2
The Water Masses of the World Ocean: Some Results of a Fine-Scale Census

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2.1 Introduction

In his original brief monograph, Helland-Hansen (1916) introduced the concept of a water mass as being defined by a temperature-salinity (T–S) curve. He found that over a large area of the eastern North Atlantic a "normal" T–S curve could be drawn. He showed that variations from this curve could be attributed to the intrusion of alien water masses that had originated elsewhere. The use of the T–S diagram has been almost universal in physical oceanography since Helland-Hansen introduced it. It is not only a powerful descriptive tool, but observers at sea routinely plot T–S diagrams and use them as a check on the tightness of their sampling bottles and the correct function of their thermometers.

The term "water mass" has been very loosely used by numerous authors. According to Sverdrup, Johnson, and Fleming (1942), a water mass is defined by a segment of a T–S curve, and a "water type" by a single value of temperature and salinity that usually falls on a T–S curve. Thus a T–S curve is made up of an infinite number of "water types." These definitions will be adhered to in this chapter as far as is possible. Oceanographers have used other methods to describe the ocean, both before and after Helland-Hansen's introduction of the T–S diagram, and these methods will be briefly discussed below, but I will deal primarily with the world water masses as defined by T–S diagrams.

The most important advance in water-mass analysis since Helland-Hansen came with the introduction by Montgomery (1958), Cochrane (1958), and Pollak (1958) of the *volumetric* T–S diagram, in which the volumes of all the world water masses were estimated. The volume of the world ocean, including adjacent seas, is 1369×10^6 km^3. Montgomery, Cochrane, and Pollak were able to divide the individual and world oceans into bivariate classes of temperature and salinity, each of which contained an assigned volume. For example, the most abundant class found by Montgomery (1958) in the world ocean was T = 1.0–1.5°C, S = 34.7–34.8‰; he calculated that this relatively small class contained 121×10^6 km^3, or 9% of the water in the ocean.

Wright and Worthington (1970) produced a volumetric census of the North Atlantic that was a direct descendant of Montgomery's (1958) work. This later census was motivated by the introduction, pioneered by Schleicher and Bradshaw (1956), of the very accurate salinometers based on the measurement of electrical conductivity. The precision of data obtained with these salinometers enabled Wright and Worthington (1970) to divide the North Atlantic into much smaller classes than Montgomery and his colleagues had used: Wright and Worthington's smallest class (below 2°C) was 0.1°C × 0.01‰. Fifty of these classes make up one of

Montgomery's classes (0.5°C × 0.1‰). This fine-scale census had clear advantages over the coarser-scale census that inspired it, and in consequence I undertook a census of the world-ocean water masses using the fine-scale classes that Wright and Worthington (1970) introduced. The greater part of this paper will be devoted to the presentation of the results of this census, with some discussion of the formation of these water masses.

2.2 Methods of Describing the Oceans

The simplest and the most universally used method of describing the oceans has been the preparation of vertical profiles of temperature, salinity, dissolved oxygen, or some other variables, constructed from oceanographic sections made across an ocean, or part of an ocean, from a ship or a number of ships. Ocean-wide temperature profiles have been drawn by oceanographers since Thomson's (1877) treatment of the *Challenger* sections, but the standard of excellence for this kind of presentation was set by Wüst and Defant (1936) in their atlas of the temperature, salinity, and density profiles from the Atlantic *Meteor* expedition of 1925–1927 and by Wattenberg (1939), who prepared the oxygen profiles. These vertical profiles were drawn in color, with detailed bottom topography provided. The atlas by Wüst and Defant (1936) provided the model for Fuglister's (1960) atlas of vertical profiles of temperature and salinity from the transatlantic sections made by various ships and observers during the International Geophysical Year. Later, Worthington and Wright (1970) drew similar profiles, for sections made by the *Erika Dan* in the northern North Atlantic in 1962. They also included dissolved-oxygen profiles modeled on those of Wattenberg, which Fuglister had been unable to do because of the poor quality of oxygen analyses made from Woods Hole ships during the International Geophysical Year.

Probably the finest example in this form is that of the vertical profiles by Stommel, Stroup, Reid, and Warren (1973) for the transpacific sections at 28°S and 43°S from *Eltanin* in 1967. These profiles are shown in six color plates; the variables are temperature, salinity, oxygen, phosphate, nitrate, and silicate. The station and sample-bottle spacing for these sections were carefully planned so as not to miss any important baroclinic gradient or variation in nutrient concentration.

Composite vertical profiles are often drawn from data provided by a number of ships from different years or even different decades. Such sections are, of course, less useful for dynamical studies, but sometimes provide an excellent description of the water. A fine example is that of Wüst's much cited north-south temperature, salinity, and oxygen profiles in the Atlantic (Wüst, 1935, plate XXIII). Reid (1965) used the same method to construct zonal and meridional profiles of temperature, salinity, oxygen, and phosphate across the Pacific.

Helland-Hansen and Nansen (1926) drew vertical profiles of temperature and salinity superimposed on each other in their work on the eastern North Atlantic. This method has been followed by others, notably Tait (1957). I find such profiles difficult to read, but that may be idiosyncratic. Helland-Hansen and Nansen (1926) also introduced vertical profiles of the anomaly of salinity—in this, they were followed by Iselin (1936). My own preference (Worthington, 1976, figures 18, 19, and 20) is to draw vertical salinity anomaly charts, preferably in color, with selected isotherms included. I feel that this method illustrates most clearly the vertical juxtaposition of different water masses.

As Wüst (1935) remarked, horizontal charts of variables are of limited use in water-mass analysis because the various layers rise and sink above and below a fixed level. Nevertheless, the best early example of such horizontal charts is their own atlas (Wüst and Defant, 1936). Such charts have other uses, however, and are of particular value in satisfying the queries of laymen about the ocean.

The use of the "core layer" ("*Kernschicht*") method to describe ocean waters is almost wholly due to Wüst (1935), his students, and, to a lesser extent, Defant (1936). In his classic description of the Atlantic, Wüst (1935) identified seven such core layers, characterized by maxima or minima of oxygen, salinity, or temperature. While the study of the spreading of these layers is of unquestionable value in descriptive oceanography, they have a drawback, pointed out by Montgomery (1938a), in that these layers are few in number, whereas the number of potential-density surfaces (which Montgomery prefers to core layers) is infinite. A further drawback, noted by Worthington (1976), is that core layers are often uncritically assumed to be the main paths of ocean circulation. He was struck by the paradox that most observers who had made hydrographic stations combined with direct current measurements in the northern North Atlantic (Steele, Barrett, and Worthington, 1962; Worthington and Volkmann, 1965; Swallow and Worthington, 1969) had been constrained by these measurements to place a level of zero motion in the salinity-minimum core layer of the Labrador Sea Water, which can be identified as Wüst's (1935) Middle North Atlantic Deep Water. The reasons for this seemed clear; the volume of Labrador Sea Water in the North Atlantic is about 6×10^6 km^3 (Wright and Worthington, 1970) and the formation rate was thought to be between 2 and 4×10^6 m^3 s^{-1}. This gives a mean residence time for Labrador Sea Water of between 50 and 100 years. Accordingly, a particle of Labrador Sea Water should move from its formation area to its geographical limit between Iceland and Scotland at a speed of only a fraction of a centimeter per second.

Montgomery (1938a) made the first really effective use of the examination of variable properties on surfaces of constant potential density in the ocean. He credits Shaw (1930) with the development of this method in the atmosphere. It was used by Montgomery (and others who followed) mainly in the study of ocean circulation; the *depth* of a potential-density surface can be used as a diagnostic tool for locating geostrophic currents since rapid changes in the depth of these surfaces occur where such currents are found. It has also been a useful qualitative tool for describing water masses, since waters of different origin on the same potential-density surface usually contain widely different concentrations of variables, such as salinity, dissolved oxygen, and nutrients. Montgomery's (1938a) study of the tropical North Atlantic illustrated (among other things) the strong contrast in most upper layers between the low-salinity waters of the South Atlantic and the high-salinity waters of the North Atlantic.

Taft (1963) used this method to describe the shallower circumpolar water masses (and their circulation), and Callahan (1972) the deeper circumpolar water masses. Reid (1965) prepared charts of salinity, oxygen, and phosphate on two potential-density surfaces in the upper Pacific. These charts provide the best qualitative description of the thermocline waters of the Pacific, and the accompanying charts of the depths and acceleration potential at these surfaces give an equally broad qualitative description of the circulation for the upper layers of that ocean.

Perhaps the finest use of this method was Tsuchiya's (1968) description of the upper Equatorial Pacific. He displayed (in color) the depth, acceleration potential, potential temperature, salinity, and dissolved-oxygen concentration on four potential-density surfaces. The effect of such features as the Pacific Equatorial Undercurrent on the water-mass distribution is seen very clearly (this current being characterized by high salinity and high oxygen). The spreading of the oxygen minimum on both sides of the equator is also shown. One could wish (in hindsight) that Tsuchiya had extended his work to greater depths in the light of the recent discovery (C. Eriksen, personal communication) of deep equatorial jet currents in the Pacific.

In his monumental atlas of the Indian Ocean, Wyrtki (1971) used *all* of the techniques listed (and more) to delineate the water masses of that ocean, including volumetric T–S diagrams of the kind introduced by Montgomery (1958), Cochrane (1958), and Pollak (1958). This atlas represents by far the most complete description we have of any ocean. It is marred by only one minor flaw; because of the international character of the atlas, Wyrtki (1971) included slightly inferior data from some ships that participated in the Indian Ocean expedition. This, however, does not present a problem to professional oceanographers, who can usually recognize and reject spurious data.

Readers who are interested in descriptive oceanography in general will find the atlas compendium of Stommel and Fieux (1978) an invaluable guide.

2.3 The World Water Masses As They Exist in the Second Half of This Century

The use of the conductivity properties of sea water to measure salinity was introduced in 1922 by Wenner (Wenner, Smith, and Soule, 1930; see chapter 14). The Wenner instrument was always calibrated by chemical titration using the Knudsen method, however, so that its full precision was never realized. In practical terms, the ocean-wide use of the conductivity method dates from 1954, when Schleicher and Bradshaw (1956) introduced their salinometer. The availability of this instrument was in large part responsible for the recommendation by Iselin in 1954 to reexamine the physical structure of the Atlantic Ocean using deep sections modeled on those of Wüst and Defant (1936). Subsequently, other oceanographic laboratories followed the lead of Schleicher and Bradshaw (1956), and a body of high-quality physical data began to appear on the world ocean; in 1973, this work on an ocean-wide census was undertaken at Woods Hole.

The coverage chart for this world-ocean water-mass census is shown in figure 2.1; it clearly requires some explanation. As in the North Atlantic census of Wright and Worthington (1970), the basic area unit used was 5° of latitude by 5° of longitude. For convenience this unit will be called a 5°-square.

