

**Satellite observation on the cold water intrusion
related to the exceptional fishery disaster
during the ENSO events in the Taiwan Strait**

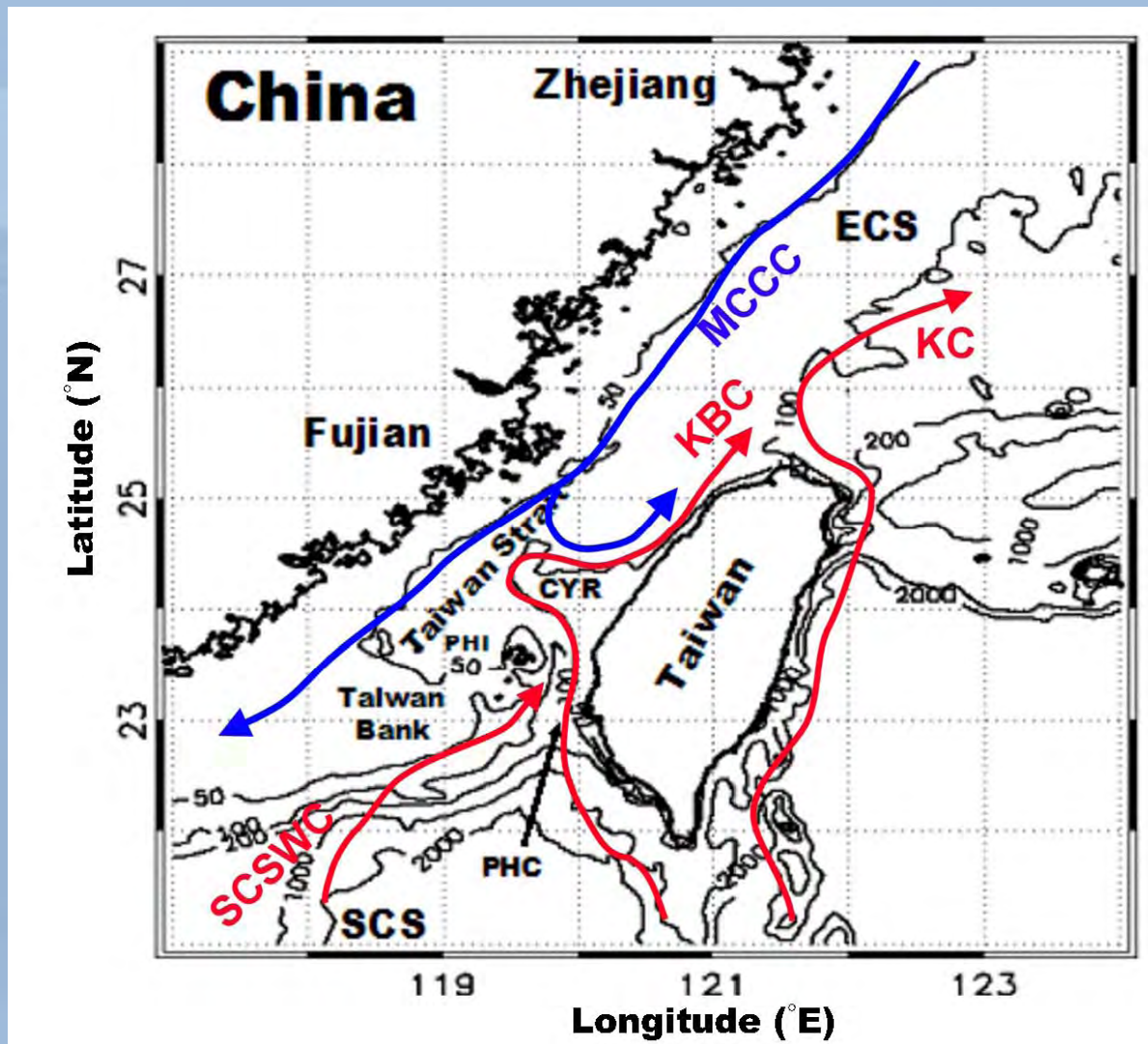
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National Taiwan Ocean University

(28 April, 10:00 C1-6174)

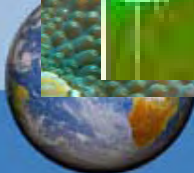
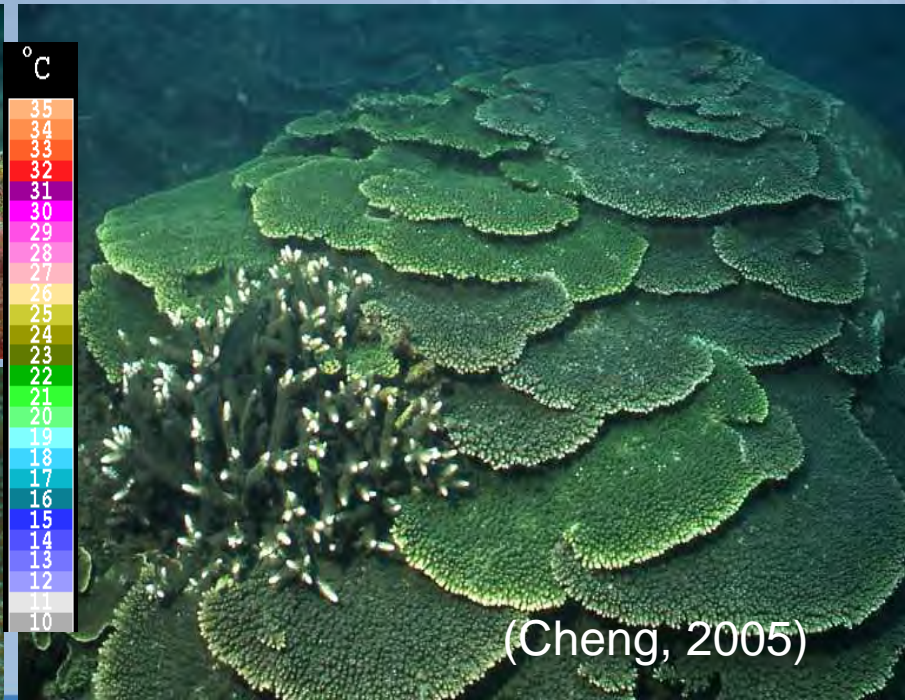
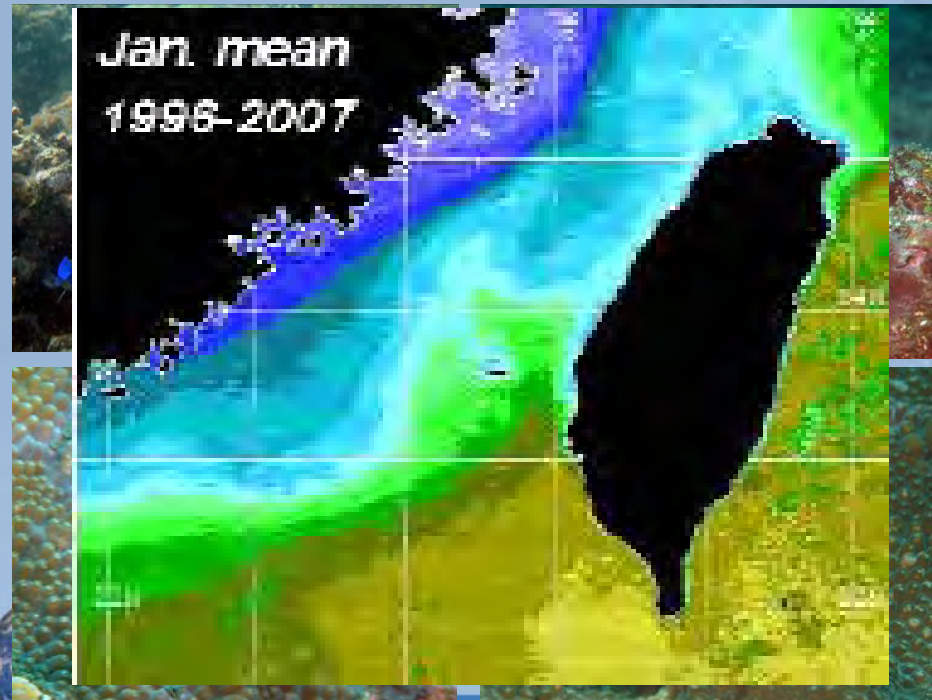
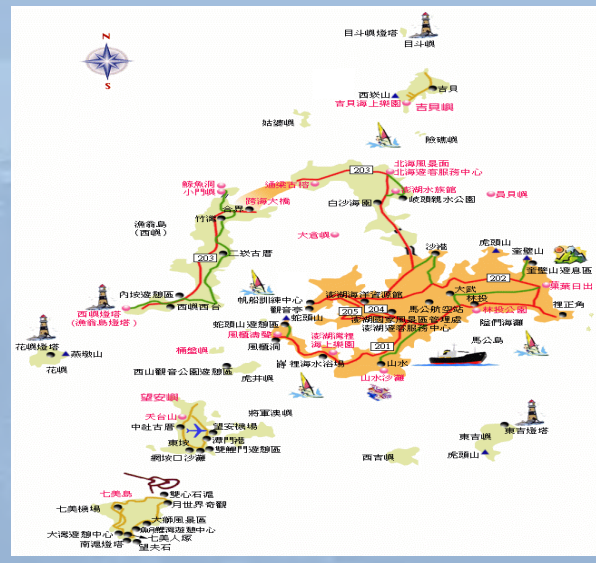
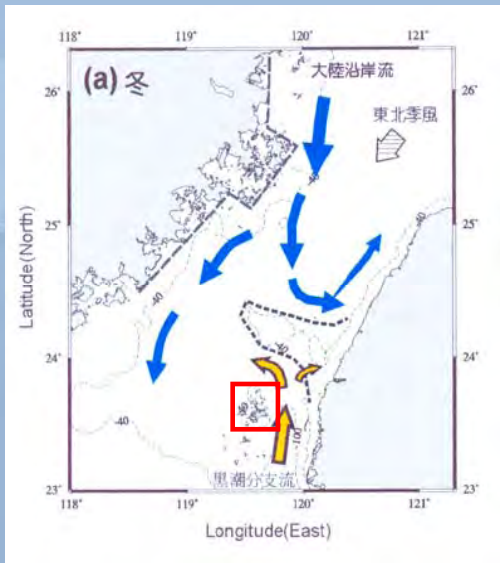


