Composition and abundance of copepods and ichthyoplankton in Taiwan Strait (western North Pacific) are influenced by seasonal monsoons

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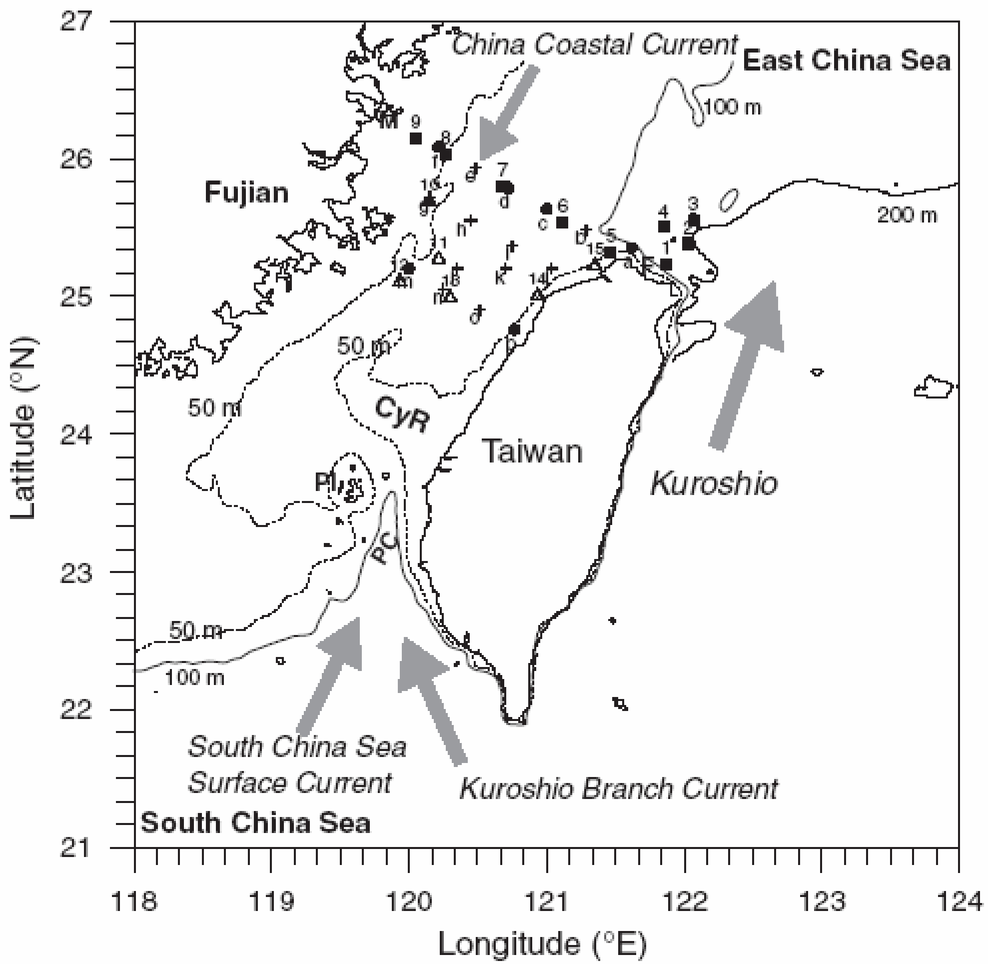
Introduction

