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【Report】

Displaying Fluctuation of Water Quality Environment and Tidal Current Data by Using MATLAB

—— In the Case of Research on the Fishing Ground for Ribbonfish Troll Fishing In Tachibana Bay ——

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Abstract

We started research on the fishing ground environment throughout the year for the purpose of finding the conditions, in which the fishing ground for ribbonfish in Tachibana Bay is formed, from relation between the water quality as an environmental factor in the fishing ground and the fishing situations. In this research, we developed a unique and quick method of displaying observation results of water quality and tidal current by using the function of "MATLAB", matrix calculation soft ware, and carried out its test operation. Consequently, in the case of each periodic observation as well as displaying the seasonal variation of each observation item and each fixed line, it became available to perform instantly the processing according to the user's request by using GUI function of "MATLAB". We acknowledged that this method could become a sufficiently useful technique to display oceanographic observation results by utilizing the original software established with "MATLAB".

1. Introduction

Tachibana Bay (hereinafter "T-Bay"), which is located in the southern part of Nagasaki Prefecture, is surrounded by Nagasaki Peninsula and Shimabara Peninsula as shown in **Fig.1**. T-Bay has a nature similar to open sea because it is connected to the Sea of Ariake in the east, to the Sea of Goto and the East China Sea in the west. In T-Bay, the ribbonfish troll fishing has been carried on after the 1970s[1]. This type of fishing conducted throughout the year at the area, which has a depth of around 50 meters, in the west side of the central T-Bay as shown in **Fig.2** of the bathymetric chart of T-bay. **Fig.3** shows the progress since 1989 in relation to the catches of ribbonfish per year which was landed in the fisheries cooperative association of Aba, Nagasaki City, a base port of the said fishing. According to the figure, the catches are decreasing in recent years, provided that the amount of fishing efforts is maintained at the same level every year. Troll fishing for ribbonfish by boat in T-Bay may sustain the yield in a more carefully planned way, if the conditions, in which the fishing ground is formed, based on the life and habit of ribbonfish are understood. Therefore it seems that the research on the fishing ground environment and the ribbonfish resources is important.

There is a report on comprehensive research in T-Bay by Seikai National Fisheries Research Institute as an example of the past studies of fishing ground and fishing situations as well as oceanic conditions in T-Bay[2]. Another research on fisheries resources in the East China Sea and the Yellow Sea was performed by the above institute[3]. There is, however no example of the research which focused on ribbonfish in the fishing ground in T-Bay.

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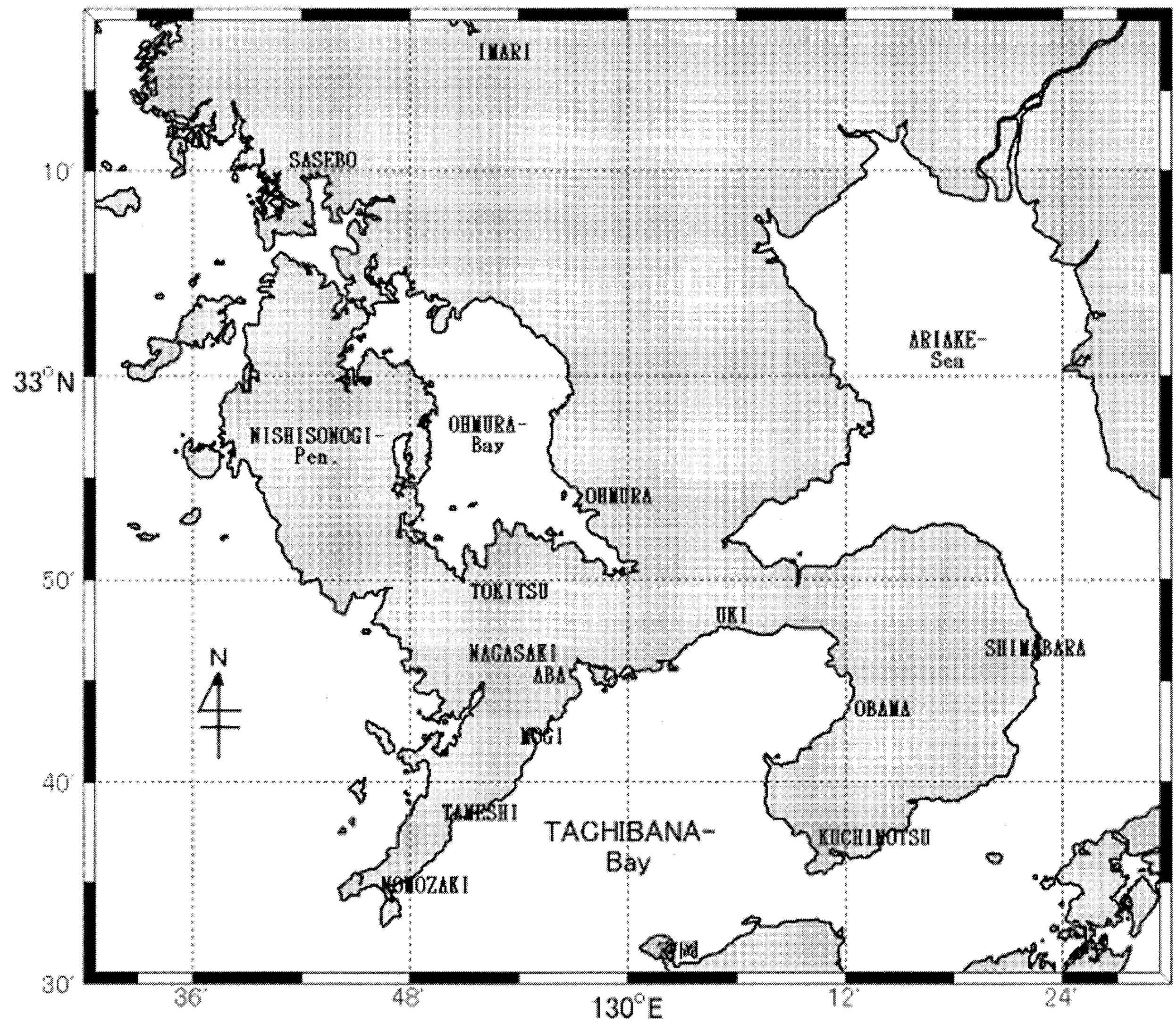

