Biology and Fishery Oceanography of Mackerels and Scads in the Adjacent Waters of Taiwan

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Abstract

Based upon purse seiner catch data and water temperature, fishery oceanography and biological characteristics of mackerels and scads were analyzed for both northeastern (NE) and southwestern (SW) offshore areas of Taiwan during 1979 to 1985. Mackerels, *Scomber australasicus* and *S. japonicus*, were the most dominant species, which contributed approximately 70% of the total catch. The scads, *Decapterus akaadsi* and *D. macrosoma*, contributed 20-30%. The size composition of *S. australasicus* and *D. akaadsi* was significantly different between the NE area and the SW area. In the NE area the mackerel and scad fishing grounds were in the coastal waters along the boundary to the Kuroshio current during their overwintering migration. The fishing grounds in the SW area were also located in the coastal waters along the boundary to the Kuroshio current during their spring spawning season. The catches of *Scomber* spp. in the NE area were significantly inversely correlated with water temperature.

Introduction

Mackerels *(Scomber japonicus, S. australasicus)* and scads *(Trachurus japonicus, Decapterus* spp.) are the most important pelagic commercial fishes in the coastal waters of Taiwan. Their catches have varied from year to year between 20,000 and 40,000 t. Before 1977 most of the mackerels and scads were caught by handliners. Since 1977 most of the handliners have been replaced by large purse seiners. The fishing grounds of mackerels and scads have also extended from the nearshore waters of Taiwan to offshore waters near to Pengchiahsu and Fishing Islands off northeastern Taiwan and near Pratas Islands off southwestern Taiwan.

A large purse seiner consists of five boats: a netting boat, two light boats and two transport boats (Tzeng 1984). Although the large purse seiner is an efficient fishing gear, fishermen spent most of their time searching for fishing grounds. If predictable, the fishermen can save much time searching for fish schools. The formation of the fishing ground of mackerels and scads was known to be related to oceanographic conditions in the Yellow Sea and East China Sea (Tsujita and Kondo 1957; Mori 1978). This paper describes the fishery oceanography, biological characteristics and the fluctuation of the catch of mackerels and scads in the waters adjacent to Taiwan.

Materials and Methods

Beginning 1979, the daily catches, location of fishing ground, fish species, water depth, surface temperature, current direction and velocity and weather were recorded by the captains or crew of the large purse seiners. Based on these data, species composition of the catch and catch per haul (CPUE) were computed for the northeastern area (NE) and southeastern area (SW) off Taiwan.

Fork lengths of 100 to 500 individuals of each species were measured monthly at the Su-Ao fish market from July 1981 to October 1983.

Monthly CPUE and water temperature anomalies were computed. The water temperature was measured at Pengchiahsu by the Taiwan Fisheries Research Institute and at Fishing Island by Nakasaki's Marine Meteorological Observatory of Japan.

Results

The annual catches of mackerels from different fisheries during 1963 to 1984 are shown in Fig. 1. The catch increased from 1963 and reached a peak in 1970. From 1970 to 1974, the catch declined rapidly to a very low level. In 1977, an efficient large type of purse seiner was introduced to Taiwan. The catch of mackerels rapidly increased and reached the 1970 level in 1984.

The annual catches of scads from different fisheries are shown in Fig. 2. 1963 to 1977, most were caught by otter trawl, bull trawl and small purse seiner. After the introduction of the large purse seiner in 1977, the total catch of scads rapidly increased.

The currents, water masses and oceanic boundaries in the East and South China Seas and the fishing grounds of mackerels and scads in the NE area and the SW area are shown in Fig. 3. The fishing grounds of mackerel and scad in the NE area were distributed in coastal waters along the

boundary with the Kuroshio current. The Kuroshio penetrated into the lower layer of the coastal waters in the continental shelf of China. A similar situation was found for the SW area. The fishing ground of mackerels and scads in this area was also located in the coastal waters along the boundary to the warm Kuroshio current.

Mackerels included *Scomber japonicus* and *S. australasicus*. These two species are fairly similar in morphology and difficult to distinguish in the field. Therefore, they were combined into a species group as *Scomber* spp. In this study, *Scomber* spp. usually made up about 70% of the catch. The scads included *Trachurus japonicus* and five species of *Decapterus* and made up 20-30% of the catch. A small number of *Etrumeus teres* was taken in the NE area and *Mene maculata* in the SW area in April-June 1983 and 1985 (Table 1).