- 季風→洋流→環境因子→浮游動物

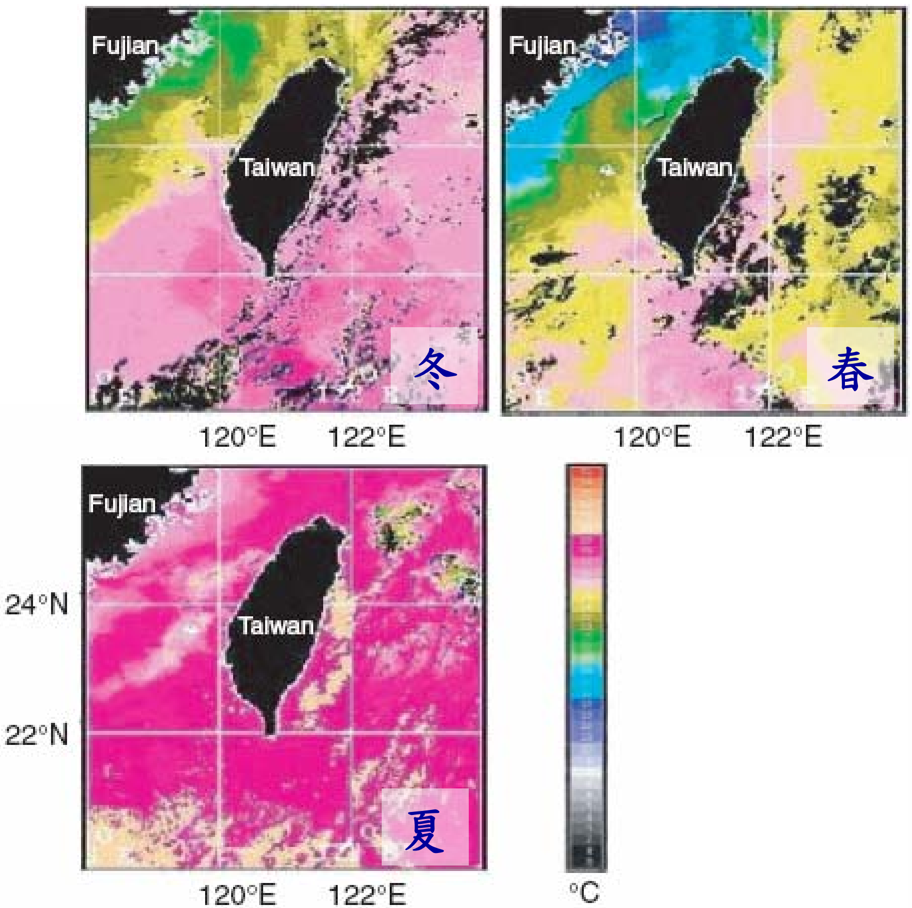
- 環境因子：溫度、鹽度、葉綠素、深度…

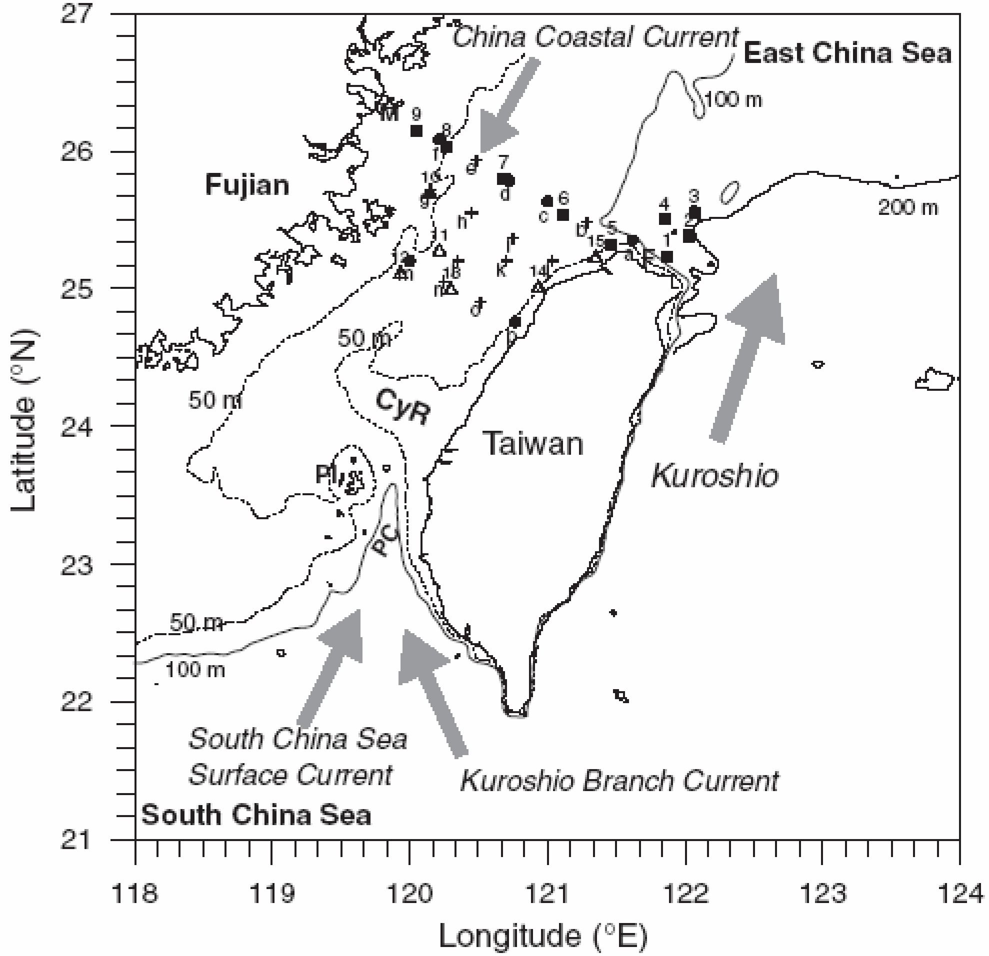
- 台灣海峽周圍：
  東海
  大陸沿岸水
  南海水
  黑潮水



- 季風→洋流→環境因子→浮游動物

- 冬季-東北季風 夏-西南季風

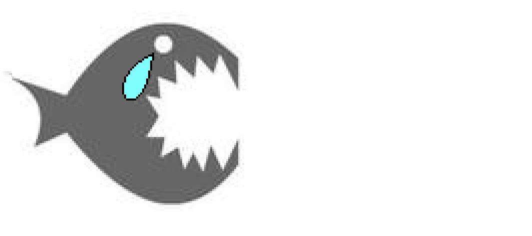




- Fish and copepod

- Zooplankton community structure is profoundly influenced by environmental factors.

- Food availability, as well as the physical environment, is an important factor influencing the survivorship of young fishes.