If no high-quality, deep hydrographic station can be found in a 5°-square, that square is shown in black. There were certain standards that had to be met for a station to be considered of high quality. The most important of these was that salinity should have been recorded to three decimal places and that such recording should have been justified. A great deal of tiresome work went into deciding whether each station met this standard. All hydrographic stations in which salinity was recorded to three places were obtained from the National Oceanographic Data Center. Potential temperature–salinity diagrams were drawn for these deep stations, and if the scatter of points on any station in the deep water was more than about ±0.01‰, the station clearly did not qualify. Experience has taught us that *all* the deep water masses of the world have a very tight potential temperature–salinity correlation and that variations from a mean curve are due to genuine geographic differences in the water masses. (Hereafter, all temperatures referred to in the text will be *potential* temperatures unless *in situ* temperature is specified. The symbol θ, for potential temperature, is

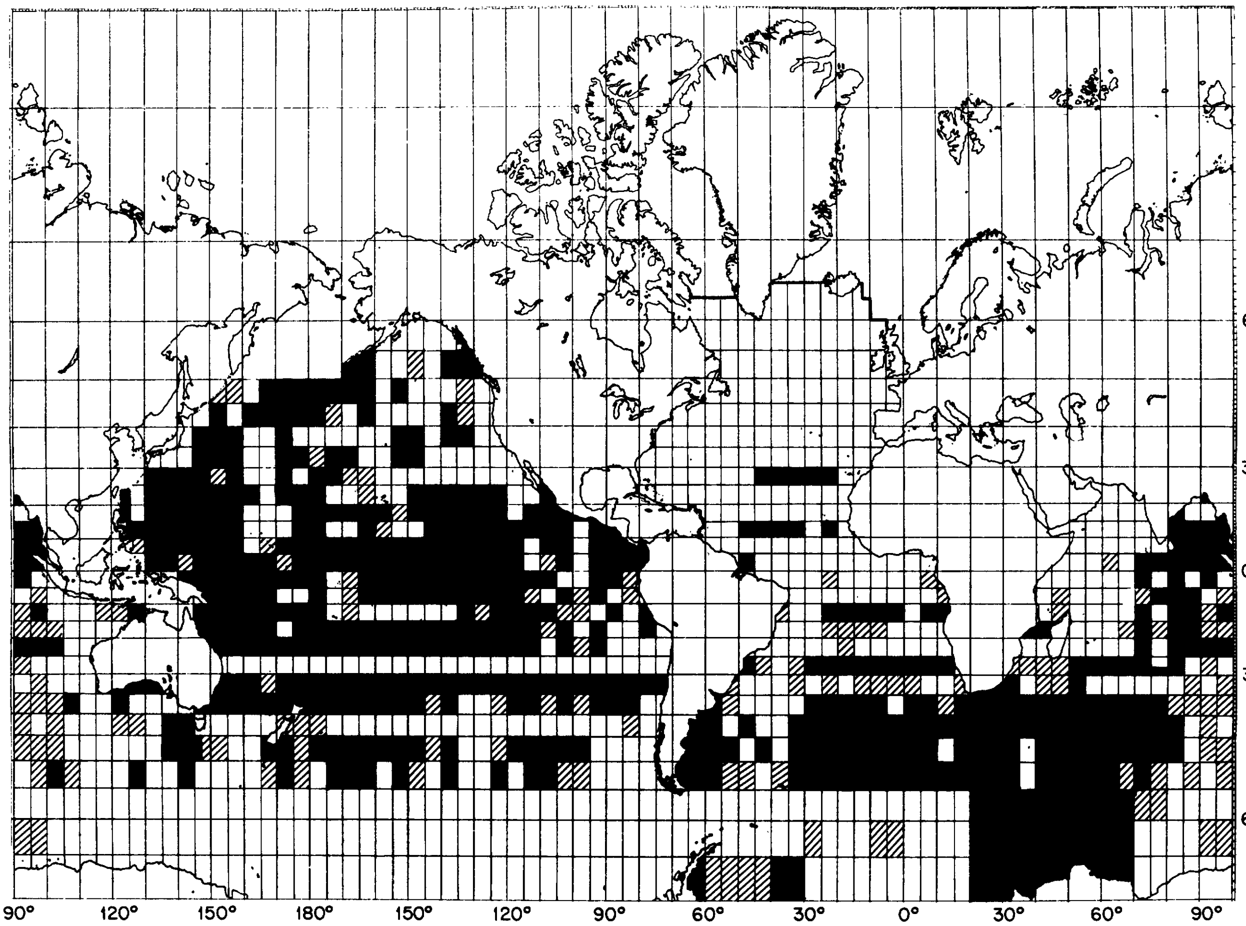

Figure 2.1 Coverage chart showing where high-quality deep stations are available (up to June 1977) in the world ocean. Unshaded 5°-squares contain at least one high-quality deep station. Crosshatched 5°-squares contain at least one high-quality station but in a shallow area of the square. Black 5°-squares contain no high-quality deep stations.

used in tables in case these should be reproduced elsewhere.) Occasionally, it appeared that a single ship, on a single cruise, had measured salinity incorrectly. This was determined by comparing the values obtained by this ship with those obtained by other ships where the data were plentiful. Usually, these systematic errors were of the order of 0.01‰. This was the most vexing determination in the census because the ship in question often traveled into virgin territory as well, but no empirical corrections were made to adjust the data from that ship to those from its fellow ships. Such data were simply omitted from the census.

Another, easier standard to be met was that the bottle spacing be sufficiently close that an unambiguous T-S curve could be drawn. Again, comparison with other stations in the same area was used to determine, for example, that no maxima or minima had been missed. The final standard involved the meaning of the word "deep." Generally, if a station extended to 90% of the water depth, it could be used in the census by extrapolation, but there are areas in the ocean where the temperature and salinity change rapidly near the bottom and extrapolation was not justified. Stations in such areas were also omitted from the census.

Accordingly, for a 5°-square to be unshaded in this coverage chart (figure 2.1), the square must contain at least one station of high quality that extended close enough to the bottom so that virtually no fictitious water could be assigned to it. Another qualification was that this station should be at, or close to, the greatest ocean depth in that 5°-square. If a 5°-square contained water somewhere that was, say, 5000 m deep, and the only station in that square did reach the bottom but only to some lesser depth (such as 3000 m) because it was taken over a seamount or on the continental slope, the 5°-square was not used in the census. Such 5°-squares are designated in figure 2.1 as crosshatched rather than black, to indicate that one or more high-quality stations exist in that square, but that they do not permit classification of all the water in that square.

It is possible that some fictitious water may exist in the census owing to systematic errors in thermometer calibration, but such volumes of water are thought to be small. Certainly no evidence for such errors was detected.

The census includes all high-quality data that were available from the National Oceanographic Data Center before June 1977. The North Atlantic census of Wright and Worthington (1970) was included unchanged. It can be seen (figure 2.1) that the North Atlantic is by far the best covered of the oceans, but as J. L. Reid (personal communication) has pointed out to me, nutrient data from the North Atlantic are sadly lacking.

The coverage chart (figure 2.1) is disappointing, coming as it does from the second half of a decade supposedly devoted to ocean exploration. In fact, by far the greater number of stations used in this census was made before this decade began. It is additionally disappointing that in spite of the large number of ocean-wide cruises made by ships of the Soviet Union before and during this decade, not a single station of theirs could be used in this census because the precision of their salinity data was not sufficient.

Certain features of this chart are worth mentioning. The North Atlantic was well covered, as we have seen, by purely physical data. Virtually all of the North Atlantic stations were made during the years 1954–1962. The excellent coverage of the Southern Ocean is almost entirely due to the work sponsored by the United States Antarctic Research Program aboard the U.S.N.S. *Eltanin*, under the leadership of Arnold Gordon. The lack of coverage in the southwest Indian Ocean and the southeast Atlantic Ocean is the result of a decision, made for financial reasons, to suspend temporarily the circumnavigation of Antarctica, combined with the cutoff date (June 1977) used for this census. The excellent coverage of the northwest Indian Ocean is due to the many participants in the International Indian Ocean Expedition whose interests lay chiefly in the glamorous monsoonal regions. Coverage in other parts of the Indian Ocean was poor except for the efforts of the Australians in the eastern part. In the South Pacific, the sections made by Stommel et al. (1973) at 28°S and 43°S are the most outstanding feature. In the North Pacific, one might deduce that there have been oceanographers working out of California and Japan, but deep coverage is generally poor.

None of these strictures applies to the upper layers of the oceans, where data are plentiful in nearly all oceans, and high precision of salinity analysis is, for the most part, not necessary to describe their broad features. However, only *precise* data have been used in this census at all depths. There are high-quality data in a number of the inland seas that connect to these oceans, but since not *all* these seas have been covered, it was decided to include none of them and deal only with the open ocean.

The volume of the oceans, excluding the adjacent seas, was found to be 1320×10^6 km^3. This figure was calculated from the following: the sounding (corrected for the speed of sound) at each deep station for the 1°-square in which that station fell; in 1°-squares where no station fell (the vast majority), the tables of Menard and Smith (1966). These tables give the mean elevation (above or below sea level) for each 1°-square from the equator to lat. 50°, for each area of 1° of latitude by 2° of longitude from lat. 50° to lat. 70°, and for each area of 1° of latitude by 5° of longitude above lat. 70°. These tables are, of course, useless near islands and land masses where a given 1°-square may contain a considerable volume of water while its *mean* elevation is above sea level.

A rough description of how this 1320×10^6 km^3 of water is distributed is shown in figure 2.2. This is a computer-simulated three-dimensional sketch of the world water masses. The apparent elevation in this diagram is proportional to the abundance of water that exists in the ocean in each class 0.1°C × 0.01‰. In the warmer parts of the ocean, where coarser classes were used, each class was prorated on the basis of this smallest class, as Wright and Worthington (1970) have described. For example, the classes in the temperature range 3–4°C have dimensions 0.2°C × 0.02‰. If such a class contained 4800×10^3 km^3, it would be prorated at 1200×10^3 km^3. In all important respects, the methods of Wright and Worthington (1970) have been followed in this work, except that a computer program has done most of the drudgery involved in separating the water at each station into the appropriate classes.

This diagram must be viewed with a certain amount of skepticism because the data on which it was based are so sparse. For example (by the standard shown in figure 2.1), only 28.7% of the North Pacific has been surveyed. For purposes of this diagram (figure 2.2), and the subsequent figures and tables, it has been assumed that the remaining 71.3% of the North Pacific is divided into the same *T*-*S* classes. The class that contains the largest volume of water, shown by the tallest peak in figure 2.2, is found in the North Pacific. This class is defined by $T = 1.1$–1.2°C, $S = 34.68$–34.69‰. According to this census, there are 26×10^6 km^3 of water in this class, but only 7.3×10^6 km^3 were actually observed in the white areas of the North Pacific (figure 2.1) in which reliable data were available.

Nevertheless, I feel that an image of the real ocean would not differ too greatly from that shown in figure 2.2. The most serious gap in the census is in the southeastern Atlantic and the southwestern Indian Ocean, where the transition between Atlantic and Indian Ocean water masses has not been properly observed. This diagram (figure 2.2) makes graphically clear what was already numerically clear from the work of Montgomery (1958), Cochrane (1958), and Pollak (1958), namely, that nearly all the water in the oceans is cold. The most abundant fine-scale class, occupying the bottom of the North Pacific, contains more water (26 ×

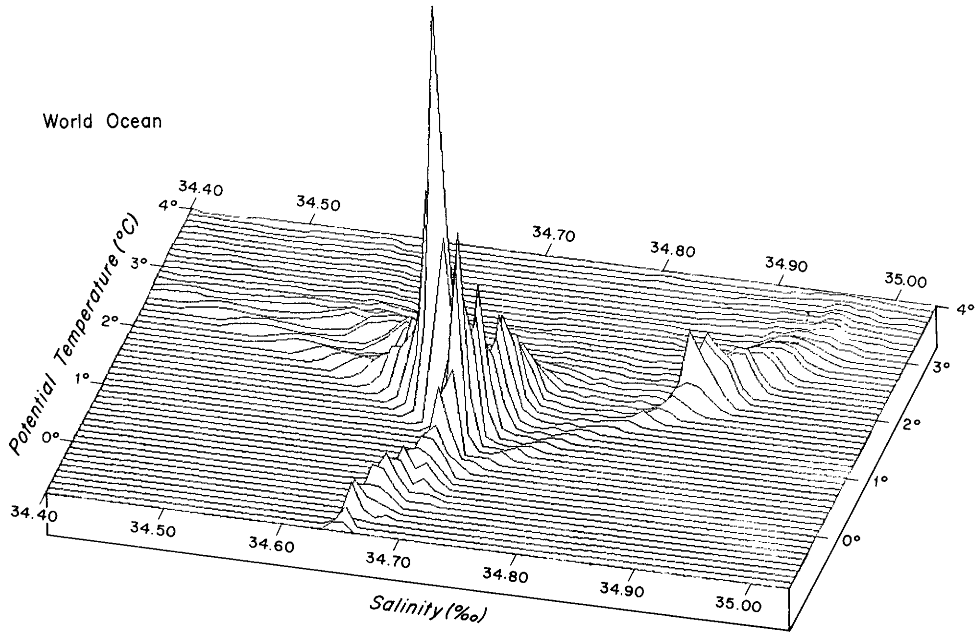

Figure 2.2 Simulated three-dimensional *T-S* diagram of the water masses of the world ocean. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to 26.0 × 10⁶ km³ per bivariate class 0.1°C × 0.01‰.

