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OCEANOGRAPHIC SURVEY METHODS

by

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FOREWORD

The present manual deals with basic knowledge concerning oceanographic observation methods. Part of this handbook was drafted, in collaboration with Mr. Hooi Kok Kuang, as a manual for the local staff and the research trainees at the Marine Fisheries Research Department, Southeast Asian Fisheries Development Center, Changi, Singapore, while the editor himself was engaged as the Fishing Ground Development Section Chief at the Department between 1970 and 1973. Chapters 7, 8 and 12 were written by Dr. Akihiko Shirota, the then Ocean Research Section Chief, and his colleagues; and Chapters 9 and 10 by Dr. Tetsushi Senta, the then Fisheries Resources Section Chief, and his colleagues.

On the occasion of this publication, the text has been revised to include further chapters, including text figures. The editor hopes that it will prove useful to those students and research scientists who engage in oceanographic research work.

Finally, the editor wishes to thank Miss B. Mountfield for her devoted assistance in the compilation of the present manual. He also thanks Mrs. Kanchana Rodchareon for her help in typing the draft.

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1. Instructions for Recording and Treating Data

1.1. Field observation notebook

Several types of field observation notebooks and forms are in use for the different purposes to be served (Table 1). In any case, the following requirements should be fulfilled by the notebooks and forms:

1) A field notebook should be firmly bound.

2) If possible, a durable cover should be provided.

3) While on board, the notebooks and forms should be clipped to a wooden board so that they will float if they are accidentally dropped into the sea.

1.2 Observation diary

An observation diary is a useful reference for making reports later and for planning observation schedules. The use of this diary is strongly recommended especially for a chief scientist who is responsible for a research cruise.

It contains records of processes and events during the observation, and of unusual phenomena occurring during the cruise or the period of observation. For example, oceanographic and meteorological conditions, division of duties during observation, locations of observation, date, time of start and finish, and troubles with instruments should be included.

When recording such matters, it is desirable to acquire the habit of recording the time and date together with the descriptions.

Table 1. Water Sampling and Temperature Measurement Form

Station No.	Date Day/Month/Year	Time Start	Time Finish	Depth	Water Colour	Transparency	Observers	Remarks:
Ry3572	20 May 1969	0440	0535	7425m	3	17m(6°)	Furuhashi, Fujiwara and Kimura	

Position Arrival	Position Departure	Position Mean	Plankton Sampling Time	Towed Dist. (Slope)	Flow Meter	Sample No.
38-00 144-00	38-00 144-01	38-00 144-00	0522	177(33°)	2020	1510, 1511

Time (Slope)	Wire Length	Phial No. S / NO_3	O_2	NS	Pl / Ch	Sampler No.	Thermom. No.	Temp. Reading I Aux.	IE	Main	IE	Cor.	Temp.I	Temp. Reading II Aux.	IE	Main	IE	Cor.	Temp.II	tp / tw	tp-tw / D	Depth Cor.	Notes
		41	E1	1	K48																		
0452	0	1			C 1					16.2	0		16.2							16.2		0	
		42	2	2	56		7163	14.9	-2	16.30	- 5	+3	16.28	15.2	-2	16.31	- 5	+3	16.29				
0452	11	2			2	301	6557	14.9	+2	16.39	-12	+2	16.29	15.0	+2	16.39	-12	+2	16.29	16.29		10	
		43	3	3	57		6532	15.0	-2	16.42	-17	+3	16.28	15.2	-2	16.43	-17	+2	16.28				
(21°)	22	3			3	302	18674	15.0	0	16.29	0	+2	16.31	15.1	0	16.28	0	+2	16.30	16.29		20	
		44	4	4	58		1144	15.0	0	16.41	-15	+1	16.28	15.2	0	16.41	-15	+2	16.28				
	33	4			4	303	6574	15.2	-1	16.29	- 3	+2	16.28	15.4	-1	16.29	- 3	+2	16.28	16.28		30	
		45	5	5	59		766	15.1	-2	14.92	-18	0	14.74	15.2	-2	14.92	-18	0	14.74				
	55	5			5	304	2828	15.1	-1	14.77	- 2	0	14.75	15.3	-1	14.77	- 2	-1	14.74	14.74		50	
		46	6	6	60		5324	14.9	-2	13.54	+ 5	-2	13.57	15.0	-2	13.55	+ 5	-2	13.58				
	82	6			6	305	1045	15.0	-1	13.69	+10	-2	13.57	15.0	-1	13.69	-10	-3	13.56	13.57		75	
		47	7	7	61		U P 6116	14.7	0	14.60	-30	-4	14.26	14.9	0	14.60	-30	-4	14.29	14.26	1.29		
							18151	14.8	+1	13.01	- 1	-3	12.97	15.0	+1	13.02	- 1	-4	12.97				
	110	7			7	381	6509	15.0	-2	13.19	-19	-3	12.97	15.3	-1	13.20	-19	-4	12.97	12.97	101	101	
		48	8	8	62		U P 1077	14.6	0	14.43	-24	-4	14.15	14.8	0	14.43	-24	-4	14.15	14.15	1.54		
							1173	14.9	-1	12.83	-17	-4	12.62	15.1	-1	12.82	-17	-4	12.61				
	137	8			8	382	10312	14.9	+1	12.68	- 3	-4	12.61	15.1	+1	12.69	- 3	-5	12.61	12.61	128	127	
		49	9	9	63		U P 17508	14.7	-1	13.68	- 4	-6	13.58	15.0	-1	13.68	- 1	-6	13.58	13.58	1.58		
							18149	14.7	0	12.04	0	-5	11.99	15.0	0	12.05	0	-6	11.99				
	165	9			9	383	18139	14.8	0	12.05	0	-5	12.00	15.1	0	12.06	0	-6	12.00	12.00	153	153	
		50	10	10	64		U P 18516	14.2	+1	12.43	0	-8	12.35	14.5	+1	12.44	0	-9	12.35	12.35	2.14		
							18136	14.6	0	10.29	0	-8	10.21	14.9	0	10.30	0	-9	10.21				
	220	10			10	384	6569	14.6	+1	10.43	-15	-8	10.20	15.0	+1	10.45	-15	-9	10.21	10.21	209	205	

1.3. General rules for introductory part

Date and time are very important for observation records and these must always be filled in prior to any observation. These data are so familiar to the observers that they are apt to think they can record them later on. In most cases, however, the more obvious a fact is the easier it is to forget recording it.

Needless to say, the year should be indicated as well as the day and month when recording dates. Recordings of time should clearly distinguish between the morning and the afternoon. The time in the afternoon can be conveniently expressed by adding 12 hours, e.g., 03.30 p.m. is best expressed as 15.30.

Information which can easily be obtained, for example, weather conditions, should also be recorded.

1.4. Recording of data

When recording data in a field notebook, it is not sufficient to fill out only the prescribed items. Any matter observed in the field should be recorded immediately and directly in the field notebook, even if it looks trivial. When only numerical data of prescribed items are recorded, and these are recorded in a disorderly fashion, the notebook cannot be regarded as a proper field notebook. As the proper method of making and recording observations has been established after the bitter experiences of predecessors, the development of proper habits of observation and recording in the field is recommended.

(1) Use of columns. The use of columns is essential for recording, especially for beginners. During the course of observation, data should be filled inside the columns in due order. The columns help to indicate if there is any omission in the recordings. The use of columns can, therefore, be regarded as a guide during observation.

(2) Recording other relevant data. All matters observed, even if columns are not provided for them, should be recorded without omission. Such descriptions sometimes give hints from which a new aspect of the problem can be developed. There should be no hesitation about recording these additional remarks.

(3) Recording directly in the notebook. The use of loose papers for recording observations in the field is not recommended. It is important that the data is recorded directly in the field notebook. When the data cannot be recorded directly in the field notebook owing to special circumstances, the loose paper used for the record should be pasted in the notebook as soon as possible.

(4) Care in recording. Recording should be made with a good quality pencil. When a wrong entry has been made, it should be crossed out with a faint line and the correct value should be recorded nearby. Do not obliterate the error.

(5) Care in taking data. During observation on board, usually one person takes the reading and another person makes the record. Under windy conditions as on board,

the communications between observers are sometimes misheard. To avoid trouble, the following method of communication should be adopted. The person who records must repeat the reading loudly and the person who reads must confirm it. During observation, these persons must interchange their roles of observation and confirm the results of each.

(6) Recording non-mentally calculated values. Do not attempt to record mentally calculated values until all observed data have been recorded.

(7) Recording unit of numerical data. During measuring, the unit might seem so obvious that it might be considered unnecessary to record it. However, some confusion could arise later on when the recordings are put in order. For example, length measurements in centimeters may be confused with millimeters.

(8) Correction of observed data. The observed data should not be altered without sufficient reason. When doubt arises as to the accuracy of the observed data, a second observation should be carried out immediately. If the first reading is incorrect, it should be crossed out with a faint line and the correct value should be inserted nearby. Describe clearly the reason for the correction in the margin. The error should not be erased or rendered illegible.

(9) Checking before completion. On completion of observations at the station, the entries should be carefully checked for any error or omission. If an item was not

observed, the space provided for it should be filled, for example, with 'x' or '-'.

(10) Clear description. Since a field notebook is a valuable document, and should be kept for future reference, it is essential that all matters recorded in it should be easily understood by any person using it. Particular attention should be paid to style of writing, especially when recording figures.

(11) Care during cruise. Needless to say, field notes should always be stored in a safe place during a cruise.

(12) Putting data in order. After observation, the field notes should be transferred onto an appropriate form, e.g., a table or diagram, while memories are still fresh.

(13) Keeping of field notebook. The field notebook, after it has been put in order, should be treated carefully.

Recordings of raw data in the field notebook should be thought of as still pictures in a movie sequence. It should be borne in mind that such raw data are quite different in quality from those obtained through calculation, and that they are also different from those of controlled experiments performed in laboratories. In the field experiment, it is never expected that identical data can be collected by subsequent observation. In other words, the data obtained by the field observation should be regarded as unique at that instant and in that position.

