EVIDENCE FOR A COUNTER-WIND CURRENT IN WINTER OFF THE SOUTHEAST COAST OF CHINA*

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Abstract

Regarding the current pattern in winter in the near sea region of Zhejiang, Fujian and Guangdong (including the western and central parts of the Taiwan Strait), oceanographers both at home and abroad had considered unanimously that under the intense influence of the northerly monsoon, the current (not only at the surface but also in the deep and near-bottom layers) flows southwestward with the wind. It was not until the end of the fifties that scientists began to question such a traditional concept.

In this paper, based on the results of more than 20 years' studies on the current patterns of the East China and South China Seas, all kinds of current data available are reanalysed comprehensively. These data include: 1) current measurements at day-night anchored stations, and with mooring buoys, collected mostly from 1959 to 1982 by many Chinese oceanographic and fisheries organizations; 2) current vectors derived from the ship-drift of Japanese naval vessels in the period from 1910 to 1921; and 3) geostrophic current velocities deduced from hydrographic observations in the periods of the CSK and 1975—1976 conducted by the Fisheries Research Station, Hong Kong, and the SOA. A combination of all the evidences revealed in the above data suggests and confirms that, besides the China Coastal Current flowing southwestward at a shallow layer of a zone closely adjacent to the coast, there also exists a northeastward counter-wind current in winter off the southeast coast of China (though its surface current may be weakened or even covered up by the drift current when the northerly monsoon strengthens). Furthermore, the two parts of the winter counter-wind current in the South China Sea and the East China Sea are connected through the Taiwan Strait. This suggestion now has been confirmed by the recent observations in the Taiwan Strait, i.e., 1) with sea-bed drifters released in 1984 (Zhang, 1985) and 2) with current meter moorings deployed in 1983 (Chuang, 1985).

It is suggested that detailed field investigation in winter for filling the gap of observations should be needed to give further confirmation of this important new finding. At the same time, dynamical, numerical and experimental studies should also be carried out for a better understanding of the mechanism of this counter-wind current, and its variations and correlation with the adjacent currents, such as the southward flowing coastal current and the northward flowing Kuroshio Branch.

I. INTRODUCTION

Regarding the current pattern in winter in the offshore region of Zhejiang, Fujian and Guangdong (including the western and central parts of the Taiwan Strait), oceanographers both at home and abroad have considered unanimously that under the intense influence of the northerly monsoon, the current (not only at the surface but also in the deep and near-bottom layers) flows with the wind from northeast to southwest. In addition, the northern part of the current may have originated from the Chinese offshore area of the East China Sea and the Huanghai Sea, and the southern part may extend even

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to the coastal area off the Indo-China Peninsula. The two parts constitute the China Coastal "Cold" Current flowing first from north to south and then from northeast to southwest. To the best of the author's knowledge, no one has ever reported that besides the current flowing with the wind there still exists a current flowing against the wind in this region in winter.

It was not until the end of the fifties that scientists began to question such a traditional concept.

More than 20 years ago, while the Chinese national comprehensive oceanographic survey (1958—1960) was conducted, a more systematic survey was made in the offshore area of the western East China Sea and the northern South China Sea. Besides monthly hydrographic observations at oceanographic stations, day-night current measurements from the surface to the deep and near-bottom layers at many anchored stations were also made. A set of better quality residual current data was thus obtained. Some new and important findings concerning the winter current pattern which had not been discovered in the past foreign investigations in this area were revealed, such as:

1. In the offshore region off eastern Zhejiang, besides the East China Sea Coastal Current flowing with the wind in the area closer to the coast, there existed a current flowing northeastward and against the wind from the near-surface layer ($\sim$5 m) down to the bottom in the area a little farther away from the coast. This flow has been known as the "Taiwan Warm Current" (Guan and Chen, 1964)

2. In the nearshore region off Shantou (east of 116°E), there also existed a current flowing northeastward and against the wind. Its velocity was so strong that the tidal current there was no longer the predominant component of the overall current (Guan & Chen, 1964).

3. In the coastal area northeast of Hainan Island, the counter-wind current was also observed. At that time, the northeastward flowing currents observed in the nearshore regions off Shantou and northeast of Hainan Island were considered to be connected with each other and were known as the "Nanhai (South China Sea) Warm Current" (Guan & Chen, 1964).

After the completion of the Chinese national comprehensive oceanographic survey, current measurents by the departments concerned (especially those carried out in the northern South China Sea in the early seventies by the South China Sea Division of the State Oceanic Administration (SOA)) provided further evidences for the existence of the Nanhai Warm Current (Guan, 1978 b). Furthermore, through an analytical study of the CSK (Cooperative Study of the Kuroshio and Adjacent Waters) data collected by the R/V Cape St. Mary of the Fisheries Research Station of Hong Kong during the winter of the years 1966—1968, a strong, narrow and band-like northeastward current was discovered on the geostrophic current field south of the Tropic of Cancer, 19—22°N, i.e. in the open sea off Guangdong (Guan, 1978 a). It was considered that this current was the main stream of the Nanhai Warm Current, while that discovered at the end of the fifties was only a weaker left flank of the Nanhai Warm Current in comparison with this (Guan, 1978 a, b).