10^6 km³) than *all* the water in the world ocean warmer than 19°C (21.9 × 10^6 km³) and more than *all* the continental ice caps (23 × 10^6 km³). It is represented by the highest peak in figure 2.2. The coldest water (<0°C) is confined to the Southern Ocean (which has been defined as south of 55°S) except for a small volume in the South Atlantic that has penetrated north of 55°S. The Atlantic is the most eccentric of the oceans, standing aloof on the saline side of this diagram, connected to the Southern Ocean only by a narrow umbilicus that contains little water. The Indian and Pacific Oceans are much more similar to each other than to the Atlantic; in order to show this, the computer has drawn figures 2.3, 2.4, and 2.5 for the Pacific, Indian, and Atlantic Oceans, respectively. By referring to these figures, the reader should be able to identify, by ocean, the gross features that appear in the world-ocean diagram (figure 2.2).

Such well-known water masses as Antarctic Intermediate Water and Mediterranean Outflow Water are barely perceptible in these figures. These mid-depth water masses have little volume relative to the deep water, and moreover, their *T-S* characteristics are diverse, so that their volumes are spread over a wide area of figure 2.2 with little elevation.

For purposes of this census, the oceans have been subdivided: North Pacific, South Pacific, and Southern Ocean (Pacific); Indian and Southern Ocean (Indian); North Atlantic, South Atlantic and Southern Ocean (Atlantic). The Southern Ocean has also been totaled separately.

The volumes of all these subdivisions and the totals for each ocean and for the world ocean are listed in table 2.1, with the mean potential temperature and mean salinity of each. For reasons that will become clear when these results are compared with those of Montgomery, Cochrane, and Pollak, the accuracy of these means depends on the percentage of the ocean that has been surveyed. It has been assumed that all the water in the *unsurveyed* areas of each ocean listed in table 2.1 is divided into the same *T-S* classes as that in the surveyed areas and in the same proportion. This assumption has the effect of assigning artificially large volumes of water to classes that are found where coverage is good. In particular, the reader should be skeptical about my means for the Pacific, which has been less than one-third surveyed.

Mention should also be made of the two regions that I have designated as 100% surveyed. In the case of the Southern Ocean (Pacific) this designation is correct; the *Eltanin* stations have missed almost nothing. In the North Atlantic (figure 2.1), there are 11 5°-squares that have no reliable data, but in their census Wright and Worthington (1970) assigned these 5°-squares to neighboring stations in order to bring their total to 100% (a procedure not generally followed in this census). I have adopted the totals of Wright and Worthington (1970) uncritically.

In order to compare the new results with those of Montgomery (1958), Cochrane (1958), and Pollak (1958), it was necessary to remove the inland seas from the totals given by these authors and reaverage without them. The results of this comparison are shown in table 2.2, and the new means for the world ocean are remarkably close to the old ones, differing by only 0.03°C in temperature and 0.01‰ in salinity. Closer

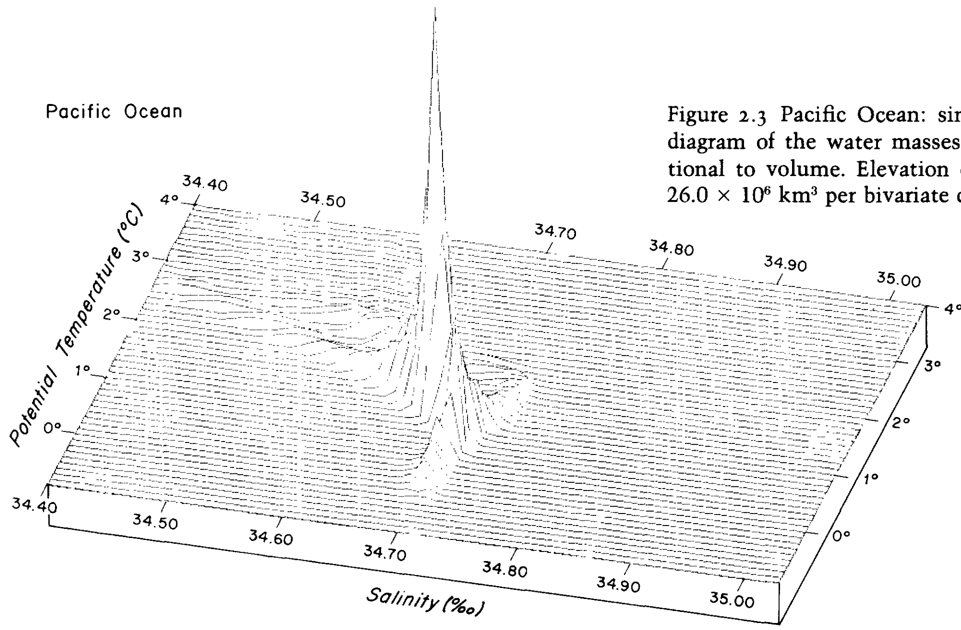

Figure 2.3 Pacific Ocean: simulated three-dimensional *T-S* diagram of the water masses. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to 26.0×10^6 km³ per bivariate class 0.1°C × 0.01‰.

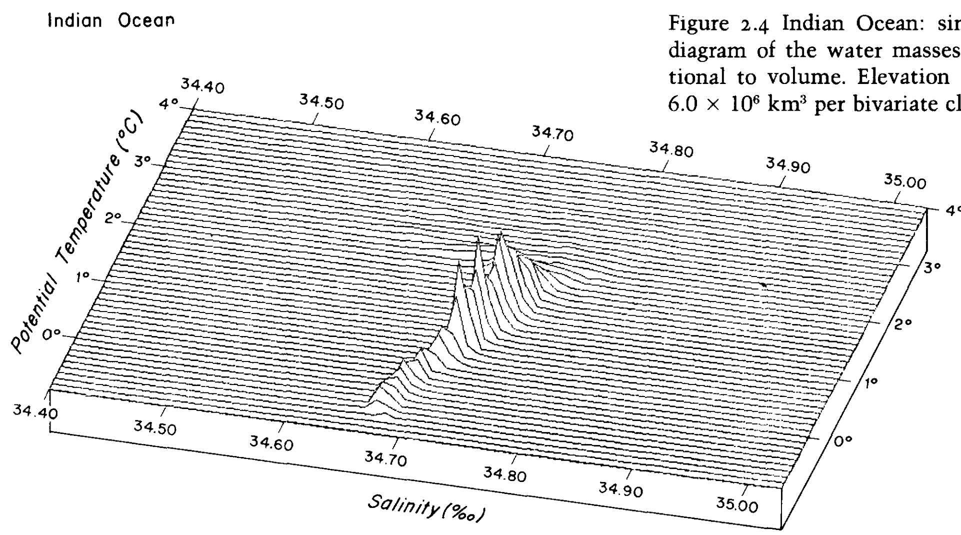

Figure 2.4 Indian Ocean: simulated three-dimensional *T-S* diagram of the water masses. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to 6.0×10^6 km³ per bivariate class 0.1°C × 0.01‰.

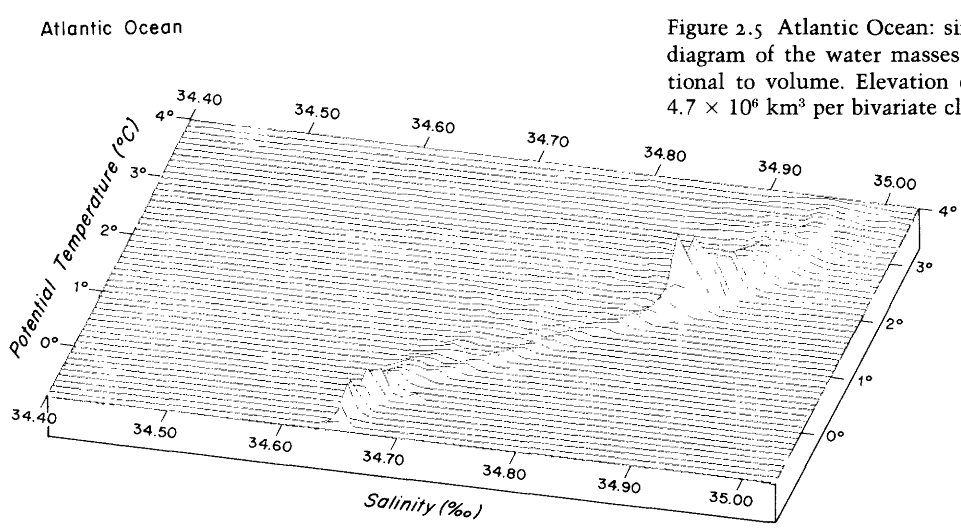

Figure 2.5 Atlantic Ocean: simulated three-dimensional *T-S* diagram of the water masses. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to 4.7×10^6 km³ per bivariate class 0.1°C × 0.01‰.

Table 2.1 Volumes ($km^3 \times 10^3$) of the Oceans, Excluding Adjacent Seas

	Ocean volume	Volume surveyed	Percentage surveyed	Mean θ	Mean S (‰)
North Pacific	332,222	95,469	28.7	3.13	34.57
South Pacific	323,951	98,458	30.4	3.50	34.63
Southern Ocean (Pacific)	55,413	55,413	100.0	1.07	34.64
Pacific Ocean total	711,586	249,340	35.0	3.14	34.60
Indian	245,974	108,585	44.1	4.36	34.79
Southern Ocean (Indian)	36,730	17,163	46.7	0.72	34.66
Indian Ocean total	282,704	125,748	44.5	3.88	34.78
North Atlantic	137,222	137,222	100.0	5.08	35.09
South Atlantic	158,238	70,397	44.5	3.81	34.84
Southern Ocean (Atlantic)	30,738	24,980	81.3	0.04	34.64
Atlantic Ocean total	326,198	232,599	71.3	3.99	34.92
(Southern Ocean total)	122,881	97,556	79.4	0.71	34.65
World Ocean total	1,320,488	607,687	46.0	3.51	34.72

Table 2.2 Comparative Volumes and Means

	This census			Montgomery (1958), Cochrane (1958), and Pollak (1958), modified to exclude adjacent seas		
	Volume ($km^3 \times 10^6$)	Mean (°C)	Mean S (‰)	Volume ($km^3 \times 10^6$)	Mean θ (°C)	Mean S (‰)
North Pacific	332.2	3.13	34.57	346.1	3.39	34.59
South Pacific	379.4	3.14	34.63	376.5	3.36	34.64
Pacific	711.6	3.14	34.60	722.6	3.37	34.62
Indian	282.7	3.88	34.78	291.6	3.70	34.75
Atlantic	326.2	3.99	34.92	321.8	3.76	34.87
World Ocean	1320.5	3.51	34.72	1336.0	3.54	34.71

examination of the table will show that there is no cause for celebration of this similarity—in individual oceans, the new results differ by much larger amounts, particularly in temperature. The new-census mean temperature for the Pacific is lower than the old mean, and the new mean is higher for both the Atlantic and Indian Oceans.

Cochrane (table 2.2) has provided separate averages for the North and South Pacific, as I have, and it is instructive to examine the reasons for the discrepancy in the North Pacific (3.13°C, contrasted with 3.39°C) in some detail. The first step was to see whether Cochrane's (relatively) coarse intervals were responsible for the disagreement; it was reasoned that, in an ocean where the vertical temperature gradient generally decreases with depth, larger volumes of water would be found toward the colder side of each coarse temperature interval, resulting in artificially low averages. Accordingly, the *new-census* mean was recalculated, using Cochrane's coarse intervals. This resulted in an artificial increase in the *new* mean from 3.13°C to 3.15°C, a change in the expected direction but not nearly sufficient to account for the discrepancy. This step does suggest, however, that Montgomery, Cochrane, and Pollak may all have overestimated the mean temperatures of the oceans by a small amount due to the coarseness of their scale.