From the above, you can understand the reason why in the field careful observations and recordings should be made. Mistakes can be avoided if one acquires proper habits during observations.

1.5 Calculation and data processing

Calculations on the raw data can be made by several methods such as mental calculations, ciphering, readings on numerical tables, slide rules and using calculators. The process of calculation should be such that it can be easily traced. A disorderly process of calculation is not encouraged.

It is generally difficult to grasp the general trend or relationship between sets of numerical data. However, the tendency can be seen clearly if the data are plotted on section papers. Graphs not only show trends but also serve as a means of checking the validity of the observed data. Graphs should be drawn whenever possible.

The purpose of any observation is to reach a result. Even if the result is only a graph or a numerical value, the observation has been of value. When a result is obtained, study the graph or the value visually and then review in the mind the whole process from the beginning to the final result.

Finally, if you have any criticism of the results, you should describe them. This includes any opinion as to modification of methods of observations, instruments, etc.

2. Winds

2.1. Apparent and true winds

Wind direction and velocity measured on a moving ship are apparent ones. This apparent wind can be resolved into the natural wind, and the wind due to the movement of the ship. The wind caused by the moving ship must be equal to the ship's speed in magnitude and opposite in direction. This is given from the course and the speed of the ship. The apparent wind can easily be obtained by measurement. With this information, the true wind is usually obtained graphically.

The circular graph (Fig. 1) is a convenient means to resolve the apparent wind into two components. In Fig. 1 the

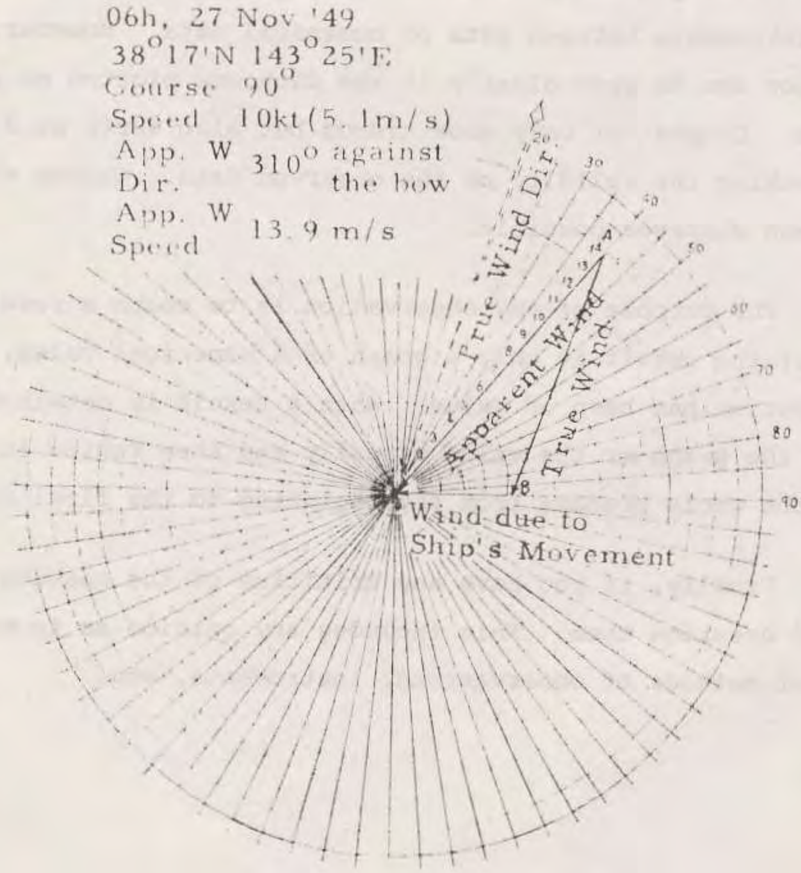


Fig. 1 Graphical Solution to determine true wind direction and speed

ship's course is 90°, the speed is 10 knots (5.1 m/sec) and the apparent wind registered on the ship is 310° in direction and 13.9 m/sec in velocity.

Prior to obtaining the graphical solution, we must calculate the apparent wind direction as follows:

(1) the angle of the ship's bow measured from the true north .... 90°

(2) the apparent wind direction measured from the bow .... 310°

+

(3) the apparent wind direction measured from the true north .... 400° $(=360^\circ+40^\circ)$ $= 40^\circ$

Next we obtain two points. As measured from the true north, one point is along the 90° line at a distance equivalent to 5.1 m/sec and the other point is along the 40° line at a distance equivalent to 13.9 m/sec from the focal point of the circular graph.

These two points and the focal point of the circular graph are joined to form a triangle.

Two sides of this vector triangle represent the directions and velocities of the apparent wind and the wind due to the movement of the ship. The third side represents the true wind.

We can measure both its direction and velocity if it is shifted to the focal point of the circular graph, since the vectors are drawn to scale.

2.2. Beaufort wind scale

We can estimate the wind velocity by visual observation without any instrument. The Beaufort wind scale is widely adopted among navigators (Table 2). Wind direction is usually expressed by 16 cardinal points, as follows:

N	NNE	NE	ENE	E	ESE	SE	SSE
S	SSW	SW	WSW	W	WNW	NW	NNW

Table 2. Beaufort Wind Scale

International Beaufort Scale	Description	Appearance of Sea Surface	Velocity (m/sec)
0	Calm	Sea like a mirror.	0.0-0.5
1	Light air	Ripples with the appearance of scales are formed, but without foam crests.	0.6-1.7
2	Light breeze	Small wavelets, still short but more pronounced. Crests have a glassy appearance and do not break.	1.8-3.3
3	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.	3.4-5.2
4	Moderate breeze	Small waves, becoming longer; fairly frequent white horses.	5.3-7.4

Table 2. Beaufort Wind Scale (Cont'd)

International Beaufort Scale	Description	Appearance of Sea Surface	Velocity (m/sec)
5	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.	7.5-9.8
6	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Possibly some spray.	9.9-12.4
7	Moderate gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	12.5-15.2
8	Fresh gale	Moderately high waves of greater length; edges of crests begin to break into the spin-drift. The foam is blown in well-marked streaks along the direction of the wind.	15.3-18.2
9	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	18.3-21.5

Table 2. Beaufort Wind Scale (Cont'd)

International Beaufort Scale	Description	Appearance of Sea Surface	Velocity (m/sec)
10	Whole gale	Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.	21.6-25.1
11	Storm	Exceptionally high waves (small and medium sized ships might be for a time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.	25.2-29.0
12	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	More than 29.1

3. Sea Conditions and Weather Conditions

3.1. Wave and swell

Wave and swell are convenient measures to express sea conditions. Wave scale and swell scale are widely adopted to express their magnitude (Table 3 and 4).

Table 3. Wave Scale

Scale	Descriptions	Height (m)
0	Calm, like glass	0
1	Rippled	0-½
2	Smooth (wavelets)	½-1
3	Slight	1-2
4	Moderate	2-3
5	Rough	3-4
6	Very rough	4-6
7	High	6-9
8	Very high	9-14
9	Phenomenal*	-

*) Seen in the center of a typhoon.

Table 4. Swell Scale (Douglas Scale)

Scale	Descriptions	
0	No swell	
1 2	Short or medium Long	Weak swell (Height is less than 2m.)
3 4 5	Short Medium Long	Rather high swell (Height is about 2-4 m)
6 7 8	Short Medium Long	High swell (Height exceeds 4 m)
9	Confused	Surface is confused by the propagation of swell from more than two directions

Range	Length	Cycle
Short	Less than 100 m	Less than 8.0 sec
Medium	100-200 m	8.0-11.3 sec
Long	More than 200 m	More than 11.4 sec

3.2. Weather Conditions

The following notations are widely employed by navigators to express weather conditions.

Table 5. Weather Scale (Beaufort Notations)

Notation	Derivations
b	blue sky
c	clouds detached
d	drizzling rain
f	foggy
g	gloomy
h	hail
l	lightning
m	misty
o	overcast
p	passing showers
q	squally
r	rain
s	snow
t	thunder
u	ugly
v	visibility
w	wet, dew
z	hazy

By drawing a single line or double lines under the above notations, the degree can be shown e.g.:

$\underline{f}$ = dense fog $\underline{\underline{f}}$ = very dense fog

$\underline{r}$ = strong rain $\underline{\underline{r}}$ = very strong rain

$\underline{\underline{s}}$ = very heavy snow

4. Echo Sounding

Almost all soundings are now obtained by sound impulse, known as echo sounding. The devices are ordinarily set at a speed of 1460 m (800 fm)/sec. For precise echo sounding, it is absolutely necessary to have a frequency-regulated power source. Otherwise, slight variations in frequencies and fluctuations in voltages will cause the speed of the synchronous drive motor to vary and result in relatively large errors in the recording of the travel time between outgoing and incoming sound impulses. These errors appear as sudden drops or rises on the echogram. Most survey echo sounders now have an internal frequency standard that provides stable drive voltages to the drive motors, producing accuracies in the range of 0.5 to 1.0 percent. Since the constant frequency devices have been developed it has become possible to get reasonable good profiles of deep ocean.

Wet and dry recording papers are used, and many recorders now have programming circuits so that an operator may select optimum signal returns for the highest quality of visual display. The method does not give absolute depths with this accuracy, because the speed of sound throughout a water column is not fully known. However, with return to the same position and use of the same frequency, the same depth should be obtained except for such minor differences as may come from variations of temperature or salinity and, of course, height of tide. As far as we know, significant changes of temperature and salinity occur only in near-surface water. Sound travels faster the higher the salinity, the higher the temperature, and the higher the pressure, but the differences are not very great.