Materials and methods

- Samples

- 1999 August
- 1999 November
- 2000 March

- Net
- Copepod – 150um
- Ichthyoplankton – 1mm

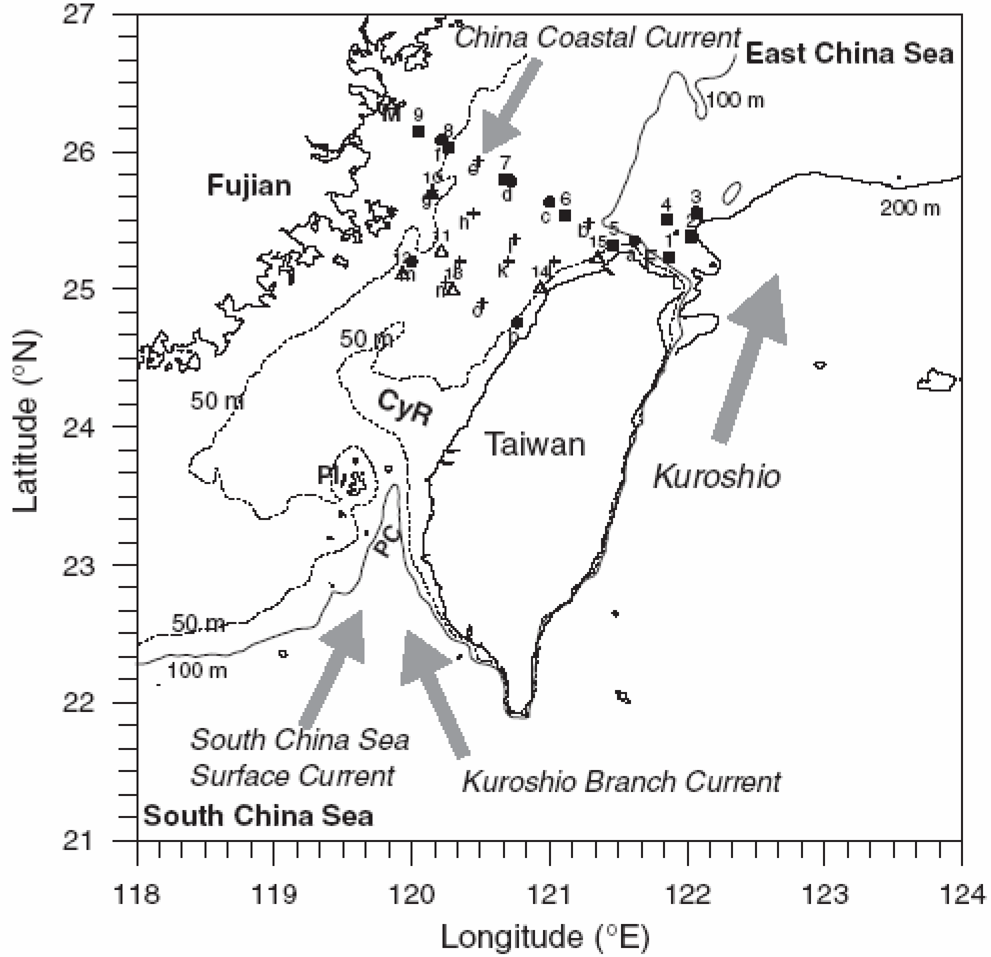


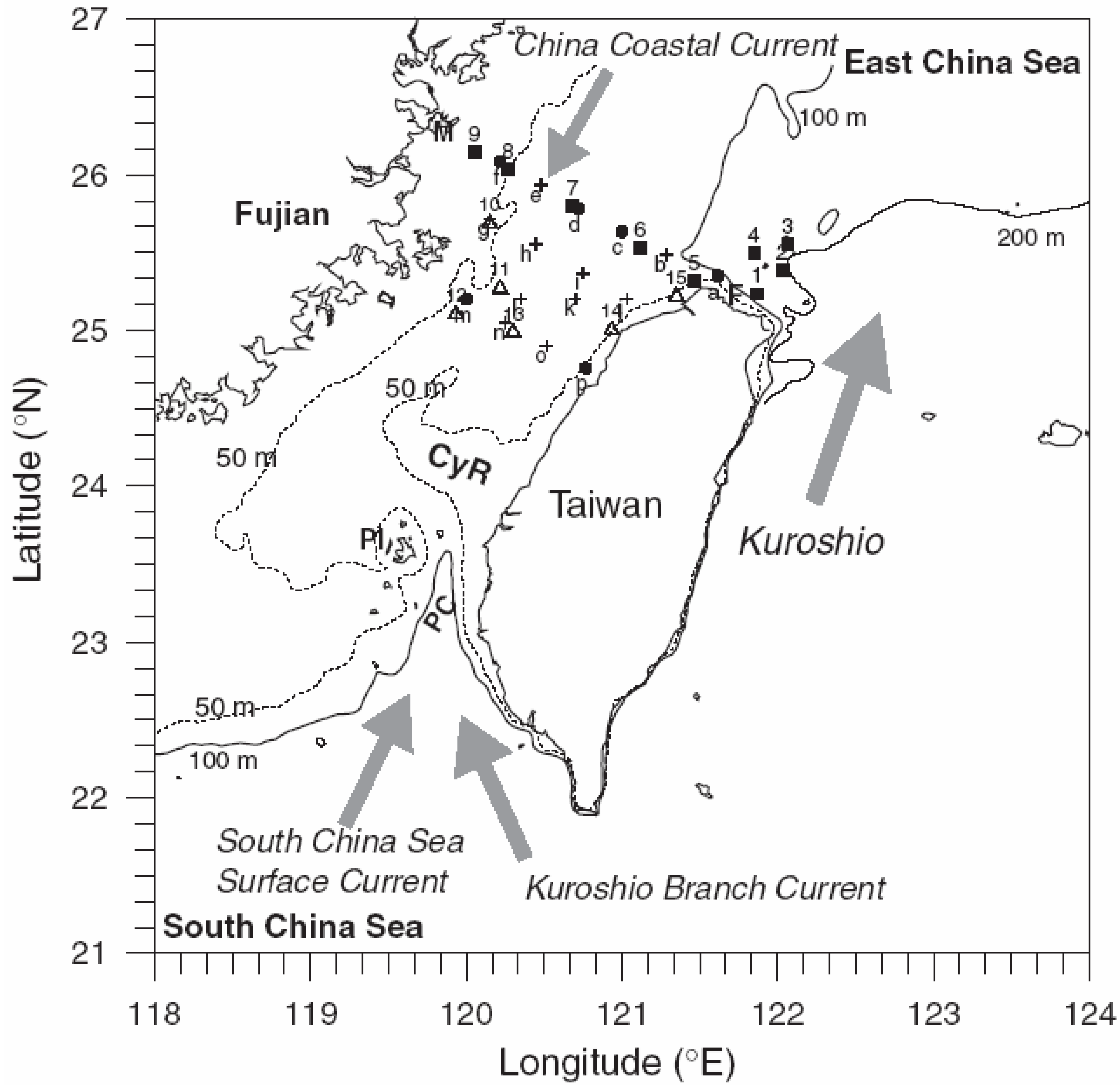
Fig. 1. Map showing sampling stations, currents, and isobaths of Taiwan Strait. The sampling stations in August 1999 (hollow triangles), November 1999 (solid squares), and March 2000 (solid circles), and the stations with only conductivity–temperature–depth (CTD) data in March 2000 (crosses) were shown. CyR, Changyun Ridge; F, Cape Fuguei; M, Matsu; PC, Penghu Channel; PI, Penghu Island.