In the early sixties, based upon the preliminary observation results of the two above mentioned counter-wind currents, i.e. the Taiwan Warm Current and the Nanhai Warm Current, the author considered such problems, as "where is the end of the China Coastal

Current which flows with the wind in winter ?", "is the direction of the deep and near–bottom currents in the Taiwan Strait consistent with that of the surface current?", and so on. At that time, the author conceived that there might also exist in the deep and near–bottom layers of the western part of the Taiwan Strait a northeastward counter–wind current. And it was further considered that should this suggestion be confirmed by the future observations, then off the southeast coast of China, besides the large amounts of cold water flowing southward with the wind in winter there should exist at the same time a part of warm water flowing northward against the wind from the coastal area east of Hainan Island, passing through the near–sea region of eastern Guangdong and the western part of the Taiwan Strait, and reaching the near sea region of Fujian and Zhejiang, It suggests that , at least a part of the water of the Nanhai Warm Current flowing against the wind in winter might be connected with the northeastward current in the offshore region of eastern Zhejiang through the Taiwan Strait (Guan et al., 1964, MS)*.

Regarding the idea of a counter–wind current in winter off the southeast coast of China suggested about 20 years ago, the author is still imbued with confidence, especially so in view of the new information of the winter current condition collected in the western part of the Taiwan Strait (Chen, 1978; Guan, 1980) and the recent data from the sea-bed drifters released by the Institute of Oceanology, Academia Sinica, Qingdao, in the middle and northern parts of the Taiwan Strait (Zhang, 1985) and from the current meter moorings deployed by Institute of Oceanography, Taiwan University, Taibei, China in the eastern Taiwan Strait(Chuang, 1985).

Based on the results (obtained since the end of the fifties) of investigations on the offshore current patterns of the East and South China Seas, this paper presents a comprehensive reanalysis of the data of the current measurements and seawater mass distribution collected during a period of more than 20 years. Some evidences of the existence of a current flowing against the wind in winter off the southeast coast of China will be suggested and demonstrated in order to confirm preliminarily my idea conceived about 20 years ago of such a current (Guan, 1983, 1984).

II. EVIDENCES FROM THE CURRENT MEASUREMENT DATA

In this aspect, there are current observation data collected by the Chinese organizations concerned since the end of the fifties, and ship–drifts data collected by Japanese naval vessels during the early part of this century.

1. In Fig. 1, the solid vectors show the residual currents at the 10 m depth in winter (Nov., Dec. and Jan.—Mar.) in the offshore area of Guangdong, and off western Taiwan and eastern Zhejiang. Most of these current measurements were taken in the periods of 1959—1960, 1971—1973 and 1977—1978. The largest solid arrow located southeast of Shantou shows the resultant velocity of the current measurements taken at a mooring station in the deep water region(~ 1000 m) in February, 1982 under very intense north-

* Guan Bingxian, Ding Wenlan and Mao Hanli, 1964. The winter surface current systems of the southern Huanghai Sea and the northern East China Sea and discussions of some related problems (MS, in Chinese).

east winds by the South China Sea Institute of Oceanology, Academia Sinica, Guangzhou (Guo et al., 1985).