Fig. 1 Geographical location of Tachibana-Bay.

When we presume the fishing season of each fishing ground, the water temperature relates closely to fish's maturity and spawning. Also the water temperature has a significant influence on the beginning and end of the fishing season. In addition, as the environmental factor which defines "the fishing ground", the current, that is, the turbidity of sea water has to be taken account of. Therefore, in order to understand the environment of fishing ground for ribbonfish, it is essential to clarify the water temperature and the place where the current is observed in the fishing ground.

From the above point of view, we started the continued oceanographic research throughout the year for the purpose of finding the conditions, in which a fishing ground for ribbonfish in T-Bay is formed, principally from relation between the water quality as an environmental factor in the fishing ground and the fishing situations. This report describes firstly overviews of the water quality observation and the data analysis method by MATLAB, and secondly examination examples of the method to display figures, and then mentions some results.

In this research, it is intended to simplify and quicken the primary processing of data acquired by using MATLAB for the reasons mentioned below. A multiparameter water quality meter (ADR-1000, Alec Electronics Co., Ltd.) contains data loading software but its data analyzing software is not satisfactory. In data analyzing, it is possible to use commercial software for CTD. However it is expensive and necessary to modify accommodative data format in order to plot data. In this observation, originally an analyzer was inputting data to spreadsheet software. It, however, took a lot of time, and its drawing was not satisfactory. Thus, we knew MATLAB and found that it allowed users to establish their own software (GUI) to meet their purpose as well as users can easily make draw-

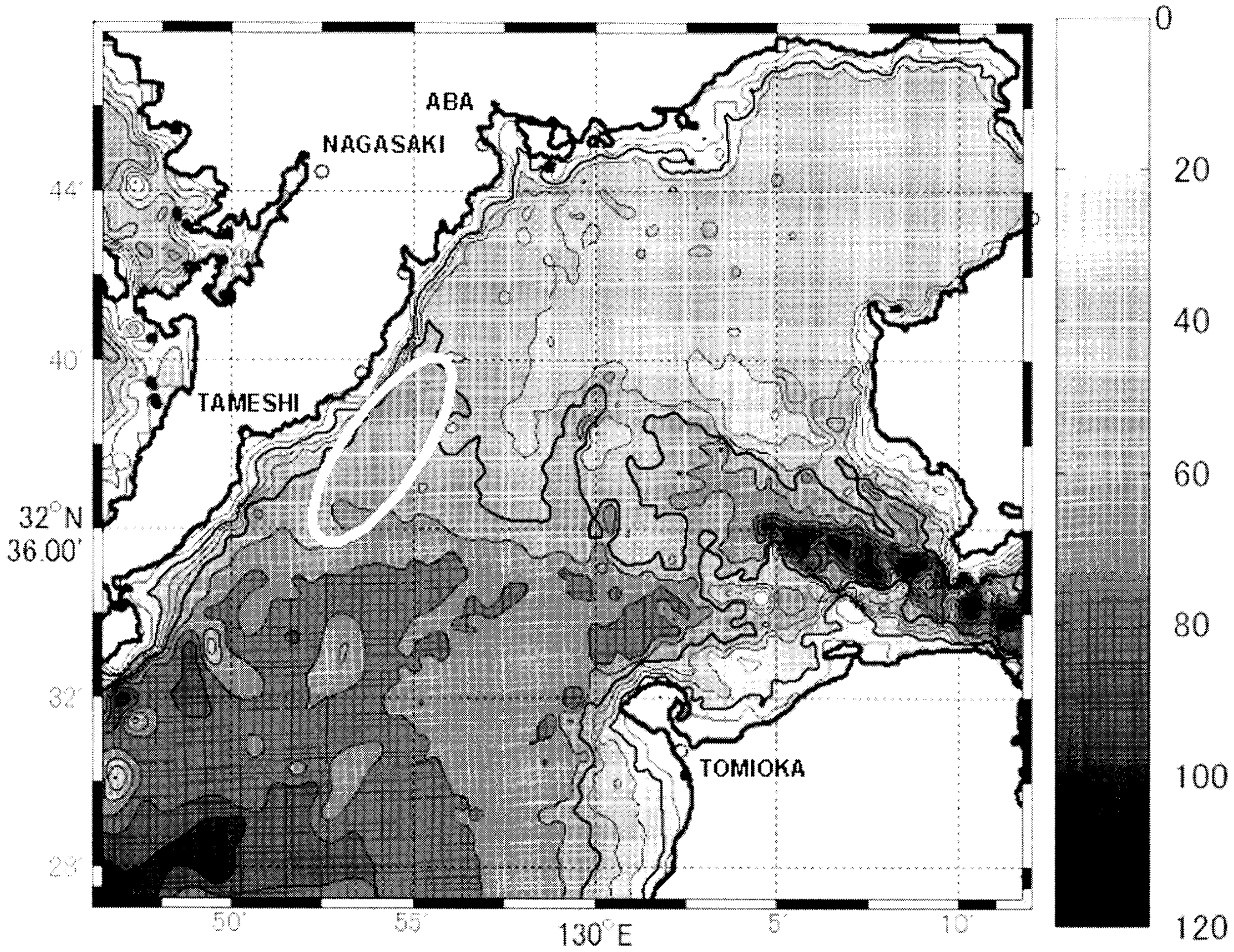

Fig. 2 Fishing ground for ribbonfish troll fishing and bathymetric chart of Tachibana-Bay*1.