The real reason for the discrepancy can be seen in table 2.3, in which the volumes and mean temperatures found by Cochrane in four temperature ranges are compared with those of this census.

It can be seen that Cochrane's total volume is slightly larger than mine. This reflects the difference in Cochrane's depth estimates [which agree closely with those of Kossina (1921)] and those of Menard and Smith (1966). The table shows that there is little difference in the mean temperature for each of these layers, although the new census does show a higher mean in the 10–20°C layer. The main difference is that this census has counted (relatively) more cold water (<4°C) and much less warm water (>20°C). This is presumably

Table 2.3 Cochrane's North Pacific Volumes (km³ × 10^6) Compared with Those of This Census in Four Layers, and the Ratio of These Volumes, with Mean Potential Temperature for Each Layer

	Total volume	<4°C	4–10°C	10–20°C	20–30°C
(A) Cochrane	346.1	274.2	48.9	15.6	7.4
(B) This census	332.2	271.1	41.8	15.0	4.3
(A)/(B)	1.04	1.01	1.17	1.04	1.72
	Mean T	Mean θ <4°	Mean θ 4–10°C	Mean θ 10–20°C	Mean θ 20–30°C
Cochrane	3.39	1.77	6.05	13.64	24.55
This census	3.15	1.76	6.08	13.93	24.48

due to the artificially small area of the North Pacific assigned to stations at *low* latitudes in this census (figure 2.1) relative to that of Cochrane (1958, his figure 1).

The conclusion to be drawn is that Cochrane's (1958) mean temperature for the North Pacific is closer to the truth than the mean obtained by this census, although it is probably very slightly too warm due to the coarse temperature interval used. By inference, the new means in other poorly surveyed oceans are also in doubt. This is regrettable since the whole object of this census was to describe, accurately, the temperature and salinity of the world ocean as they exist in the second half of this century in case this description should be useful to future oceanographers (if any) whose interests might lie in the climatic mean ocean and its changes. Nevertheless, I think I can show that this census has been worthwhile, especially in the deep ocean, by virtue of its finer scale.

Montgomery (1958) combined Cochrane's (Pacific Ocean) and Pollak's (Indian Ocean) totals in each bivariate class with his own Atlantic totals to provide a volumetric T–S diagram for the world ocean. In the deep ocean, he lists three bivariate classes (0.5°C × 0.1‰) that contain more than 100 × 10^6 km³. These classes are listed in table 2.4 with the comparative values obtained by this census (given in italics below Montgomery's values).

The big difference here is that the new census has 43.3 × 10^6 km³ more water in the class 1.0–1.5°C, 34.6–34.7‰, and 34.7 × 10^6 km³ less in the class 1.0–1.5°C, 34.7–34.8‰. This, I believe, is almost entirely due to a disagreement between this census and Cochrane's about how much water there is in the North Pacific with a salinity greater than 34.7‰. Of Montgomery's 121.2 × 10^6 km³ in the class 1.0–1.5°C, 34.7–34.8‰ (table 2.4), the North Pacific contributes 44.6 × 10^6 km³, according to Cochrane, while my figures show only 4.6 × 10^6 km³. In this case, I believe, my numbers are more correct than Cochrane's because his data are all from chemical titration. Nobody has claimed an accuracy better than ±0.02‰ for salinity analyses made at sea, and experience has taught me that few of the old titrators could justifiably claim an accuracy of better than ±0.03‰. It is easy to see how even a quantity as large as 45 × 10^6 km³ in the North Pacific could be assigned to the more saline class since (as Cochrane himself has remarked) this water lies close to the borderline at 34.7‰.

My estimate of the distribution of water in the class 1.0–1.5°C, 34.6–34.7‰ is listed in table 2.5.

This table, I believe, justifies the fine scale used in this census because it shows that most of the water is concentrated in a few fine-scale classes on the salt-cold side of Montgomery's relatively coarse-scale class (0.5°C × 0.1‰). There are *small* amounts of water on

Table 2.4 Montgomery's (1958) Volumes (km³ × 10⁶) in Three Principal Bivariate Classes of The World Ocean (Volumes from This Census in Italics)

	34.6‰–34.7‰	34.7‰–34.8‰
1.5–2.0°C	112.1 *115.6*	
1.0–1.5°C	115.3 *158.6*	121.2 *86.5*

the fresh-cold side of this table, and two fine-scale classes contain no water whatsoever. The high concentrations of water that are numbered 1, 2, 4, 5, 6, and 9 fall on the *T–S* curve for the deep Pacific Ocean. These numbers represent their rank by volume in the world ocean. The class 1.1–1.2°C, 34.68–34.69‰, 26.0 × 10^6 km³, is the most abundant class; it is represented, as we have seen, by the peak in figures 2.2 and 2.3. One hundred percent of this water (to the nearest percentage point) is found in the North Pacific, as is also 100% of the next most abundant class (1.2–1.3°C, 34.67–34.68‰).

The third-ranked class, which does not appear in table 2.4, is 0.7–0.8°C, 34.71–34.72‰. This is a circumpolar class, common to the South Pacific, 48%; the Southern Ocean (Pacific), 9%; the Indian Ocean, 35%; the Southern Ocean (Indian), 5%; the South Atlantic, 2%; and the Southern Ocean (Atlantic), 1%. This cosmopolitan water type is found in all the oceans except the North Pacific and the North Atlantic. The most abundant classes, those that, together, contain 50% of the world ocean (according to this census), all fall in the numbered squares (and rectangles) in figure 2.6. The numbers, 1–186, are their rank by abundance. The least of these, number 186, contains just under 1 × 10^6 km³. All of them fall below 3°C. All these classes are also listed by rank in the appendix (23 pages at the end of this chapter), with their volumes and the percentages of these volumes that are found in each of the subdivisions of this census. Thus the reader can, for example, identify class number 80 in figure 2.6, turn to the appendix and find that it contains 2,449 × 10^3 km³; he will see that it is a circumpolar class since it is found throughout the Southern Ocean (16% in the Pacific sector, 44% in the Indian Ocean sector, and 15% in the Atlantic sector), and that it is also found north of 55°S in the Indian Ocean (17%) and the South Atlantic (15%).

The classes that contain 50% of the volume of the world ocean (figure 2.6) are divided into two groups: a larger, Y-shaped group composed of the large-volume classes of the Southern Ocean, the Pacific and Indian Oceans (with some South Atlantic water present); and a smaller, lozenge-shaped group, somewhat warmer and about 0.2‰ more saline, that is exclusively Atlantic. A discussion of these two groups follows, but the reader is asked to bear in mind that the world-wide distribution of high-quality deep hydrographic data (figure 2.1) is far from satisfactory.

The deep North Pacific contains no water colder than 0.8°C, and so it is absent from the base of the Y-shape. It is the freshest of all the deep oceans, and we shall see that this relative freshness extends well up into the thermocline. It is also the most exclusive of the oceans—15 of its large-volume classes, which contain a total of 88.9 × 10^6 km³, are shared with no other ocean. In many more, relatively fresh, classes, the contribution from other oceans is trivial. These classes occupy the fresher side of the left-hand arm of the Y-shape (figure 2.6). In the middle of this left-hand arm it shares a number of classes (e.g., 4, 5, 9, 15, and 40) with the South Pacific, but shares virtually no deep water with any other ocean.

The coldest class that contains South Pacific water is class 84; 0.2–0.3°C, 34.70–34.71‰. This class is cosmopolitan, being found in the Southern Ocean (Pacific and Indian), the Indian Ocean, and in the South Atlantic. It is lacking in the Southern Ocean (Atlantic). Considerable amounts of South Pacific water can be found in a number of circumpolar classes (3, 24, 32, 70, 89, and 94) that lie between 0.3 and 0.8°C and between

Table 2.5 Volumes (km³ × 10⁶) in the Class 1.0–1.5°C, 34.6–34.7‰ According to This Census[a]

Potential temperature (°C)	Salinity (‰) 34.60–34.61	34.61–34.62	34.62–34.63	34.63–34.64	34.64–34.65	34.65–34.66	34.66–34.67	34.67–34.68	34.68–34.69	34.69–34.70
1.5–1.4			0.1	0.7	3.1	4.1	5.3	7.0	4.8	5.3
1.4–1.3					0.5	3.0	6.1	9.8[9]	5.5	3.8
1.3–1.2						0.5	3.7	14.0[2]	13.5[4]	4.0
1.2–1.1						0.1	0.5	6.0	26.0[1]	12.9[5]
1.1–1.0								0.2	5.8	12.0[6]

a. Classes containing less than 0.05 × 10⁶ km³ have been omitted. Superscript numbers (1, 2, 4, 5, 6, and 9) indicate rank, by volume, in the world ocean.

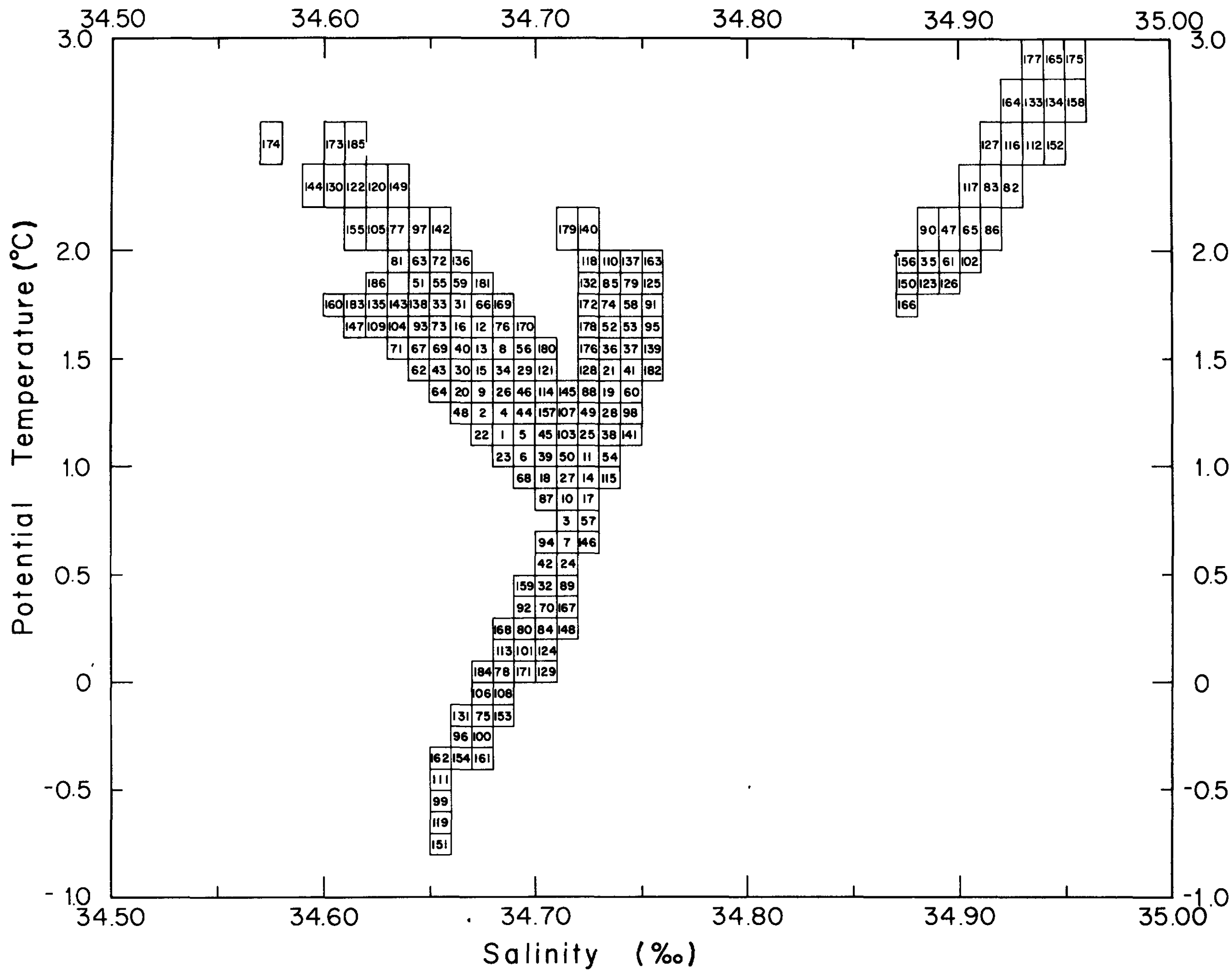

Figure 2.6 Catalog of the 186 most abundant fine-scale bivariate classes in the world ocean. These classes contain 50% of the world-ocean volume. The number in each bivariate class represents its ranking according to volume.