(PICES symposium, 2010)

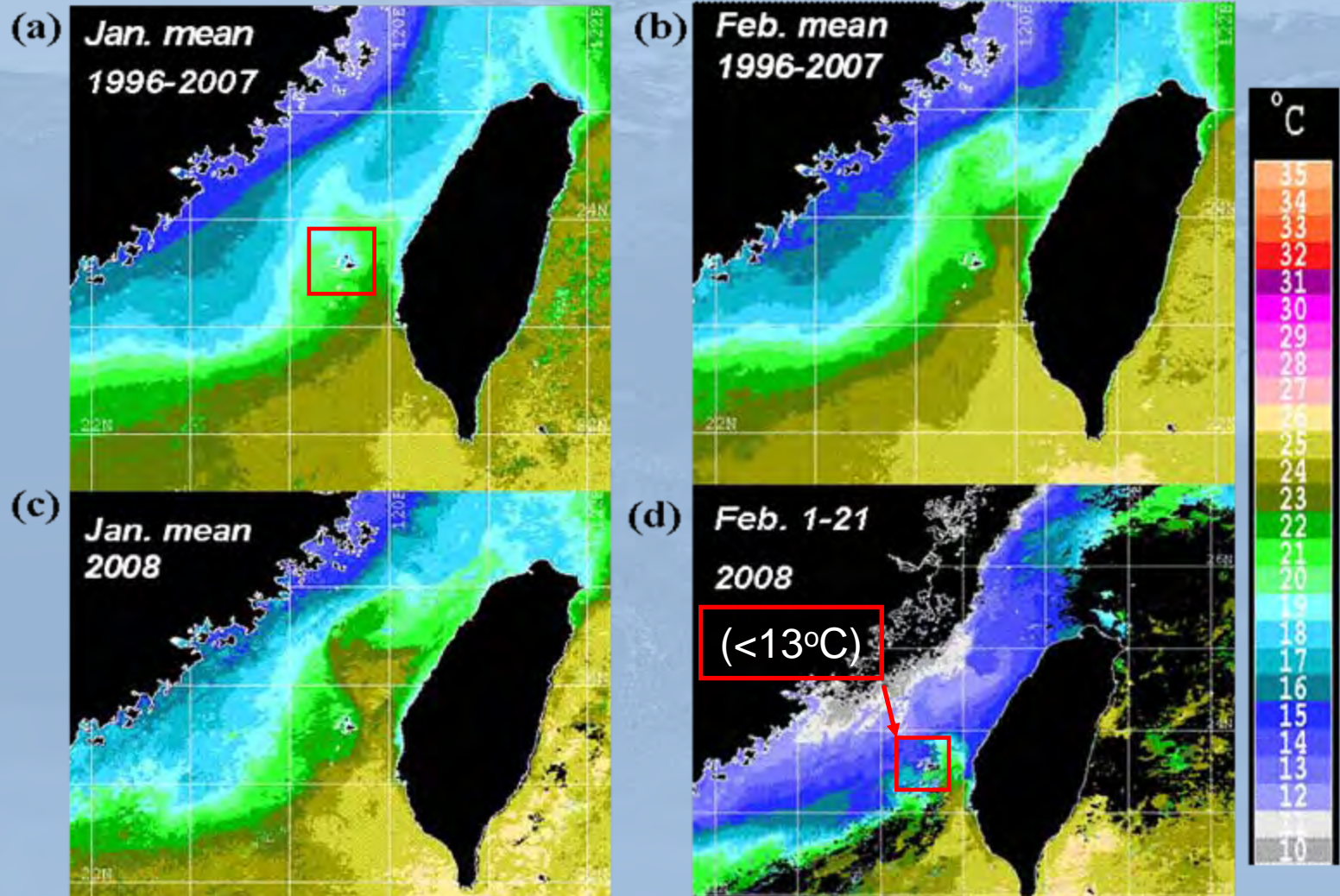


Map of the study area with bottom topography and summary view of current circulation (redrawn from Tang et al. 2000, Jan et al. 2002).



