergence of Q-vector

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

Buoyancy

\[ b = -\frac{g \rho}{\rho_0} \]

\[ \nabla \cdot Q > 0 \quad \text{Downwelling} \]

\[ \nabla \cdot Q < 0 \quad \text{Upwelling} \]
METHODOLOGY

EDDY DETECTION

RELATIVE ABUNDANCE OF SWORDFISH

CPUE = \( 1000 \frac{\text{Total # of fish catch}}{\text{Total # of hooks}} \).
RESULTS

SEASONAL CHANGE OF SWORDFISH CPUE

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

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

Southern region: 25°N - 35°N
Northern region: 35°N - 45°N
RESULTS

INTERANNUAL CHANGE IN THE KUROSHIO EXTENSION SYSTEM

Stable KE path
2004-2005, 2010

Unstable KE path
2006-2009

KE path length

Unstable period

North Monthly Integrated CPUE

CPUE increase during unstable phase

Unstable period

South Monthly Integrated CPUE

CPUE decrease during unstable phase
PHYSICAL CONDITIONS FOR HIGH SWORDFISH CATCH

RESULTS

In Northern region,
- Higher CPUE values are mostly associated with negative vorticity $\zeta < 0$ in rotating regime with negative OW.
  - Anticyclonic eddies.
- Bin-averaged CPUE as a function of $\nabla_h \cdot Q$ suggests slightly positive value: DOWNWELLING TENDENCY

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

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

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

Bower and Rossby, 1989 for Gulf Stream
RESULTS

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.

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

Also this tendency is caused by anticyclonic eddies in the northern region during unstable KE period.
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 [m²s⁻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 anticyclones.
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