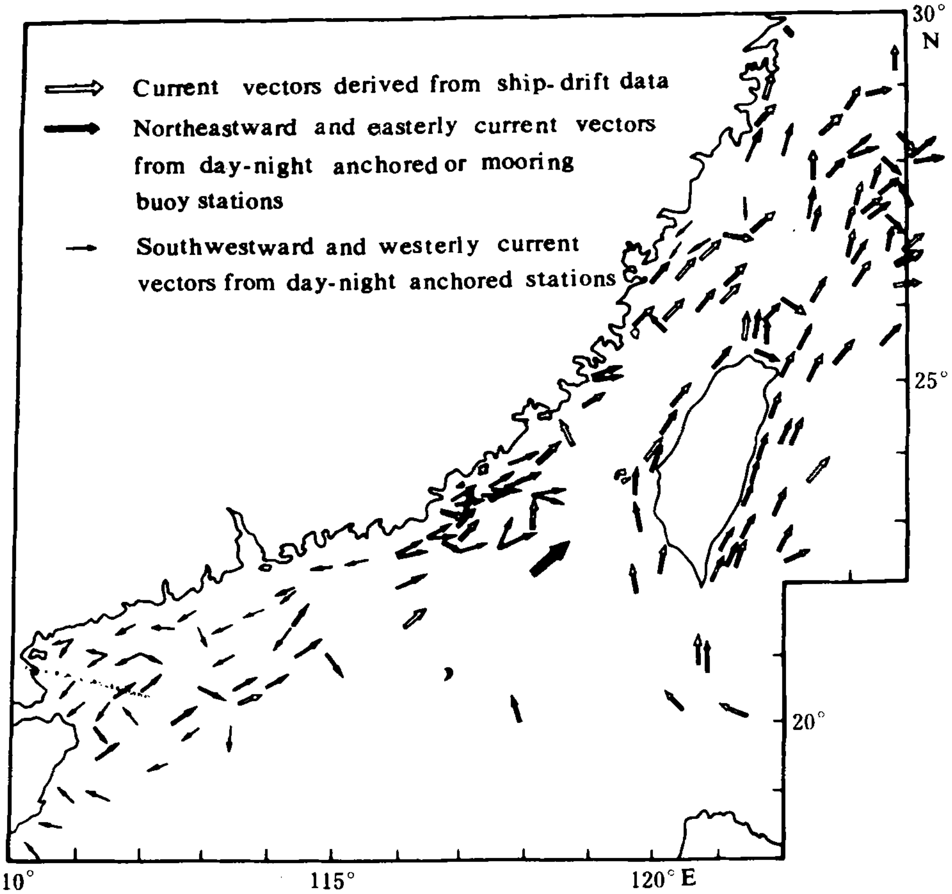

Fig. 1 Observation results of the current in winter off the southeast coast of China.

2. Concerning the winter current regime of the western side of the Taiwan Strait, observations since the late fifties showed that the current did not entirely flow southwestward; the southward East China Sea Coastal Current appeared only at a shallow layer (< 10 m) of a zone closely adjacent to the Zhejiang-Fujian coast (depth < 25 m). Its maximum velocity generally did not exceed 30 cm/s, and only during the strongest northeast wind did it reach to the neighbouring area off Quanzhou and the layer deeper than 10 m. And the current in the offshore region (depth > 25 m) and at a deeper layer (> 10 m) in the western part of the Strait still flowed against the wind, i.e. it flowed northeast ward or northward as in spring and summer (Chen, 1978; Guan, 1980).

3. Figs. 2 a, b were reproduced from the "Meteorological and Ocean Current Charts in the Adjacent Sea of Japan" (Figs. 20 and 23. JHO, 1925). The current vectors on these charts were compiled based on the observation reports of Japanese naval vessels in the period from 1910—1921. The current part consisting of four charts gives the surface

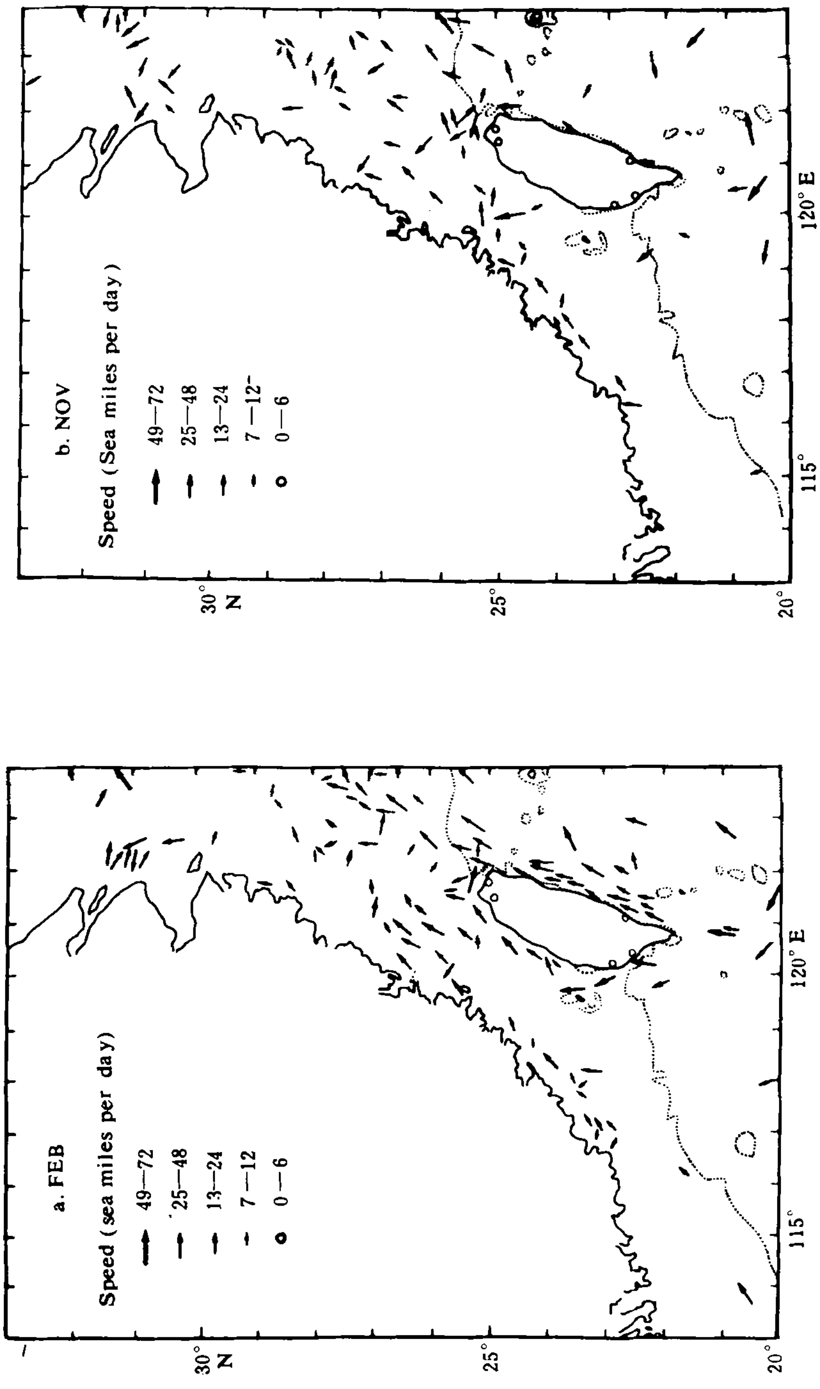

Fig. 2 Current vectors derived from ship-drift data(From JHO. 1925).