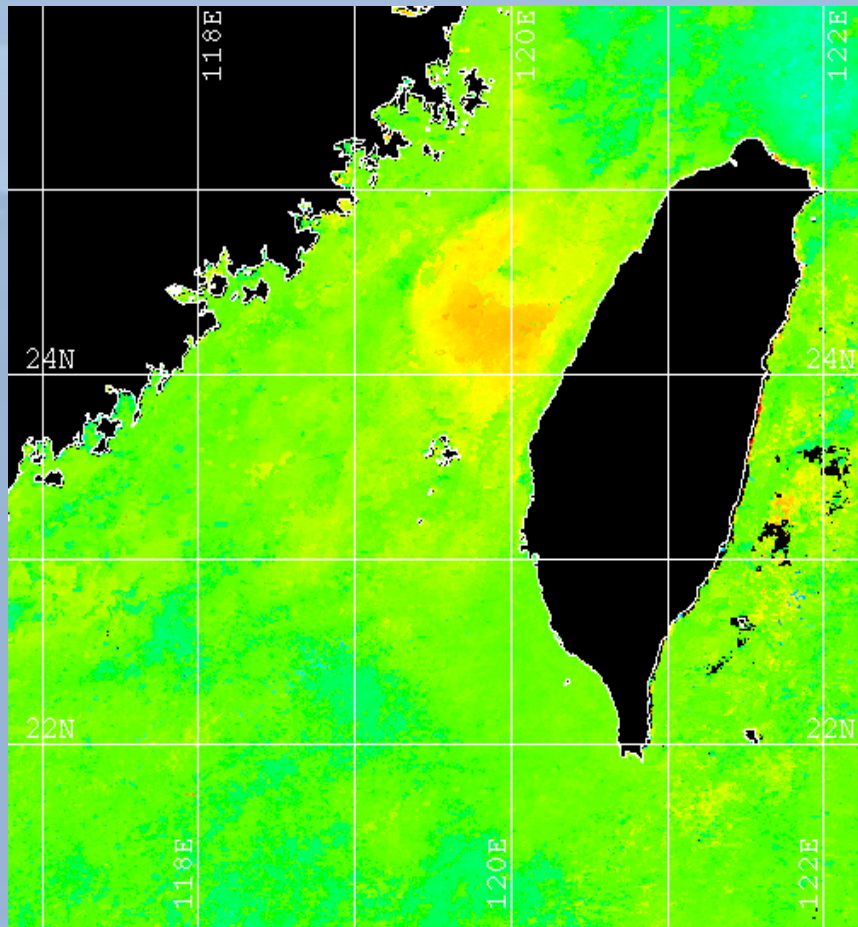


AVHRR monthly mean SST images(1996~2007) & 2008

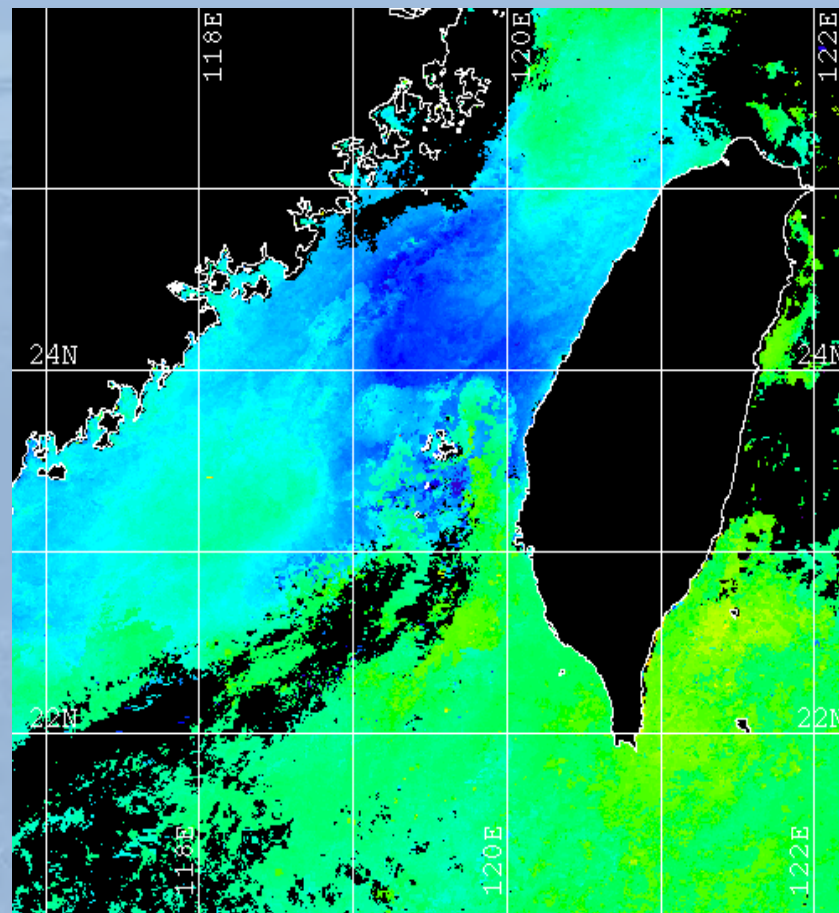


SST around Peng-Hu Islands is usually higher than 20°C in winter, but dropped to 13°C between late January and middle February in 2008. (Lee et al., 2009)

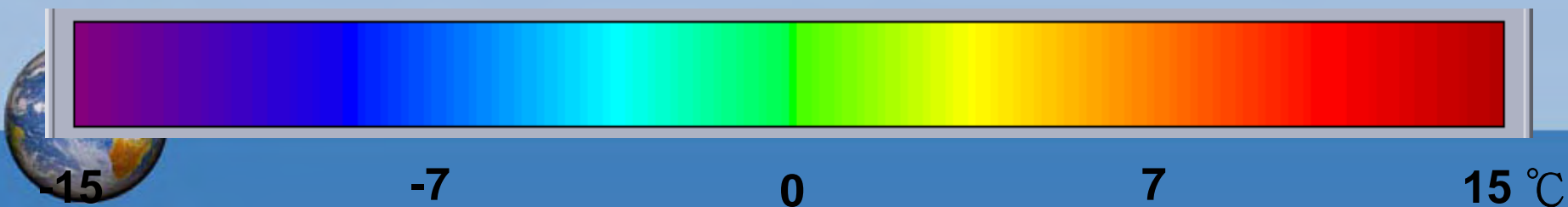


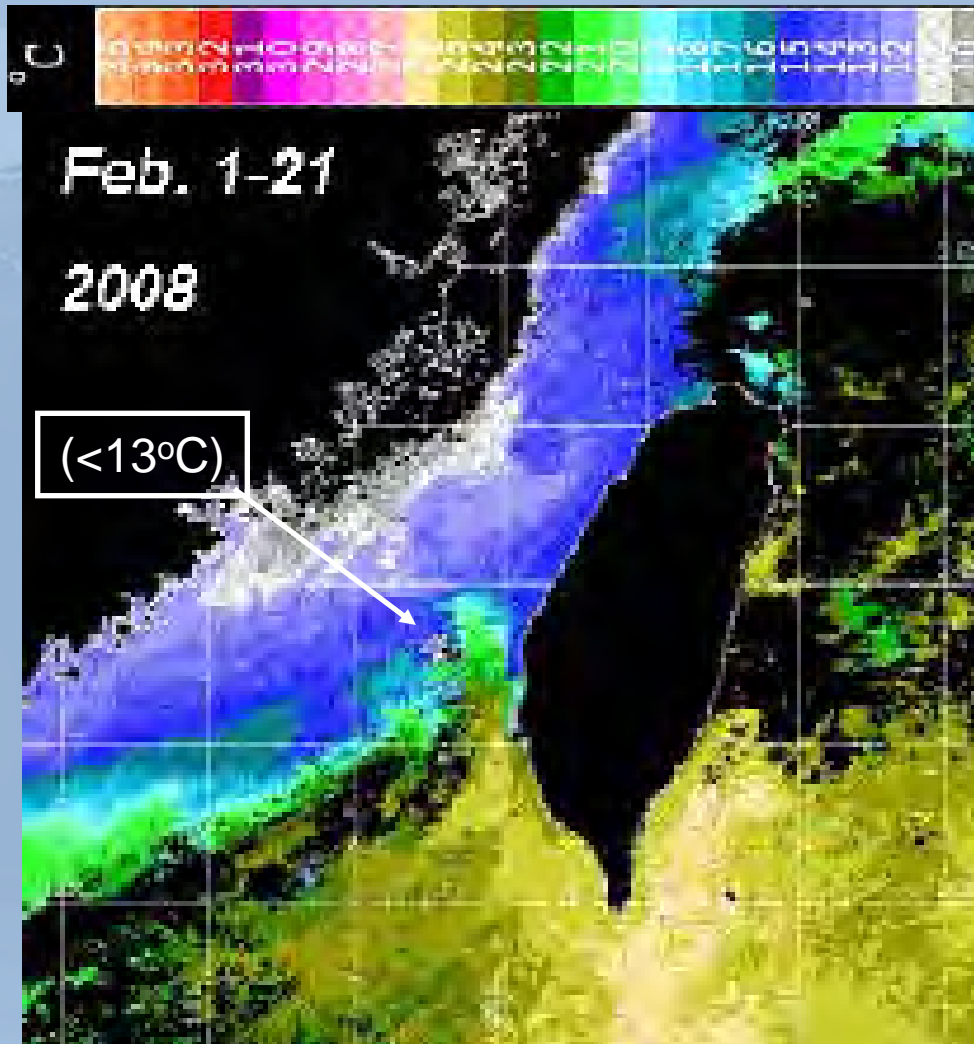


**Difference 2008 Jan. - 1996-2007 Jan.
mean + 5°C**



**Difference 2008 Feb. - 1996-2007 Feb.
mean - 7°C**





The cold current has spelt disaster for both fisheries and coastal marine habitats (anon, 2008).



A large number of fish was found dead on the beaches around Peng-Hu Islands (PHI), southern TS, in Feb. 2008. **Marine experts evaluate that "more than 300" varieties of fish, unable to tolerate the cold water temperatures.**





The photos show the exceptional intrusion of cold water caused the fishery resource (included cobia and grouper) disaster with the economic fishery losses about NT\$350 million (US\$11 million) in February 2008.



The object of this study

- This study was tried to investigate the effect of the cold temperature event in 2008 La Niña winter on coastal fisheries by analyzing long-term SST, wind, and fishery data against the Ocean Niño Index

Data and Method



(1) sea surface temperature

AVHRR (Advanced Very High-Resolution Radiometer)



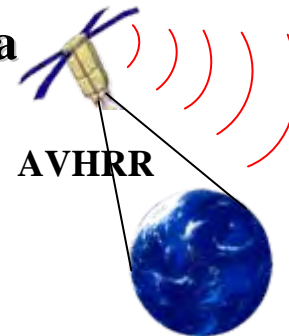
NOAA -12,15,16,17,18 AVHRR data



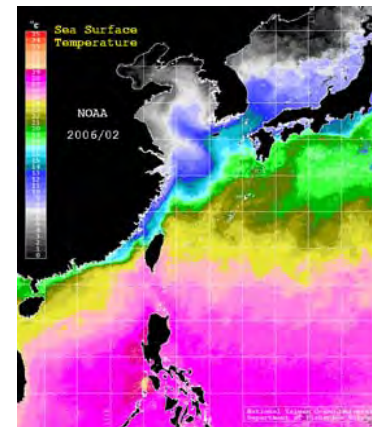
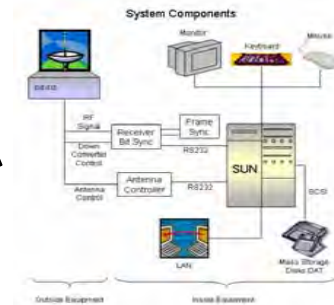
Date period: 1996~2009



Spatial resolution → 1.1 km



AVHRR



Images

Satellite-derived wintertime SST data measured by AVHRR (Advanced Very High Resolution Radiometer) sensors during the 14-year period from 1996-2009 were obtained from NTOU

(Remote Sensing Laboratory of Taiwan Ocean Research Institute, NTOU)



2. In situ wind speed and fishery data

(a) In situ wind speed and ONI data:

daily wind speed data measured by the gauge station on Peng-Hu Islands were used, and the Oceanic Niño Index (ONI) was also analyzed as the indicator of El Niño/La Niña events.