One of the problems confronting both the surveyor and the scientist regarding echo soundings is whether or not to apply corrections to give true depths rather than the depths recorded using a velocity of 1460 m/sec. The actual depths of the deepest parts of the ocean should be known to leaders of expeditions investigating these depths so that they can apply corrections for sound velocities. On the other hand, to make soundings useful for navigation for vessels operating with echo sounders set for 1460 m/sec, much can be said in favour of publishing uncorrected soundings. For example, in crossing a valley, trough, or ridge with a relatively even axial slope, a position can be obtained by comparing the depth at which the axis is crossed with the chart. However, if the published depths are corrected so that they do not agree with the fathometer of the vessel, the navigator may be thrown off position. Mariners should bear in mind that many charts apply these corrections. Actually, however, there are few places where the corrections will interfere seriously with echo sounder navigation.

Another inaccuracy in echo soundings comes from the fact that the sound beam sent out by the transducer or sound head has a spread in most cases of about 30° from the vertical on both sides. As a result, where there is a steep submarine slope, the echo usually comes from the nearest point on the slope, rather than from the bottom directly beneath the vessel. This can make a large difference. However in crossing a valley, it is often possible to get the true valley floor depth by observing a curved surface that often rises as an arc beneath the echoes coming from the walls. A strong echo can be obtained when the center of the valley is crossed. Narrow-beam echo sounders between 5° and 7° are now being used on a few oceanographic ships. They are of special value in delineating small sea-floor features. Work is also under way in using tridimensional bathymetry with a sweeping array of transducers.

5. Water Sampling and Temperature Measurement

Water sampling and temperature measurement are the most important and basic observations of physical oceanography. The methods of sampling water and measuring temperature are considerably different for deep layers and for surface layers.

For the deeper layers below the surface, samples of the ocean water can be taken in Nansen reversing bottles (Fig.2). The

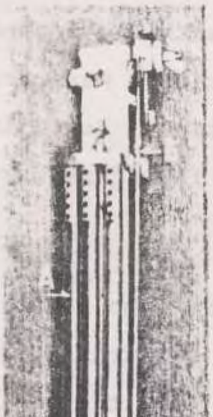


Fig. 2 Nansen Reversing Bottle

cylindrical metal bottle is open at both ends, but has caps or seals that can be closed automatically. When attached to a wire and submerged, water flows freely through the bottle until it has reached the desired depths. A weight called a messenger (Fig. 3)

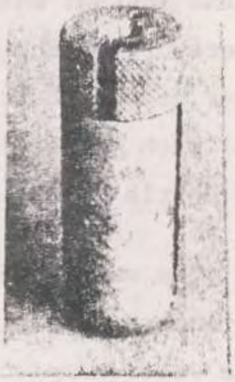


Fig. 3 Messenger

is dropped down along the wire to a device which closes the top and bottom of the bottle, trapping the water within it. When this happens, the bottle turns over and this movement fixes the mercury column in a thermometer fastened to the outside of the bottle. The reversing thermometer (Fig. 4) thus records the

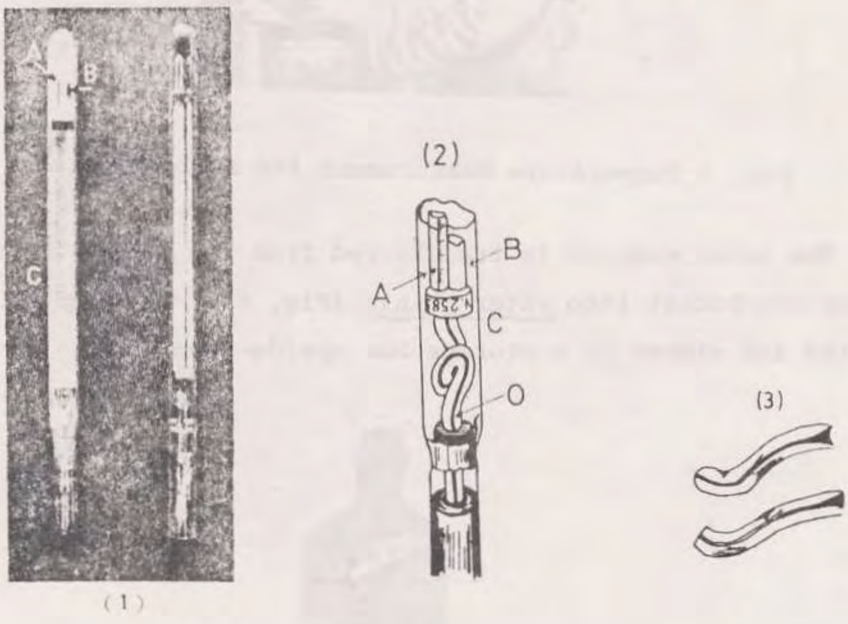


Fig. 4 Reversing Thermometers, Protected (left) and Unprotected (right) types

temperature of the water at the instant when the bottle was turned over. In this way, the temperature of the ocean at any depth can be measured. As a rule, a number of such bottles are employed at the same time at various depths. Each bottle, as it closes, releases a messenger which drops to the bottle below, repeating the process.

For the surface layer, the water sample is taken in the water sampling bucket. The temperature is measured by immersing a rod type thermometer in the water sampled on board just after the bucket has been heaved up (Fig. 5).

Fig. 5 Temperature Measurement for Surface Water

The water sampled is transferred from the Nansen bottle or the sampling bucket into water phials (Fig. 6). These phials are stoppered and stored in a storage box upside-down.

Fig. 6 Water Phial

5.1. Water sampling and temperature measurement for layers below the surface

The selection of the observation layers is not always definite; the layers should be decided considering the circumstances. The following depths, in meters, have been recommended by the International Association of Physical Oceanography (1936):

0, 10, 20, 30, 50, 75, 100, 150, 200, (250), 300 .....

Procedure

1. After the ship has stopped at the station with her board of observation facing the weather, read the depth on an echo-sounder and then decide the layers to be observed.

2. Payout the wire from the winch through the depth gauge (Fig. 7) suspended from the davit. Attach a weight to

Fig. 7 Depth-gauge

the end of the wire and lower the weight into the water so that it acts as a stabilizer to the wire. When the ship is rolling, it is preferable to pay out more wire.

3. When a sufficient length of the wire is paid out, attach the Nansen bottle to the wire (Fig. 8-9).

Figs. 8-9 Temperature Measurement and Water Sampling for Deeper Layers

Before lowering, inspect each part of the bottle and set the hands of the gauge to zero. When inspecting, special care should be taken of the thermometers, the seals and the screws of the devices by which the bottle is attached to the wire.

4. Lower the bottle until it has reached the desired depth, then attach the second bottle to the wire. The inspection

method is the same as for the first bottle, but never forget to attach a messenger. The same process is repeated until the last bottle is attached. When the last bottle is attached, read the depth gauge before lowering the bottle.

5. Lower the last bottle until the middle part reaches the surface, then stop the winch and read the depth gauge. The difference in length of this reading from that made when the last bottle was attached corresponds to the height from the level at which the bottles were attached to the sea surface. In order that each bottle reaches the desired depth, this length must be added.

6. Five minutes are enough for the mercury column of the thermometer to equilibrate. While waiting, measure the slope angle of the wire (Figs. 10 and 11) and

Fig. 10 Measuring an inclination Angle of Wire

Fig. 11 Clinometer

carry out temperature measurement and water sampling of the surface water[1/]. When 5 minutes have elapsed after the completion of the lowering of bottles, cast down the messenger and confirm (by feeling the wire) if the messengers bump successively into the bottles.

7. When the wire is heaved up, on person must wipe off the water from the wire and another person must coat the wire with grease. Take care not to bump the bottle against the ship when heaving up.

8. Detach the bottle and messenger from the wire and hang the bottle on the rack. Repeat the process.

9. After the mercury column inside the thermometer has settled, read first the temperature of the auxiliary thermometer and then that of the main thermometer (Fig. 12). Never give the thermometer any shock when it is in the reversed state.

Fig. 12 Reading and taking Records of Temperature on a Reversing Thermometer

1/ Refer to the related section.

10. When the observer is reading the temperature, he should report it loudly to the recorder and the recorder should repeat the value read. The observer should read it again to confirm it. It is preferable to have the temperature read again by another observer.

The temperature must be read to the order of 1/100 ^{o}C for the main thermometer and 1/10 ^{o}C for the auxiliary thermometer. The order of reporting is as follows:

(1) Depth ________________ m

(2) Nansen bottle number ________________

(3) Thermometer number ________________

(4) Auxiliary thermometer (Aux.) ______________ ^{o}C

(5) Main thermometer (Main) ______________ ^{o}C

11. After the temperature of all layers has been read, the sample water of each layer should be transferred to phials. First pour out the water which has been kept in the phials[2/]. Rinse the phial two to three times with the water collected. The rubber stopper must be cleaned when the rinse water is poured out.

2/ The phial used for the salinity determination is usually a glass bottle which is brown in colour and can be plugged with a rubber stopper; never allow the bottle to dry up. Some volume of sea water must always be kept in the phial, even after the salinity determination has already been completed. This will prevent the formation of salt particles in the bottle. On the other hand, do not rinse with fresh water. In either case, the salinity of the sample water will be affected.

12. Take the sample water into the phial, leaving some space. Never fill the phial to the brim.

13. Plug the phial firmly with a rubber stopper, then keep the phial in a box upside-down. The phial number must be recorded. The same care in reporting must be exercised as in the case of reading the temperature:

    (1) Depth ________________ m

    (2) Nansen bottle number ______________

    (3) Phial number(s) ______________

14. After the temperature has been read and the sample water has been taken, the reversing thermometer must be kept in the normal state. Keeping it in the reversed state for a long time leads to misfunction of the thermometer.

5.2. Water sampling and temperature measurement for the surface layer

The term surface water generally means the well-mixed water down to 1 to 2 m below the surface.

