Analysis of the impact of mesoscale eddies on the abundance and distribution of Japanese chub mackerel (*Scomber japonicus*) in the northwest Pacific Ocean

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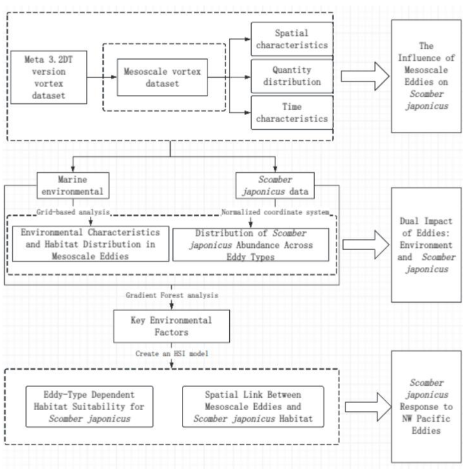
Background:

The Japanese chub mackerel (*Scomber japonicus*) is a key economic pelagic fish in the northwest Pacific Ocean, where it exhibits a trend towards a younger, smaller population. This species plays a vital role in the local trophic cascade, with a diet that shifts from copepods to euphausiids and fish as it matures. Its recruitment is highly sensitive to environmental variability.

Mesoscale eddies are abundant in this region and significantly influence the marine environment. Cyclonic eddies promote cold-water upwelling, while anticyclonic eddies involve warm-water downwelling. These processes alter temperature-salinity structures, nutrient transport, and chlorophyll-a distribution.

Eddies may regulate *S. japonicus* distribution through multiple pathways: by reshaping prey fields via vertical mixing, acting as physical barriers at their edges, and transporting eggs and larvae via rotational flow fields. The synergistic mechanisms and nonlinear impacts of these environmental factors on the species' abundance require further systematic investigation.

Method:



Result 1: Statistical Analysis of Mesoscale Eddies in the Northwest Pacific Ocean

Figure 1 The Spatial Distribution of Anticyclonic and Cyclonic Eddies in the Northwest Pacific Ocean. Variation in the Monthly and Annual Numbers of Anticyclonic and Cyclonic Eddies in the Northwest Pacific

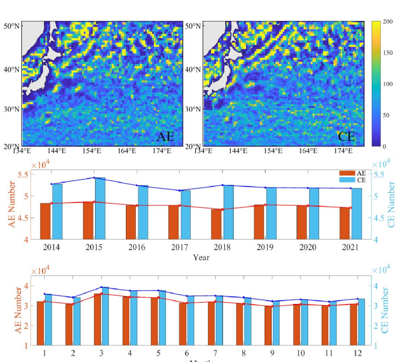


Figure 2 Spatial Distribution of Mesoscale Eddy Characteristic Parameters in the Northwest Pacific. Temporal Variation in the Number of Mesoscale Eddy Characteristic Parameters in the Northwest Pacificr.

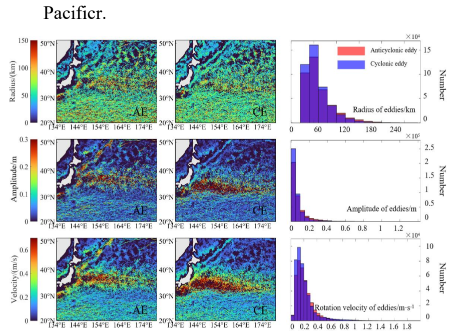
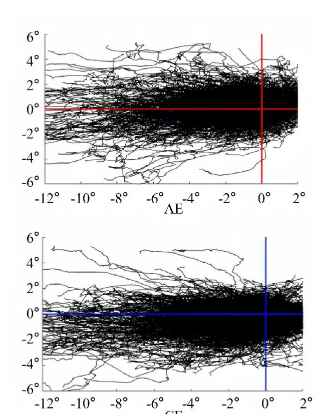
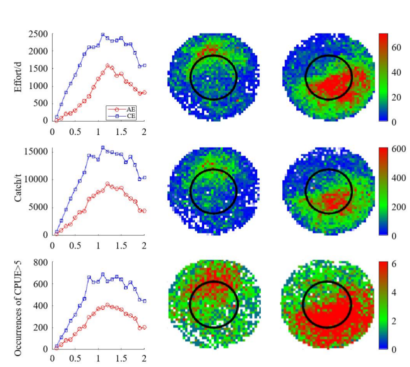