currents in winter (February), spring (May), summer (August) and autumn (November), respectively. Each vector on the charts represents one observation. The speed of the current is shown in 5 scales. The superiority of these charts is that they may be considered as original data sets indicating the current conditions that were actually happening then. On the other hand, the other prevalent current charts were compiled through a process of taking scalar or vector averages of vectors of currents observed in a longitude and latitude grid. Therefore, the fewer vectors of non–predominant currents are covered up by the more numerous vectors of predominant currents so that the non–predominant currents are not displayed on the charts. In order to make a special effort to analyse (besides the current flowing southward with the wind) whether or not there exists a counter–wind current in winter off the southeast coast of China, only the current vectors directing northward (along the Guangdong, Fujian, Zhejiang and Taiwan coasts) and eastward are reproduced in the Figs. 2 a, b; while the vectors directing southward along the coasts and westward are not reproduced.

It is evident from a comparison of the above mentioned figure that the information of the winter current conditions off Guangdong, Fujian and Zhejiang provided by these two sets of data collected more than half a century apart is quite similar. The current vectors derived from shipdrift (observed in 1910—1921) and those from current measurements at day–night anchored stations (observed in 1959—1982) all indicate that, off the eastern part of Hainan Island and Guangzhou, along the eastern Guangdong coast and the western coast of Taiwan, and off eastern Zhejiang, there really exists a counter–wind current flowing from southwest to northeast. It is in obvious contrast to the traditional concept that the current there totally flows from northeast to southwest. Judging from the density (dense or scarce) of the distribution of current vectors, these two sets of data supplemented each other. For example, the northeastward vectors derived from ship–drift are scarce in the area off Guangdong, but those from current measurement are relatively numerous. The current measurement data in the coastal area from Xiamen to Wenzhou are scarce, while the northeastward vectors derived from ship–drift are comparatively numerous there. In the coastal zone of eastern Guangdong and southern Fujian, both these kinds of data are sufficient. Because the ship–drift data from Japanese Current Charts are limited to the area north of 20°N, the current regime in the area east of Hainan Island can only be explored from the data of current measurements and geostrophic current deduced from the water mass distribution.

The autumn–winter current regime in the area off central Fujian shown by Chen (1978) also agrees with that deduced from ship–drift data.

Therefore, the counter–wind current flowing northward in winter which has been observed for more than 20 years (since the late fifties) is not an accidental phenomenon as it was also observed about half a century ago. However, it was covered up by the majority of observation results of the predominant southward drift current and had not attracted people's attention.

In order to get a more eye–catching and continuous impression, the vectors derived from the ship–drift in Fig. 2 a (February) are overlapped in Fig. 1. In this figure, the northeastward vectors derived from day–night observations at anchored stations accounted for more than 36 in the period from November to March, and those derived from the ship-drift accounted for 31 in February. Hence, the northeastward currents were observed nearly 70 times in winter altogether. Therefore, the trend of counter-wind current originating from the area east of Hainan Island and flowing northeastward seems more apparent. At the same time, it is also shown that the Kuroshio branch entering the South China Sea through the Bashi Channel in winter flows northward mainly along the west coast of Taiwan, moving side by side with the above mentioned counter-wind current flowing northward along the coast of Guangdong, Fujian and Zhejiang.

It may be been from the current measurement data in Fig. 1 that the velocity of the counter-wind current was around 50 cm/s (~1 knot ——the strongest) off the eastern Guangdong coast, around 20 cm/s (~0.4 knot) immediately northeast of Hainan Island, around 15 cm/s (~0.3 knot ——the weakest) off eastern Zhejiang. The current velocity in Fig. 2 was deduced from ship-drift data. Though its accuracy is less than that of direct current measurement, the figure shows that the northward speed off eastern Guangdong