Procedure

1. Collect the surface water in the water sampling bucket, then pour it out. Repeat the process two to three times. This procedure will allow the temperature of the sampling bucket to approximate that of the water.

2. Dip up the water again, then immerse the rod type thermometer into the water sampled and stir well in a shady place, away from winds. It is preferable to carry out water sampling from the weather side of the ship, near the bow. Never collect the water near discharge pipes.

3. Read the temperature just after the mercury column has settled, with the thermometer as fully immersed in the water as possible. The time interval for the mercury to settle is usually within 40-60 sec. Temperature readings from the surface water are taken to the nearest $1/10^{\circ}C$ (Fig. 5).

4. Temperature reading must be carried out as quickly as possible.

5. Sample water must be taken from the water from which the temperature has been measured. The method of reporting is the same as in the preceding section.

6. Bathythermograph (BT)

The BT is used for obtaining the vertical profile of temperature; temperature is continuously recorded against the depth. Error for temperature is $\pm$ $0.05^{\circ}C$, and for depth 1% (Figs. 13 and 14).

Fig. 13 BT Observation

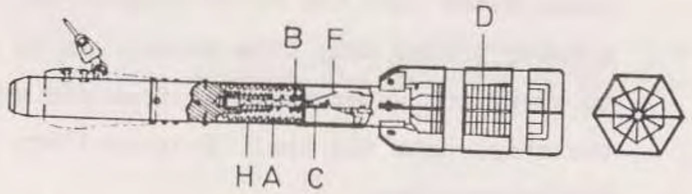


Fig. 14 Bathythermograph (BT)

Procedure

1. It is not necessary to attach the nose sleeve for a towing speed of 5 knots or so, but preferable to attach the sleeve for speeds of more than 10 knots.

2. Insert the slide glass to touch the bottom of the holder with the recording surface facing the stylus.

3. Before lowering, inspect every part of the BT, especially the shackle connecting BT and wire. Slide the pen-touch sleeve to the guide screw just before lowering.

4. When lowering, never bump the BT. Allow the BT to equilibrate with the surface water for at least 30 sec , before releasing winch.

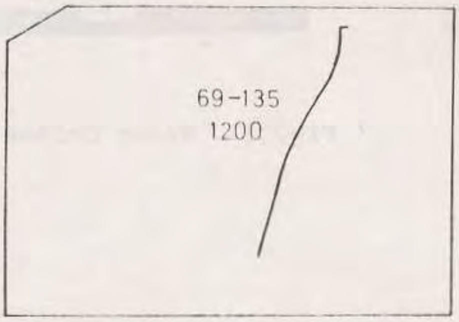
5. As soon as BT reaches the depth required, start to heave it up. Suitable speed of heaving-up is 1.5-2.0 m/sec. Slow down the heaving-up speed when BT is coming up to about 30 m below the surface and take care not to bump it against the ship.

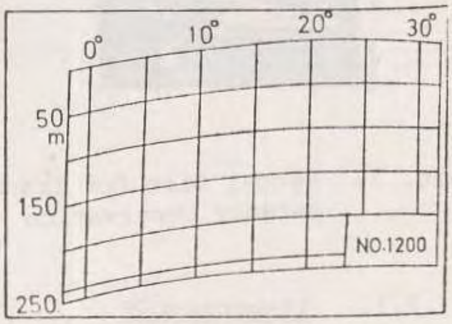
6. Remove the pen-touch sleeve while the BT is suspended from the davit. Never give any shock to the BT when the pen is touching the slide glass.

7. Measure and record the surface water temperature just before casting and just after heaving up.

8. Rinse the BT thoroughly with fresh water. Store the BT in its box. Never expose it directly to the sunshine. Never keep the thermal senser in a temperature above 35°C.

9. Record the station number, BT number and date on the slide glass (Fig. 15).





Figs. 15(a)-(b) Data recorded on a BT slide glass (left), and a Scale for reading Temperature and Depth (right)

10. Rinse the slide glass in fresh water and allow it to dry, then lacquer it, and store.

7. Transparency and Water Colour

The light penetration into sea water can be determined by the Secchi disc (30 cm in diameter) and the Standard Water Colour Set (Figs. 16 and 17).

Fig. 16 Secchi Disc for Transparency Observation

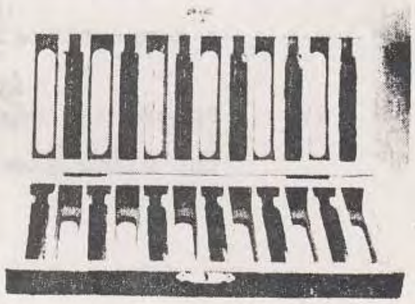


Fig. 17 Water Colour Meter

7.1. Transparency

Procedure

1. Connect the weight to the rope at the lower end of the Secchi disc. Then lower the disc into the water on a graduated rope. Note the depth at which it disappears.

2. Lift the disc up until it reappears and record the depth.

3. Use the clinometer to measure the slope angle of the rope.

4. Calculate the vertical depths and take the average of these two calculated depth readings as the limit of visibility.

7.2. Colour of sea water

Compare the colour of sea water with the Standard Water Colour Set and record the colour solution number on the Oceanographic Survey form.

Remarks: The transparency and colour tests of sea water must be carried out in the day-time.

8. Plankton Sampling

The most widely used apparatus for collecting plankton is the plankton net. The plankton net is essentially a cone made of fine mesh bolting silk or nylon. The front part of the net is attached to a metal ring by which the net is towed through the water, and the terminal end of the net is provided with a bucket in which the plankton is allowed to settle. The net may be towed horizontally or hauled vertically through the water. If towed horizontally from board, the depth can be set by depressors or paravanes. Vertical hauls may be continuous from the bottom or from a fixed depth to the surface, or divided, using a mechanism to close the net at a given depth.

Qualitative sampling at the surface is a simple matter. A suitable net is towed at about 1½ to 2 knots for ten minutes, which usually suffices to give an adequate amount of plankton. But the quantitative determination of plankton bristles with difficulties. To assess the amount of plankton in a given water column is never possible with any real accuracy. This is because some of the water is spilled out before it has been filtered during the operation. Particularly when working with a fine-mesh net in waters rich in phytoplankton, the meshes get progressively clogged and so the filtration rate falls off in time with more and more water spilling from the front of the net as resistance increases. In order to overcome these difficulties, a flow-meter is placed in the mouth of the net so that the water passing into the net activates a small propeller attached to a counting mechanism. When properly calibrated, the number of revolutions of the propeller is taken to indicate the amount of water which has passed through the net. From this, the plankton biomass can be calculated. However, owing to unavoidable irregularities in filtration or analysis, the figures obtained usually are at best only an approximation.

8.1. Vertical hauling

The three types of nets, the zooplankton net, the phytoplankton net and the Norpac net (North Pacific standard net) are used to collect vertical plankton samples.

Procedure

1. Before the operation starts, firmly tie a flow-meter (Fig. 18) at the central part of the mouth of the plankton net and suspend a meter wheel under the davit which is projected from the hull at a right angle.

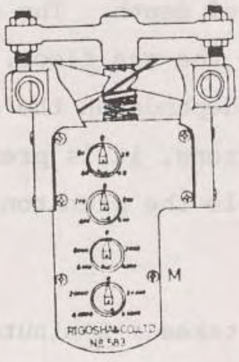


Fig. 18 Flow Meter

2. When the vessel has stopped at the station, switch on the echo-sounder and read the depth of the station from the recording paper.

3. Tie a chain of weights to the rope at the lower end of the plankton net.

4. Pay out the wire from the sounding machine through the meter wheel and attach the net to the end loop of the sounding wire.

5. Before lowering the net, inspect the tap of the bucket and the flow-meter to make sure:

   (a) The tap (the opener) is parallel to the bucket position (i.e. the bucket is kept closed).

   (b) The flow-meter is set to zero.

6. Lower down the plankton net into the sea until it reaches the desired depth. The depth desired is usually 3 m above the sea floor. Thus, the length of wire released depends on the sea condition. If the current is strong, it is preferable to pay out more wire to enable the plankton net to reach the lower water.

7. The plankton net takes 1-2 minutes to return to a straight vertical position in water. During that time, use the clinometer to measure the slope angle of the sounding wire.

8. Haul up the plankton net with the speed of 1 m/sec. When heaving the wire, use a cloth to wipe off the water from the wire.

9. As soon as the plankton net is pulled up onto the deck, read the flow-meter immediately and record it on the oceanographic survey form.

10. Detach the plankton net from the sounding wire and release the weight tied on the rope of the net.

11. Immerse the lower end of the plankton net in water contained in a plastic vessel for samples. Then wash off the plankton specimen attached on the net into the bucket. Open the tap of the bucket and let the bucket water drain into a 250 ml plastic sample bottle. Close the tap and repeat the same procedure until all the specimens have been collected. (In case the tube of the bucket is blocked by jellyfish

or other macroplankton, press the cylindrical plastic tube of the bucket tightly and remove the bucket carefully. Then pour the bucket-water into the sample bottle.)

12. Add neutral solution of formaldehyde to the sample to make up 4-5% of the total volume*.

13. Record the date, time, depth, wire length, station number and sample number on the record form.

*) The absolute formaldehyde solution is about 40%. Eight to ten times dilution of the solution will give a 4-5% concentration.

8.2. Horizontal towing

Use the Norpac net and zooplankton net in horizontal towing to collect surface plankton samples.

Procedure

1. Connect the plankton net and weights to the towing rope, which is tied at the davit projected from the hull.

2. When the vessel is at a uniform speed of 2 knots, lower the plankton net to the sea. The mouth of the plankton net must be adjusted to immerse completely on the surface water.

3. After towing for exactly 10 minutes, pull up the net onto the deck and read the flow-meter immediately.

4. Collect the plankton specimen in a 250 ml plastic bottle and preserve the sample in 4-5% formaldehyde.

5. Record the date, time and period of towing, the station number, sample bottle number and flow-meter on the record form.