(The portion enclosed with white line shows the fishing ground. The depth contours are drawn at a 10m interval.)

*1 Data from http://www.jodc.go.jp/service_j.htm of Hydrographic and Oceanographic Department, Japan Coast Guard.

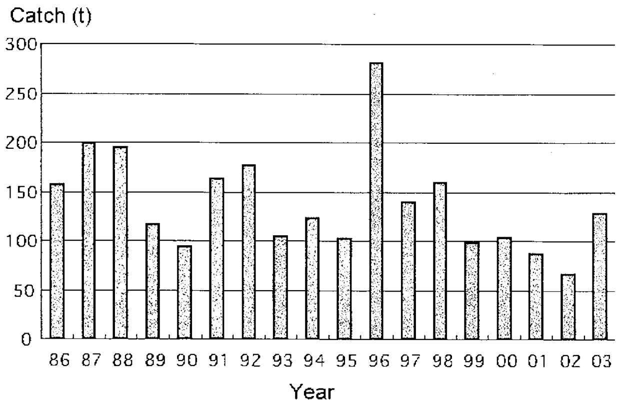

Fig. 3 Fluctuation of ribbonfish catches land on the fisheries cooperative association of Aba (Data from the fisheries cooperative association of Aba)

ing with it. Since a current meter captures data according to the special format shown in the table described later, it was necessary to sort data for drawing in order to analyze such data. Since MATLAB enables a calculation of x-axis and y-axis elements of data to be processed on its program, a user does not need a recalculation. It is possible to finish with only the process of data loading and plotting. Therefore, we are able to anticipate the substantial saving of time.

2. Methods

1) Overview of the oceanographic observation

In the beginning, observation points were examined. According to Yamada's report on the ribbonfish's migration course into T-Bay[1], ribbonfish migrates to the bay along the slope of seabed after staying in the depressed on the migration course for a while. We fixed thirty-six observation points as shown in **Fig.4**. Observation points were arranged at 1.9 miles interval along the north-south direction as Line 1 to 6 and 1.7 miles interval along the east-west direction as Line A to F. These points may cover the central T-Bay.