Monthly length-frequency distributions of the four dominant species, *Scomber australasicus, S. japonicus, Decapterus akaadsi* and *D. macrosoma,* are shown in Figs. 4-7.

The monthly CPUEs were computed for *Scomber* spp., *D. akaadsi* and *D. macrosoma*. The peak catch of *Scomber* spp. in the NE area occurred during December-January. The peak catch of *D. akaadsi* occurred in November. The peak catch of *D. macrosoma* occurred during the September-October period, about two months earlier than that of *Scomber* spp. The fishing season of purse seiners in the SW area was short, from February to May.

The relationship between the catch and water temperature was studied for *Scomber* spp. The peak catch appeared to be from autumn to winter (September-January) when water temperatures were low. The peak catch seemed to be related to the temperature gradient between Fishing Island and Pengchiahsu. The greater the gradient the stronger the oceanic front. As shown previously, the fish schools aggregated near the oceanic front (Fig. 3). CPUEs of *Scomber* spp. were significantly negatively correlated with water temperature ($r = -0.3823$, $P < 0.05$), suggesting that more *Scomber* spp. immigrated into the NE area when the water temperature decreased (Fig. 8).

In addition, the monthly CPUE anomalies (ΔCPUE) and monthly water temperature anomalies ($\Delta^{o}C$) in the NE area were computed and compared. The trend of the frequency distribution of CPUE was opposite to that of $\Delta\ ^{o}C$ in the corresponding year. Δ CPUE was lower when water temperature was higher at the coast of Pengchiahsu and Fishing Island in 1983 and 1984 and vice versa in 1982 and 1985.

Discussion

The peak fishing season of mackerels and scads in the NE area was from September to January, corresponding to the period when water temperature decreased. In general, mackerels and scads migrate southward in the autumn and winter and northward in the spring and summer in the East China Sea. Their fishing season in the SW area from February to May was their spawning season (Ku and Tzeng 1985).

The length-frequency distribution of mackerels and scads was significantly different between the NE area and SE area, especially for *S. australasicus* and *D. akaadsi* (Figs. 4 and 6). *S. australasicus* in these two fishing areas might belong to different stocks (Chang and Chen 1976; Ku and Tzeng 1985). However, *D. akaadsi* may belong to the same stock (Chang et al. 1976).

The fishing grounds of *Scomber* spp. were distributed in the coastal waters along the boundary to the Kuroshio current (Fig.3). According to Chu (1970), the China coastal current comes from north China. It flows toward south along the coast when northeast winds prevail during the winter, and retracts back when the southwest monsoon prevails during the summer. A boundary between the Kuroshio current and coastal current develops in the offshore waters of northeastern Taiwan, particularly in the winter. The boundary is characterized by the difference in water properties between the Kuroshio current and coastal current. Its position shifts with season and changes according to the intensity of flow on both currents. The Kuroshio water has high temperature and salinity, while the coastal water has low temperature and salinity. The water temperature anomalies near the coast of Pengchiahsu and Fishing Island were higher in 1983 and 1984 possibly causing the low catch of mackerels and scads in the NE area at that time.

Mackerels and scads always aggregated at the oceanic front (Fig. 3). If fishermen know the location of the oceanic front, they may easily locate the fish schools. Now, the oceanic conditions can be determined quickly by remote sensing techniques and the fishing ground can be predicted.

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Table 1. Species composition of the catches of large purse seiners in the offshore areas of northeastern (NE) and southwestern (SW) Taiwan, during July 1982 to September 1985.

