Environmental impact assessment of spawning grounds in the Western Guangdong Waters, South China Sea, using RS/GIS

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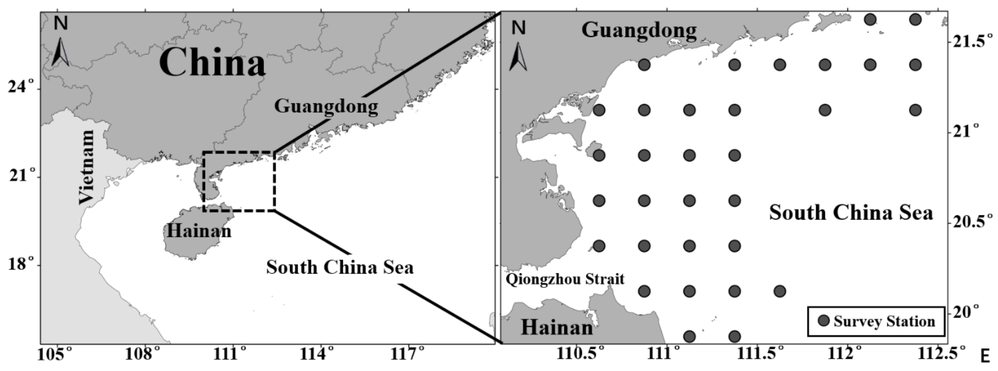
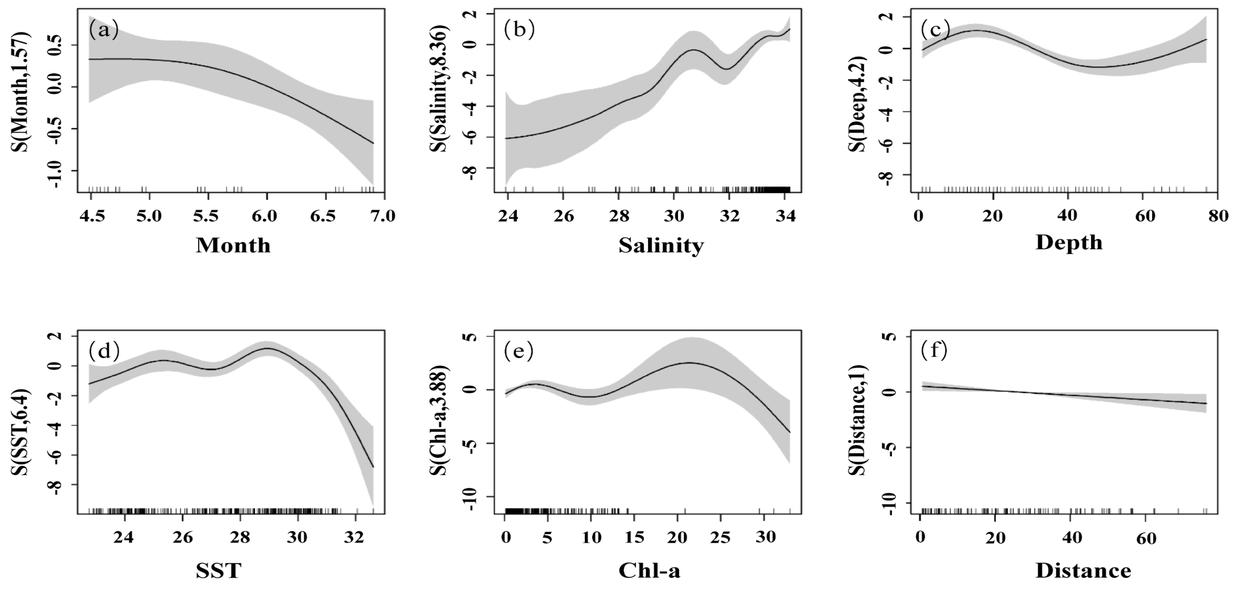
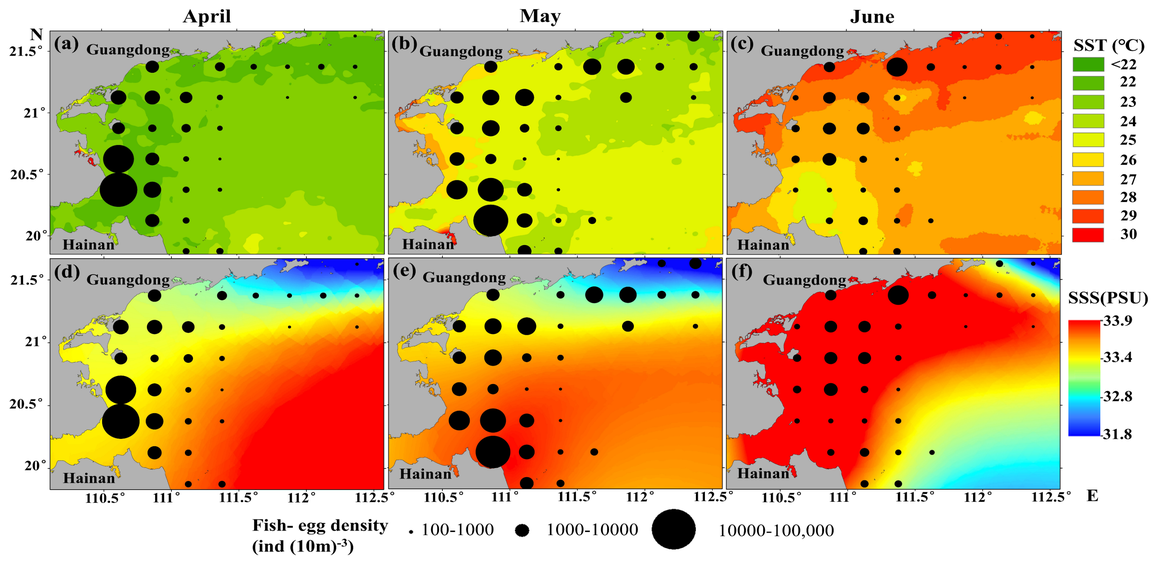
Introduction