Note: In both vertical hauling and horizontal towing, after collecting the plankton samples, never forget to do the following:

(1) Wash the plankton net throughly.

(2) Set the flow-meter to zero.

(3) Turn the tap to a position parallel to the bucket.

8.3. Twin net towing

Because of convenience of operation, it is recommended to employ twin-net towing for plankton sampling. Two sets of net are used:

a) Japanese standard net: zooplankton net and phytoplankton net.

b) CSK standard net: 0.11 mm mesh net and 0.35 mm mesh net.

Procedure

1. Before the operation starts, firmly tie a flow-meter at the central part of the mouth of the plankton net and suspend a meter wheel under the davit which is projected from the hull at a right angle.

2. When the vessel has stopped at the station, switch on the echo-sounder and read the depth of the station from the recording paper.

3. Tie a chain of weights (10-20 kg) to the rope at the lower end of the plankton net.

4. Pay out the wire from the sounding machine through the meter wheel and attach the net to the end loop of the sounding wire.

5. Before lowering the net, inspect the tap of the bucket and the flow-meter to make sure:

   (a) The tap (the opener) is parallel to the bucket position (i.e. the bucket is kept closed).

   (b) The flow meter is set at zero.

6. Pay out the wire cable carefully: do not allow slacking of the cable. Where the depth of the sea exceeds 150 meters, pay out the wire cable as much as 150 meters. Measure the angle of the wire on deck with a clinometer and refer to the cosin table to check the length of wire to be paid out so that the net will reach the desired depth (150 m). The desired depth in areas shallower than 150 m is 5 meters above the sea bottom.

7. When the net has reached the desired depth, immediately haul up the line at a speed of about 1 m/sec. Haul should not be stopped until the net is raised up to about 1 meter below the sea surface. Then haul up the line by turning the handle of the winch until the net is

raised up above the sea surface. (This is to prevent over-rotation of the flow-meter.) When heaving the wire, use a cloth to wipe off the water from the wire. The hauling time should also be taken by using a stop-watch.

8. When the net comes above the sea surface, wash the net with water from outside so that specimens adhering to the inner surface of the filtering cloth are all washed down to the bucket.

9. Haul the sinker hauling rope. Then, haul the bucket of the net on deck. Be careful not to turn the bucket upward.

10. Read dial gauge of the flow-meter and record it on the oceanographic survey form.

11. Immerse the lower end of the plankton net in water contained in a plastic vessel for samples. Then wash off the plankton specimens attached on the net into the bucket. Open the tap of the bucket and let the bucket water drain into a 250 ml plastic sample bottle. Close the tap and repeat the same procedure until all the specimens have been collected. (In case the tube of the bucket is blocked by jelly-fish or other macroplankton, press the cylindrical plastic tube of the bucket tightly and remove the bucket carefully. Then pour the bucket water into the sample bottle.)

12. Add neutral solution of formaldehyde to the sample to make up 4-5% of the total volume.

13. Record the date, time, depth, wire length, station number and sample bottle number on the record form.

8.4. Sampling with a closing net

In order to study the vertical distribution of plankton, sampling with a closing net at 0-30 m, 30-60 m and 0-60 m should be done (Fig. 19).

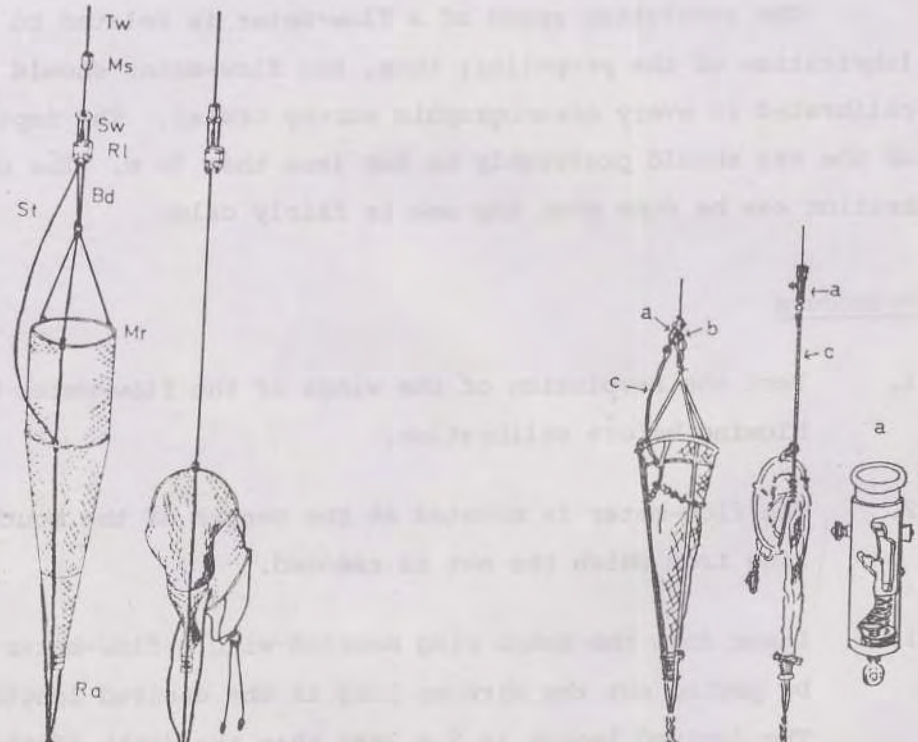


Fig. 19 Various Types of Closing Plankton Net

Procedure: Lower down the closing net into the water. When the plankton net reaches the lower desired depth (e.g. 60 m of 30-60 m sampling), immediately haul up the line until the net reaches the upper desired depth (e.g. 30 m of 30-60 m sampling). Then close the net by casting down the messenger. Haul up the net and collect the plankton sample.

8.5. Calibration of flow-meter

The revolution speed of a flow-meter is related to the lubrication of the propeller; thus, the flow-meter should be calibrated in every oceanographic survey cruise. The depth of the sea should preferably be not less than 70 m. The calibration can be done when the sea is fairly calm.

Procedure

1. Test the revolution of the wings of the flow-meter by blowing before calibration.

2. The flow-meter is mounted at the centre of the mouth ring from which the net is removed.

3. Lower down the mouth ring mounted with a flow-meter by paying out the wire as long as the desired length. The desired length is 5 m less than the depth of the sea or not exceeding 150 m.

4. As soon as the desired length of wire is paid out, measure the wire angle with a clinometer and haul up the wire at a speed of 1 m/sec.

5. When the ring is raised on deck, read the dial gauge of the flow-meter and record the reading on the oceanographic record. The angle of wire is recorded for information, but not for calculation of the depth of haul.

6. Repeat the above procedure until nearly constant revolutions are obtained.

7. The revolution rate of the flow-meter is calculated as follows:

$$r_m = \frac{\text{Revolution without net}}{\text{Wire length paid out during calibration}}$$

where r_m is the rotation of flow-meter without net.

8. The volume of water filtered by the net is calculated as follows:

$$V = ¶\ r^2 \times \frac{R_d}{r_m}$$

where V is filtration volume, r radius of net, and R_d the rotation of flow-meter in sampling with net from a depth d.

CSK standard net is 45 cm in mouth diameter and Japan standard net is 23 cm, thus the mouth areas of the two nets are:

CSK $\pi r^2 = 3.1416 \times 22.5^2 = 1590 \text{ cm}^2 = 0.16 \text{ m}^2$

Japan $\pi r^2 = 3.1416 \times 11.5^2 = 415 \text{ cm}^2 = 0.04 \text{ m}^2$

9. If the mean revolution of the flow-meter without net for 80 m haul is 834 and the revolution of the flow-meter in a 75 m plankton sampling haul with CSK net is 700, then the filtration volume is:

$$r_m = \frac{834}{80} = 10.42$$

$$V = 0.16 \times \frac{700}{10.4} = 10.8 \text{ m}^3$$

8.6. Measurement of biomass

Plankton biomass can be represented by weight or by volume. The former is measured by wet weight and the latter by displacement volume for zooplankton and settling volume for phytoplankton.

A. Settling volume: The volume of phytoplankton is measured by settling volume. This procedure is done before measuring the wet weight of the sample.

Procedure

1. Transfer the phytoplankton sample in a 10 ml or 25 ml measuring cylinder. Then add water in the cylinder until the water level reaches the mark of 10 ml (for 10 ml cylinder) or 25 ml (for 25 ml cylinder).

2. Let the sample settle to the bottom of the cylinder. After a 5-hour settling interval, read the settling volume of the phytoplankton.

B. Wet weight

Procedure

1. Wet a piece of nylon netting (70 mm diameter, mesh size 0.064 mm) in water and wind dry the nylon netting for two minutes on a filter paper. Measure the weight of the nylon netting by means of an electric balance.

2. Filter the sample through the nylon netting to remove the preservative from the organisms.

3. Place the bolting silk with organisms on a piece of filter paper and then wind dry under a fan for about two minutes. Weigh the organisms with the nylon netting.

4. Calculate the actual wet weight of the organisms by substracting the weight of the net from the weight of the net with organisms.

C. Displacement volume: The volume of zooplankton is measured by displacement volume.

After weighing of the sample, immediately put the organisms with the nylon netting in a 10 ml measuring cylinder which contains a certain known volume of

4% formalin. The volume increase of the formalin solution less the displacement volume of the nylon netting gives the displacement volume of the plankton. The displacement volume of the nylon netting must be determined beforehand.

D. Preservation of samples: Plankton samples are usually preserved with neutral formalin. The preservative used is made up by one part of neutral formalin to six part of sea water.

Neutral formalin is prepared by adding 1.5 gm to 2 gm of hexamine to 100 cc of 35% formalin to give a PH of 7 to 7.5.

9. Larval Fish Collection

9.1. Larval net collection

Procedure

1. Tow the net for 10 minutes at about 2 knots at sea surface twice a day, around noon and after sunset. Each time before towing, check whether the net-end is tied tightly.