We used "Kakusui", a research vessel of 27 G/T

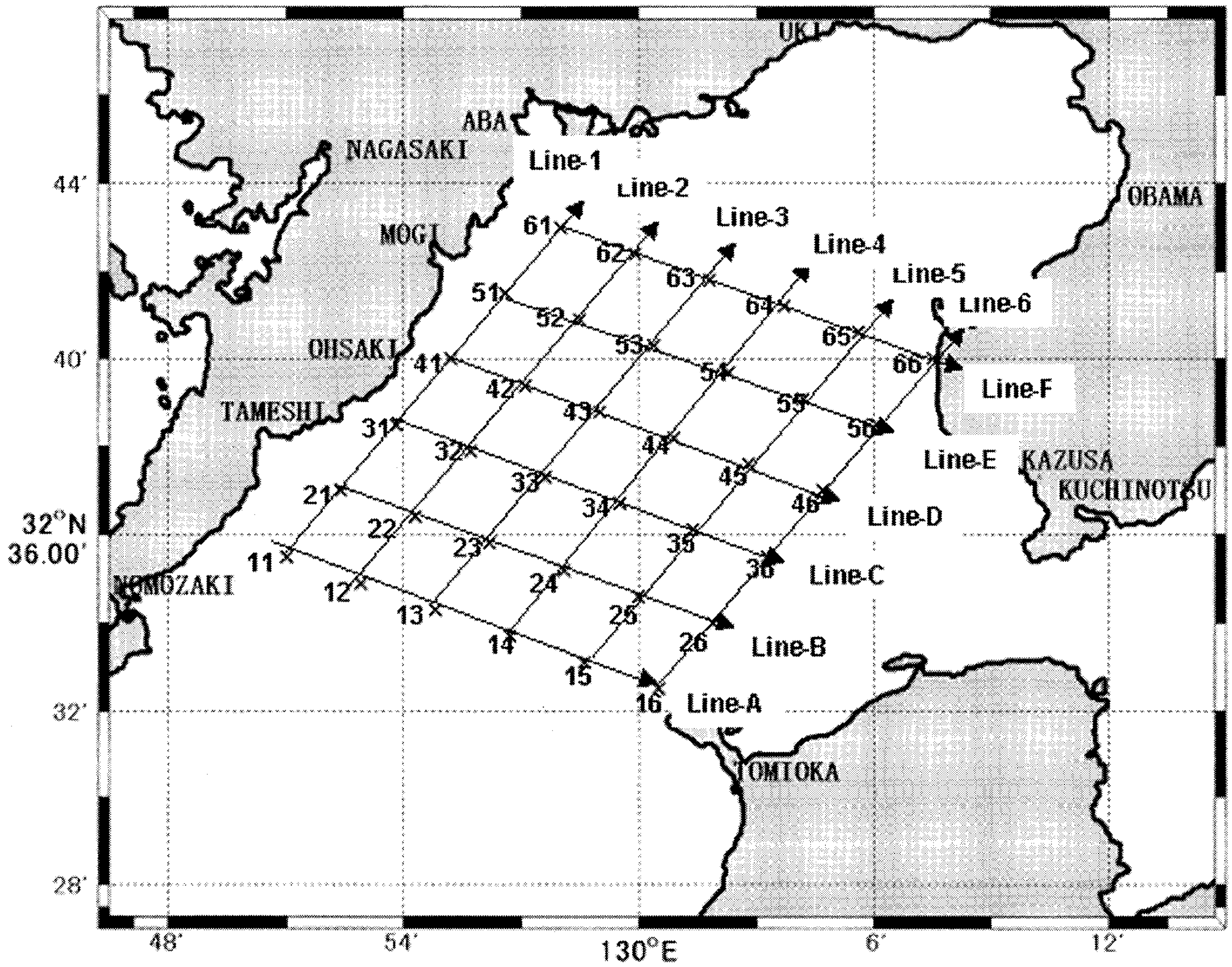

Fig. 4 Location of observation points in Tachibana-Bay.

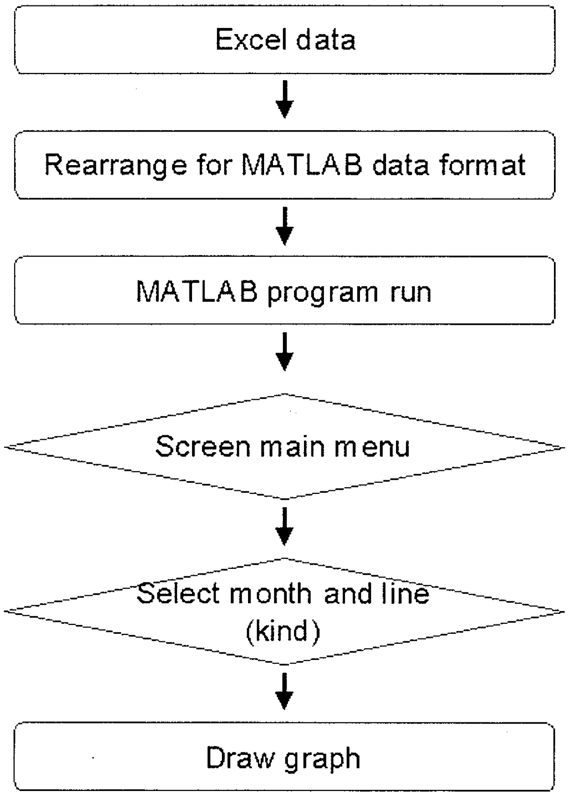

Fig. 5 Flowchart from data acquisition up to drawing a figure by MATLAB.

belonging to Nagasaki University Faculty of Fisheries. In the oceanographic observation, we used a current meter (CI-60G) to obtain the tidal current's speed and direction over the ground (hereinafter "tidal current data") because of the necessity to know the tidal current speed around the fishing ground. In addition, we measured water temperature, salinity, dissolved oxygen and turbidity (hereinafter "water quality data") by using a multi-parameter water quality meter (ADR-1000, Alec Electronics Co., Ltd.) at each observation point. Tidal current data was obtained on random time interval and at random depth as described later. Water quality data was acquired in the following depth ; 1, 5, 10, 20, 30, 40 and 50 meters. Wherever the depth was shallower than 50 meters, the deepest layer for the measurement was one meter above seabed.

2) Data analysis by MATLAB

MATLAB is matrix calculation software, a kind of scientific and technological calculation software, and is able to perform numerical calculation, visualization and programming[4), Users can use this software by simple command operations.

Table 1 MATLAB data format.

Lino−1	Position		Depth (m)	Sea depth (m)	Range and interval					Data (First time)				
St.No	Long	Lat			Temp	Sal	σt	DO (%)	Turb	Tomp	Sat	σt	DO (%)	Turb
11	129.850	32.592	−1	−65	Range 10−30℃, Interval 0.5℃	Range 20−40psu, Interval 0.5psu	Range 10−30, Interval 0.5	Range 50−150%, Interval 1.5%	Range 0−2.5ppm, Interval 0.1ppm	25.89	33.23	21.734	111.1	0.38
11	129.850	32.592	−5	−65						25.53	33.30	21.898	105.1	0.32
11	129.850	32.592	−10	−65						25.26	33.38	22.041	104.7	0.32
11	129.850	32.592	−20	−65						25.21	33.40	22.071	104.9	0.23
11	129.850	32.592	−30	−65						24.65	33.43	22.282	96.1	0.35
11	129.850	32.592	−40	−65						24.33	33.45	22.373	91.9	0.47
11	129.850	32.592	−50	−65						22.54	33.96	23.278	81.7	1.43
21	129.873	32.617	−1	−54						25.93	33.26	21.745	108.4	0.32
21	129.873	32.617	−5	−54						25.32	33.41	22.045	110.7	0.26
21	129.873	32.617	−10	−54						24.92	33.41	22.166	107.2	0.38
21	129.873	32.817	−20	−54						24.77	33.39	22.196	107.3	0.38
21	129.873	32.617	−30	−54						24.54	33.42	22.288	104.8	0.38
21	129.873	32.617	−40	−54						23.94	33.54	22.556	90.5	1.05
21	129.873	32.817	−50	−54						20.85	34.27	23.980	79.2	4.08
31	129.897	32.642	−1	−48						25.98	33.21	21.692	109.0	0.32
: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat	: Repeat