The ONI was estimated by the 3-month running mean of SST anomalies in the Niño 3.4 region (5°N - 5°S , 120° - 170°W), based on the 1971-2000 base period.

(b) Fishery data:



Data source: Peng-Hu Fishermans Association

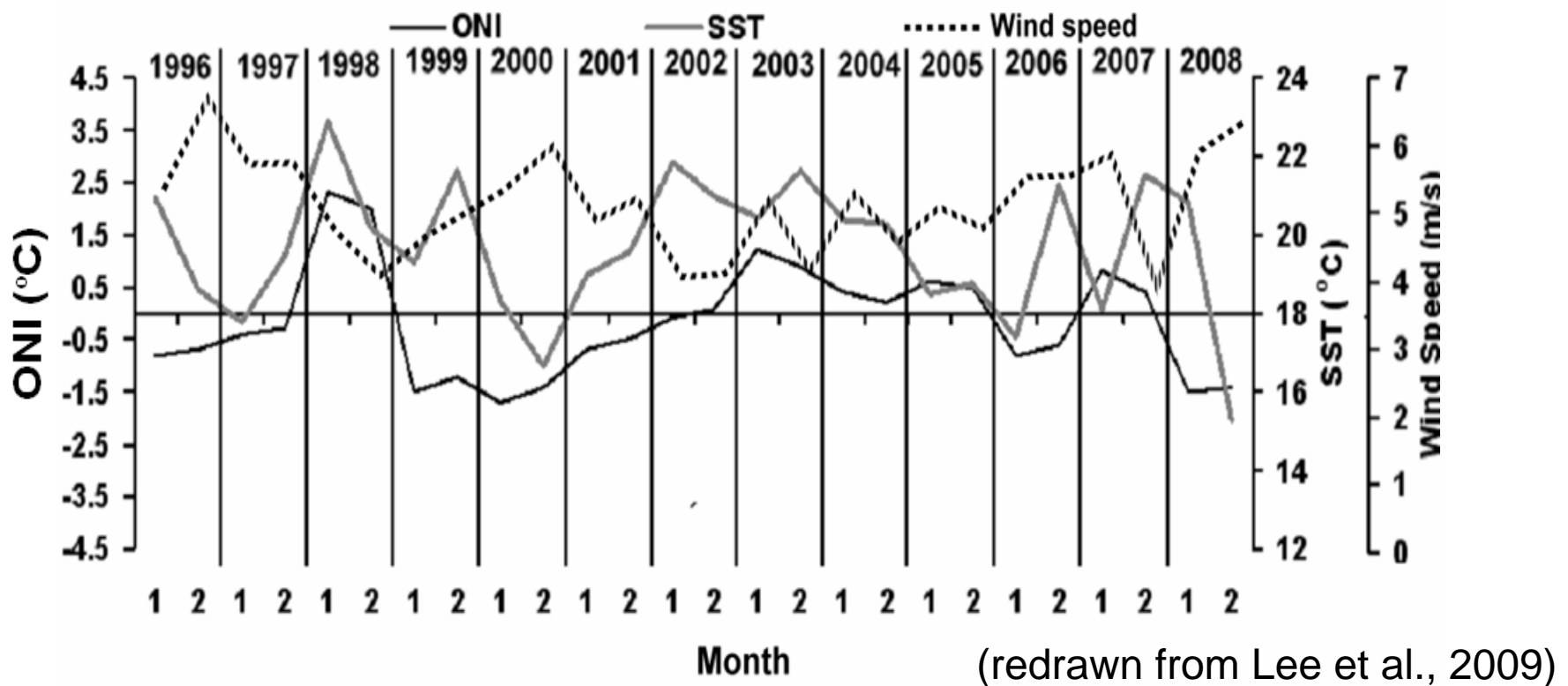


Data Period: Jan to June, 1996~2009

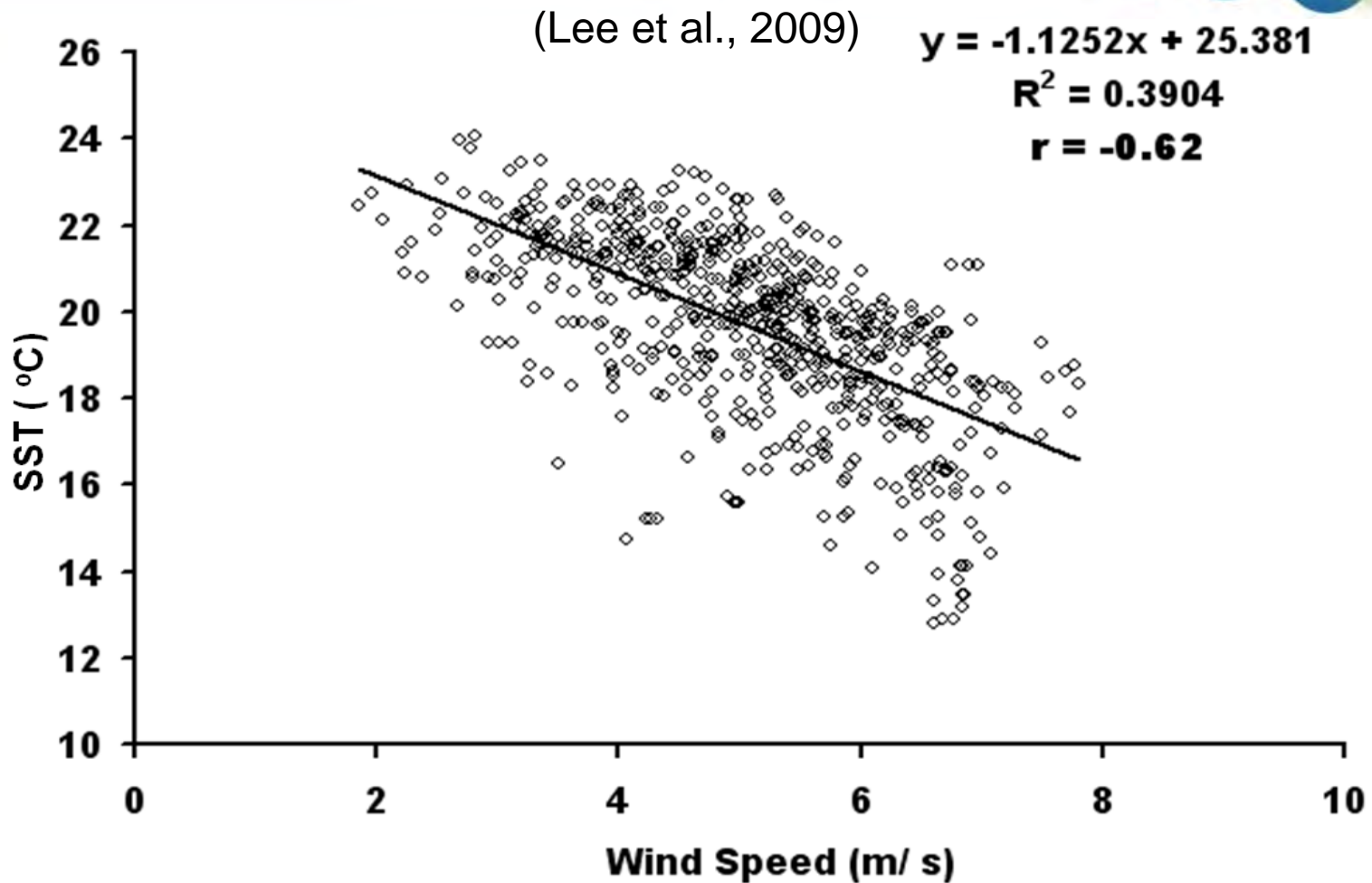
There are four major fisheries in the water around Peng-Hu Islands (PHI), they are: pole & lines; gill net; long line; and set net. During the period of 2006 to 2009, all fish catch compositions of these four fisheries were recorded through questionnaire and then classified as non-migratory and migratory species, for evaluating the influence of this exceptional cold water intrusion.