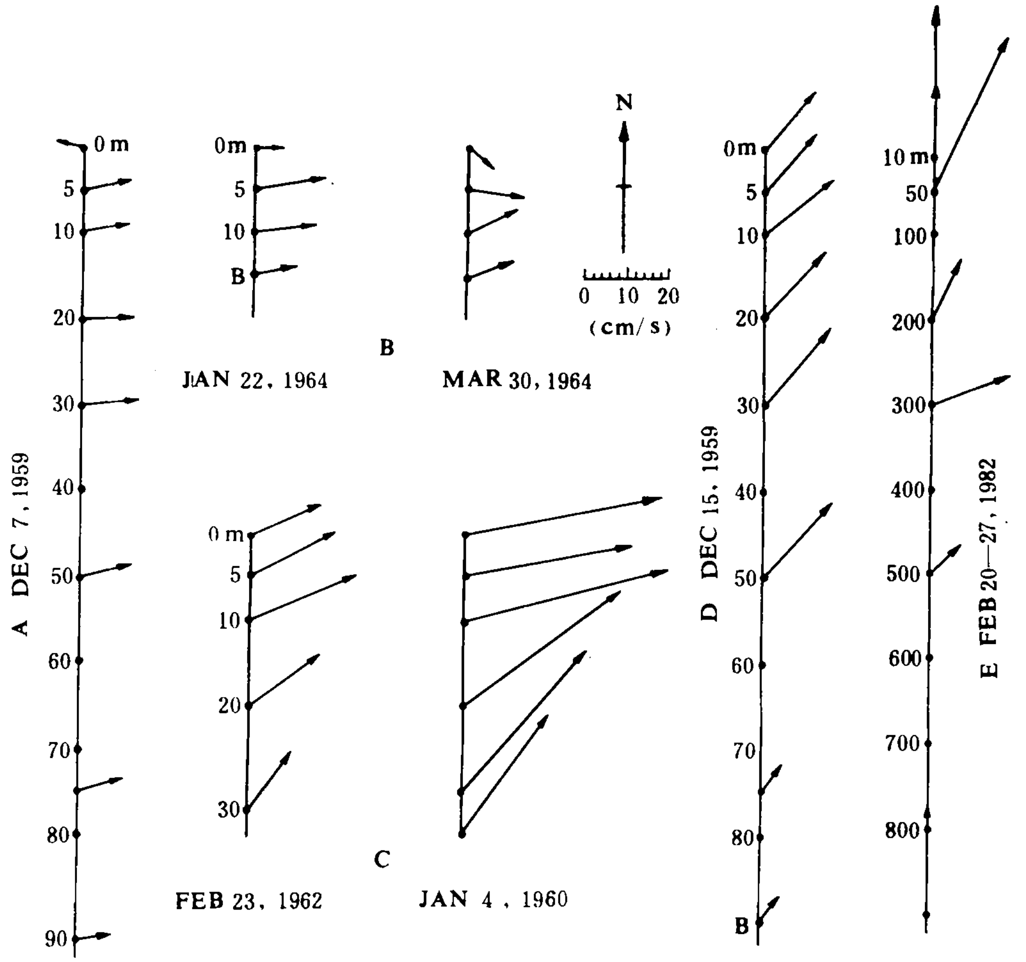

Fig. 3 Vertical structures of the residual current at some day-night anchored and mooring buoy stations in winter off the southeast coast of China.

and southern Fujian is still rather strong.

The author believes that the main stream of the Nanhai Warm Current may meet its left flank off eastern Guangdong, thereby strengthening the northeastward velocity of the current there and forcing a part of the Nanhai Warm Current to flow through the western side of the Taiwan Strait. And this part of water may extend farther to become the northeastward current off eastern Zhejiang. The author would like to point out that in the open sea off eastern Zhejiang in winter, the possibility of the existence of a Kuroshio branch (separated from the Kuroshio main stream northeast of Taiwan) at the subsurface layer is not excluded. But the northeastward current in the near-shore region of eastern Zhejiang should have originated mainly from the western side of the Strait.

Fig. 3 shows the vertical structures of the velocity at some day-night anchored and mooring buoy stations over which this counter-wind current flowed. Stations A,B,C,D and E are located in the offshore regions of eastern Zhejiang, Quanzhou, Shantou, east of Hainan Island and in the deep-water area southeast of Shantou, respectively.

Some characteristics may be seen from the vertial profiles of the current vectors at different levels in Fig.3.

1. Except for the surface layer of individual stations, current directions of the upper and lower layers are basically the same and the variation of the speeds is also not large. This suggests that except for the surface layer, this current is rather homogeneous vertically, or its barotropic nature (or barotropy) is relatively evident.

2. The maximum velocity appears at the 5—30 m layer in the offshore region of Quanzhou and Shantou where the water is shallow, and at the 30—50 m layer in the offshore or open sea region of eastern Zhejiang, Guangdong and east of Hainan Island where the water is deep.

3. The velocity of the near-bottom current is relatively small, and the nearer to the bottom, the closer the current direction approaches NNE or NE.

4. At some stations, the direction of the surface current is different from that of the current below, and the velocity is also smaller because of the counter-wind movement of this current. Therefore, when the northeast wind strengthens this current will very likely be covered up by the drift current and will disappear at the surface layer. However, the depth of the wind effect is not large.

It may be seen from the above-stated characteristics that the distribution of the residual currents at the 10 m depth in Fig. 1 is more representative of the current condition there.

III. EVIDENCES FROM THE WATER MASS FIELD DATA

To make up for the fewer current measurements and lack of ship-drift data in the offshore region east of Hainan Island, the water mass field, that is the geostrophic current data of two sections southeast of Hainan Island, was used to demonstrate the existence there of a northeastward current almost all the year round.