Species	Fishing ground	Species composition of the catch (%)																
		1982			1983					1984					1985			
		Jul-Sept	Oct-Dec	Total	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Total	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Total	Jan-Mar	Apr-Jun	Jul-Sept	Total
Scomber spp.	NE	65.25	72.87	69.99	85.22	39.51	54.34	61.68	62.45	84.80	84.83	67.77	78.24	77.11	94.32	48.28	57.00	72.10
	SW					65.59			65.59	72.30	54.53			60.14	60.55	28.19		36.78
Decapterus macrosoma	NE	16.50	15.67	15.99	0.82	7.90	24.32	5.04	10.61			25.30	19.18	15.59	2.16	22.59	18.49	11.91
	SW					3.92			3.92		17.05			11.64	0.25	5.53		4.11
D. akaadsi	NE	11.22	5.05	7.39	11.62	2.84	3.30	4.61	5.61	12.41	11.22	5.05	1.80	5.51	2.09	12.16	0.91	2.32
	SW					12.34			12.34	23.18	16.13			18.36	7.49	0.75		2.55
D. maruadsi	NE	5.43	2.59	3.67	0.54	13.09	9.64	18.16	10.86	0.52	3.94	1.87	0.62	1.38	0.02	0.34	10.80	5.39
	SW					7.49			7.49		9.42			6.43	4.12	6.29		5.70
D. macarellus	NE	1.50	2.17	1.93	1.80		1.50	7.75	3.58	1.98			0.16	0.37	1.09			0.46
	SW					1.93			1.93	4.53	0.26			1.61	11.49	1.09		3.86
D. tabl	NE	0.09	0.23	0.18				0.72	0.25	0.26				0.04	0.11		0.02	0.06
	SW															0.68		0.50
Trachurus japonicus	NE		0.49	0.30			0.38	1.97	0.81	0.03				0.004	0.20	16.63	12.59	7.67
	SW					7.91			7.91						3.75	5.08		4.72
Etrumeus teres	NE		0.93	0.58		31.11	6.51		5.24									
	SW					0.41			0.41		1.02			0.70				
Katsuwonidae	NE					5.56		0.07	0.58						0.01		0.19	0.10
	SW					0.07			0.07		1.43			0.98				
Mene maculata	NE																	
	SW					0.34			0.34		0.15			0.11	12.36	52.38		41.68
Total catch (t)	NE	5,266	8,646	13,913	1,837	810	2,604	2,787	8,038	1,918	1,622	3,602	5,631	12,773	4,552	872	5,325	10,748
	SW					1,455			1,455	906	1,953			2,859	801	2,196		2,997

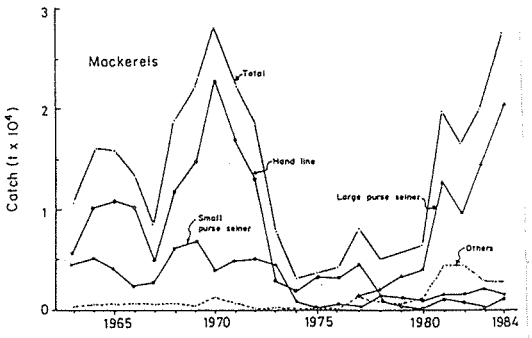

Fig. 1. Annual catches of mackerels of each type of fishery in Taiwan.

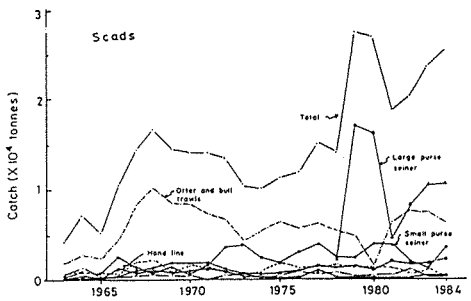

Fig. 2. Annual catches of scads of each type of fishery in Taiwan.

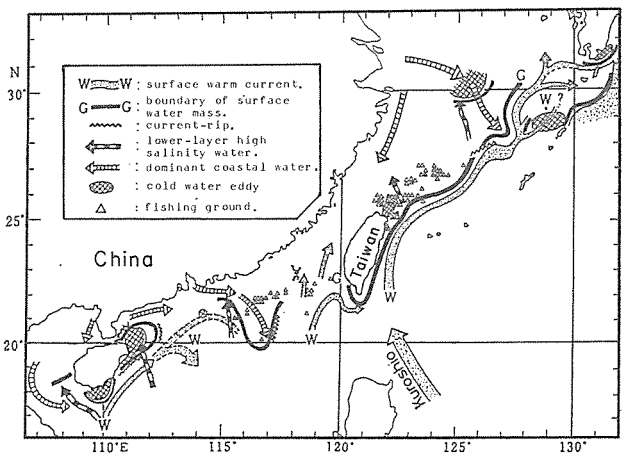

Fig. 3. The ocean current, coastal water and the boundary of water mass in the East and South China Seas and the distribution of the fishing grounds of mackerels and scads in the offshore areas of northeastern and southwestern Taiwan.