34.70 and 34.72‰. These circumpolar classes comprise the warmer portions of the base of the Y-shape (figure 2.6). The bulk of South Pacific water is found on the saline side of the left-hand arm of the Y-shape; the fresher side of this arm, as we have seen, is almost wholly North Pacific water. Large amounts of more saline water in the South Pacific are found on the fresher side of the right-hand arm of the Y-shape (e.g., classes 140, 118, 132, 172, 178, 76, and 128). These classes are all shared with the Indian Ocean. They represent, typically, the saline water found by Stommel *et al.* (1973) in the western South Pacific in the *Scorpio* sections at 28°S and 43°S. This water has entered the western South Pacific from the Indian Ocean. Traces of this more saline water are present in classes 137, 79, 58, 53, 37, 41, 60, 98, and 141. These classes lie between 1.0 and 2.0°C and between 34.74 and 34.75‰. (It is also of course found in the intermediate salinity range, 34.73-34.74‰; e.g., classes 110, 85, and 79.)

By far the greater part of the right-hand arm of the Y-shape is Indian Ocean water, although traces of South Atlantic water are found there, particularly on the saline side of the arm (e.g., classes 139, 182, 60, 98, 141, 54, and 115). Indian Ocean water (as can also be seen from figure 2.4) is represented by a nearly straight line from 2.0°C, 34.74‰ to −0.3-0.2°C, 34.66-34.68‰ (classes 154 and 161). The colder Indian Ocean classes in the base of the Y-shape are shared with the Southern Ocean classes from all the sectors.

The Atlantic Ocean *T-S* curve extends from about 3.0°C, 34.95‰ to class 166, 1.7-1.8°C, 34.87-34.88‰. All these classes (figure 2.6) are common to the North and South Atlantic; on the fresh side of the curve (e.g., classes 156, 90, 117, 127, 164, and 177), South Atlantic water predominates, and on the saline side, the North Atlantic water predominates. There are no large-volume classes that connect the Atlantic Ocean to the circumpolar oceans, but we shall see later that there is a thin group of relatively small-volume classes that does make this connection.

The coldest classes in the Southern Ocean (99, 119, and 151) belong exclusively to the Atlantic sector of that ocean, being found in the Weddell Sea. Class 110 contains a trace of South Atlantic water (north of 55°S). Class 162 (−0.4 to −0.3°C, 34.65 to 34.66‰) is exclusively in the Atlantic sector, but the two classes found on the saline side of this class (154 and 161) contain water from the Indian Ocean sector of the Southern Ocean and the Indian Ocean itself. Surprisingly, in the temperature range −0.3 to +0.3°C, the classes that are predominantly from the Atlantic sector of the Southern Ocean (classes 96, 131, 184, and 168) are found on the fresh side of the *T-S* curve; between 0.0 and 0.1°C (classes 184, 78, 171, and 129), what one considers the "normal" situation is exactly reversed. The Pacific sector dominates the saline side of the curve and the Atlantic sector the fresh side; 93% of class 129 is in the Pacific sector of the Southern Ocean, and 70% of class 184 is in the Atlantic sector.

There is a group of classes between 0.0 and 1.7°C that are truly circumpolar, being found in *all* sectors of the Southern Ocean. The warmer end of this group (classes 176 and 178) claim a niche on the *fresh* side of the right-hand arm of the Y-shape and contain water found in all oceans except the North Atlantic and the North Pacific. These circumpolar classes represent water carried by the Antarctic Circumpolar Current.

The water masses that embrace 50% of the world ocean (when ranked in order of volume) are diverse, owing to the widely different locations in which they have been formed and, presumably, to slow changes that have taken place in these water masses since their formation as the result of mixing with their neighbors. For example, all the relatively fresh North Pacific water (figure 2.6) must have been formed near the periphery of Antarctica, but the South Pacific water masses found in the warm half of the base of the Y-shape, which intervene between the North Pacific and the Southern Ocean (Pacific), are far more saline at the present time. There is thus no connection, at present, between the circumpolar water masses and the vast volumes of deep North Pacific water. The relatively low salinity of this North Pacific deep water is probably the result of slow mixing with the even fresher waters that lie above them. We have no conception of the time scale of such a mixing process, but I would hazard a guess that it is of the order of centuries or, conceivably, millennia.

By contrast with the world ocean (figure 2.6), the North Atlantic is far less diverse; it takes 186 fine-scale classes (ranked in order of volume) to contain 50% of the world ocean (figure 2.6), but Wright and Worthington (1970) show that 50% of the North Atlantic is contained in only 43 classes, 75% in 157 classes, and 90% in 295—in spite of the fact that they identify five separate sources of deep water for the North Atlantic.

The Sea of Japan is probably the least diverse of any considerable *inland* sea (this sea has not been included in this census, but its water masses have been tallied). The Sea of Japan contains 1,590 × 10^3 km^3; 50% of it is found in only three fine-scale classes, 75% in 7 classes, and 90% in 28 classes. The sea surface within the Sea of Japan is its sole source of deep and bottom water, and this is undoubtedly the cause of its homogeneity.

The process of ranking the fine-scale classes of the world ocean for this census has been carried out until 75% of its volume was classified. To carry this process out to 90% [as Wright and Worthington (1970) have done for the North Atlantic] would not only be excessively time consuming but also unjustified by the distribution of reliable deep hydrographic data (figure 2.1). The classes that make up the third quarter of the volume of the world ocean are shown in figure 2.7 (included in the pocket at the back of the book). The first half of the ocean, the classes that are ranked by number in figure 2.6, are represented by the blacked-out areas in figure 2.7. One should always remember that the volume of water represented by these blacked-out classes is *double* that of the remainder of the water represented by the numbered classes in figure 2.7; these latter classes (187–693) are also listed in the appendix. Their volume diminishes with rank from class 187 (975 × 10^3 km^3) to class 693 (192 × 10^3 km^3). The *pro rata* volume of class 693 is 96 × 10^3 km^3. As the volume of these classes diminishes, their diversity increases; 50% of the world ocean is in only 186 classes, while the next 25% requires 507 classes.

The *T-S* diagram for these 507 classes (figure 2.7) again resembles a primitively drawn, lopsided Y-shape. Roughly speaking, the Pacific Ocean dominates the fresher side of the Y-shape, and the Atlantic the more saline side. Indian Ocean water is found in both arms of the Y-shape, but its greater volume is found in the center, where the base and the arms of the Y-shape are joined.

In the temperature range 0.9–3.6°C, North Pacific water dominates the fresher edge of the Y-shape. From class 332 (0.9–1.0°C, 34.68–34.69‰) to class 627 (3.4–3.6°C, 34.24–34.26‰), all classes on this edge contain at least 50% North Pacific water. In the warmer part of the fresh edge, above 3.0°C, considerable volumes of (eastern) South Pacific and South Atlantic water are found. Virtually all the classes between 3.0 and 4.0°C and between 34.30 and 34.64‰ are shared among the North Pacific, the South Pacific, the Indian Ocean, and the South Atlantic; the exceptions are classes 673 and 565 (3.0–3.2°C, 34.30–34.34‰), which contain no Indian Ocean water. These classes represent an unnamed water mass of considerable volume that lies below the Antarctic Intermediate Water and above the Antarctic Bottom Water in the South Pacific and Indian Oceans, and between the Antarctic Intermediate Water and the

North Atlantic Deep Water in the South Atlantic. They are also found south of the southern limit of North Atlantic Deep Water. In the North Pacific they fall between the North Pacific Intermediate Water and the bottom water. This unnamed water mass presumably originates south of the Antarctic Polar Front. A typical class from the middle of this group is class 573—3.4-3.6°C, 34.44-34.46‰. It contains 594 × 10^3 km^3 of water: 31% in the North Pacific; 31% in the South Pacific; 17% in the Indian Ocean; and 21% in the South Atlantic.

There are only 10 classes above 4°C that are included in the third quarter of the world-ocean volume. These 10 classes are relatively coarse scale, each of them having the equivalent area on the *T-S* diagram of 25 of the finest-scale classes (those below 2°C). The combined volume is considerable—28,723 × 10^3 km^3; this is slightly more than the volume of the highest-ranking class (25,973 × 10^3 km^3), but the *pro rata* volume of these classes, that is, the volume contained in each 0.1°C × 0.01‰ bivariate fine-scale class is quite small. Class 586, the richest of these classes, contains 3,574 × 10^3 km^3, but its *pro rata* volume is only 143 × 10^3 km^3. Four of the saltier of these classes (586, 609, 631, and 677) are cosmopolitan, being found in all five of the major oceans, north of 55°S. These represent the Antarctic Intermediate Water, which is formed north of the South Polar Front and pushes across the equator into the North Pacific and the North Atlantic; these four classes are the only ones shared by these northern hemisphere oceans. Wright and Worthington (1970) show that none of this water penetrates north of 15°N in the North Atlantic. The South Pacific dominates the remaining five classes (688, 659, 669, 680, and 619).

The Indian Ocean occupies the center of the Y-shape (figure 2.7). The classes in the square representing the temperature range 2.0-3.0°C and the salinity range 34.70-34.80‰ are predominantly Indian Ocean classes, but in the warmer part of this square considerable volumes of South Atlantic water are present. For example, class 493 (2.6-2.8°C, 34.75-34.76‰; 392 × 10^3 km^3) contains 60% Indian Ocean water and 40% South Atlantic water. We have seen above that Indian Ocean water is found in nearly all the classes between 3 and 4°C and 34.30 and 34.64‰, in the left-hand arm of the Y-shape. Indian Ocean water is also found on the fresher side of the right-hand arm of the Y-shape (e.g., classes 665, 472, 676, 530, 553, 660, 516, and 657). These classes contain the most saline water found in the Indian Ocean between 3.2 and 4.0°C. This high salinity results from the contribution of saline overflow water from the Red Sea.

A closer examination of one of these classes (665) is instructive. This class contains 436 × 10^3 km^3; 37% of this volume is found in the Indian Ocean. Its *high* salinity relative to the rest of that ocean is the result of the contribution from the Red Sea outflow. The North Atlantic claims 39% of this class, and examination of the atlas of Wright and Worthington (1970) reveals that 100% of this North Atlantic water (172 × 10^3 km^3) is found in the Labrador Basin, where its *low* salinity is the result of the formation of Labrador Sea water, the freshest of the deep-water masses in that ocean. This illustrates how water masses of widely different origin that never connect geographically with each other can occupy the same class in the *T-S* diagram. The remaining 24% of this class is South Atlantic water that is also isolated from Red Sea water by water from the southern Indian Ocean that contains no perceptible fraction of Red Sea Outflow water.

The right-hand arm of the Y-shape (figure 2.7) is composed entirely of Atlantic water except for the few Indian Ocean classes that have just been discussed. As one would expect, the North Atlantic dominates the more saline side of this arm and the South Atlantic the fresher side. The coldest class in figure 2.7 that contains South Atlantic water is class 555 (0.0-0.1°C, 34.66-34.67‰). We have seen, however, that in the first 50% of the ocean (figure 2.6) traces of South Atlantic water colder than −0.4°C can be found.