△ 8月(夏)
station 10~15

■ 11月(冬)
Station 1~9

● 3月(春)
Station
a, c, d, f, m, p

+ 3月(春)-僅CTD
Station
b, e, g, h, I,
j, k, l, n, o



Data analysis

- CCA (canonical correspondence analysis)
- The species composition data
- Temperature, salinity, bottom depth and fluorescence

- TWINSPAN (two-way indicator species analysis)
- Base on the presence/absence of the dominant species at each station
- station cluster, and cluster-associated indicator species

Result and Discussion

summer

winter

spring

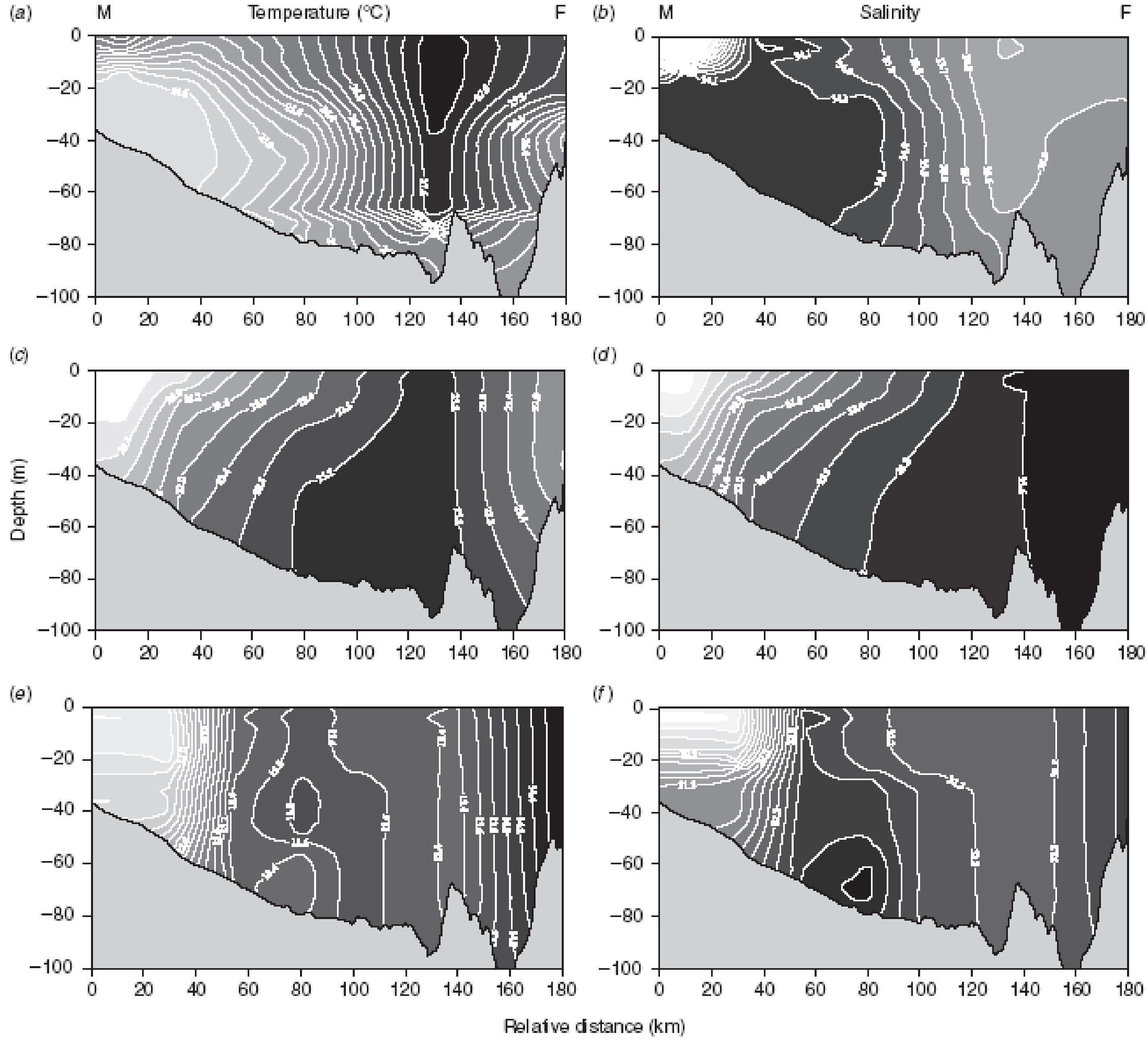


Fig. 3. Vertical sections of (*a*) temperature and (*b*) salinity in the north transect (From Matsu (M) to Cape Fuguei (F)) in summer, (*c*) temperature and (*d*) salinity in winter, and (*e*) temperature and (*f*) salinity in spring.