2. It is desirable to tow the net outside the wake of the ship's bow. To attain this, the towing rope of the larval net must be tied at the tip of the boom which is projected from the hull at a right angle. At the same time, connect directly the ring of the larval net with the

hull by a thin rope in order to make it easier to pull up the net.

3. After pulling up the net onto the deck, open the net-end and reverse 40-50 cm from the end. Wash out the specimens attached inside the netting into a bucket 2/3 filled with sea water. Pour water in the bucket into the collector. Remove the Eimer of collector carefully, and pour the specimens into a sample bottle. Repeat the same procedure. If necessary (when the amount of specimens collected is extremely abundant), repeat once more. Larger pieces of floatsam such as plant leaves, twigs, fragments of seaweeds, etc. or larger jellyfish should be carefully removed before filtering the collector.

4. Read the flow meter before and after towing.

5. Record the necessary data on the oceanographic survey form.

6. Put the following label on the bottle containing the sample, adding formalin up to 10% of total volume.

Date: ____/ ____/ 197 __, Time: ______

St. No.: ______, Lat. _____N, Long. ______E.

Method: Larval Net/Dip Net (with Lamp)/
Trawl/
Flotsam ________________

Layer: Surface/ ______m/ Bottom/ ______m

Direction: Horizontal/Oblique/Vertical

Reading of Flow-meter: ______________

Collector: ________________

7. Wash the terminal end of the larval net well so as to keep the net always clean.

Never forget to tie the net-end.

9.2. Dip net collection

Provided that circumstances permit, collect juvenile fishes gathering under the lamp during the time when the vessel is drifting in the night with a dip net. Preserve the sample in 10% formalin together with the label above.

10. Manual for other Biological Surveys on Board

10.1. Trawl catch

1. Total Catch and Species Compositions: Sort the catch into species or groups as detailed as possible. Weigh the total weight of catch according to species or groups, check the number of individuals of large-sized fish such as sharks, rays, groupers, red snappers,

Spanish mackerels, black king fish, bat fish, etc. Record this information on the catch record form, including trawling time.

2. Minor organisms: Record the number or weight of the animals and plants such as corals, sponges, sea anemones, etc., caught together with fish in the same form as for the above.

3. Fishing boats sighted by the vessel: Record the number and type of fishing boats operating near the vessel in the operation record form.

4. Size Measurement:

   a) Measure the total length (fork length for scombroid fish), the standard length, the body weight of 50 individuals selected at random from the daily catch of the fishes listed in the catch measurement form.

      When the number of individuals is less than 50, measure all of them.

   b) List of Fish: Saurida tumbil, Tachysurus sp., Priacanthus tyanus, Scomberomorus commersoni, Trichiurus sp., Racycentron canadum, Epinephelus tauvina, E. sp., Lutjanus erythropterus, L. sebae, L. argentimaculatus, L. sp., Abalistes stellatus, Platax sp.

5. Examination of Stomach Contents:

   a) Dissect and remove the stomach of 10 individuals per day for each species listed in the form. Put the stomach in a numbered bag or bottle together with a label. Record total length (F.L. for scombroids), body weight, number of the container, together with gonad weight and sex, in the stomach record form. Preserve the stomach in 10% formalin.

b) List of Fish: Saurida tumbil, Tachysurus sp., Racycentron canadum, Upeneus sp., Epinephelus tauvina, Pristipomoides typus, Lutjanus erythropterus, Leiognathus sp., Abalistes stellatus, flatfish, etc.

6. Examination of Gonad:

a) On the same number and species as the above, keep a record in the biological record form.

b) Label for Stomach and Gonad Collections:

Species ______________, Sample No. ___________
Total Length ________cm, Body Weight _________g.
Method of Collection ____________________________
Date of Collection ______________________________
Locality _________________, Depth ____________m
Collector ________________, ____________________
Labels must always be written in pencil.

7. Note: Carry out identification of doubtful species to avoid confusion which would be encountered when measuring the catch.

10.2. <u>Visual observation for future study</u>

Whenever possible, the following records should be taken during the cruise:

1. Dolphin School: Date, Time, Location, Species (Characteristics, Size, Colour), Number of individuals, Direction of Movement.

2. Flying Fish: Date, Time, Location, Species, Number of individuals observed in unit time (10 minutes for example).

3. Fish Schools densely aggregating at the surface: Date, Time, Locality, Species, Size of school.

4. Flotsam: Kind of flotsam (e.g. drifting weed, mass of palm leaves, brown seaweeds, etc.), Size of the flotsam. When trollings are operated, record the catch, measure the fish caught.

11. <u>Current Measurement</u>

There are two basic ways to describe fluid flow, the Eulerian method in which the velocity (i.e. speed and direction) is stated at every point in the fluid, and the Lagrangian method in which the patch followed by each fluid particle is stated as a function of time. In both cases the statements are usually made with respect to axes which are stationary relative to the solid earth.

Perhaps the most used Eulerian instrument is the <u>Ekman-Mertz current meter</u> (Figs.20-21). This consists of a multi-bladed propeller, about 10 cm in diameter, which is mounted on low friction bearings in

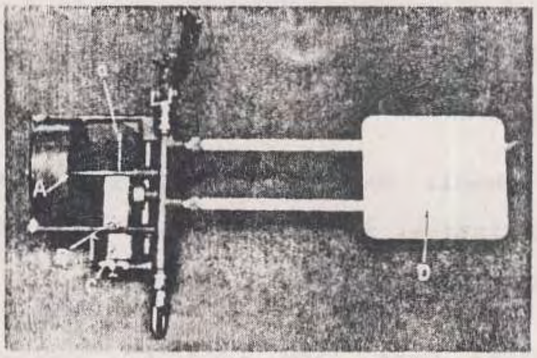


Fig. 20 Ekman-Mertz Current Meter

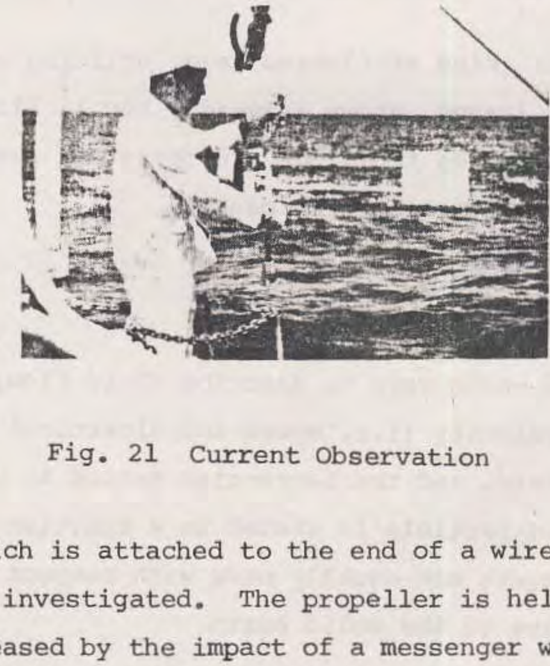


Fig. 21 Current Observation

a frame-work which is attached to the end of a wire and lowered to the depth to be investigated. The propeller is held stationary by a catch until released by the impact of a messenger weight which is slid down the wire. After being allowed to rotate for a measured time the propeller is stopped by a second messenger, and then the meter is brought back on deck and the number of revolutions read from a set of pointers geared to the propeller. The water speed is directly proportional to the number of revolutions per minute from about 2 to 250 cm/sec. The direction of the current is recorded in a most ingenious manner. The whole instrument is free to rotate on the end of a wire, and a vane at the rear causes it to point into the current. At intervals, while the propeller is turning, small bronze balls are released to fall on to the top of a magnetic compass needle, run down a trough on its upper side, and fall thence into a tray divided into 36 sectors (Figs. 22-23). As the compass and trough

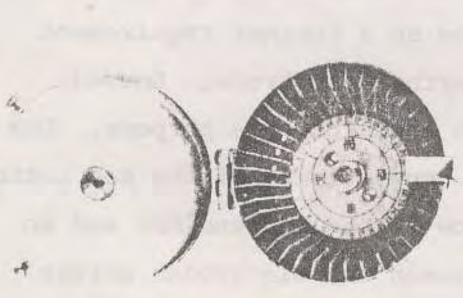


Fig. 22 Compass Box of Ekman-Merz Current Meter

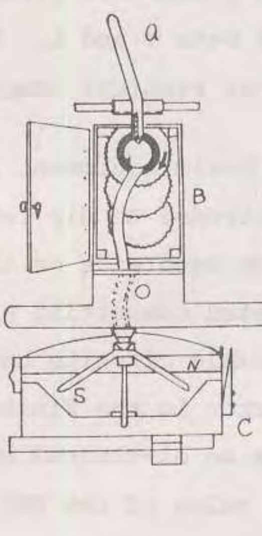


Fig. 23 Dial Gauge and Compass Box of Ekman-Merz Current Meter

remain fixed in the magnetic meridian while the remainder of the instrument, including the tray, is oriented by the current, the particular sector into which the balls drop gives an indication of the current direction. The whole arrangement sounds rather far-fetched but this instrument does work at sea, and it is strongly recommended to include it in oceanographic equipment. It has the disadvantage of being discontinuous and having to be retrieved for each measurement.

Another fundamentally different principle, which was originally suggested by Farady, is to use the EMF induced in a conductor moving in a magnetic field. Sea-water is a conductor and when it flows across the lines of force of the earth's magnetic field, an EMF, $E = B.L.v$, will be generated where v is the water speed, L the width of the current and B the strength of the component of the earth's magnetic field in a direction perpendicular to the direction of both v and L. For a horizontal current along a channel B would be the vertical component of the earth's field.