ONI Index with SST & wind speed Time Series(1996~2008)

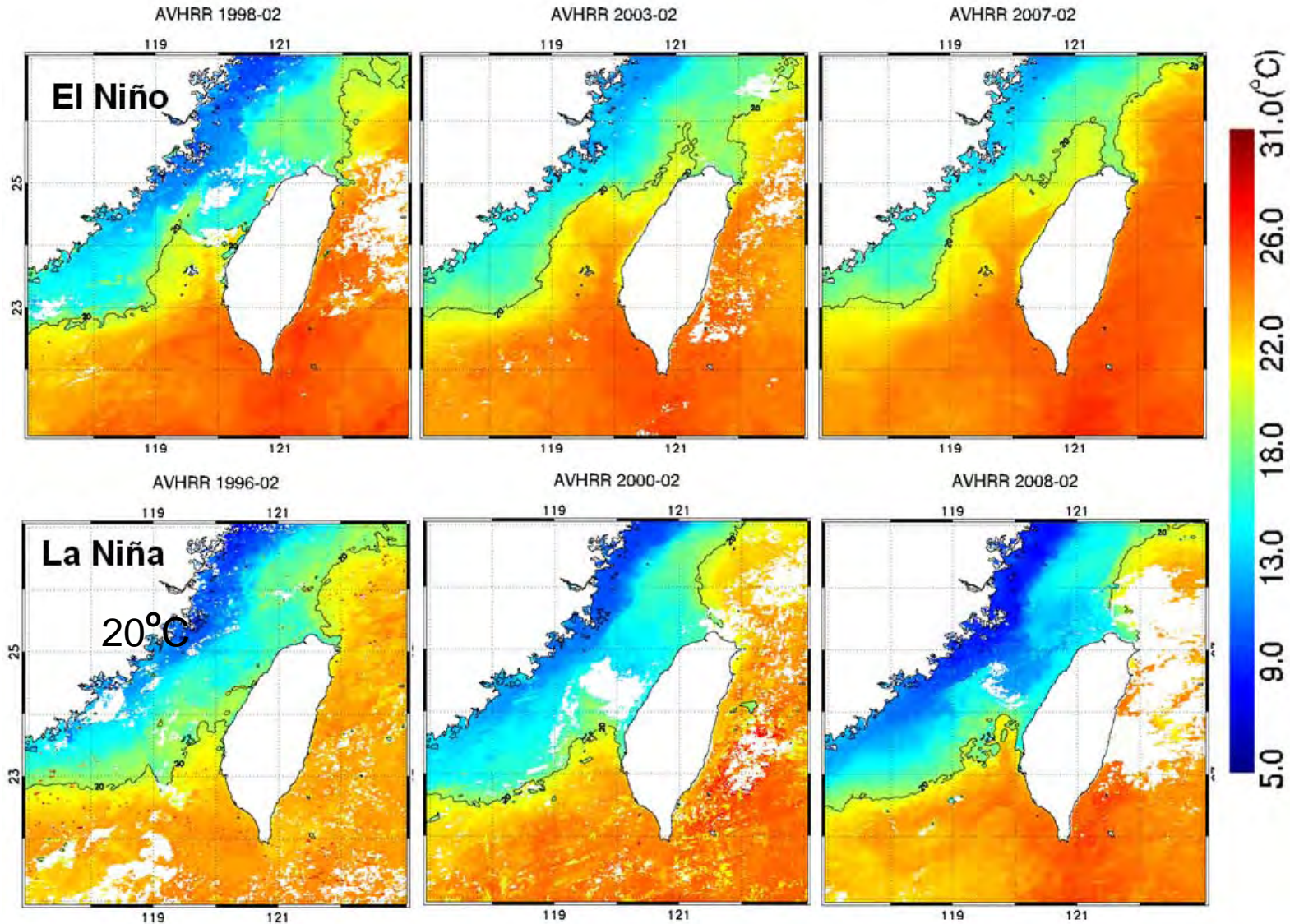


SST varied similarly with the trend of ONI. SST was warmer in El Niño winters (1998, 2003, 2007), but cooler in La Niña winters (1996, 1999~2000, 2008). The correlation between the ONI value and wind speed is highly negative ($r=-0.75$).



In other words, the wind speed was more intensive in La Niña winters (1996, 1999~2000, 2008; ONI value was negative) than in El Niño winters (1998, 2003, 2007; ONI value was positive). Thus, wind speed during El Niño/La Niña plays an important role in affecting SST variation in the TS.

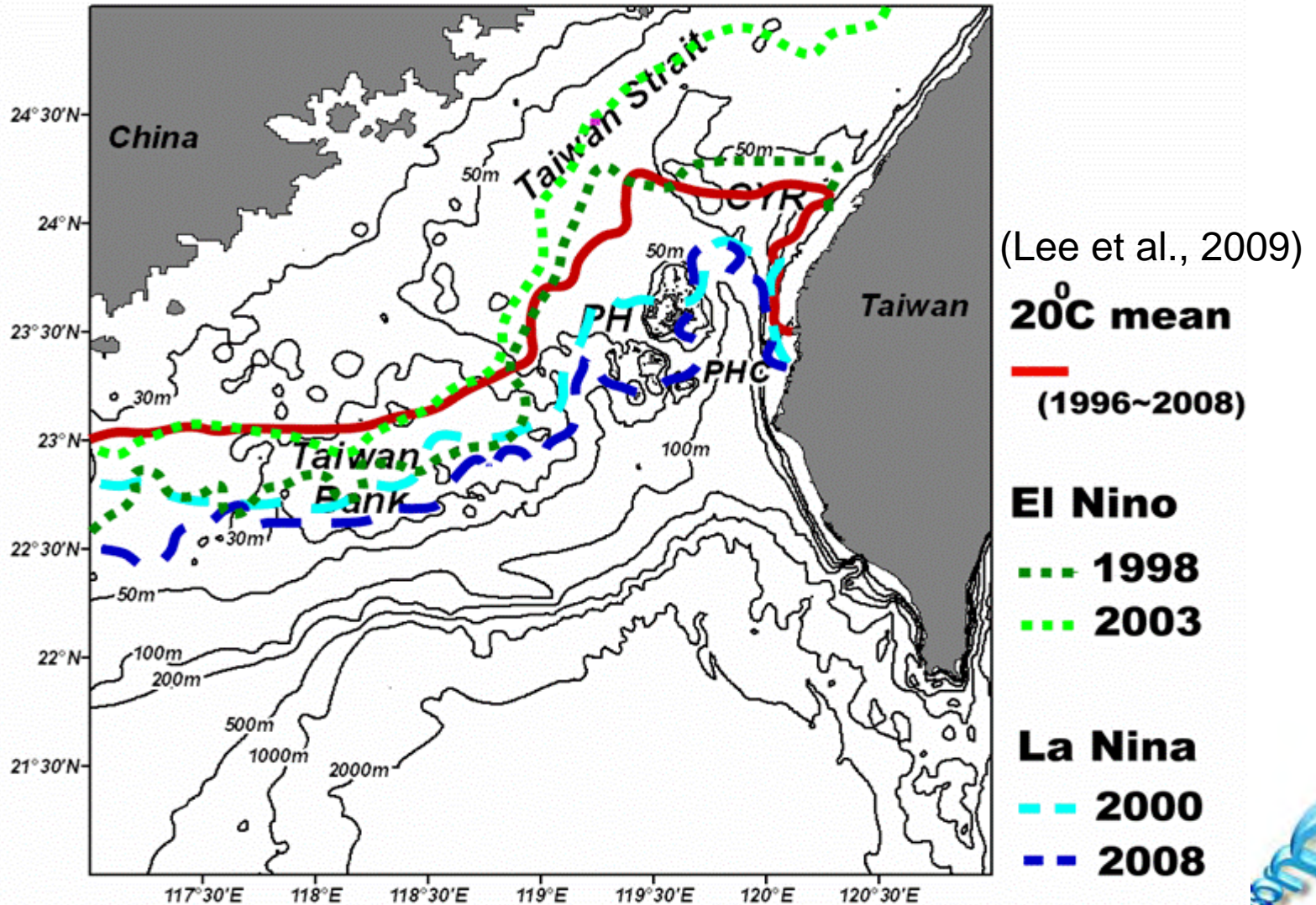
Wintertime SST patterns related with climate change