Western Guangdong waters (WGWs) are located in the northern South China Sea (SCS). This is an important place for fish spawning, feeding, breeding, and migration. Satellite remote-sensing technology provides all-weather, large-scale, and high-resolution marine-surface information, and it was successfully applied to marine-fishery research. In this study, satellite remote-sensing data were applied in the analysis of the environmental effects of the spatiotemporal distribution of spawning grounds in WGWs. The early supplementary mechanism of fishery resources in WGWs was explored, providing a reference for the protection of fish habitats in the SCS.





GAMs analysis of the effects of the spatiotemporal and environmental factors on the fish-egg density in WGWs



Materials and methods

Chl-a data were derived from MODIS Aqua products of NASA, for which temporal resolution was 8 days, and spatial resolution was 4 km. SSS data were obtained from the Global Ocean Physical Reanalysis Product of the CMEMS, for which temporal resolution was one month, and spatial resolution was 1/12° . The digital elevation model (DEM) of WGWs was derived from elevation data of Google Earth, with an elevation level of 18 and a spatial resolution of 8.85 m.

(1) GAMs Fitting Procedures

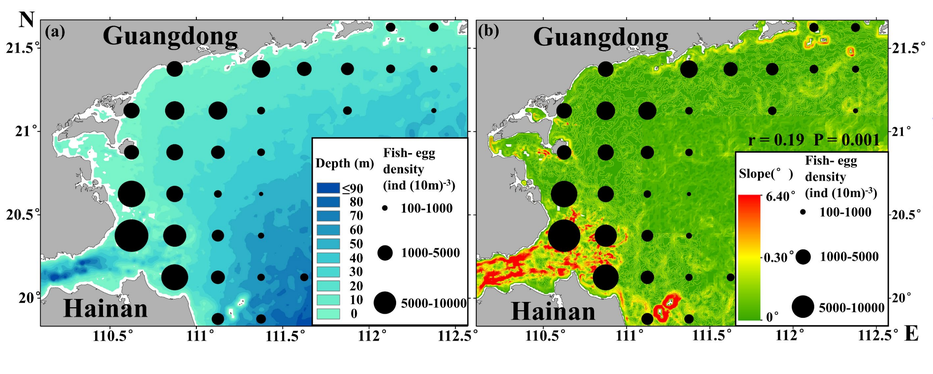
$$Y = \alpha + \sum_{j=1}^{n} f_i(x_j) + \varepsilon$$

(2) . Center of Gravity of Spawning Grounds

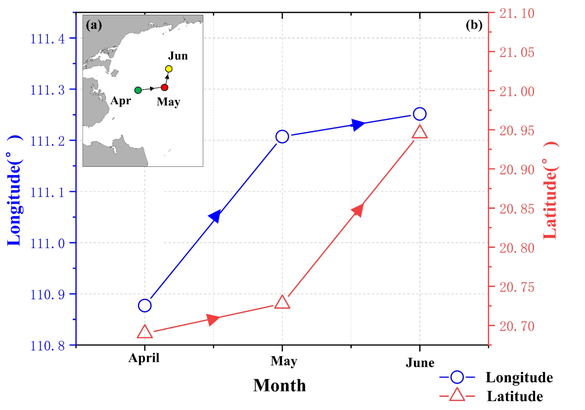
$$X = \sum_{i=1}^{K} (C_i \times X_i) / \sum_{i=1}^{K} C_i$$