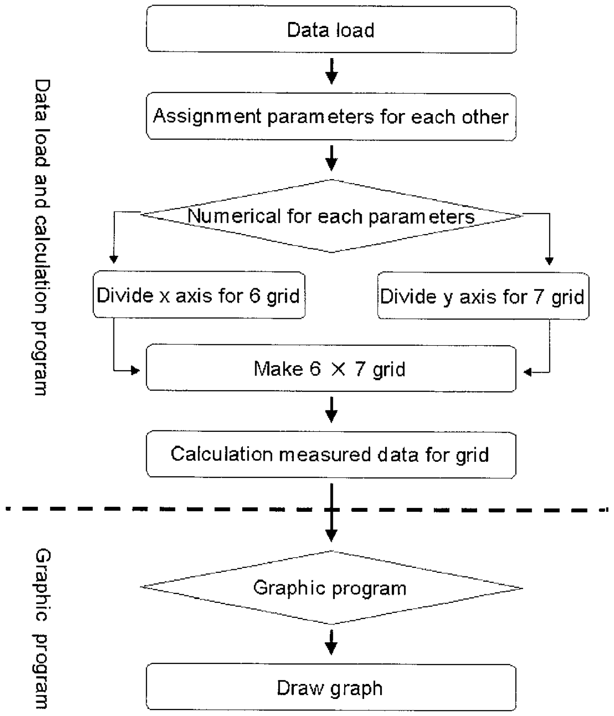

Fig. 6 Flowchart to draw a vertical cross section by MATLAB.

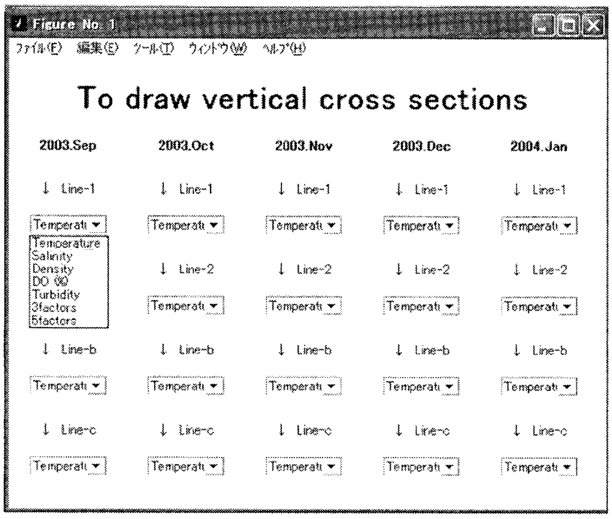

Fig. 7 Selection screen for displaying observation data item.

When drawing the oceanographic observation results on figures, a variety of software, which is marketed and generally quite useful in visualization, is available. Accordingly, other commercial software instead of MATLAB seems to be enough for those unfamiliar with command operations. In the meantime, when data analysis is programmed beforehand with taking advantage of command operations in MATLAB, it is able to draw an original graph which above commercial software can not. From the above point of view, we attempted to draw the oceanographic observation results on figures by MATLAB. **Fig.5** shows a flow of drawing a figure by MATLAB. This is similar to a flow by using other commercial software. However, in order to acquire the tidal current data, we used new data acquisition software which was developed by ourselves and was applied serial data communication through RS-232C cable as we presented in the previous report[5].

3. Tentative displaying observation results

1) Drawing a vertical cross section by MATLAB

Table 1 shows a format to import water quality data to MATLAB. In this table, measurement depth and measurement results of every item are placed for