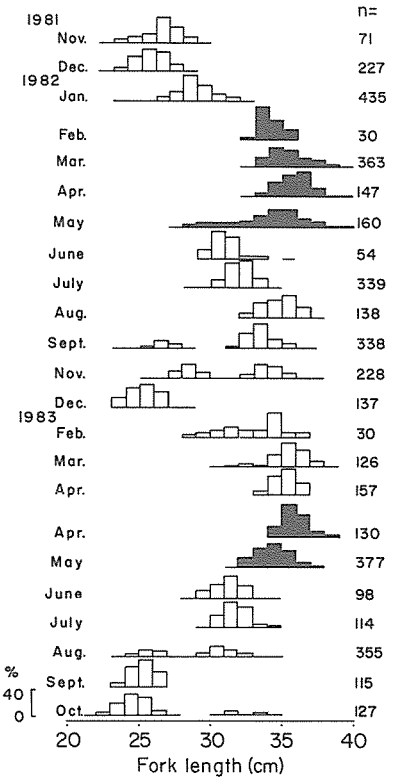

Fig. 4. Monthly length-frequency distribution of *S. australasicus* in the northeastern (open columns) and southwestern (solid columns) offshore areas of Taiwan during the period from November 1981 to October 1983 (N, sample size).

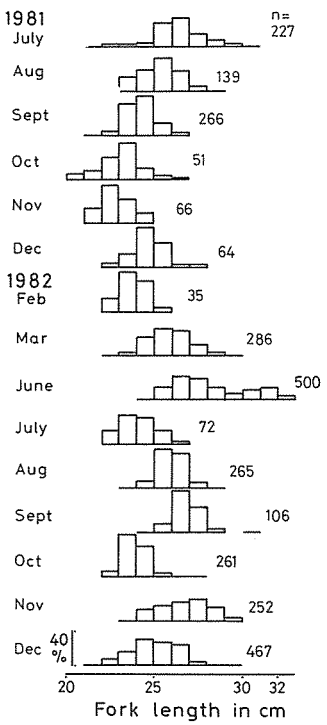

Fig. 5. Monthly length-frequency distribution of *S. japonicus* in the offshore area of northeastern Taiwan, July 1981-December 1982.

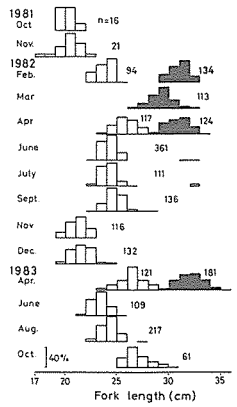

Fig. 6. Monthly length-frequency distribution of *D. akaadsi* in the offshore areas of northeastern (open columns) and southwestern (solid columns) Taiwan, October 1981-October 1983.

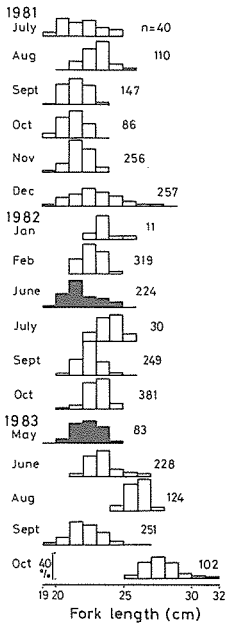

Fig. 7. Monthly length-frequency distribution of *D. macrosoma* in the offshore areas of northeastern (open columns) and southwestern (solid columns) Taiwan, October 1981-October 1983.

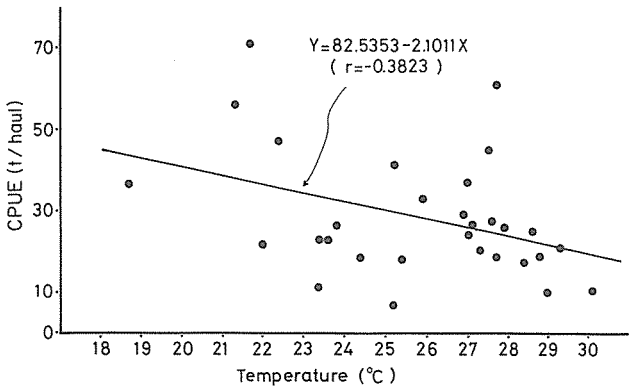

Fig. 8. Relationship between monthly mean CPUEs of *Scomber* spp. and mean water temperature in the offshore area of northeastern Taiwan, July 1982-September 1985.