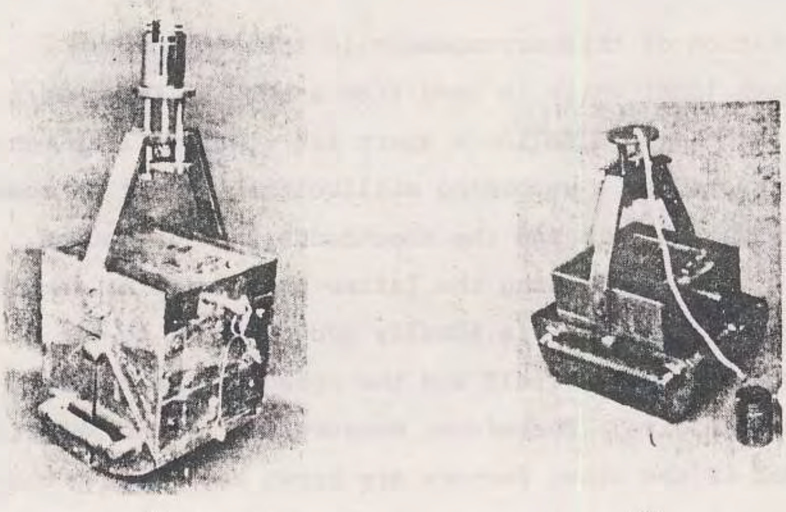
The basic equipment required is a recording millivoltmeter and two electrodes to dip into the sea. The electrodes are best placed one on each side of the current and so a further requirement is an insulated connecting wire to the farther electrode. Unused commercial cable circuits have often been used for this purpose. One source of error is the finite electrical conductivity of the sea bottom which allows an electrical current to flow to the induced EMF and so reduces the value of the EMF observed between the electrodes across the current. This introduces a constant scaling-factor which may be determined by making some current measurements with another type of meter while the electromagnetic system is in operation.

An adaptation of this arrangement is the geomagnetic electrokinetograph (GEK) which is used from a ship at sea. In this, two electrodes which are 30 to 100 m apart are towed in line behind the ship and connected to a recording millivoltmeter. If an ocean current is carrying the ship and the electrodes in a direction perpendicular to the wire joining the latter there will be an EMF induced in the wire. This EMF is ideally proportional to the wire length, the earth's magnetic field and the speed of the current perpendicular to the wire. Therefore, measurement of the EMF will yield the current if the other factors are known and remain constant. The GEK works best for the surface currents over relatively stationary deep water, so that the latter can short circuit the EMF generated simultaneously in the surface water and leave the EMF in the wire incompensated and measurable. In shallow water the short circuiting effect of the subsurface water may be incomplete and the observed EMF will be less than the theoretical one by an uncertain amount. As the GEK only yields the component of current perpendicular to the wire, it is necessary to change the ship's course for a few minutes at intervals in order to measure the second component to permit adding the two vectorially to determine the total current velocity.

One requirement for either electromagnetic method is stable electrodes so that varying electrochemical EMFs will not complicate the measurement. Silver wire coated with silver chloride is the most satisfactory electrode for use in the sea.

12. Bottom Sampling

The bottom sampler used in the vessel consists of three parts: the weight, the conical cup and the collecting bag. It is only practical for collecting superfacial sediment of the sea bottom. The other types of sampler are shown in Figs. 24 and 25.



(a) (b)

Figs. 24(a)-(b) Ekman Barge Type Bottom Samplers

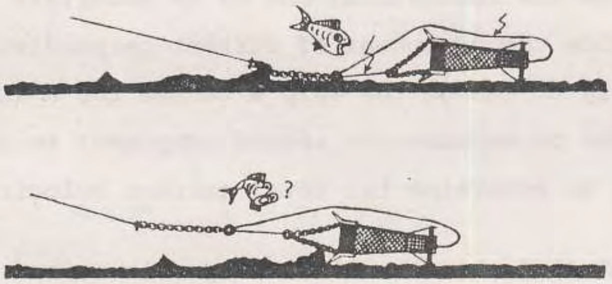


Fig. 25 Dredge Type Bottom Sampler

Procedure

1. Attach the bottom sampler to the end loop of the sounding wire.

2. Pay out the sounding wire from the sounding machine and lower the sampler into the sea. The length of wire paid out is about two times the depth of the sea. This is to enable the sampler to drag at the sea bottom so that the superfacial sediment is collected into the collecting bag when heaving up the sounding wire.

3. After pulling up the sampler onto the deck, drain away the water from the conical cup and pour the sample in the collecting bag into a plastic bag (size: 25cm x 35cm).

4. Record the date, station number, sample number, depth and wire length on the plastic bag and record form.

5. The sample in the plastic bag will take 1 to 2 hours to settle to the bottom. When the sample has completely settled, drain away the water at the upper layer from the plastic bag.

6. Never forget to wash the collecting bag well after use.

13. Coring Devices

Coring techniques have greatly improved in recent years and many new methods have been devised. Gravity corers are still used rather commonly despite the considerable advantage of piston coring. The core is obtained in a plastic liner which allows easy storage.

Most small gravity corers take a core of 2.5 cm diameter, but 5 to 6.5 cm core barrels can be used just as easily and will ordinarily take somewhat longer cores.

Because of the danger of fouling wire, it is unwise to lower a core tube at high speed. For this reason, the free-fall method of coring has proved helpful in increasing the velocity and momentum of the core tube prior to hitting bottom. The device is lowered to the bottom rather slowly, where a suspended weight hits first, releasing a lever arm that allows the core barrel to fall freely for a few meters and sink rather deeper into the bottom than if it were directly attached to the evenly descending cable (Fig. 26). Another advantage is that

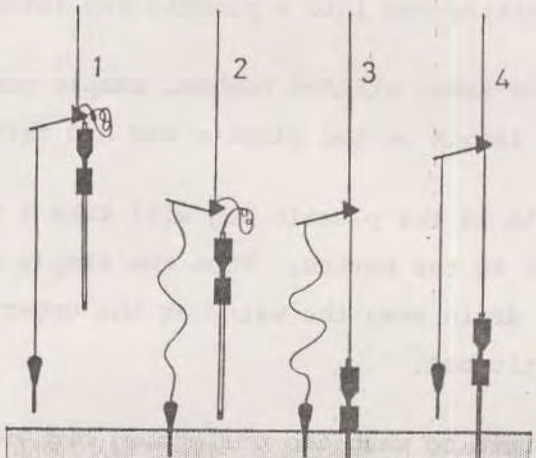


Fig. 26 Gravity Core Sampler

the free-fall corer avoids the danger of the operator not recognizing the bottom when an ordinary corer is lowered in deep water. The free fall gives a much clearer indication on the winch tensionmeter than does the lowering of an ordinary corer to the bottom.

The piston corer also falls freely after being released by the same method as the free-fall corer. The piston in the inside of the core tube remains attached to the wire so that the core tube falls past the piston and hence avoids serious friction in taking the core.

A serious difficulty in piston coring develops whenever the core barrel is not completely filled when the tube stops penetration. In such cases, the lifting of the apparatus by pulling on the piston tends to raise the core in the barrel and suck in bottom material or water from below. Thus the core is deformed by being pulled up through the barrel, and unknown amount of material is added to the bottom. A common result is that the lower portion of the core has vertical flow lines indicative of the flow of material into the barrel during retraction. Core material may also be sucked into the tube when the device hits hard bottom and tips over pulling up the piston and drawing in surface sediment. The nature of the top of the core can often be determined by a study of the material obtained in a small gravity corer used as a pilot weight. The two cores may be comparable provided the piston was pushed to the top and the tube was filled before retraction. In any case, the pilot core ordinarily will be considerably shorter than the piston core; the difference in length is caused by frictional compaction of the sediment in the pilot core, which has no piston, whereas the piston cores causes only minor changes of length.

14. Salinity Measurement

The classical Knudsen method of measurement is to determine the chlorinity by titration with the standard silver nitrate solution and then to calculate the salinity. In routine use, an accuracy of $\pm$ 0.02°/oo is considered reasonable with rather better accuracy if special care is taken and replicate titrations are made. A careful operator may titrate 50 samples per day. It must be remembered that this method is a volumetric one, whereas salinity is defined gravimetrically (i.e. by mass). In consequence it is necessary either to correct for deviations of the temperature of the solutions from the standard, or preferably to carry out the titrations in a temperature controlled room. This titration method is practical but not very convenient to use on board a ship.

The determination of salinity through the electrical conductivity measured by means of an a.c. bridge has been in use. The method was not more widely used for many years because of the bulk and expense of the equipment required. This is because the conductivity is as much a function of temperature as of salinity. This necessitates thermostating the samples to $\pm$ 0.001°C during measurement. However, improvements in circuits and equipment encouraged a number of laboratories to bring this method into wider use and an accuracy of $\pm$ 0.003°/oo is obtained in routine use. This is very substantially better than the titration method and makes it possible to distinguish water mass which was previously not distinguishable. One of the great advantages of the electrical salinometer is that it uses a null-balance method which is much less tiring for the operator to use than the end-point method of chemical titration. However, the overall bulk of the equipment which measures 1.5 to 2 m^3, is inconvenient, and variability in characteristics of the platinum electrodes is till a problem.

In 1961, Brown and Hamon in Australia described an <u>inductive salinometer</u> design which has now come into wide use (Figs. 27 and 28).