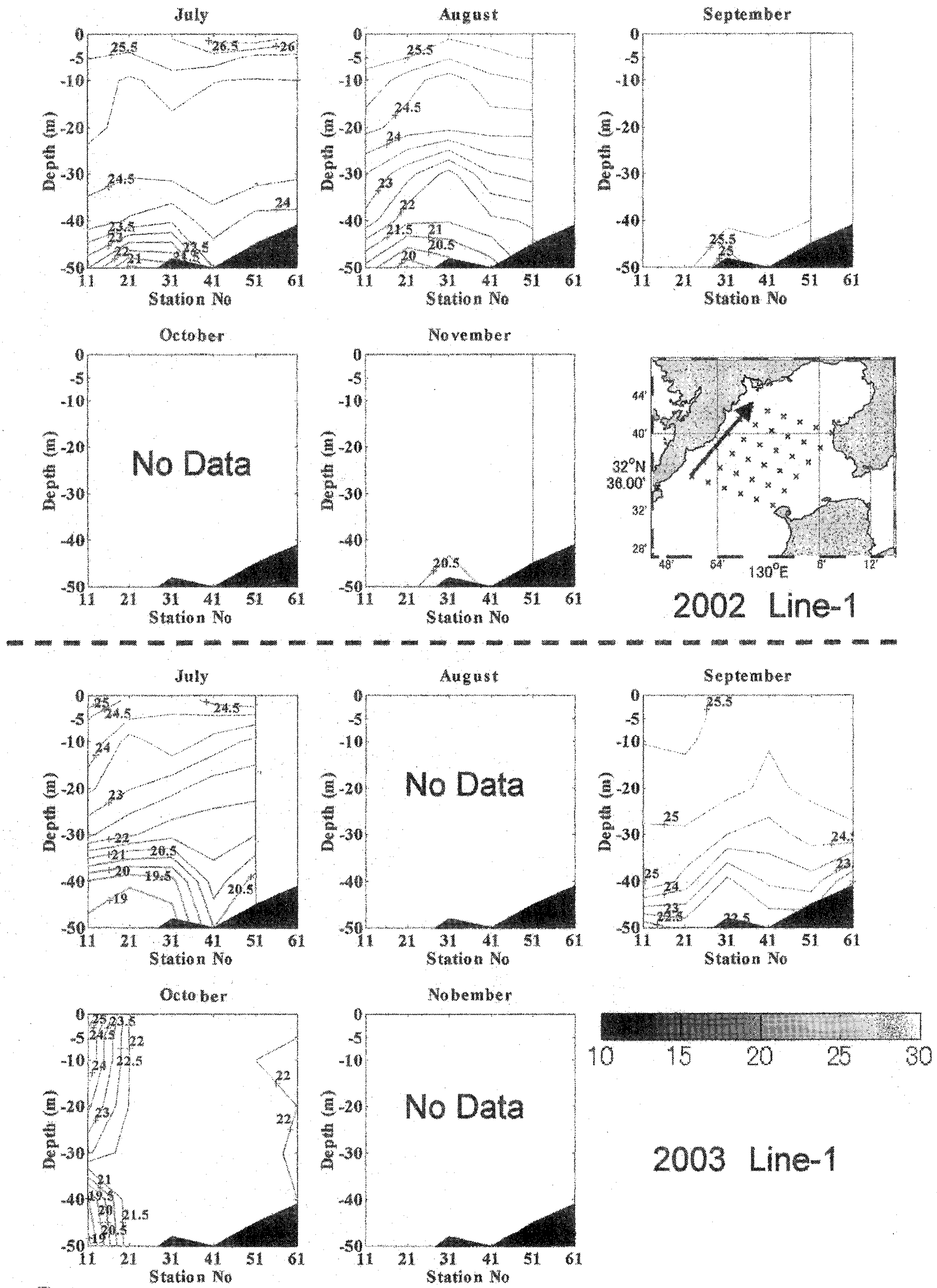

Fig. 8 Vertical cross sections of water temperature in 2002 and 2003 at line-1.

each Line. Measurement results will be imported as a unit of data for each Line to MATLAB. **Fig.6** shows a flowchart to draw a vertical cross section of the observation data by MATLAB.

When drawing contours, MATLAB divides the object area into grids of a certain size, insert data there, and connects the place of equal value. Other commercial software requires only two parameters, the value range of contour between maximum and minimum and the contour interval. MATLAB requires, in addition to the above, the grid interval. As in many other math calculations, the smaller grid interval makes a contour smoother in MATLAB. As for a grid interval, a suitable value must be set up according to data. In this research, we made observations at 6 points along each Line and in 7 depth layers which cover 1m to 50m of maximum depth. We set six grids on the x-axis and seven grids on the y-axis, and plotted every value on a graph. The value range of contour between maximum and minimum is defined freely. In view of the fluctuation throughout the year, the range of observation value of each item was defined as follows: water temperature ; 10 to 30℃, salinity ; 20 to 40 psu, σt ; 10 to 30, dissolved oxygen ; 50 to 150%, and turbidity ; 0 to 2.5 ppm. The interval of contour was fixed as follows: water temperature ; 0.5℃, salinity ; 0.5 psu, σt ; 0.5, dissolved oxygen ; 1.5% and turbidity ; 0.1 ppm.

Fig.7 is an example of actual screens which were displayed after above processing, and is the one to draw vertical cross sections for five months from September 2003 to January 2004. This makes it possible to draw, from top to bottom at each Line, water temperature, salinity, density (σt hereinafter "density"), dissolved oxygen, turbidity, three factors (water temperature, salinity, density), and five factors (water temperature, salinity, density, dissolved oxygen, turbidity).

Fig.8 shows actual observation results of operating abovementioned program. There are vertical cross sections of water temperature at Line 1. The upper half is results in year 2002 and lower half is in 2003. The portion blacked out in this figure is seabed. There is no data for October 2002 and August 2003 because no observation was made in these months. The area to be drawn and contour intervals are same as above.

(1) **Consideration of water temperature observation results**

There is a difference in water temperature over 3 centigrade between the surface layer and the lower layer through July into August 2002 and through July into September 2003 despite of no observation in August 2003. This means a thermocline was formed although it was weak. It would appear that the water temperature in T-Bay tends to rise under the influence of sunrays in summer because of T-Bay's shallow depth in comparison with open sea like the East China Sea. Although this thermocline was still observed at Station No.11 near the entrance of the bay in October 2003, it disappeared in September 2002 and in November 2003. As for these tendencies, further observations would be required in order to reveal the trend of the marine environment in T-Bay.

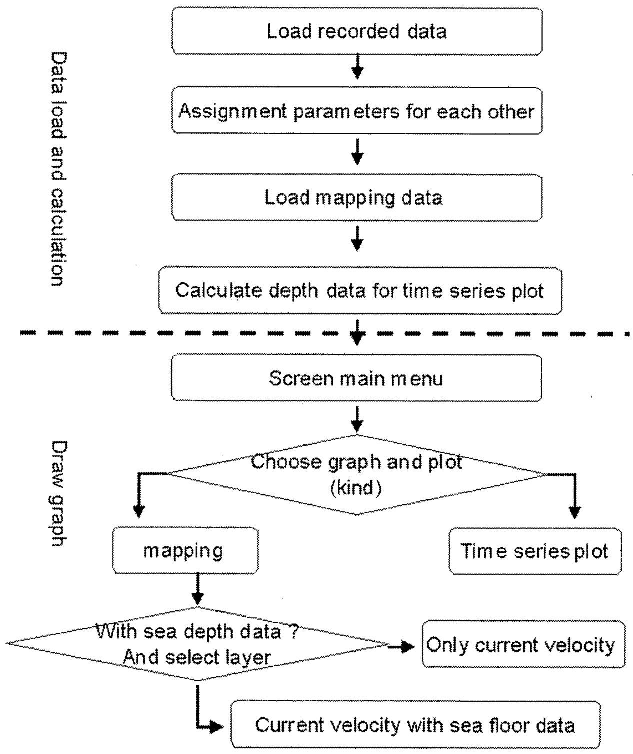

Fig. 9 Flowchart from acquisition of the tidal current data up to drawing a figure.