$$Y = \sum_{i=1}^{K} (C_i \times Y_i) / \sum_{i=1}^{K} C_i$$

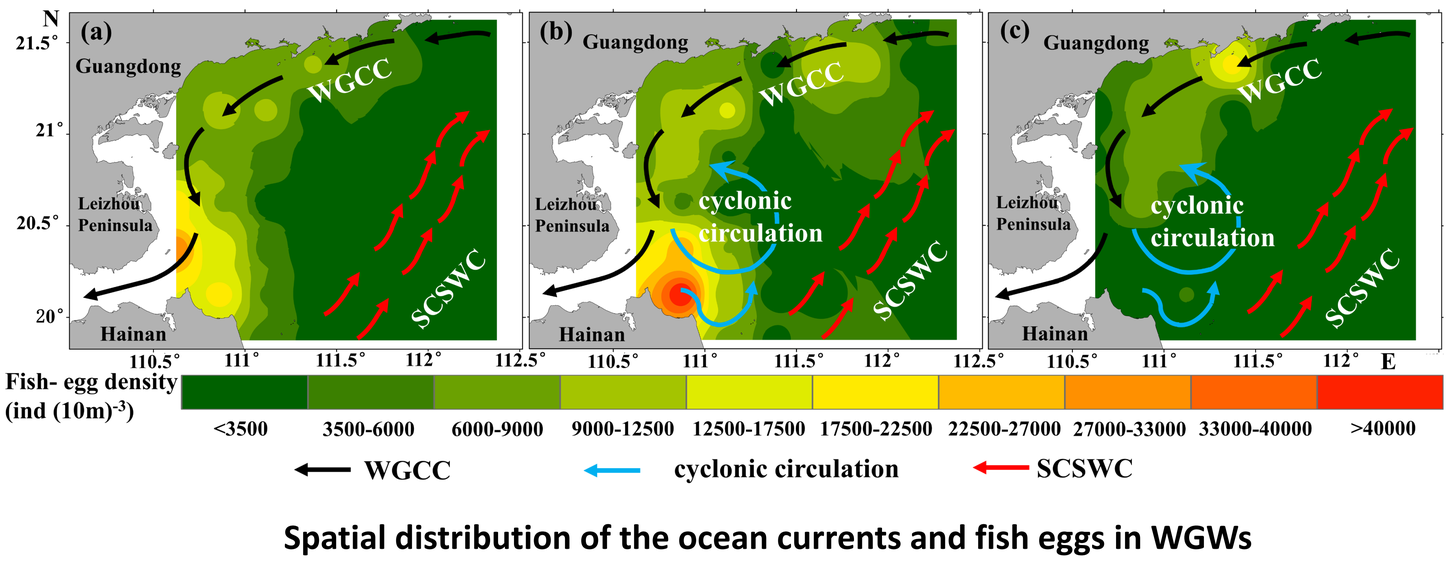
Relationship between the spatiotemporal distributions of the fish-egg density, water temperature, and salinity in WGWs



Relationship between the fish-egg density and spatial factors in WGWs



Changes in the central spawning-ground gravity of the spawning grounds



Spatial distribution of the ocean currents and fish eggs in WGWs

Results and Discussion

Deviance analysis for the GAMs fitted to the fish-egg density

Model factors	AIC value	GCV value	Adjusted R^2 value	Deviance explained (%)	Residual deviance
Log(Y+1) = NULL	1354.16	6.30	0	0.00	1808.76
Log(Y+1) = s(Month)	1349.69	6.21	0.02	2.6	1761.76
Log(Y+1) = s(Month)+s(SSS)	1251.74	4.43	0.32	34.7	1181.80
Log(Y+1) = s(Month)+s(SSS)+s(Depth)	1214.40	3.89	0.41	43.5	1022.39
Log(Y+1) = s(Month)+s(SSS)+s(Depth)+s(SST)	1169.28	3.34	0.51	54.2	829.06
Log(Y+1) = s(Month)+s(SSS)+s(Depth)+s(SST)+s(Chl-a)	1161.02	3.26	0.52	56.8	781.28
Log(Y+1) = s(Month)+s(SSS)+s(Depth)+s(SST)+s(Chl-a)+s(Distance)	1159.03	3.24	0.53	57.2	774.32

Contributions of the selected variables in GAMs

Variables	Contribution (%)	d.f.	Pr(*F*)	Pr (*chi*)
SSS	32.1	10.57	2.2×10^{-16} ***	2.2×10^{-16} ***
SST	10.7	9.02	5.7×10^{-9} ***	4.6×10^{-10} ***
Depth	8.8	2.82	8.3×10^{-9} ***	1.9×10^{-9} ***
Month	2.6	1.81	0.019 *	0.018 *
Chl-a	2.6	4.28	0.004 **	0.004 **
Distance	0.4	0.45	0.047 *	0.046 *

Conclusion

This study analyzed for the first time the environmental effects of the spatiotemporal distribution of the spawning grounds in WGWs on the basis of satellite remote-sensing and survey data. The most important environmental factor affecting the fish egg density was the SSS, followed by the SST, depth, month, Chl-a, and distance. The spawning grounds in WGWs were mainly distributed in waters with an SSS of 33.0–34.5 PSU, SST of 24–29 ° C, and depth of 5–25 m. The complex seabed terrain was conducive to the accumulation of fish eggs. The results of this study were helpful in understanding the spatiotemporal distribution of early supplementary populations of fishery populations and their response mechanisms to environmental changes in WGWs.

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