Table 1. Dominant species of copepods in each season, the average relative abundance (%) also shown

Summer		Winter		Spring	
Copepod					
Parvocalanus crassirostris[C]	15.11	*Paracalanus parvus*[D]	16.07	*Paracalanus parvus*[D]	53.64
Paracalanus parvus[D]	12.68	*Paracalanus aculeatus*[B]	10.56	*Corycaeus affinis*	17.53
Oncaea venusta[D]	8.90	*Calanus sinicus*[B]	9.64	*Oithona similis*	10.51
Temora turbinata[A]	6.56	*Acartia pacifica*[A]	9.51	*Calanus sinicus*[B]	6.66
Euterpina acutifrons	5.37	*Scolecithricella longispinosa*	3.34	*Oncaea venusta*[D]	1.97
Canthocalanus pauper[A]	5.20	*Oncaea venusta*[D]	3.00	*Paracalanus aculeatus*[B]	1.74
Acrocalanus gibber[D]	4.28	*Temora turbinata*[A]	2.76	*Clausocalanus furcatus*[D]	0.54
Oithona attenuata	4.20	*Canthocalanus pauper*[A]	2.34	*Clausocalanus minor*[B]	0.44
Oncaea conifera	3.03	*Clausocalanus furcatus*[D]	2.18	*Acrocalanus gibber*[D]	0.38
Oithona plumifera[A]	2.51	*Clausocalanus minor*[B]	1.98	*Temora stylifera*	0.30
Paracalanus serrulus	2.48	*Acrocalanus gibber*[D]	1.86	*Parvocalanus crassirostris*[C]	0.25
Corycaeus lubbocki	2.37	*Subeucalanus subcrassus*	1.55	*Corycaeus pacificus*	0.20
Clausocalanus furcatus[D]	1.92	*Oithona plumifera*[A]	1.53	*Oncaea mediterranea*	0.20
Oithona brevicornis	1.74	*Subeucalanus pileatus*	1.46	*Lucicutia flavicornis*	0.18
Acartia pacifica[A]	1.58	*Oithona fallax*	1.18	*Euchaeta plana*	0.17
Total	77.93		68.96		94.71

[A] Species occurring both in summer and winter; [B] species occurring both in winter and spring; [C] species occurring both in spring and summer; [D] species occurring in all three seasons.

Table 2. Dominant species of larval fishes in each season, the average relative abundance (%) also shown

Summer		Winter		Spring	
Larval fish					
Trichiurus lepturus[D]	13.60	*Bregmaceros nectabanus*	22.97	*Sebastiscus marmoratus*[B]	15.48
Encrasicholina heteroloba[A]	7.44	*Myctophum asperum*	12.50	*Benthosema pterotum*[B]	9.09
Saurida elongata[A]	4.32	*Trichiurus lepturus*[D]	11.46	*Boleophthalmus pectinirostris*	8.33
Priacanthus macracanthus	3.43	*Benthosema pterotum*[B]	8.96	*Scomber japonicus*	7.76
Leiognathus rivulatus	3.19	*Encrasicholina heteroloba*[A]	8.53	*Platycephalus indicus*	6.90
Apogon endekataenia	2.68	*Sebastiscus marmoratus*[B]	6.25	*Bregmaceros arabicus*[C]	4.17
Auxis rochei[A]	2.65	*Auxis rochei*[A]	3.13	*Myctophum nitidulum*	4.17
Secutor insidiator	2.28	*Pseudolabrus japonicus*	3.13	*Trichiurus lepturus*[D]	2.01
Diaphus theta	1.81	*Saurida elongata*[A]	2.30	*Liza affinis*	0.94
Diaphus pacificus[A]	1.72	*Diaphus pacificus*[A]	2.08	*Decapterus maruadsi*	0.86
Bregmaceros arabicus[C]	1.64	*Engyprosopon multisquama*[A]	2.08	*Decapterus russellii*	0.57
Ceratoscopelus warmingi	1.54	*Hyperoglyphe japonica*	2.08	*Hygophum proximum*	0.57
Symphurus orientalis	1.46	*Lampanyctus ritteri*	2.08	*Pagrus major*	0.57
Engyprosopon multisquama[A]	1.44	*Limnichthys fasciatus*	2.08	*Scomber australasicus*	0.57
Selar crumenophthalmus	1.43	*Pterycombus petersii*	2.08	*Tarphops oligolepis*	0.47
Total	50.63		91.71		62.46

[A] Species occurring both in summer and winter; [B] species occurring both in winter and spring; [C] species occurring both in spring and summer; [D] species occurring in all three seasons.

• Copepod and ichthyoplankton compositions

- Copepod – 146 species (50 genera, 28 families)
- Ichthyoplankton – 99 species (82 genera, 50 families)