2) **Creation of tidal current data by MATLAB**

Here we describe displaying the tidal current data by MATLAB. **Fig.9** shows a flow from the acquisition of tidal current data up to drawing a figure by MATLAB.

We developed new software which was able to import the tidal current data to spreadsheet by serial data communication though RS-232C cable. First of all, we read the instruction manual of a current meter (CI-60G) *1 and found data format. As shown in **Table 2**, the data format is as follows: ① - date and time, ② - ship's position, ③ - ship's course and speed, ④～⑥ - each data of tidal current in 3 layers, ⑦ - mean volume back-scattering strength, ⑧ - depth. We developed software to acquire following data out of the above mentioned items : date and time, ship's position, ship's head, GPS course and speed, current meter course and speed, first to third layer's depth/current

*1 : Color current plotter Instruction Manual. (FURUNO Co., Ltd)

Table 2 The Data format.

①	A0020030925094900U+0000	Day, Time
②	B0GP0N3242750E1295743000	Position
③	COGP09904200G1020442N04370	Ship's speed and course
④	D3001002DG00218370N01	Data (No1 Layer)
⑤	D3002010DG00216160N01	Data (No2 Layer)
⑥	D3003020DG00222190N01	Data (No3 Layer)
⑦	J10 070 −062 −062 −064 −064 G−019 −010	MVBS
⑧	Z0002183700216160022219042	Depth

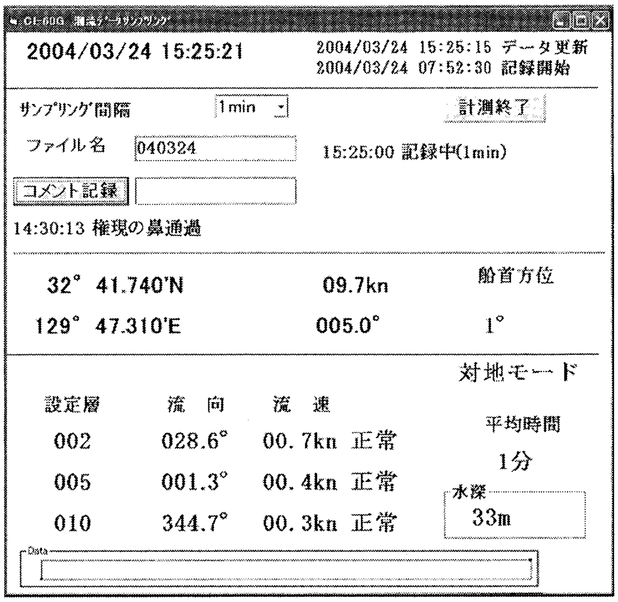

Fig. 10 Example screen of acquisition of the tidal current data by R.V. Kakusui.

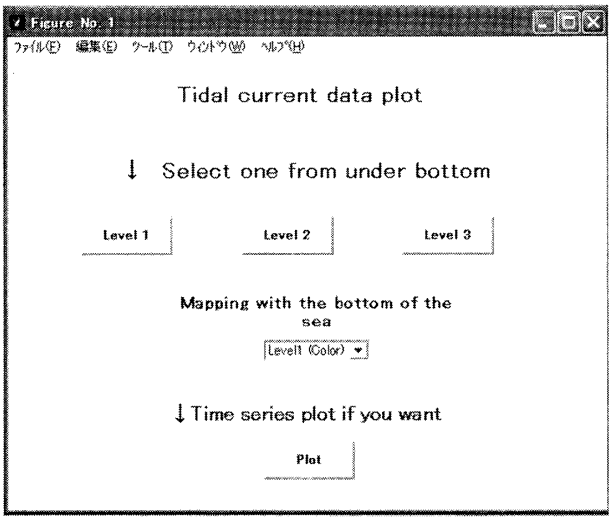

Fig. 11 Screen of drawing the tidal current data on figures by MATLAB.

direction/current speed, normal (0)/abnormal (1), mean time, depth, over the ground (G)/through the water (W). For vector displaying in MATLAB, data has to be divided into components of x-direction and y-direction, and then should be inputted to the system to draw a figure. Consequently, acquired data, without recalculation, could be imported to MATLAB in order to draw figures. **Fig.10** is a screen of recording the tidal current data along the flow in **Fig.9** and **Fig.11** is an example of MATLAB menu-screen to draw figures.

Fig.12 shows the results of the tidal current. The drawing in **Fig.12** was produced by using no other software but only MATLAB Toolbox*[2] with shoreline (land) data*[3] acquired from Internet. In **Fig.12**, upper portion is the tidal current data superimposed on a map, and lower portion is the vertical time-series-analysis figure. In both portions, the top of figure is north. It should be noted that the time-series-analysis figure shows not a current of vertical direction but the vertical direction showing northern or southern current as well as the horizontal direction showing eastern or western current. Since the current meter of "Kakusui" measured only horizontal components of the current, and didn't measure the distribution of the vertical direction of the current, such data was excluded from drawing figure.