In the period of 1975—1976, systematic hydrographic observations on two parallelly spaced sections between Hainan Island and the Xisha and Zhongsha Islands were conducted by the South China Sea Division of the SOA and time series data covering 20 months were obtained. The respective month by month fluctuations of the maximum surface velocity of the northeastward component of the geostrophic current at the two sections are shown in Figs. 4 a, b. The maximum differences of the dynamic height ($\triangle$D, 0/500 db, dyn. m.) between two adjacent stations of the section are used as the index of the current velocity. The differences were calculated from the dynamic height of the right station Dr (in the down-stream direction) minus that of the left one De, with the positive values indicating northeastward current (Guan, 1981).

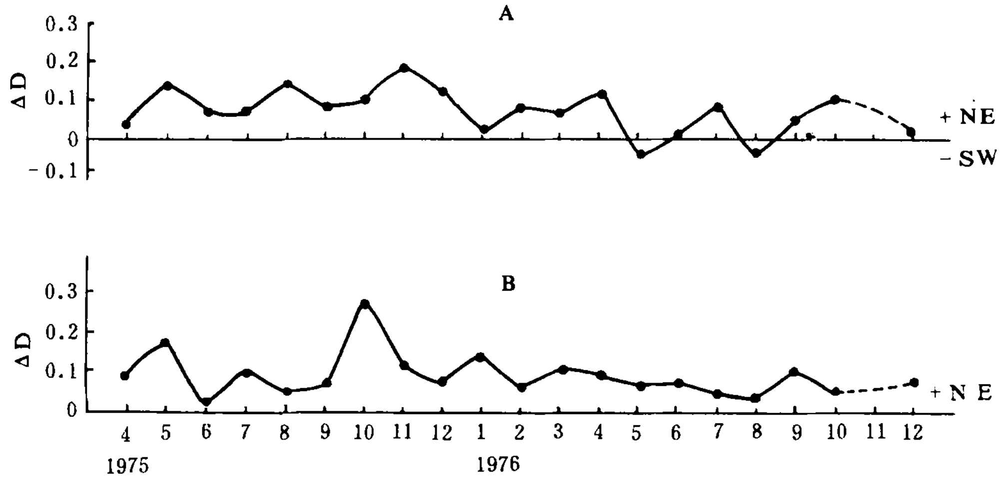

Fig. 4. Maximum surface velocity of the northeastward component of the geostrophic current ($\triangle$D, dyn. m., 0/500 db) at two sections southeast of Hainan Island (Guan, 1981).

It is evident from Fig. 4 that except for the cases in May and August, 1976, the northeastward current appeared at these two sections all the year round. In addition, the velocity in the winter half of the year (October—March) was generally higher than that in the summer half of the year (April—September). For example, the maximum of the northeastward current at two sections appeared in October and November, respectively. The respective $\triangle$D of two stations 42 nautical miles apart reached 0.28 and 0.18 dyn.m, (equivalent to velocities of 84 and 55 cm/s around 15°—18°N). Therefore, the northeastward counter-wind current is rather strong. The location of the maximum velocity is also relatively stable. It generally appears around the central part of the sections.

Therefore, there is no doubt that in the area between Hainan Island and the Xisha and Zhongsha Islands there exists a northeastward counter-wind current in the winter half of the year on the geostrophic current field. Of course, on both sides of the northeastward current there also exist the southwestward currents flowing with the wind.

The hydrographic data obtained during the CSK (No. 72) by the R/V Cape St. Mary of the Fisheries Research Station of Hong Kong in the south part of the Taiwan Strait from January 9—10, 1966, also provided evidences of the existence of a northward current in the western part of the Taiwan Strait. From the density (σ_t) and geostrophic current distributions of the W-E section Hong Kong—Heng Chun, as shown in Fig. 5 a, b, it is evident that the northward current on the left side of the section (between St. 2—3) corresponds to the northeastward current observed in the open sea south east of Shantou, while the northward current on the right side (between St. 4—5) may be the Kuroshio branch entering the South China Sea flowing northward along the west coast of Taiwan; or it may be the same as that between St. 2—3, this needs to be further identified. The geostrophic current velocity in Fig. 5 b is calculated with reference to a level which is the maximum observation depth common to the neighbouring station pair.