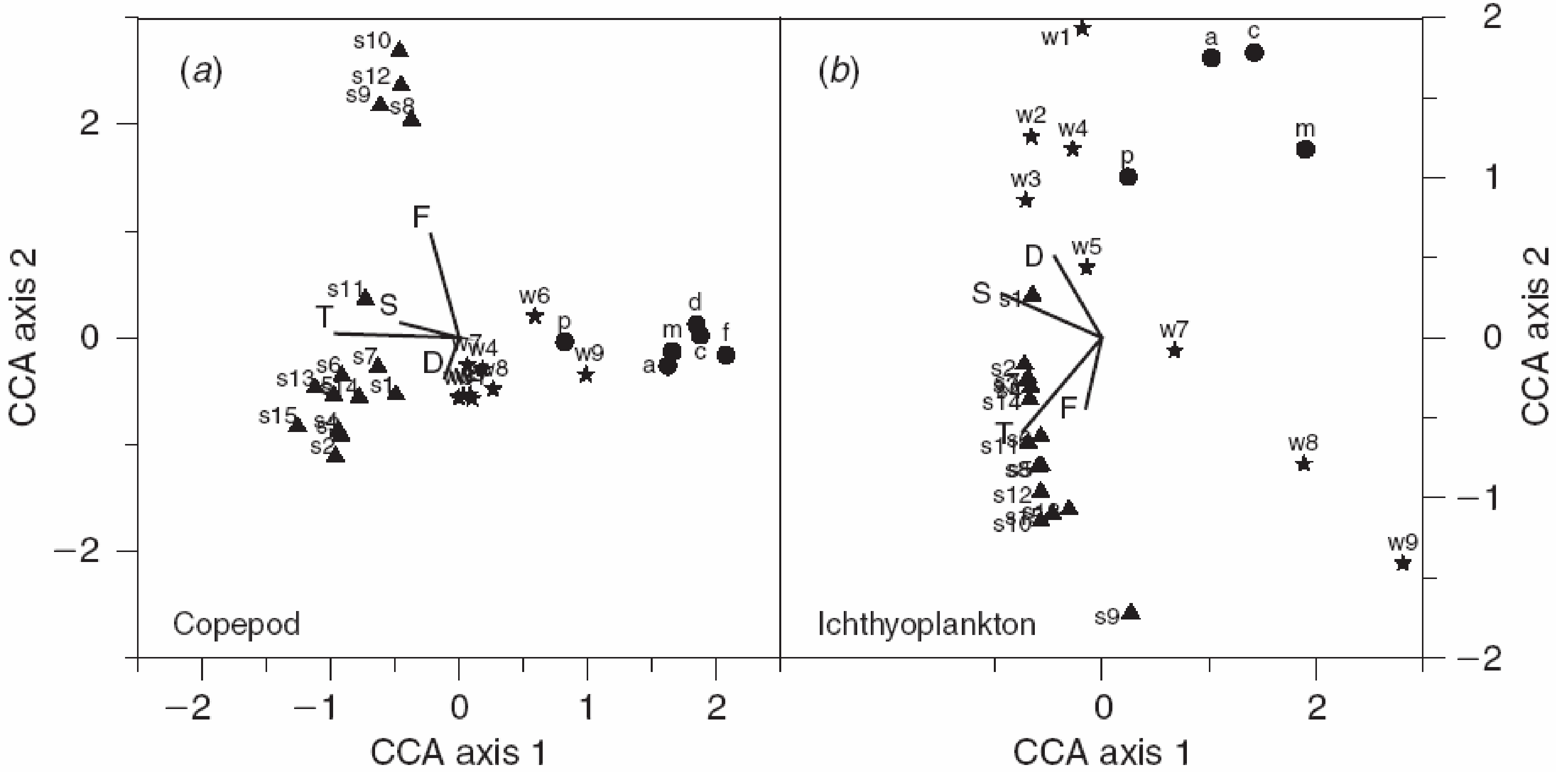
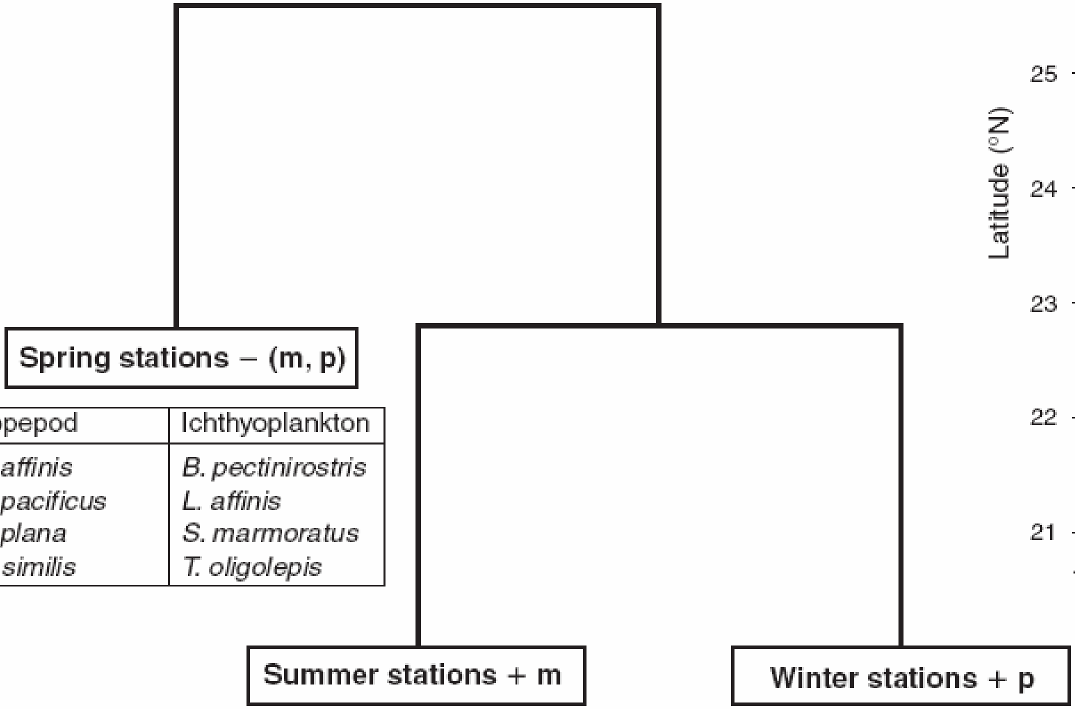


Fig. 4. Ordination diagram of canonical correspondence analysis (CCA) based on the species compositions of (*a*) copepods and (*b*) larval fishes. Triangles, stars and circles indicate stations in summer, winter and spring respectively.