4. Conclusion

In this research, we conducted tentative operation to display the oceanographic observation results by MATLAB, and developed new software which acquires the data from the current meter of "Kakusui" through RS-232C cable and displays such data. We applied above operation and software to the result of the oceanographic observations and the tidal current observations in T-Bay and displayed them. We examined the usefulness and the versatility of our research and acknowledged that it well functions to the purpose.

*[2]: http://www2.ocgy.ubc.ca/~rich/map.html
*[3]: http://www.ngdc.noaa.gov/mgg/shorelines/shorelines.html

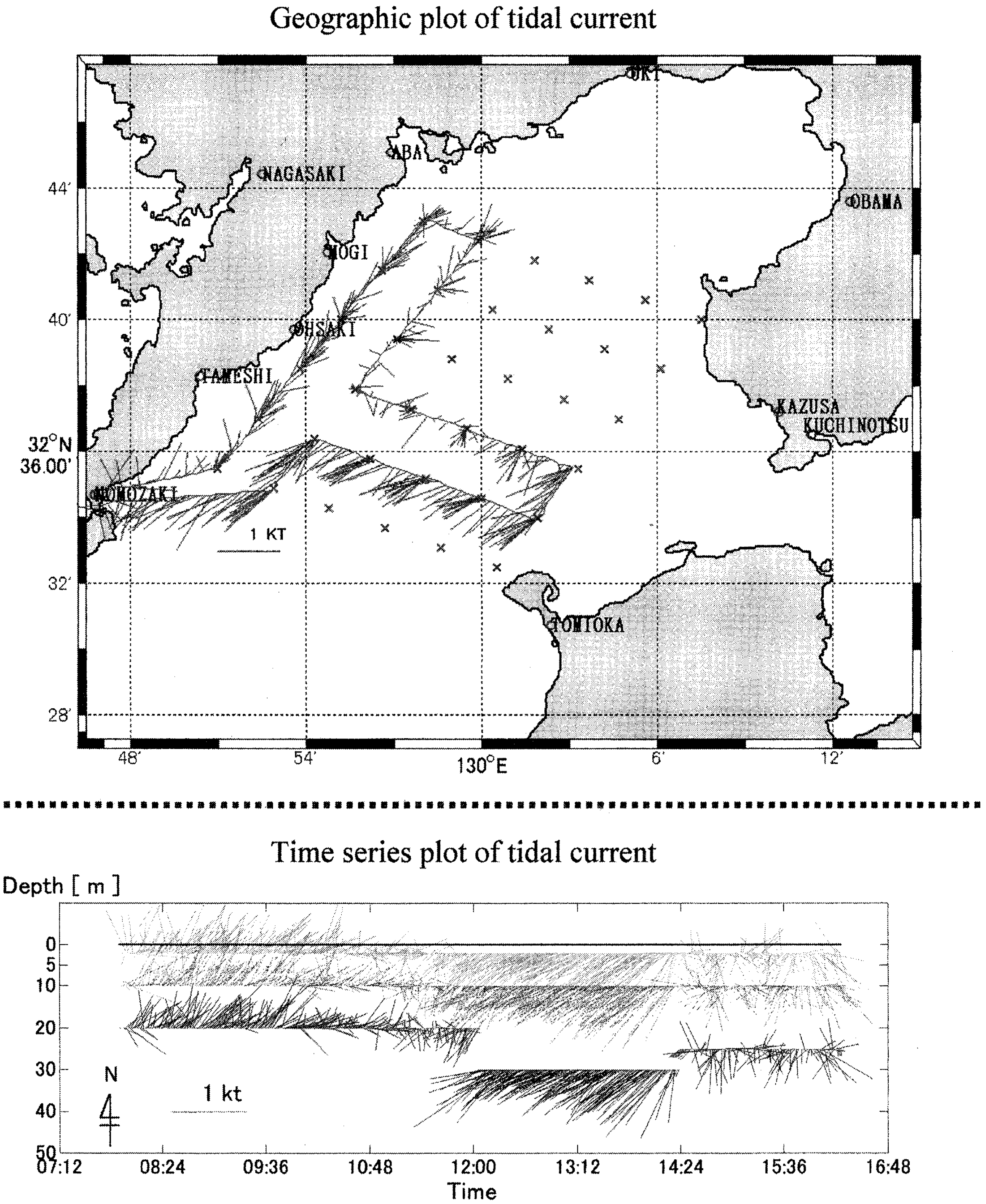

Fig. 12 Example of drawing figures of the tidal current data

upper : plane displaying
lower : time-series-analysis displaying at every depth layer.

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MATLABを用いた水質環境及び潮流データの表示

―― 橘湾タチウオ曳縄漁場調査を例として ――

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和文要旨

橘湾タチウオ漁場の成立条件を，水質の漁場環境条件とタチウオ漁況との関係から見出すことを目的に，周年の漁場環境調査を開始した。本研究では，海洋の水質および潮流観測結果を数学行列計算ソフト“MATLAB”の機能を応用して， 迅速かつ独自の表示法の開発を行い，その試験的運用を試みた。その結果，“MATLAB”によるGUIの機能を用いることにより，毎回の定期観測，観測項目毎および各定線毎の季節変動の一括表示などにおいて，ユーザーの要求に応じた処理が瞬時に行えるようになった。この点，“MATLAB”によって構築したオリジナルソフトを活用することにより，海洋観測結果の表示に関して，十分有用な手段になり得るものと認められた。

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