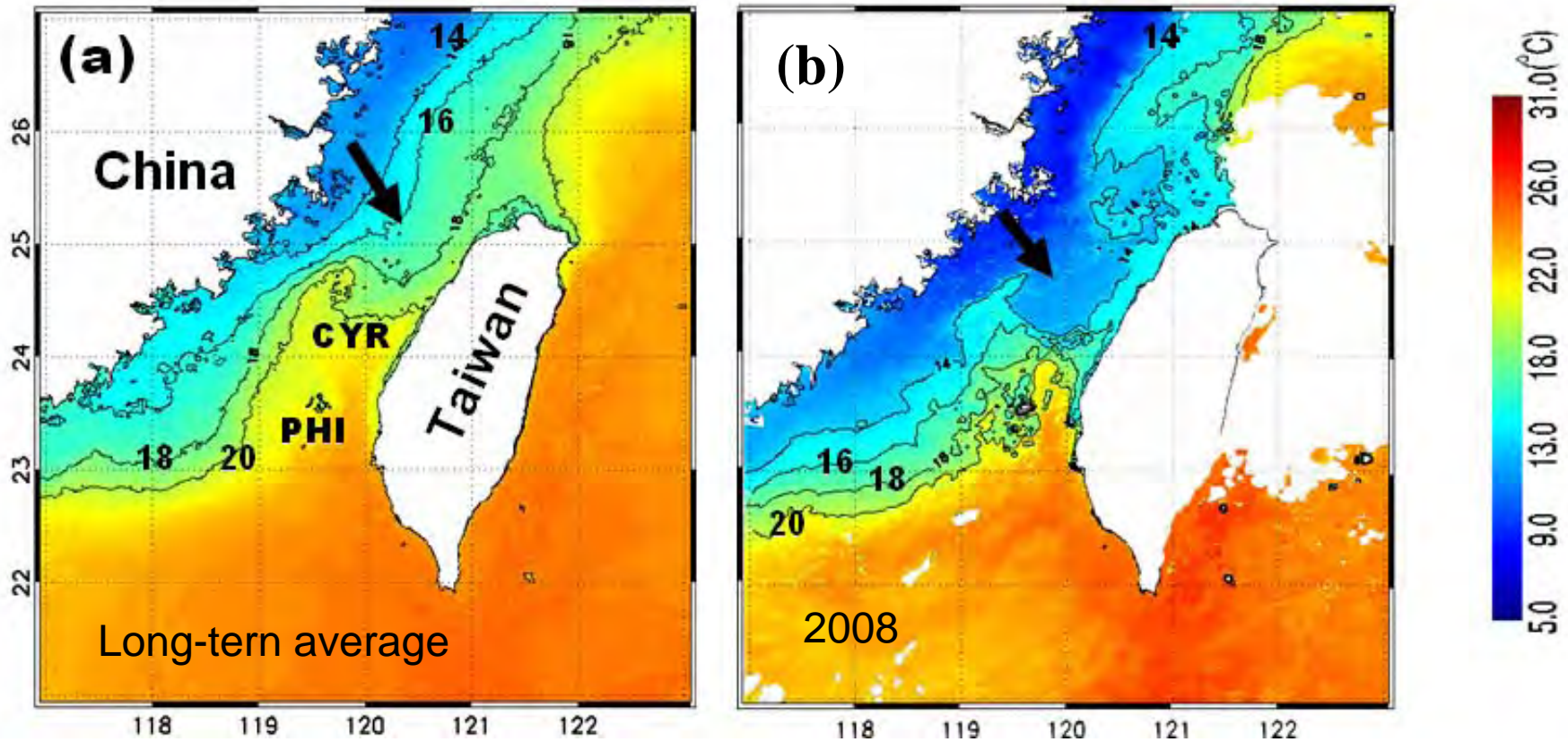


SST in the Strait was warmer during El Niño years (upper panels), but cooler in La Niña years (lower panels).

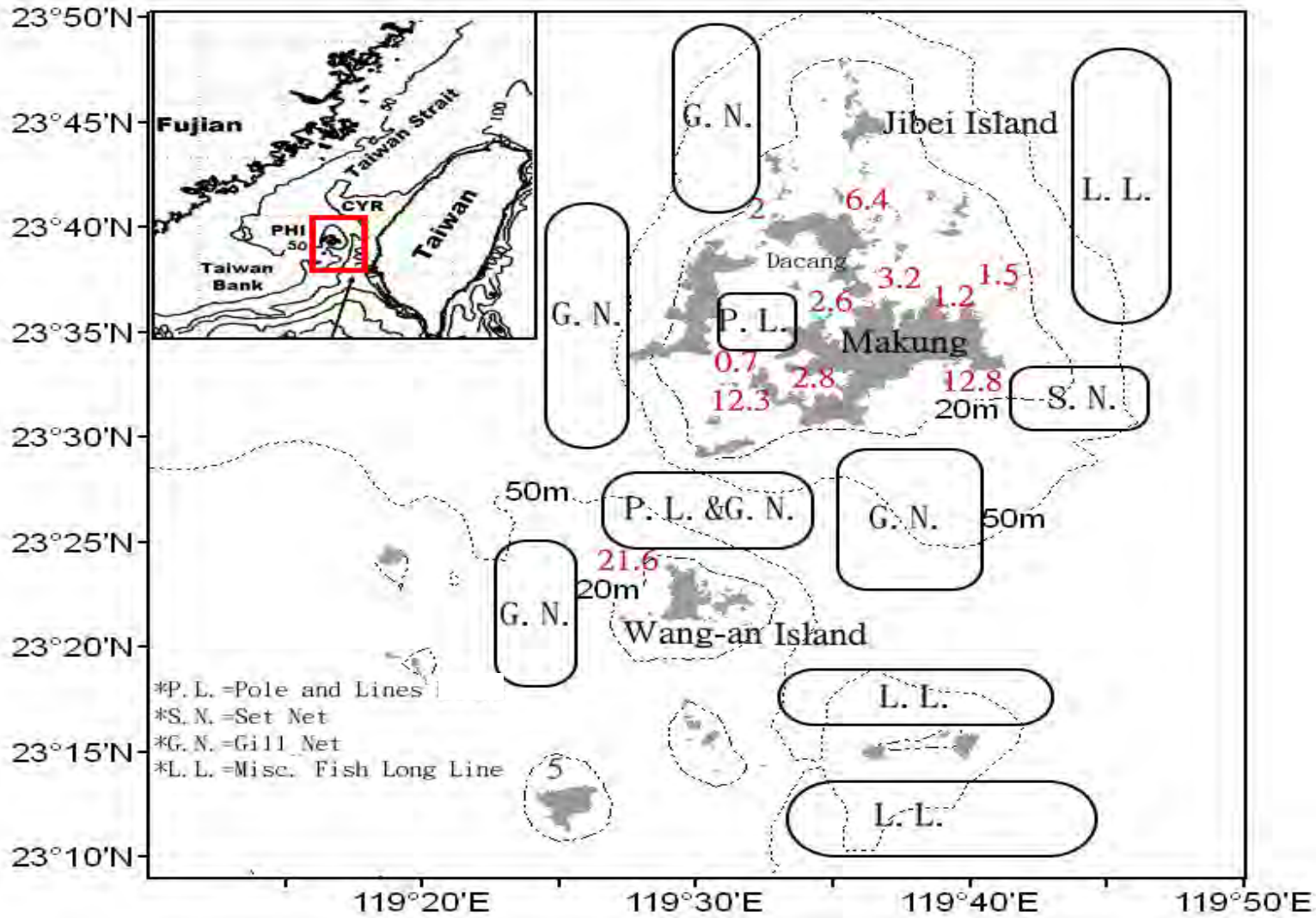


The monthly February mean of AVHRR SST 20°C isotherm during the period of 1996 to 2008, related to the El Nino and La Nina year.