Figure 3 Relative Propagation Trajectories of Cyclonic and Anticyclonic Eddies in the Northwest Pacific



Result 2: The Relationship Between Eddies and the Abundance of S. japonicus

Figure 4 Distribution Patterns of Japanese Mackerel *Scomber japonicus* in Anticyclonic and Cyclonic Eddies



Result 3: Screening of Key Environmental Factors

Figure 5 Ranking of the Importance of Oceanic Environmental Factors on the CPUE of Japanese Mackerel *Scomber japonicus*

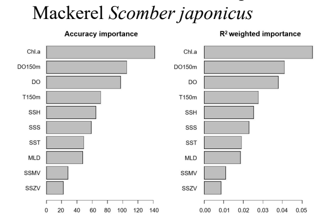


Figure 6 Fitting Curves of Japanese Mackerel *Scomber japonicus* CPUE and Key Environmental Factors

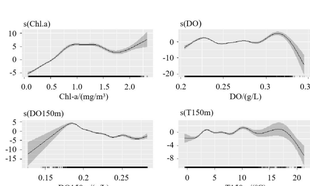
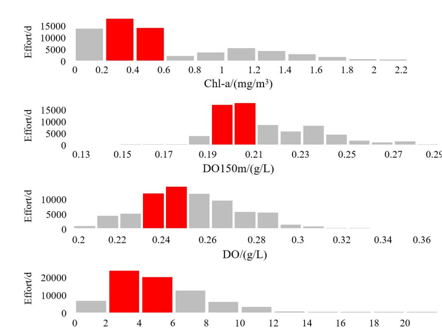


Table 1 Statistical results of the GAM model

GAM 变量	edf	Chi-sq	P-value	R^2-adj	偏差解释率
				0.07222	7.3%
Chl-a	7.982	114.70	<0.001***		
DO150m	8.582	66.76	<0.001***		
DO	8.769	49.18	<0.001***		
T150m	8.620	19.37	<0.001***		

Figure 7 Relationship Between the Distribution of Fishing Effort and Different Environmental Factors



Result 4: Environmental Variations Inside and Outside Eddies

Figure 8 Distribution of External and Internal Environmental Factors in AE and CE with Japanese Mackerel *Scomber japonicus* Operations

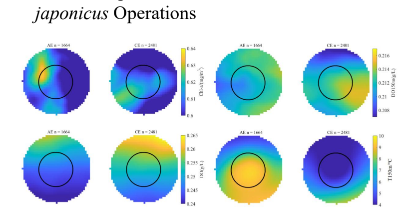
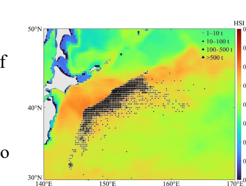


Table 2 Percentages of the suitable environment in the core and periphery of eddies

环境变量 environmental variable	0-R		R-2R	
	反气旋涡 /% anticyclonic eddy	气旋涡 /% cyclonic eddy	反气旋涡/% anticyclonic eddy	气旋涡 /% cyclonic eddy
Chl-a	41.69	48.25	41.19	50.44
DO150m	42.85	43.35	44.35	43.18
DO	34.03	32.27	34.67	34.63
T150m	17.56	69.37	34.97	59.11

Figure 9 Overlay of Japanese Mackerel *Scomber japonicus* Catch and HSI Values from April to November 2021