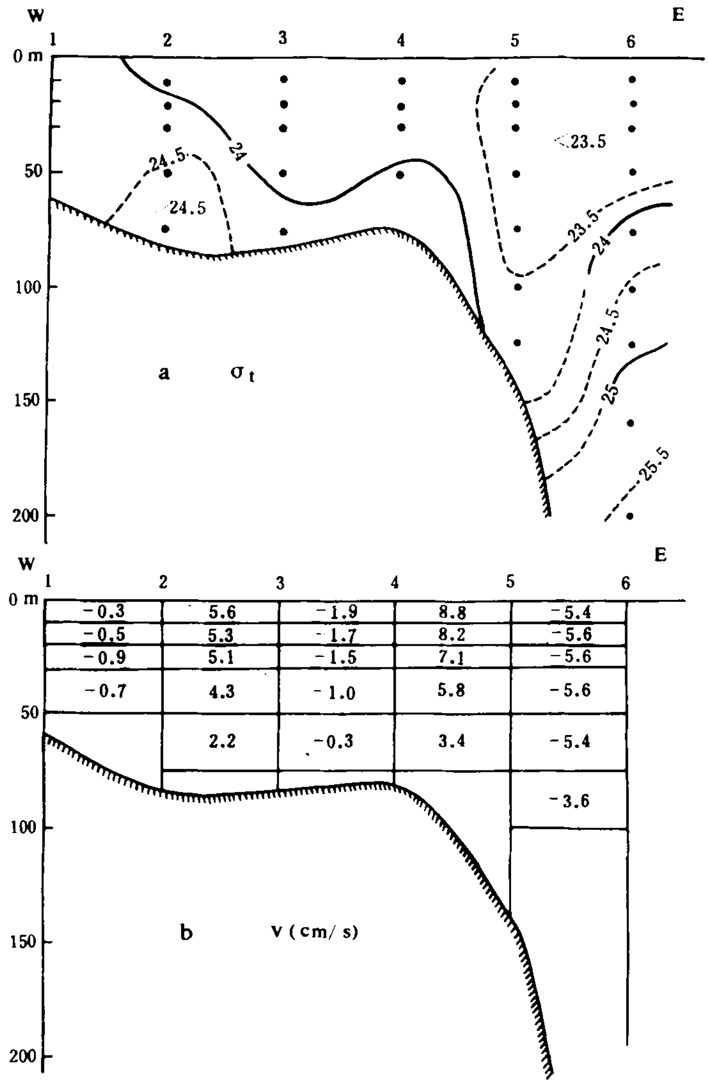

Fig. 5 Density (a, σ_t) and geostrophic current velocity (b, cm/s, positive northward) of the W-E section Hong Kong—Heng Chun, in Jan., 1966.

IV. EVIDENCES FROM THE RECENT INFORMATION

The above two northward currents revealed in the geostrophic current section on both sides of the Taiwan Strait agree with the recent information obtained from the data of sea-bed drifters and current meter moorings in the Strait during the northerly wind period.

1. Results from sea-bed drifters.

In the period of February—August, 1984, 3,050 sea-bed drifters were released in the area of the Taiwan Strait and north of Taiwan Province by the Institute of Oceanology, Academia Sinica in cooperation with the Fujian Fisheries Research and Fujian Oceanography Institutes. The recovery percentage of the sea-bed drifters attained 4%. Most of the drifters were recovered after 30 days of drifting in the sea, so their representation of the current condition may be considered acceptable. Preliminary analysis of the data of sea-bed drifters indicates that the drifters released in winter (February—March) all moved northward; especially those released in the northern Strait, the drifting direction was even more consistently northeastward, their drifting speed was around 1—4 nautical miles per day. The velocity of the drifters released in March was evidently higher than that in February. The drifters released in spring (April—June) also moved in a northerly direction.

The above-mentioned drifting direction of sea-bed drifters suggests that, in winter and spring (February—June), the deep and near-bottom water in the Taiwan Strait moves northward, that is to say, there exists a northeastward current flowing from southwest to northeast along the direction of the Strait. The northernmost part of this current may reach the area near the estuary of the Oujiang River. In the deep and near-bottom layer of the sea area north of Taiwan there also exists a northwestward current which may reach the area near Zhoushan Islands (Zhang Yiken, 1985).

2. Results of the current meter mooring observations.

Two current meter moorings were deployed in the Taiwan Strait from April 3 to May 5, 1983, by the Institute of Oceanography, Taiwan University, Taibei, China. One (St. B) was located in the northern part of the Strait and the other (St. C) at the head of the trough between Taiwan and Penghu Island. Their respective depths were about 55 m and 100 m. A current meter (Aanderaa RCM-4) was attached to each mooring at 14 m and 20 m above bottom at these stations. The average wind stress (0.07 dy/cm], corresponding to a wind speed of only about 4 knots) during the study period was toward the southwest, though it was in the transition period from NE to SW monsoon wind.

Analysis shows that the mean currents at St. B and C are strongly affected by local geographic conditions. The mean current flows northward at St. C (2°, 24, 2 cm/s) and northeastuard at St. B(51°, 28.6 cm/s). The magnitude of the speed is about 20% greater at St. B where the water is shallower. As the wind and the mean along-strait current are in opposite directions, they do not appear to be directly related. The observed persistent, up-Strait drift (at 25 cm/s, and the accompan-ying large volume transport to the East China Sea) must be induced by some forcing mechanism other than the wind (Chuang WenSi, 1985). The observation results confirm that there also exists a significant counter-wind current in the deep and near-bottom layers of the eastern part of the Taiwan Strait under the northeast wind in spring.

V. DISCUSSION AND REMARKS

In conclusion, two problems will be discussed briefly in the following paragraphs.

1. Why has this northeastward cunter-wind current in winter been overlooked for such a long time in the past?

In the sea area studied in the paper, especially for the surface layer, southwestward currents were observed to flow with the prevailing wind in winter. The northeastward current flowing against the wind is relatively strong in some local regions but rather narrow in width and flanked by southwestward currents on either side just as mentioned in the paper entitled "The Warm Current in the South China Sea" (Guan, 1978 a, b). Therefore, under the action of the intense northeast wind, this counter-wind current is likely covered up by the surface drift current, and can not appear in the near-surface layer temporarily.