The Atlantic *T-S* diagram extends from the coldest water in the Southern Ocean sector (classes 272 and 247) in a more-or-less straight line through the South Atlantic classes up to the large classes shown by the more saline blacked-out area (figure 2.7) that represents the North Atlantic Deep Water. All water on this curve is usually named the Antarctic Bottom Water. The warmest classes on this part of the *T-S* curve, those between 1.3 and 1.7°C, are common to the North and South Atlantic; the more saline of these warmer classes are found in the North Atlantic, and the fresher classes in the South Atlantic. Traces of Antarctic Bottom water as cold as 0.6°C (class 286: 0.6-0.7°C, 34.75-34.76‰) can be found in the North Atlantic, but these traces do not enter the deep North American Basin, according to Worthington and Wright (1970), but remain close to the equator. No classes in the Southern Ocean (Atlantic) can be traced to the North Atlantic. The "Antarctic Bottom Water" classes that are found in the North Atlantic are composed chiefly of the North Atlantic Deep Water with a very small amount of *true* Antarctic Bottom water mixed in. In other words, no "Antarctic Bottom Water" in the North Atlantic can be traced, unchanged, to its point of origin in the Weddell Sea. On the other hand, many North Atlantic Deep Water classes can be traced, unchanged, from their origin as overflow water from the Norwegian Sea all the way down into the South Atlantic. This argues either for a more rapid production rate for the North Atlantic Deep Water or (if production of both water masses is equal) for a higher mixing rate along the T-S curve that represents the Antarctic Bottom Water.

In the Southern Ocean, the extended classification of figure 2.7 includes a number of classes not represented in figure 2.6. These less abundant classes confirm the curious fact that the "normal" distribution of salinity is reversed; the Atlantic sector of the Southern Ocean contains the freshest water (e.g., class 316: −0.3–−0.2°C, 34.65-34.66‰) and the Pacific sector the most saline (e.g., class 513: −0.3–−0.2°C, 34.71-34.72‰).

In general, expanding the description from 50% to 75% of the ocean results in the addition of few cold, deep classes, compared to the greater number of warmer classes. I believe that if we all made perfect observations of temperature and salinity, the number of deep classes would be even fewer than those listed in the appendix. The ocean is probably more finely stratified than we can observe at the present time.

One is tempted to play endless games with figures 2.6 and 2.7 and the appendix, and the reader is, of course, invited to do so, but, again, he should bear in mind that the coverage (figure 2.1) is really quite poor and the real rankings may be somewhat different from those listed in the appendix.

In order that the less abundant classes should not be wholly slighted, figures 2.8 and 2.9 have been constructed. These are contoured volumetric T-S diagrams for the cold water (<4°C), and the thermocline and warm water (>4°C), respectively. The crosshatched area (<4°C) attached to the warm-water diagram (figure 2.9) encloses the cold water that is contoured in detail in figure 2.8. Each contour represents the volume in $km^3 \times 10^3$ that is found in each 0.1°C × 0.01‰ class, and the contours mapped are $2^n \times 10^5$ km^3, where $n = -2, -1, 0, 1, 2, \ldots, 8$; this last contour contains only the winning class from the North Pacific. Contours of 5 and 10 × 10^3 km^3 have been added in figure 2.9 because otherwise the thermocline and warm-water masses of the oceans would scarcely appear at all.

For example, the 5 × 10^3-km^3 contour in the upper right-hand corner of figure 2.9 contains two classes that comprise the 18° Water in the North Atlantic (Worthington, 1959). These classes are 17-18°C, 36.4-36.5‰, 827 × 10^3 km^3, and 18-19°C, 36.5-36.6‰, 556 × 10^3 km^3; there are 100 fine-scale classes in each of these relatively coarse-scale warm-water classes, so the *pro rata* volumes of these two classes are 8.3 × 10^3 and 5.6 × 10^3 km^3, respectively.

The analogy between these figures and a physical relief map is difficult to avoid because the dominant water masses in this presentation (and in figures 2.2-2.5) resemble mountain ranges. The highest of these ranges (below 34.8‰) is roughly Y-shaped. The left-hand branch of the Y-shape is composed predominantly of Pacific water (in which the highest peak is found), and the right-hand branch of the Y-shape contains mostly South Pacific and Indian Ocean water. The far lower range centered on 2.0°C, 34.89‰ is the Atlantic. The highest peak in this range contains only 4659 × 10^3 km^3. The warmer extensions of these ranges fall off rapidly into what might be analogous to a coastal peneplain—however, no prominent monadnocks appear. An isolated elevation of 100 × 10^3 km^3 per class occurs near 6°C, 34.35‰. This represents part of the Subantarctic Mode Water described by McCartney (1977). The warm extension of this elevation (>50 × 10^3 km^3 per class) toward the northeast also consists of Subantarctic Mode Water, mostly in the South Pacific and in the Indian Ocean.

The warmest water (>10°C) is divided into three low prongs. The freshest of these prongs consists principally of North Pacific water, but there is a considerable contribution from the eastern South Pacific. The central prong is cosmopolitan—it contains water formed in the subtropical convergences of the southern hemisphere. The saline side of the central prong consists principally of South Atlantic and Indian Ocean water, but a considerable volume was found in the Guiana and Guinea Basins of the North Atlantic by Wright and Worthington (1970). In the center of the central prong, South Atlantic, South Pacific, and Indian Ocean waters are found in roughly equal proportions. On the fresh side of the central prong, South Pacific water predominates, but there is a considerable volume of water from the subtropical North Pacific. The saline prong is composed of Western North Atlantic Water, but in temperature intervals below 13°C the Red Sea water in the Indian Ocean claims a significant proportion of the water (>25%).

The contour of 5 × 10^3 km^3 per class encloses two warm islands isolated from the main prongs; one of these, an extension of the saline prong, comprises the 18° Water in the North Atlantic, as we have seen. The other, an extension of the central prong, is composed mainly of South Pacific water. This one is probably artificial because much of the surface mixed layer on the western half of the *Scorpio* section at 28°S was between 19 and 20°C and between 35.6 and 35.8‰, according to Stommel et al. (1973, plates 1 and 2). Undue weight was given to this section on account of the shortage of other high-precision hydrographic data in the South Pacific.

The thermocline and warm water-mass parts of this census, as they are illustrated here (figure 2.9), are merely a sketch, and no really reliable quantitative estimates of the volumes of these water masses in the world ocean exist. The reader is referred to Wyrtki's (1971, pp. 526-527) admirable volumetric diagrams for the Indian Ocean and to those of Wright and Worthington (1970) for the North Atlantic. For the other oceans, the warm-water diagrams (coarse scale) of Montgomery

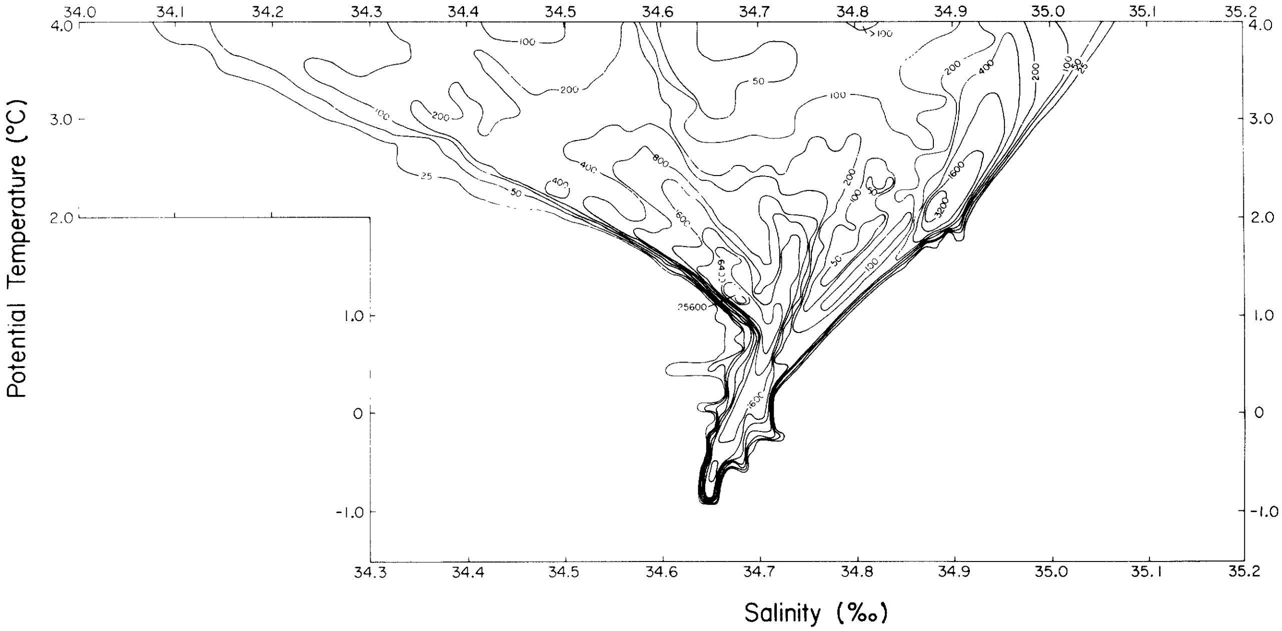

Figure 2.8 Contoured volumetric *T-S* diagram for the cold (<4°C) water in the world ocean. The values are volumes (km³ × 10³) that are found in each class of 0.1°C × 0.01‰.

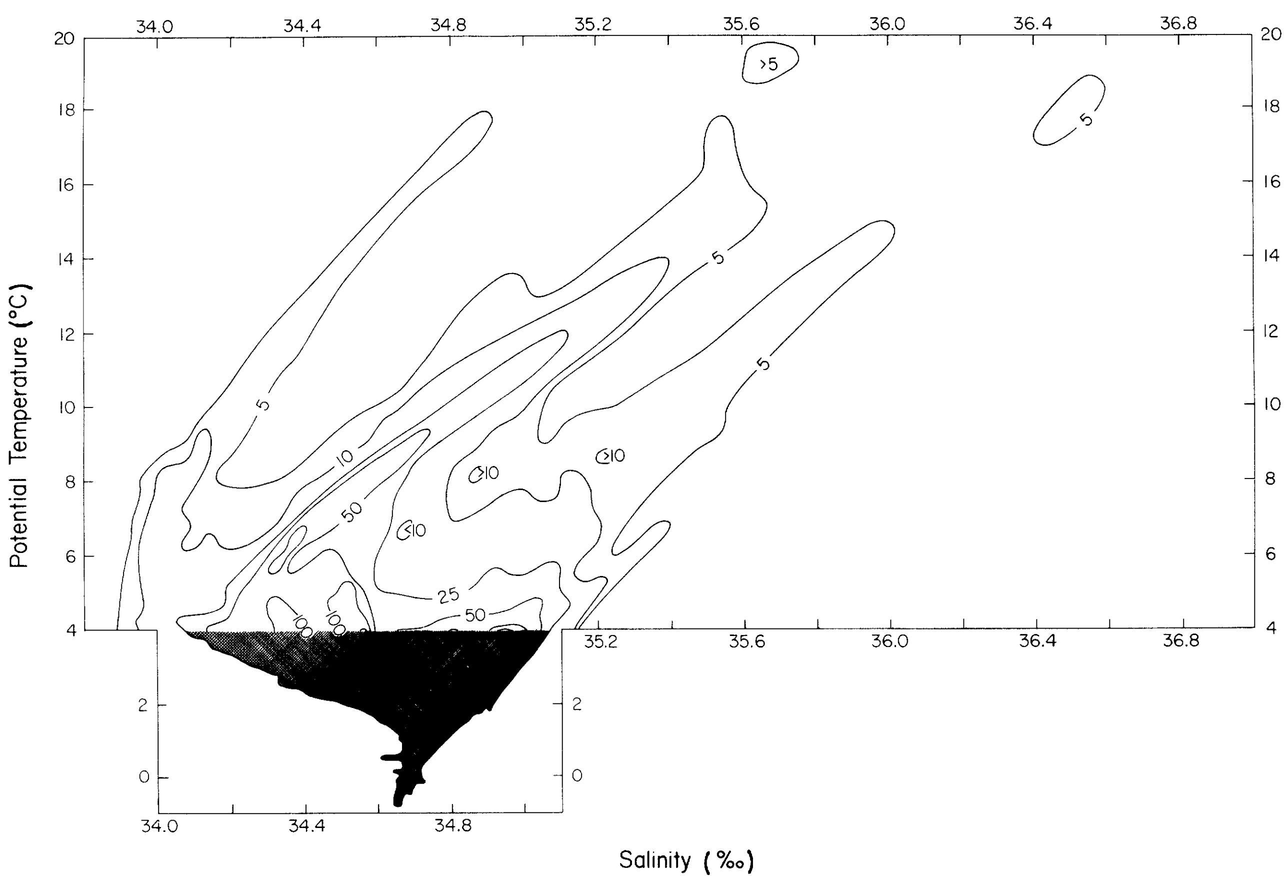

Figure 2.9 Contoured volumetric *T-S* diagram for the thermocline (>4°C) and warm (>16°C) waters of the world ocean. The values are the volumes (km³ × 10³) that are found in each class of 0.1°C × 0.01‰. Shaded area encloses the cold-water classes that appear in figure 2.8.