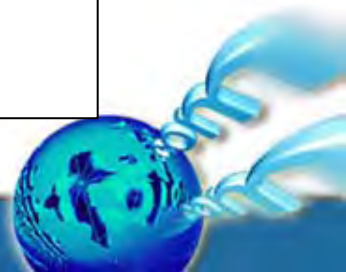
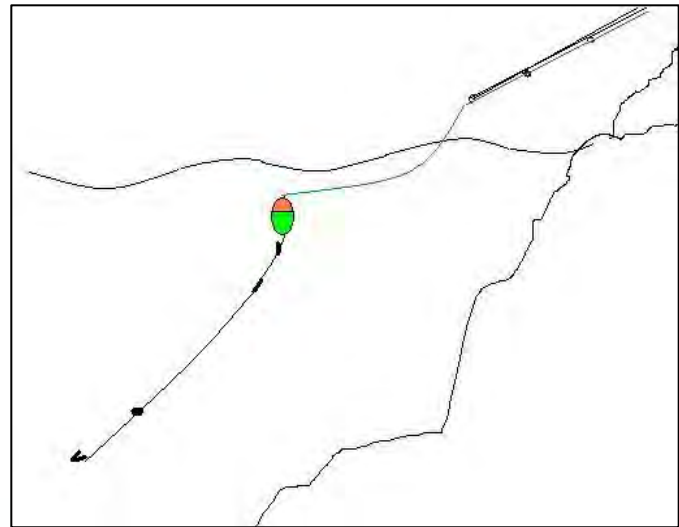
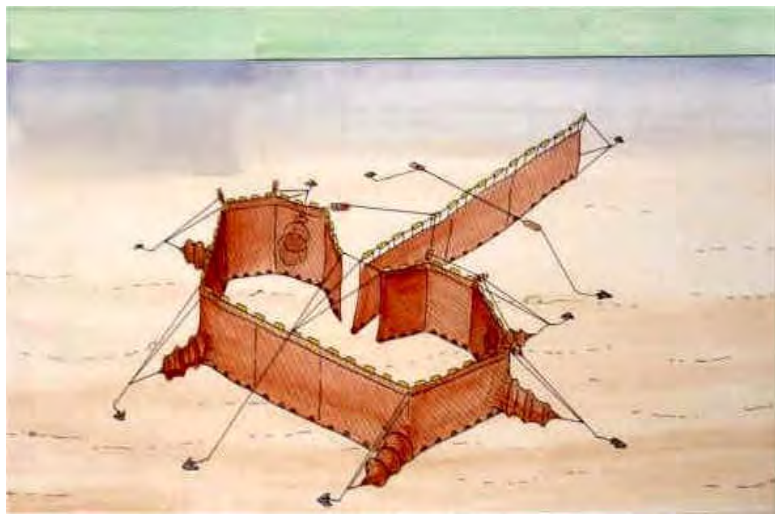
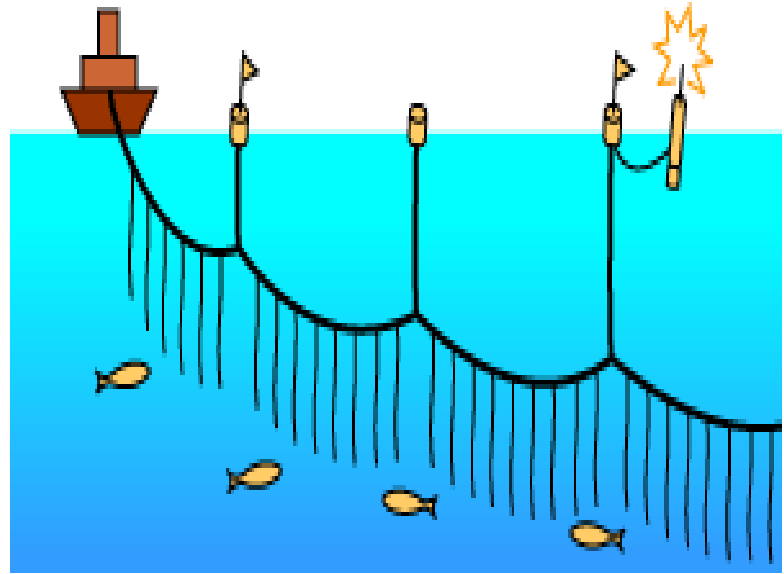
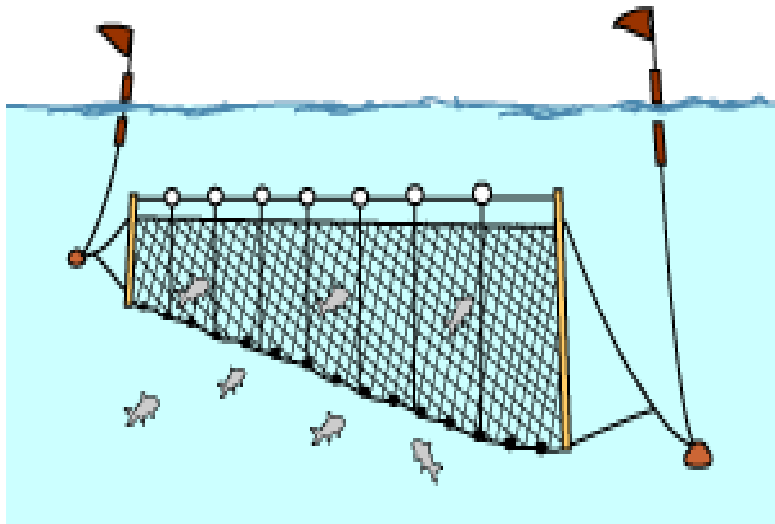


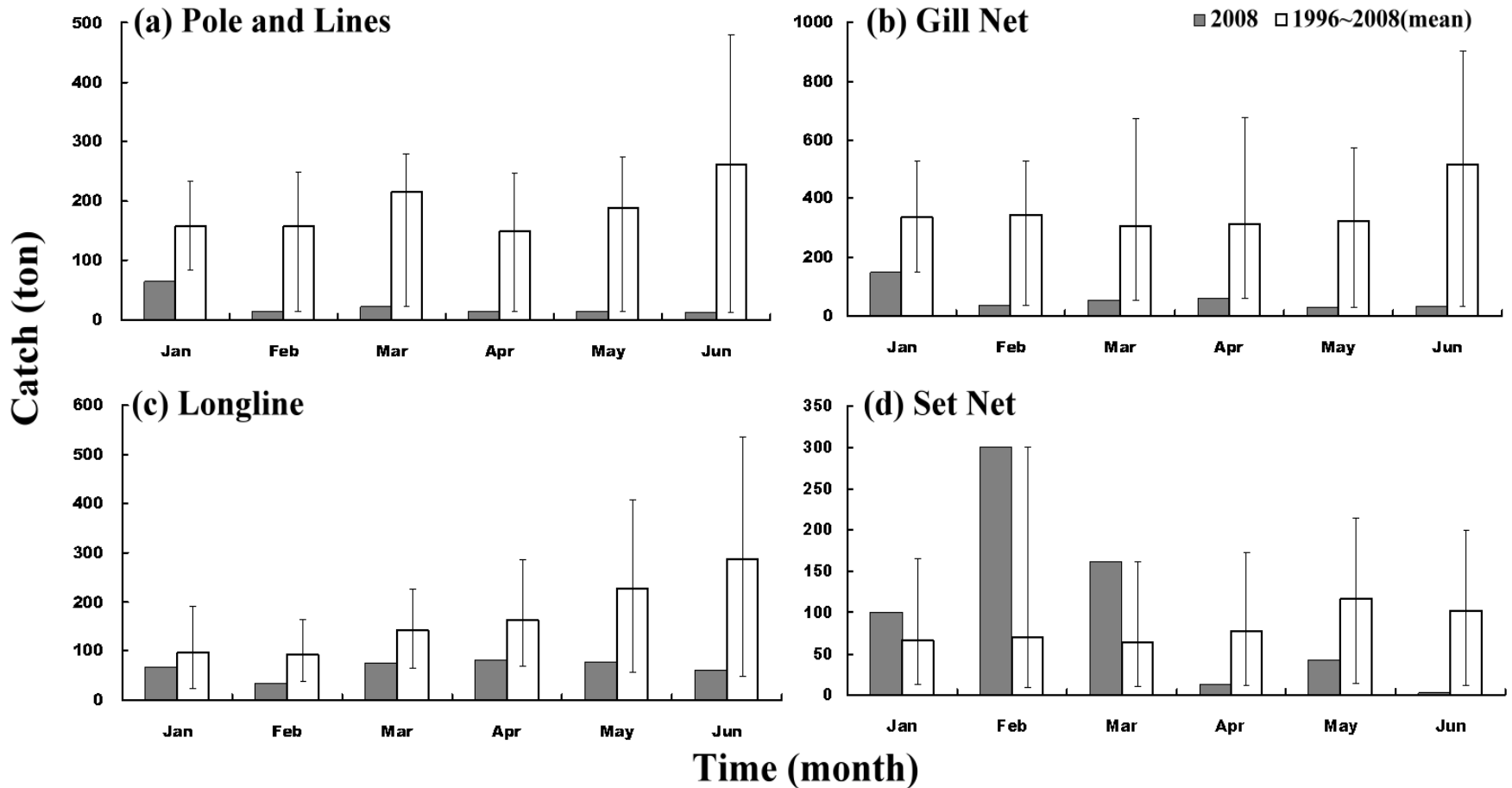


Unlike the features of the long-term average (left panel), the cold water tongue usually blocked at the northern Strait intruded into the south of Chang-Yuen Ridge (arrow in right panel) with the SST lower than $13\text{ }^\circ\text{C}$. The northward intrusion of warm water in the southeastern Strait was bounded near the north end of the Peng-Hu Channel. As a consequence, the most of the water around the PHI is lower than $15\text{ }^\circ\text{C}$ instead of the warmer water in the long-term average.



The exceptional southward intrusion of cold water in February of 2008 not only decreased SST sharply, but also coincided with an ecological (fishery) disaster.