The knowledge of the current system is derived mostly from the data of ship-drift and current bottle-drift to this day, As mentioned above, through a process of taking scalar and vector averages of current vectors observed in a grid region, the predominant current sticks out while the non-predominant current is covered up. The data of current bottle-drift mainly reflect the direction of the predominant drift current at the surface layer, and could hardly reflect the narrow counter-wind current which sometimes may be covered up. In addition, the drifting path of the current bottles is still unavoidablely influenced more or less by the wind effect. Therefore, this counter-wind current in winter has not been reflected in these two kinds of data for a long time. But, as a matter of fact, indications of this non-predominant and counter-wind current can be seen, though indistinctly, on the current charts attached with current scale and stability(vector resultant velocity/scalar resultant velocity) or current roses. For example, on the chart of "Oceanographic and Meteorological Observations in the China Seas and in the Western Part of the North Pacific Ocean" (Royal Netherlands Meteorological Institute, 1935), the stability of resultant velocity in grids of the above-stated sea area in winter is relatively small. At the same time, its current roses also consist of northward or northeastward components.

2. How should we assess the quality of the current data derived from ship-drifts?

There is no doubt that the current data derived from ship-drifts are less accurate than that of current measurements. Hence, data sets of northeastward vectors in Fig. 2 a,b might be suspected to be random phenomena that do not reflect real conditions. A rough statistical analysis of the current data in autumn and winter in the above Japanese current charts has been made in order to check their quality. In the near-sea area along the Guangdong coast west of 116°E, (except for the left flank of the counter-wind Nanhai Warm Current appearing farther away from the coast) the currents observed with current meters since the end of the fifties almost all flowed southwestward with the wind. In addition, on the Japanese current charts, in the corresponding area west of 116°E, about

40 current vectors derived from ship-drift data in February and November (except for one to two vectors directing northeastward) are almost all directed southwestward, too (JHO, 1925). Furthermore, on either side of Taiwan, current data derived from ship-drift depict nearly without exception the patterns of the intense Kuroshio flowing northward along the coasts of Taiwan. Therefore, in this area the current conditions depicted by the ship-drift data agree with what were actually happening.

Let us consider the current situation in the sea area east of 116°E and northward along the coast of Guangdong, Fujian and Zhejiang. There are nearly 90 current vectors derived from ship-drift data in February and November, respectively. Among these, there are about 30 current vectors (ca. one third) directed northeastward, depicting the counter-wind current. The other vectors depict southwest current flowing with the wind. At the same time, it may be seen from Figs. 2 a, b that in general, the geographic distribution of such counter-wind current vectors is apparently continuous and not isolated. Therefore, regarding again the situation in the sea area west of 116°E and on both sides of Taiwan, in spite of the less accurate quality of the current vectors derived from ship-drift data, the reality of current characteristics depicted by the vectors in the area east of 116°E and northward along the coast of Guangdong, Fujian and Zhejiang is also beyond doubt; to say nothing of the fact that the current conditions depicted by these vectors agree too with the observed in the neighbouring area.

Current measurement results reveal that in the above-described area, when the northeast wind becomes stronger and stronger, the surface current flows southwestward with the wind, but the sub-surface current below the 5 m depth still flows northeastward. During the period of weak northeast winds, this counter-wind current even appears on the surface layer. It is speculated that the northeastward current vectors in Figs. 2 a, b were likely for the most part observed under conditions of weak northerly winds. These northeastward current vectors provided valuable information for our research on the existence of this counter-wind current which was not noticed for more than half a century.

On the basis of a combination of all the data mentioned above, it may be confirmed that there exists a northeastward and northward counter-wind current in winter in the offshore region of the South and East China Seas. Furthermore, the two parts of the winter counter-wind current in the South China Sea and the East China Sea are connected together through the Taiwan Strait. This hypothesis has been affirmed by the results of current meter mooring observations in the Taiwan Strait entitled "EXIST" (Experiment in the Strait of Taiwan) conducted recently by the Institute of Oceanography Taiwan University, Taibei, China (Wang, D.P. 1985, Personal communication).

Notwithstanding the facts stated above, the data collected in this paper are still not very sufficient and comprehensive: especially as current measurement data are still lacking for some local regions.

It is suggested that further field investigations in winter with CTD, with current meters and/or mooring buoys are needed for filling the gaps of observation in order to further confirm this important and new finding. Besides these, dynamical, numerical and experimental studies should also be carried out for a better understanding of the mechanism of this counter-wind current and its variations and correlations with the other currents in the surrounding area, such as the southward flowing coastal current and the northward flowing Kuroshio Branch.

It is considered that the finding and the confirmation of the existence of this counter-wind current would, in a greater dagree change the traditional concept of the current system, especially the coastal current system of the China Seas. A joint study (i. e. field work plus dynamic investigation) of the mechanism of this current would help much in raising our country's research level in shallow water oceanography.

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