Spring stations – (m, p)

Copepod	Ichthyoplankton
C. affinis	*B. pectinirostris*
C. pacificus	*L. affinis*
E. plana	*S. marmoratus*
O. similis	*T. oligolepis*

Summer stations + m

Copepod	Ichthyoplankton
C. lubbocki	*A. rochei*
E. acutifrons	*D. pacificus*
O. attenuata	*D. theta*
O. conifera	*E. multisquama*
P. serrulus	*L. rivulatus*
P. crassirostris	*P. macracanthus*
T. stylifera	*S. insidiator*
T. turbinata	*S. crumenophthalmus*
	T. lepturus

Winter stations + p

Copepod	Ichthyoplankton
C. sinicus	*B. nectanbanus*
S. longispinosa	*M. asperum*
S. subcrassus	

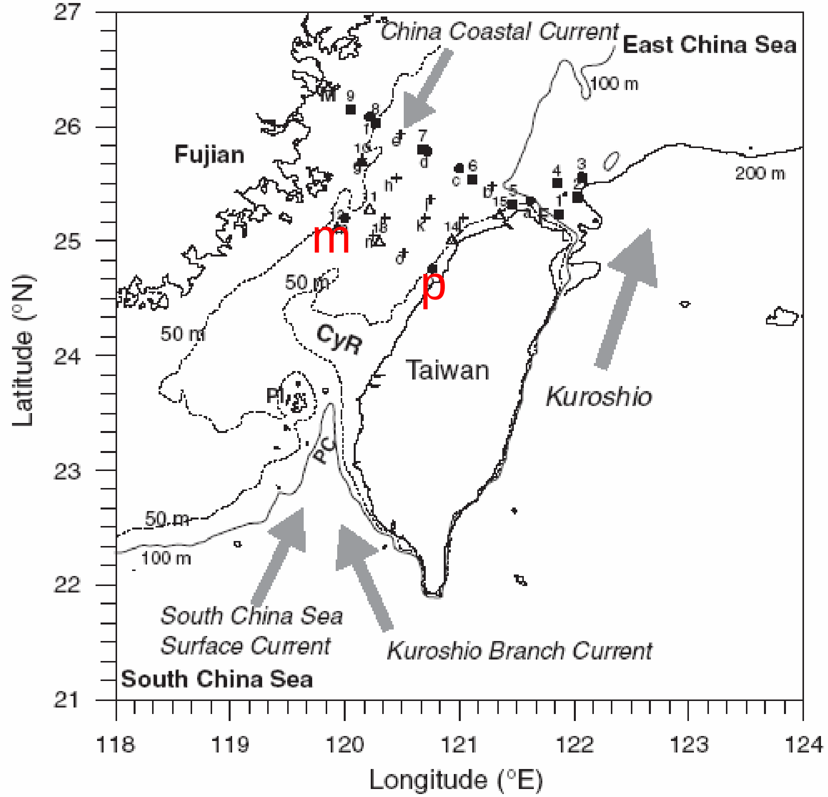
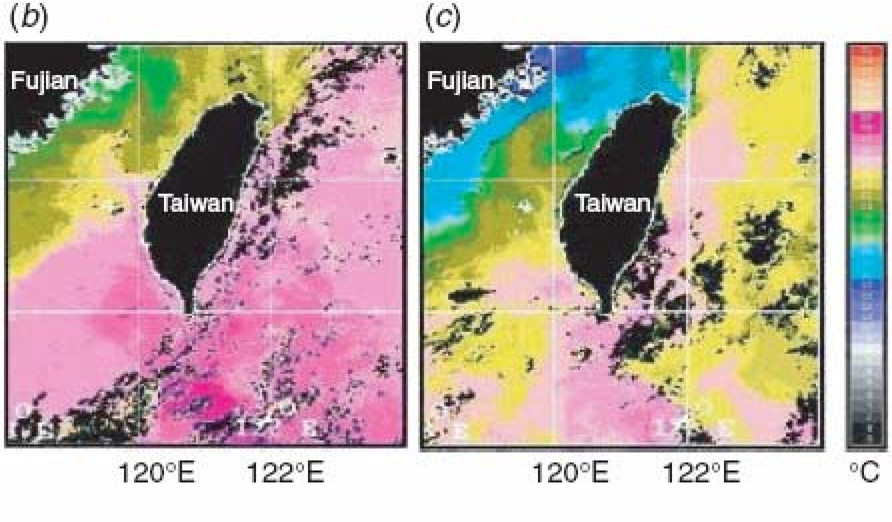
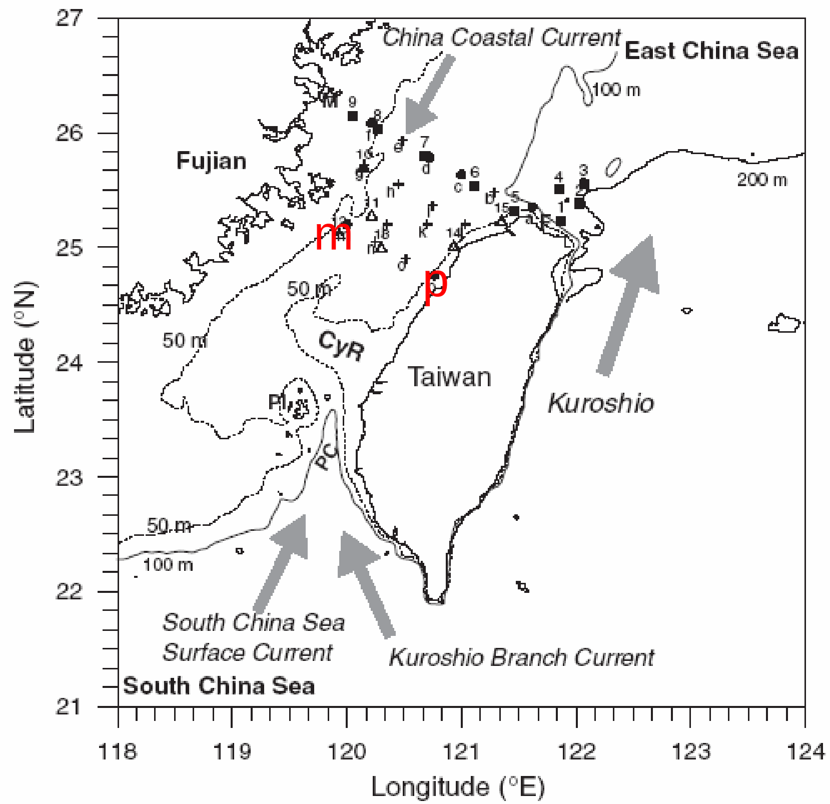