Result 5: HSI Model

Table 3 Fitted SI Model and Its Statistical Parameters

Month	Model	R^2	P
April	$SI_{Chl\text{-}a}$=EXP[-467.861*(chl-0.083)^2]	0.806	<0.001
	SI_{Do}=EXP[-528.093*(do-0.188)^2]	0.916	<0.001
	SI_{Do150}=EXP[-708.819*(do150-0.184)^2]	0.961	<0.001
	SI_{T150}=EXP[-0.079*(t150-8.203)^2]	0.997	<0.001
May	$SI_{Chl\text{-}a}$=EXP[-344.105*(chl-0.087)^2]	0.832	<0.001
	SI_{Do}=EXP[-311.959*(do-0.194)^2]	0.872	<0.001
	SI_{Do150}=EXP[-1193.25*(do150-0.204)^2]	0.922	<0.001
	SI_{T150}=EXP[-0.05*(t150-6.32)^2]	0.912	<0.001
June	$SI_{Chl\text{-}a}$=EXP[-366.395*(chl-0.101)^2]	0.727	<0.001
	SI_{Do}=EXP[-1196.821*(do-0.224)^2]	0.991	<0.001
	SI_{Do150}=EXP[-822.636*(do150-0.199)^2]	0.949	<0.001
	SI_{T150}=EXP[-0.098*(t150-4.84)^2]	0.974	<0.001
July	$SI_{Chl\text{-}a}$=EXP[-15.833*(chl-0.406)^2]	0.801	<0.001
	SI_{Do}=EXP[-1351.855*(do-0.233)^2]	0.887	<0.001
	SI_{Do150}=EXP[-800.174*(do150-0.205)^2]	0.921	<0.001
	SI_{T150}=EXP[-0.107*(t150-4.389)^2]	0.984	<0.001
August	$SI_{Chl\text{-}a}$=EXP[-0.831*(chl-0.435)^2]	0.926	<0.001
	SI_{Do}=EXP[-698.974*(do-0.259)^2]	0.865	<0.001
	SI_{Do150}=EXP[-331.341*(do150-0.211)^2]	0.908	<0.001
	SI_{T150}=EXP[-0.125*(t150-3.298)^2]	0.953	<0.001
September	$SI_{Chl\text{-}a}$=EXP[-1.238*(chl-1.139)^2]	0.900	<0.001
	SI_{Do}=EXP[-1257.33*(do-0.255)^2]	0.971	<0.001
	SI_{Do150}=EXP[-455.85*(do150-0.206)^2]	0.842	<0.001
	SI_{T150}=EXP[-0.243*(t150-2.41)^2]	0.956	<0.001
October	$SI_{Chl\text{-}a}$=EXP[-2.56*(chl-0.647)^2]	0.965	<0.001
	SI_{Do}=EXP[-1162.3*(do-0.259)^2]	0.998	<0.001
	SI_{Do150}=EXP[-682.588*(do150-0.198)^2]	0.908	<0.001
	SI_{T150}=EXP[-0.24*(t150-2.009)^2]	0.955	<0.001
November	$SI_{Chl\text{-}a}$=EXP[-6.178*(chl-0.463)^2]	0.941	<0.001
	SI_{Do}=EXP[-756.926*(do-0.242)^2]	0.893	<0.001
	SI_{Do150}=EXP[-1268.04*(do150-0.19)^2]	0.879	<0.001

Result 6: Distribution of Suitable Habitats for S. japonicus within Eddy Influence

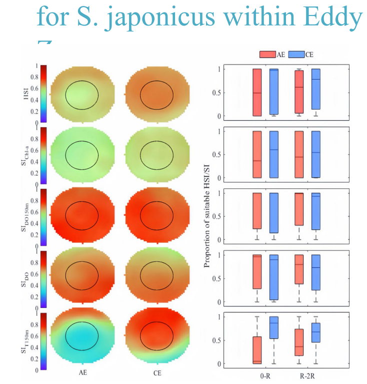


Figure 10 Spatial distribution of Mean SI Corresponding to Chl-a, DO at 150m, DO, and T at 150m around AE and CE. Boxplot of the Proportion of Suitable SI Values (SI ≥ 0.6) Corresponding to Chl-a, DO at 150m, DO, and T at 150m around AE and CE

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