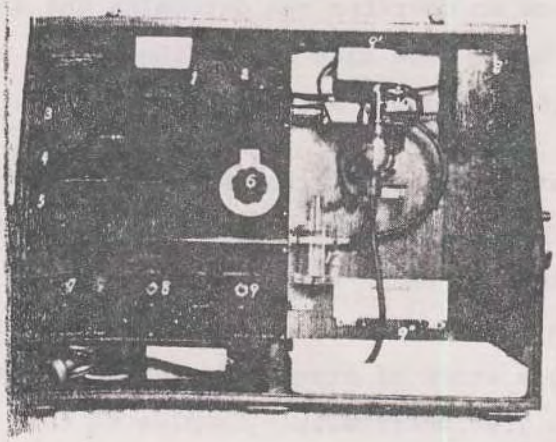


Fig. 27 Inductive Salinometer

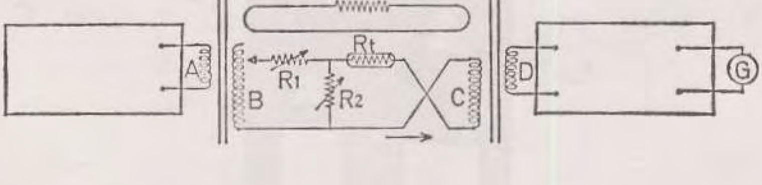


Fig. 28 Circuit Diagram of Inductive Salinometer

In this instrument the temperature effect is eliminated not by thermostating the sample but by measuring the temperature while the conductivity is being measured and correcting for its effect automatically in the electrical circuit. The salinity may be measured to an accuracy of $\pm$ 0.003°/oo over a range from 32 to 39°/oo, and with a little practice an operator can determine the salinity of up to 45 samples per hour. The size of the instrument is about 0.06 m^3 (0.6 x 0.2 x 0.5 m) and its weight is only 27 kg.

One feature of all the above methods, which should be noted, is that they are all comparative rather than absolute. A so-called "Normal Sea-Water" is prepared in the Laboratoire Oceanographique near Copenhagen, Denmark, and has an accurately known chlorinity by comparison with a stock of standard sea-water whose chlorinity has been determined gravimetrically. Samples of this Normal Sea-Water sealed in glass ampoules (Fig. 29) are used by oceanographic laboratories throughout the world to standardize the silver nitrate used for titration or to standardize the electrical conductivity bridge.

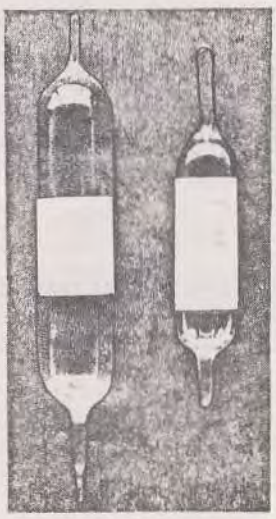


Fig. 29 Standard Sea Water

The above methods are all laboratory methods. The in situ measurement of water properties has always been something to aim for but has not yet been achieved for some of the reasons described below. Electrode type salinometers have the disadvantage for in situ use that a variety of substances and organisms in ocean water tend to cause fouling of the electrodes and consequent change of calibration. The inductive salinometer is more suitable and several instruments are available or under development. One disadvantage is that the in situ sensing element has to be connected to the deck instrument by a multi-core electrical conductor cable which is bulky and requires a special winch with electrical slip-rings if long lengths are to be used.

Oceanographic Survey Methods

A. Exercises:

1. What kind of requirements should be fulfilled in keeping a field notebook?

2. When a wrong entry has been made in a field notebook, what should we do?

3. When recording data, how do the columns of the field notebook help us?

4. When data cannot be recorded in a field notebook, what should we do?

5. When taking records on board ship, what kind of care should be taken?

6. When measured on board a moving ship, do the wind direction and speed obtained show true values? If not, explain the reason why.

7. When crossing over a trough, does the depth measured by an echo sounder show the actual depth? If not, is the depth measured shallower or deeper?

8. For the deeper layers below the surface, how are water samples collected and temperature measured?

9. In order that each Nansen bottle reaches the desired depths, how should we proceed?

10. How long should we wait until the wire is heaved up after the completion of lowering the Nansen bottles? Describe the reason why we have to wait.

11. Describe the process of transferring water samples from a Nansen bottle into a water phial.

12. Describe the care to be taken when measuring surface temperature.

13. Explain BT, as simply as possible.

14. What are the Secchi disc and the standard water colour set used for?

15. What kind of apparatus is necessary for plankton sampling?

16. Describe the procedures of vertical and horizontal hauling of the plankton net, as briefly as possible.

17. Explain the advantages of twin net towing.

18. What kind of care should be taken for towing a fish larval net?

19. Explain the Ekman-Mertz current meter, as simply as possible.

20. What is Normal Sea Water used for?

B. Solutions:

1. A field notebook should be firmly bound. If possible, a durable cover should be provided. While on board, the notebook should be clipped to a wooden board so that it will float if it is dropped into the sea accidentally.

2. Recordings in a field notebook should be made with a good quality pencil. When a wrong entry has been made, cross it out with a faint line and record the correct value nearby. Do not obliterate the error.

3. During observation, data could be filled in the columns in due order. The columns help in indicating the next step of the observation, and they also indicate if there are any omissions in the recordings. The use of columns can, therefore, be regarded as a guide during observation.

4. It is important that the data is recorded directly in the field notebook. If the data cannot be recorded directly in the field notebook owing to special

circumstances, the loose paper on which the record has been written should be pasted in the notebook as soon as possible.

5. During observation on board, usually one person observes (e.g. reading temperature, meters, etc.) and another person records. To avoid mishearing between observers, the person who records must repeat loudly the reading and the person who reads must confirm it. These two persons must interchange their role of observer and confirm each other's results. On completion of observation, the entries should be carefully checked for any errors in recordings or any omissions.

6. Wind direction and speed measured on board a moving ship do not show true values, because of the ship's motion relative to the wind. The apparent wind obtained on board a ship is a composite result of the true wind and the wind due to the movement of the ship.

7. The sound beam sent out by the transducer of an echo sounder has a spread in most cases of about 30 degrees from the vertical on both sides. As a result, where there is a steep submarine slope, the echo usually comes from the nearest point on the slope, rather than from the bottom directly beneath the vessel.

8. For the deeper layers below the surface, samples of the ocean water can be taken in Nansen reversing bottles. The cylindrical metal bottle is open at both ends, but has caps that can be closed automatically. When attached to a wire and submerged, water flows freely through the

bottle until it has reached the desired depths. A messenger is dropped down along the wire to a device which closes the top and bottom of the bottle, trapping the water within it. When this happens, the bottle turns over and this movement fixes the mercury column in a thermometer fastened to the outside of the bottle. The reversing thermometer thus records the temperature of the water at the instant when the bottle was turned over.

9. In order that each Nansen bottle reaches the desired depth, more wire should be paid out than the reading of the depth gauge and the length should be the height from the level at which the bottles were attached on board to the sea surface.

10. Usually, we have to wait for five minutes until the wire is heaved up after the completion of lowering the Nansen bottles, in order to equilibrate the mercury column of the reversing thermometer.

11. Just before transferring water samples from a Nansen bottle into a water phial, we have to pour out the water which has been kept in the phial and then rinse the phial two to three times with the water collected. The rubber stopper must be cleaned when the rinsed water is poured out.

12. In order that the temperature of the sampling bucket is approximated to that of the surface water, the process of collecting water and pouring it out should be repeated two to three times. Temperature readings should be made

as quickly as possible after the water has been collected. Before reading, the water sample should be stirred well, with the thermometer still immersed, in a shady place, away from winds.

13. The BT is used for obtaining the vertical profile of temperature; temperature is continuously recorded against the depth on a slide glass. When lowering and heaving up, care should be taken not to bump it against the ship.

14. The Secchi disc and the Standard Water Colour Set are used for the determination of transparency and colour of sea water, respectively. Both observations should be carried out in the day-time.

15. The most widely used apparatus for collecting plankton is the plankton net, essentially a cone made of fine mesh bolting silk or nylon. The front part of the net is attached to a metal ring by which the net is towed through the water and to the terminal end of the net is attached a bucket in which the plankton is allowed to settle. For qualitative sampling, a flow meter is placed in the mouth of the net so that the water passing into the net activates a small propeller attached to a counting mechanism.

16. 1) Vertical hauling: Before lowering, a weight is tied to the rope at the lower end of a plankton net, and inspection should be made to make sure that the bucket is kept closed and the flow meter is set at zero. After the completion of lowering the plankton net down to the

desired depth, a few minutes should be allowed until heaving-up to return it to as vertical a position as possible. Hauling-up speed should be about 1 m/sec. As soon as the net is pulled up onto the deck the reading of the flow-meter should be made.

2) Horizontal towing: The plankton net and weight are connected to a towing rope which is tied at the davit projected from the hull. When the vessel is at a uniform speed of 2 knots, the net is lowered to the sea. Before lowering, the same care with regard to the bucket and the flow meter as in vertical hauling should be taken. The mouth of the net must be adjusted to immerse completely in the surface water. After towing for exactly 10 minutes, the net is pulled up onto the deck and the flow meter is read immediately.

17. To save time, twin net towing is sometimes recommendable for plankton sampling. With this, zooplankton and phytoplankton are collected at the same time.

18. The fish larval net is towed for 10 minutes at about 2 knots at the sea surface. It is desirable to tow the net outside the wake of the ship's bow. The flow meter is used for the same purpose as in plankton sampling.

19. The Ekman-Mertz current meter is the most used Eulerian instrument. This consists of a multi-bladed propeller which is mounted on low friction bearings in a framework having a vane at the rear. The whole instrument is free to rotate on the end of the suspending wire,

and the vane causes it to point into the current. The number of revolutions of the propeller can be read from a set of pointers geared to it. At intervals, while the propeller is turning, small bronze balls are released to fall onto the top of a magnetic compass needle, run down a trough on its upper side, and fall thence into a tray divided into 36 sectors. As the compass and trough remain fixed in the magnetic meridian while the remainder, including the tray, is oriented by the current, the particular sector into which the balls drop gives an indication of the current direction. The propeller can be allowed to rotate or stopped by the impact of messengers.

20. Normal Sea Water is specially prepared sea water whose chlorinity has been determined gravimetrically. Samples of this Normal Sea Water in glass ampoules are used for standardizing the silver nitrate for titration or standardizing the electrical conductivity bridge of a salinometer.