Fig. 5. Diagram of two-way (station and species) indicator species analysis based on presence/absence of the dominant species, showing station clusters depicting season categories with significant corresponding indicator species.

winter (November) spring (March)





- Spring station 'm' → Summer station

  The first station that encountered the effects of the Kuroshio Branch Current

- Spring station 'p' → Winter station

  The last station to be influenced by the China Coastal Current as the prevailing NE monsoon began to retreat

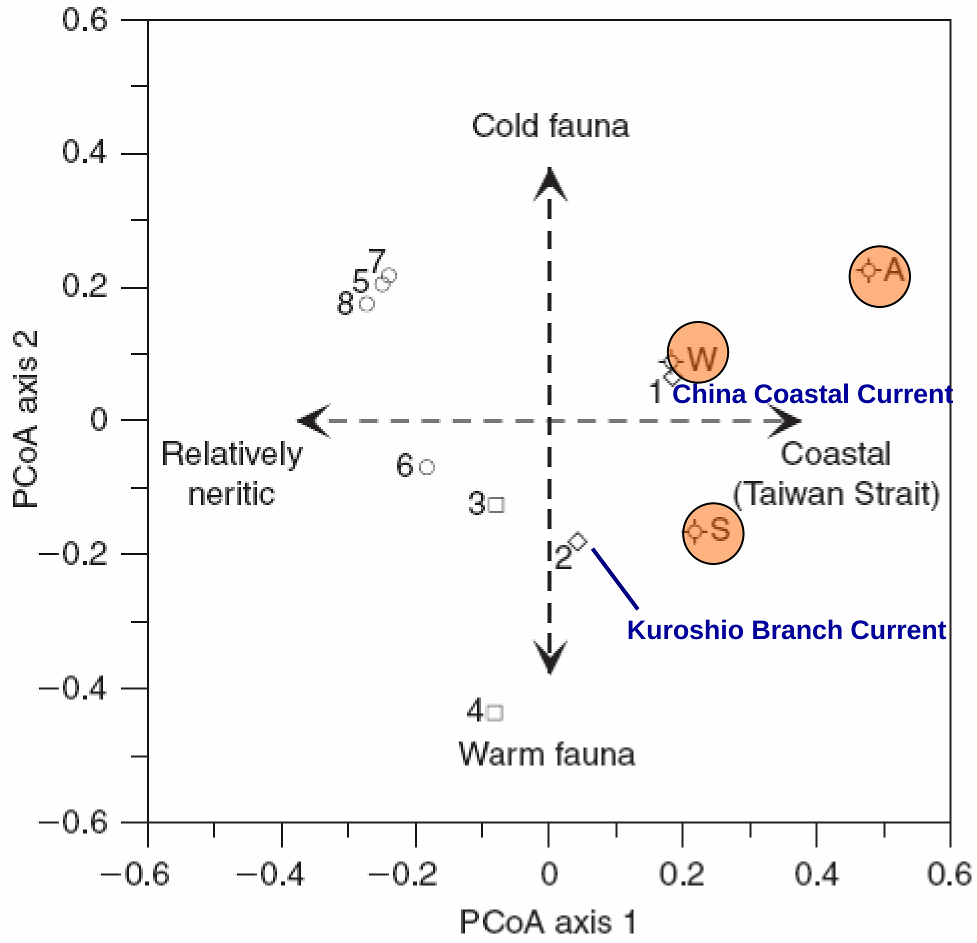


Fig. 6. Ordination diagram of principal coordinate analysis (PCoA) based on relative abundances of dominant copepod species extracted from four extant materials. Diamonds from Lan *et al*. (2004): 1 – China Coastal Current and 2 – Kuroshio Branch Current; square from Lo *et al*. (2004*a*, 2004*b*): 3 – upwelling and 4 – SW Taiwan Strait; circle from Shih and Chiu (1998): 5 – East China Sea, 6 – Kuroshio proper, 7 – mixing water of East China Sea and Kuroshio proper, 8 – north coast of Taiwan; and starred circle from this study: A – spring, S – summer, W – winter.

Conclusion

- 結論

- 海洋環境因子(溫度、鹽度、螢光值等)影響了浮游生物(橈足類、仔稚魚)族群的組成。
- 台灣海峽水文環境的變化，主要受到季風強弱以及形成時間影響。

Thanks for your attention!