(1958), Cochrane (1958), and Pollak (1958) still stand, but I believe that their classes are too large. One can see that by merging the present classes into divisions as large as 0.5‰ of salinity, as Cochrane and Pollak have done, or 1.0‰, as Montgomery has done, the high-volume warm prongs (figure 2.9) would be artificially blurred and merged with one another.

One or two colleagues have asked whether I could not use a logarithmic volume scale in such presentations as figures 2.2–2.5 so that the warm water masses (if included) could be made to stand out more clearly, but one of the principal virtues of the volumetric *T–S* diagram is that it displays the relative abundances of the water masses as they actually exist. The *concentration* of water in the most abundant North Pacific class exceeds that in the warm-water prongs (shown in figure 2.9) by a ratio of about 25,973 to 10 or less. This is analogous to comparing the elevation of Mount Everest to that of Water Street, Woods Hole, near the original building of the Woods Hole Oceanographic Institution. In fact, if we were able to sample and measure salinity more perfectly, the apparent elevations shown in the deep water in figure 2.8 would probably be even higher.

The feelings I have about the census are compounded equally of fascination and frustration. The frustration is the result of the decrease in the rate of acquisition of new high-quality data. This decrease is due in part to the trends in modern physical oceanography in which the dramatic improvements in direct current measurements have understandably taken priority over routine measurements of water properties on a large scale. It is also clear that there is a long delay (as much as 5 years) between the time hydrographic data are obtained at sea and the time these data become available on tape from the National Oceanographic Data Center (in part because some investigators take a long time to turn their data in to the Data Center). I have been reluctant to obtain new data informally, from friendly colleagues, however, because I do not think that the Data Center should be bypassed at present; its function would be impaired if data were only exchanged between a cabal of skilled observers.

The fascination results from the precise but peculiar way in which the water masses of the oceans are arranged—particularly the deep water masses that make up the greater part of the oceans. Why, for instance, are the big, exclusive North Pacific classes fresher than existing circumpolar and South Pacific waters? Are they fossil water masses that were formed in some past millennium when the oceans were somewhat fresher, or are they still undergoing a change toward the fresher as the result of slow vertical mixing (across density surfaces) with the still fresher water that lies above them at the present time? I do not think that we can supply answers to such questions at present, and answers will not be available even in the future without painstaking observations. There are indications this style of observations may be coming back into vogue. The authorless Scripps data report of the INDOPAC expedition (Scripps Institution of Oceanography Reference: 78-21) is an excellent example. It should be worthwhile to reactivate this census (which was closed as of June 1977) when more high-quality data of this kind are available from NODC, and I shall probably propose to do so at some time in the future.

2.4 The Formation of Water Masses

There is only one hypothesis about water-mass formation that is universally agreed upon, that is, that the cold, dense water that fills the great ocean basins has been formed at high latitudes. The manner in which the thermocline–halocline is formed is under dispute, and there are almost as many notions of the *rate* at which all the various water masses are formed as there are investigators.

Given the extraordinary regularity of the *T–S* curves that are found in much of the oceans, it is natural to assume that these curves are the result of vertical mixing between two end water masses. Very simply stated, this assumption implies that the bottom water (as all agree) has been formed at high latitudes, that the surface water at middle and low latitudes has received its *T–S* characteristics from the atmosphere by the uneven processes of evaporation and heating, and that the remainder of the water column is a mixture of surface and bottom water. Wüst (1935) clearly recognized that this was an oversimplification, and his use of the "core-layer" method reflects his conviction that different water masses can be traced to a small number of more-or-less point sources at the sea surface over a wide range of latitude.

The notion that *all* the thermocline water masses can be traced to the sea surface is generally attributed to Iselin (1939a). He constructed a *T–S* diagram from winter observations at the surface of the western North Atlantic, and found that it corresponded closely to the *T–S* diagram obtained from a typical hydrographic station in that ocean. It is worth noting that Wüst (1935, p. 3) anticipated Iselin (in the South Atlantic) by 4 years. He wrote, "The vertical structure of the Subantarctic Intermediate Water, with its horizontal spreading at depths, is analogous to a vertical figure of the horizontal arrangement of temperature and salinity at the surface of the formation region." Wüst did not dwell on this subject further, and it is clear that he regarded core layers as more important as indices of ocean circulation.

In his 1939a paper, Iselin stressed "lateral mixing" as responsible for the *T–S* curve in the western North Atlantic. Sverdrup, in chapter XV of *The Oceans* (Sverdrup, Johnson, and Fleming, 1942) amplified Iselin's concept; he suggested that "subtropical convergences" were the dominant source of the waters in the thermocline-halocline. In these convergences, according to Sverdrup, surface water sinks, in late winter, over a wide range of latitude. He compared late-winter, sea-surface T-S points to the T-S curves obtained from subsurface hydrographic data and found a close correspondence in the south Indian Ocean, the eastern and western South Pacific, and the western North Pacific, just as Iselin (1939a) had done for the North Atlantic.

In this type of water-mass formation, very little change takes place in each individual water type—when 10°C water outcrops at the sea surface, it sinks again at 10°C or nearly so, not at 4°C. In vertical-mixing models, the water types are constantly changing. In the most violent of these, Stommel (1958) held that bottom water was produced at two sinks, the Weddell Sea in the south and the Irminger Sea in the north. He theorized that bottom water was produced constantly and moved upward through the thermocline. The thermocline in this theory was maintained by a downward diffusion of heat that balanced the upward advection of cold bottom water. Later, Stommel and Arons (1960b) produced a simple schematic model in which $20 \times 10^6\ m^3 s^{-1}$ was formed in each sink and flowed equatorward in the form of deep western boundary currents. Subsequently, this water upwelled through the thermocline (as outlined in Stommel's earlier paper) with an upward velocity of about $4\ m\,yr^{-1}$.

Cooper (1955a) refocused attention on the Norwegian Sea overflows as a source of the North Atlantic Deep Water, and this paper touched off a series of investigations into these overflows, using newly developed methods of direct current measurement such as the Swallow float (Swallow, 1955), I (1970) have summarized some of the earlier investigations (see also chapter 1, this volume). In essence, it was evident that if cold bottom water does in fact flow across the sills of the Norwegian Sea into the deep Atlantic Ocean, relatively warm surface water must be drawn into the Norwegian Sea to replace it. It was possible to write water and heat budgets for the Norwegian Sea; the cold outflows ($9 \times 10^6\ m^3 s^{-1}$) transported 63×10^{12} less calories per second than the warm inflows (also $9 \times 10^6\ m^3 s^{-1}$). This excess heat must go to the atmosphere, and the calculated heat loss from the oceanographic data, $75\ kcal\,cm^{-2} yr^{-1}$, corresponded pretty well with Budyko's (1963) calculated heat loss from meteorological data—about $60\ kcal\,cm^{-2} yr^{-1}$.

Of the $9 \times 10^6\ m^3 s^{-1}$ of cold water flowing out of the Norwegian Sea, $3 \times 10^6\ m^3 s^{-1}$ is embodied in the shallow, fresh East Greenland Current. The remaining $6 \times 10^6\ m^3 s^{-1}$ is dense overflow water; the overflows entrain a further $4 \times 10^6\ m^3 s^{-1}$ of Atlantic water at their sills and a total of $10 \times 10^6\ m^3 s^{-1}$ flows southward along the western side of the North Atlantic as a narrow deep western boundary current. The fact that this current originates in the Norwegian Sea and not in the Irminger Sea does not affect the theory, but it is naturally of vital interest to the descriptive oceanographer.

Thus the formation of North Atlantic Deep Water follows a classic pattern—cold, dense water is formed at high latitudes, and warm surface water flows poleward to replace it. In this pattern, the process of water-mass formation changes the water characteristics radically. Much of the replacement water must come from the tropical South Atlantic since the North Atlantic Deep Water flows into the South Atlantic at a rate of $9 \times 10^6\ m^3 s^{-1}$ according to Sverdrup et al. (1942), or $7 \times 10^6\ m^3 s^{-1}$ according to my box model (Worthington, 1976, figure 11). As this tropical surface water flows north, it gradually transfers heat to the atmosphere and undergoes enormous changes in its T-S characteristics before it finally becomes North Atlantic Deep Water.

This pattern is clearly consistent with the Stommel (1958) theory since upwelling of the North Atlantic Deep Water must take place—provided that the volume of the North Atlantic Deep Water remains constant. One could conceive of a water mass that refuses to mix with its neighbors—in this case the Antarctic Intermediate Water, the Circumpolar Deep Water, and the Antarctic Bottom Water—but, instead, pushes them bodily aside, preserving the purity of its original T-S characteristics and increasing its own territory. In the case of the North Atlantic Deep Water, it seems unlikely that such behavior has taken place. The area of the Atlantic Ocean is $82.4 \times 10^6\ km^2$. The North Atlantic Deep Water is found throughout two-thirds of this area. Its volume is $89 \times 10^6\ km^3$—$62 \times 10^6\ km^3$ in the North Atlantic according to Wright and Worthington (1970) by their definition, and the remaining $27 \times 10^6\ km^3$ in the South Atlantic according to this census (same definition). The mean thickness of the North Atlantic Deep Water is thus about 1500 m. The width of the South Atlantic at the southern limit of more or less pure North Atlantic Deep Water (35°S) is 6400 km. To advance 1° of latitude (110 km) southward, the North Atlantic Deep Water would have to increase in volume by $1.06 \times 10^6\ km^3$. If $7 \times 10^6\ m^3 s^{-1}$ cross the equator, as I have suggested, this flux should result in an advance of 1° of latitude every 4.5 years if no upwelling were taking place. Since the *Meteor* expedition was made, over 50 years ago, the southern limit of the North Atlantic Deep Water would have had to advance 11° of latitude; it plainly has not done so. We should, however, be cautious even in crude calculations like these, since our numbers for the amount of water formed may not be even approximately correct. For example, most of the measurements made in the deep, dense overflows from the Norwegian Sea were made in the 1960s—a cold decade in the northern North Atlantic relative to the decades that preceded it (Colebrook, 1976). This could easily have resulted in an overestimation of the climatic mean flow of the dense overflows.

We should probably not regard the Iselin (1939a) theory of the thermocline-halocline formation as exclusive of the Stommel (1958) theory, or vice versa. The evidence that water sinks along density surfaces that have outcropped at the sea surface seems inescapable, yet there is equally strong evidence that upwelling of deep water through the thermocline must take place, at least in the Atlantic.