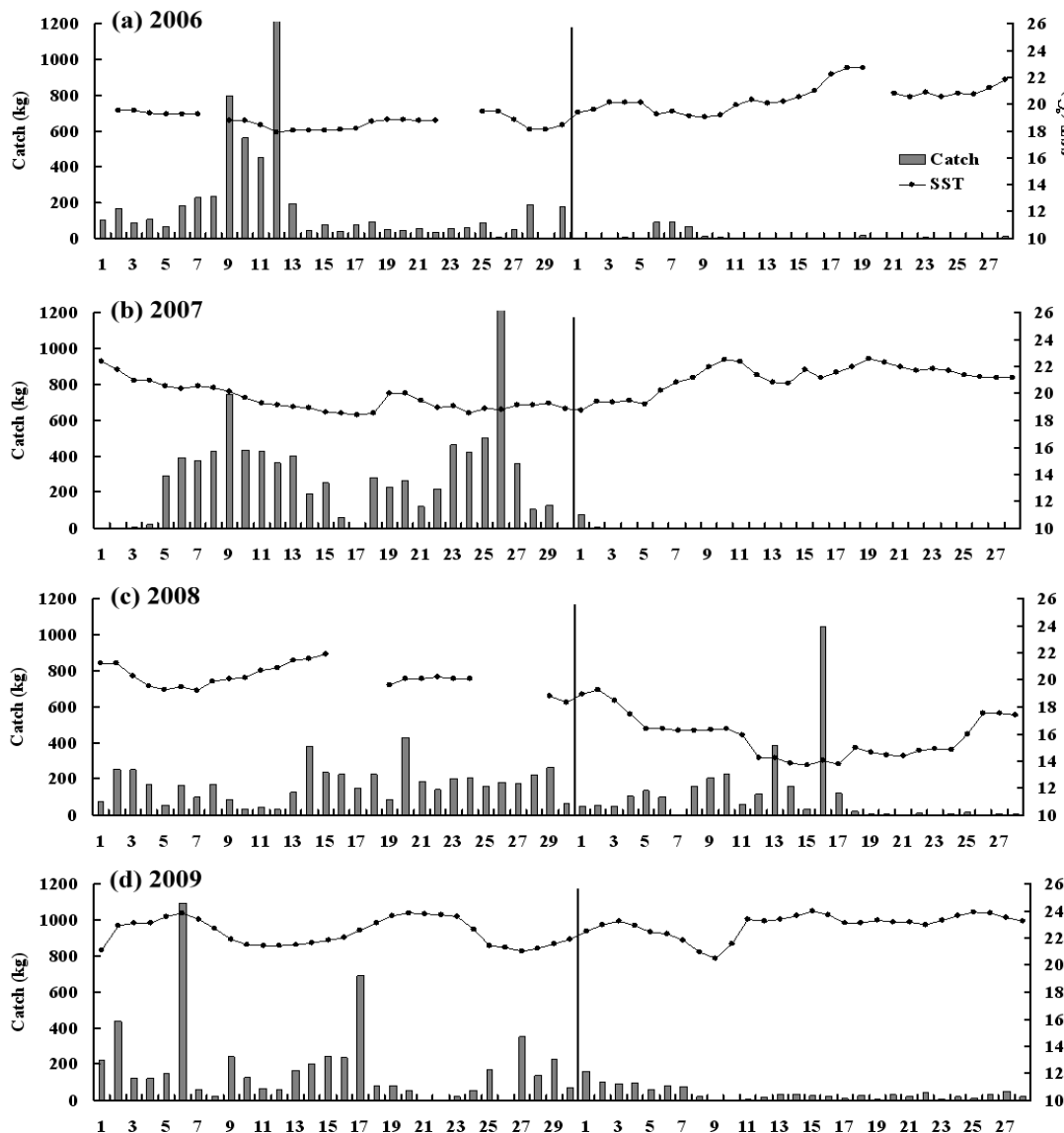
For the first three fisheries (a, b, c) dominated by non-migratory species (Anon., 2008), the monthly catch of 2008 (grey bar) was significantly less than the long-term average, but the catch of set net fishery (d) dominated by migratory species was higher in January, February, and March, and lower in April, May, and June than the long-term average of 1996-2008.



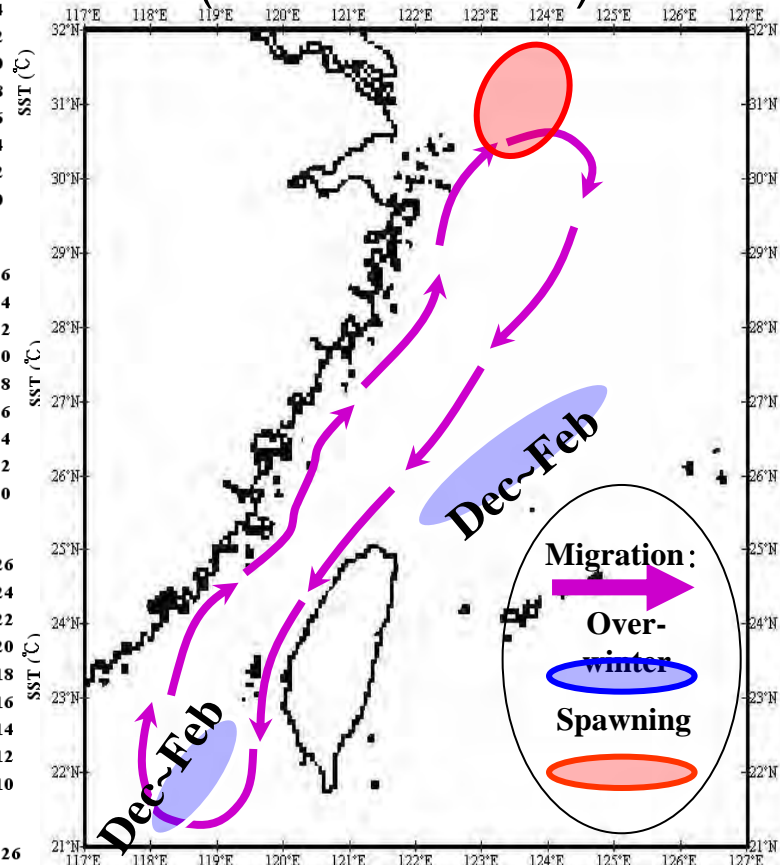
Fishing gear Year	Pole and Lines	Longline	Gill Net	Set Net
1996-2008	182.4	111.8	324.2	74.4
1996	132.7	102.0	351.1	21.3
2000	147.3	98.7	268.5	66.3
2008	33.96 -82%	75.1 -32.9%	79.41 -74.5%	187.4 +150%

Due to the lack of fishery questionnaire data in both years of 1996 and 2000, it is difficult to explain and compare the yearly impacts influenced by the different intensity of La Niña.





(Yamada 1964)



Trichiurus lepturus

<http://fishdb.sinica.edu.tw/2001new/main1.asp>

Shih (2004) indicated that the hairtail fish is mainly distributed in the East China Sea and migrates to the TS and South China Sea for spawning in winter. It is suggested that the high catch of hairtail fish in this cold SST event might be attributed to the abnormal southward intrusion of the cold water.

Summary

The long term observation reveals an exceptional cold water intrusion into the southern TS happened in February 2008. The warm KBC, which dominates the water around CYR year round, was restricted to the southern Strait. Comparing the SST and wind speed during El Niño/La Niña events, we found that SST was warmer in the El Niño winters (1998, 2003, 2007) than in the La Niña winters (1996, 2000, 2008), and wind speed was more intensive in the La Niña winters than in the El Niño winters.

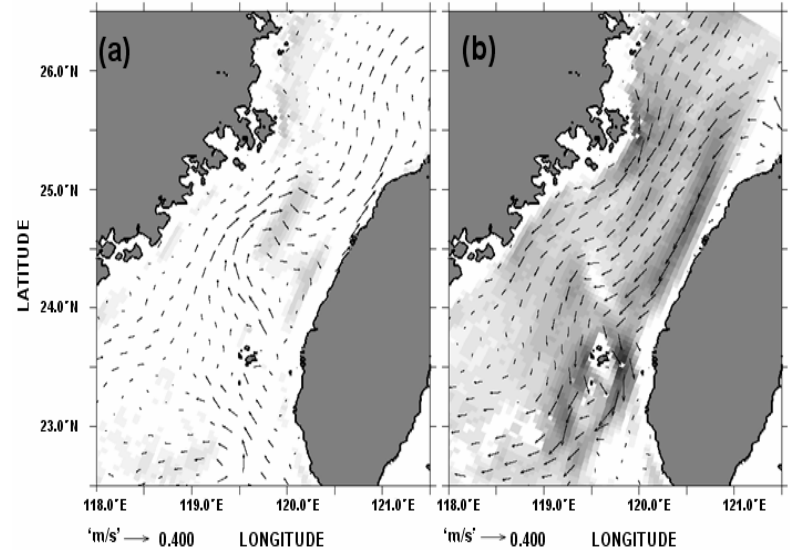
In the winter of 2008, the strong and continuous northeasterly wind caused by La Niña event probably drove the cold MCCC more southward to penetrate into the southern TS north of the CYR and a portion of this current intruded eastward south of the Peng-Hu Islands.

The low SST event also significantly damaged marine life and cage aquaculture, causing the death of more than 73 mt of non-migration fishes; and at the same time brought increased abundance of migratory species.



Future work

The mechanism of cold water intrusion needs further examination. The modeling simulation with high spatial resolution may be a way to establish better scientific method.



(Redrawn from Wu et al., 2007)

To meet this challenge, analyses of *in situ* data combined with modeling simulation should be undertaken to improve our understanding of causes and precursors of such exceptional SST variation in the Strait. The influence of different strengths of climate change in wind fields should be considered in further studies.