Recently (Worthington, 1977a), I have questioned the Stommel-Arons (1960b) model as it applies to the Pacific Ocean. The argument is a simple one; the deep water in the Pacific contains not less than 7 g of dissolved silicon per cubic meter, and the upper layers are very nearly silicon-free. If the deep water (formed in the Weddell Sea) upwells through the thermocline throughout the Pacific and flows southward in the upper layers, two processes must take place. First, the dissolved silicon must be removed from the deep water before it can return southward to the formation area, free of silicon. Second, an equal, or nearly equal, amount of silicon must be replaced before the surface water sinks below 2000 m in the Weddell Sea. The removal and replacement rate necessary to accommodate the model can be calculated to be about 30×10^{14} g of silicon per year. I believe that to ask the ocean to perform feats like this is unreasonable and that the most logical conclusion to be drawn is that the deep waters in the Pacific are not being renewed at the present time. One could guess that they might not be renewed until the time when the rate of accumulation of ice on the Antarctic continent begins to exceed that of ablation and runoff.

The *surface* waters around Antarctica are fairly rich in silicon, as are those of the northern North Pacific. Reid (1973b) has attributed this situation in the North Pacific to upwelling, and this also is the most reasonable explanation for the state of affairs around Antarctica. Nutrient-rich upwelled water, augmented by runoff from Antarctica, flows equatorward until the amount of sunlight is sufficient to cause photosynthesis; then the silicon (and other nutrients) is immediately used for plant growth—consistent with the rich biota in the zone around Antarctica and with the high rate of accumulation of siliceous sediments beneath this zone (Lisitzin, 1972).

By comparison, the North Atlantic surface waters (except in the coastal zones) are a desert because they consist of nutrient-stripped water from the middle and low latitudes, and Metcalf (1969) has shown that newly formed North Atlantic Deep Water is also silicon poor. The subject clearly invites further investigation, but, as a first approximation, one might suppose that in silicon-poor oceans such as the Atlantic, the Stommel (1958) theory holds true, but in silicon-rich oceans, such as the Pacific and Indian Oceans, the process of deep-water formation has been suspended and the Stommel mechanism awaits application for the next cold, climatic variation in the southern hemisphere. If such a cold variation should take place, and if the vast store of nutrients that has (I believe) been accumulating in the deep Pacific through the years should be brought up into the sunlight, the results, in terms of biological productivity, might be staggering.

If this hypothesis is even approximately correct, we are faced with the problem of how the thermocline-halocline is maintained in the Pacific and Indian Oceans. A clue to this has been provided by McCartney (1977). He has identified a family of water types in the South Atlantic, South Pacific, and Indian Oceans that he has termed Subantarctic Mode Water. These layers appear to originate by deep convective overturning immediately equatorward of the Antarctic Circumpolar Current. They can be identified at great distances from their formation regions by thermostads with *T*-*S* characteristics identical to those of the deep overturned waters, and usually by an oxygen maximum in these thermostads. These layers are strongly reminiscent of the 18°-Water thermostad formed south of the Gulf Stream (Worthington, 1959) and of the Subtropical Mode Water (Masuzawa, 1969) south of the Kuroshio and the Kuroshio Extension. They differ from 18° Water and the Subtropical Mode Water in that they are found at much greater distances (up to 3000 km) from their points of origin and that they occur over a wider range of temperature (14–4°C).

Although the matter is still under investigation (McCartney, 1980), it appears that most of the southern hemisphere thermocline waters (in terms of volume) originate in these thermostadal layers by means of convective overturn. Certainly, all the southern, high-volume classes between 4 and 14°C that appear at the base of the central prong in figure 2.9 can be traced to the deep mixed layers described by McCartney (1977).

Water-mass formation is a complicated process. There seems to have been no major hypothesis on the subject that can be entirely accepted or entirely rejected. The earth's geography and the atmospheric circulation encourage the production of a wild variety of water masses, and evidently these water masses are formed in a number of different ways. I have attempted to describe some of these. The study of water-mass formation is intimately tied to the study of the general ocean circulation. The most promising method for the future will be to combine these two studies by means of direct current measurements and the rigorous observation of the distribution of variables in the oceans and of the atmospheric processes that bring about these distributions.

Appendix: Census of World-Ocean Water Masses with Division by Bivariate (°C × ‰) Classes and Rank by Volume

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
1	1.1- 1.2	34.68-34.69	25,973	25,973	100	-	-	-	-	-	-	-
2	1.2- 1.3	34.67-34.68	14,010	39,983	100	-	-	-	-	-	-	-
3	0.7- 0.8	34.71-34.72	13,571	53,554	-	48	9	35	5	-	2	1
4	1.2- 1.3	34.68-34.69	13,494	67,048	91	9	-	-	-	-	-	-
5	1.1- 1.2	34.69-34.70	12,905	79,953	82	18	-	-	-	-	-	-
6	1.0- 1.1	34.69-34.70	11,988	91,941	95	5	-	-	-	-	-	-
7	0.6- 0.7	34.71-34.72	11,930	103,871	-	55	12	24	6	-	2	1
8	1.5- 1.6	34.68-34.69	10,337	114,208	5	95	-	-	-	-	-	-
9	1.3- 1.4	34.67-34.68	9,826	124,034	99	1	-	-	-	-	-	-
10	0.8- 0.9	34.71-34.72	9,607	133,641	-	52	8	34	3	-	2	1
11	1.0- 1.1	34.72-34.73	9,252	142,893	-	24	9	63	2	-	1	1
12	1.6- 1.7	34.67-34.68	8,836	151,729	16	84	-	-	-	-	-	-
13	1.5- 1.6	34.67-34.68	7,881	159,610	22	78	-	-	-	-	-	-
14	0.9- 1.0	34.72-34.73	7,618	167,228	-	26	15	49	7	-	2	1
15	1.4- 1.5	34.67-34.68	7,027	174,255	49	51	-	-	-	-	-	-
16	1.6- 1.7	34.66-34.67	6,627	180,882	23	77	-	-	-	-	-	-
17	0.8- 0.9	34.72-34.73	6,487	187,369	-	28	17	40	11	-	3	1
18	0.9- 1.0	34.70-34.71	6,434	193,803	68	28	-	2	1	-	-	1
19	1.3- 1.4	34.73-34.74	6,387	200,190	-	10	9	78	2	-	-	1
20	1.3- 1.4	34.66-34.67	6,052	206,242	100	-	-	-	-	-	-	-
21	1.4- 1.5	34.73-34.74	6,030	212,272	-	10	7	81	2	-	-	-
22	1.1- 1.2	34.67-34.68	6,024	218,296	100	-	-	-	-	-	-	-
23	1.0- 1.1	34.68-34.69	5,844	224,140	100	-	-	-	-	-	-	-
24	0.5- 0.6	34.71-34.72	5,676	229,816	-	29	40	21	6	-	3	1
25	1.1- 1.2	34.72-34.73	5,497	235,313	-	23	12	61	1	-	1	2
26	1.3- 1.4	34.68-34.69	5,473	240,786	38	62	-	-	-	-	-	-
27	0.9- 1.0	34.71-34.72	5,382	246,168	-	60	9	27	1	-	2	1
28	1.2- 1.3	34.73-34.74	5,328	251,496	-	14	14	65	5	-	1	1
29	1.4- 1.5	34.69-34.70	5,322	256,818	-	100	-	-	-	-	-	-
30	1.4- 1.5	34.66-34.67	5,301	262,119	100	-	-	-	-	-	-	-
31	1.7- 1.8	34.66-34.67	5,065	267,184	19	80	-	-	1	-	-	-
32	0.4- 0.5	34.70-34.71	4,906	272,090	-	28	27	21	15	-	5	4
33	1.7- 1.8	34.65-34.66	4,844	276,934	34	65	-	-	1	-	-	-
34	1.4- 1.5	34.68-34.69	4,760	281,694	4	96	-	-	-	-	-	-
35	1.9- 2.0	34.88-34.89	4,659	286,353	-	-	-	-	-	19	81	-
36	1.5- 1.6	34.73-34.74	4,640	290,993	-	11	8	78	3	-	-	-
37	1.5- 1.6	34.74-34.75	4,550	295,543	-	11	10	72	7	-	-	-
38	1.1- 1.2	34.73-34.74	4,471	300,014	-	16	17	52	12	-	3	-
39	1.0- 1.1	34.70-34.71	4,384	304,398	58	39	1	-	-	-	-	2
40	1.5- 1.6	34.66-34.67	4,349	308,747	74	26	-	-	-	-	-	-
41	1.4- 1.5	34.74-34.75	4,337	313,084	-	12	11	65	11	-	1	-
42	0.5- 0.6	34.70-34.71	4,134	317,218	-	25	21	29	16	-	5	4
43	1.4- 1.5	34.65-34.66	4,065	321,283	100	-	-	-	-	-	-	-
44	1.2- 1.3	34.69-34.70	4,048	325,331	34	64	1	-	1	-	-	-
45	1.1- 1.2	34.70-34.71	3,843	329,174	53	44	1	-	1	-	-	1
46	1.3- 1.4	34.69-34.70	3,801	332,975	-	100	-	-	-	-	-	-
47	2.0- 2.2	34.89-34.90	7,579	340,554	-	-	-	-	-	21	79	-
48	1.2- 1.3	34.66-34.67	3,717	344,271	100	-	-	-	-	-	-	-
49	1.2- 1.3	34.72-34.73	3,655	347,926	-	20	14	62	1	-	1	2
50	1.0- 1.1	34.71-34.72	3,621	351,547	-	71	9	15	2	-	1	2
51	1.8- 1.9	34.64-34.65	3,566	355,113	43	56	1	-	-	-	-	-
52	1.6- 1.7	34.73-34.74	3,536	358,649	-	15	10	72	3	-	-	-
53	1.6- 1.7	34.74-34.75	3,504	362,153	-	12	10	72	6	-	-	-
54	1.0- 1.1	34.73-34.74	3,465	365,618	-	11	21	45	17	-	6	-
55	1.8- 1.9	34.65-34.66	3,404	369,022	14	85	1	-	-	-	-	-
56	1.5- 1.6	34.69-34.70	3,371	372,393	-	98	1	-	-	-	-	1
57	0.7- 0.8	34.72-34.73	3,330	375,723	-	9	22	52	11	-	6	-
58	1.7- 1.8	34.74-34.75	3,239	378,962	-	14	8	69	9	-	-	-
59	1.8- 1.9	34.66-34.67	3,211	382,173	13	85	1	-	1	-	-	-
60	1.3- 1.4	34.74-34.75	3,205	385,378	-	15	13	51	19	-	2	-
61	1.9- 2.0	34.89-34.90	3,141	388,519	-	-	-	-	-	85	15	-
62	1.4- 1.5	34.64-34.65	3,128	391,647	100	-	-	-	-	-	-	-
63	1.9- 2.0	34.64-34.65	3,064	394,711	24	74	1	-	1	-	-	-
64	1.3- 1.4	34.65-34.66	3,040	397,751	100	-	-	-	-	-	-	-
65	2.0- 2.2	34.90-34.91	5,958	403,709	-	-	-	-	-	75	25	-
66	1.7- 1.8	34.67-34.68	2,957	406,666	4	95	-	-	1	-	-	-
67	1.5- 1.6	34.64-34.65	2,896	409,562	100	-	-	-	-	-	-	-
68	0.9- 1.0	34.69-34.70	2,886	412,448	97	-	-	-	1	-	-	2

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
69	1.5- 1.6	34.65-34.66	2,864	415,312	100	-	-	-	-	-	-	-
70	0.3- 0.4	34.70-34.71	2,829	418,141	-	21	37	14	17	-	8	3
71	1.5- 1.6	34.63-34.64	2,796	420,937	100	-	-	-	-	-	-	-
72	1.9- 2.0	34.65-34.66	2,708	423,645	15	83	1	-	1	-	-	-
73	1.6- 1.7	34.65-34.66	2,707	426,352	86	14	-	-	-	-	-	-
74	1.7- 1.8	34.73-34.74	2,698	429,050	-	14	12	67	7	-	-	-
75	-0.2--0.1	34.67-34.68	2,630	431,680	-	-	2	7	25	-	47	19
76	1.6- 1.7	34.68-34.69	2,609	434,289	-	98	1	-	-	-	-	1
77	2.0- 2.2	34.63-34.64	5,106	439,395	25	69	3	1	1	-	-	1
78	0.0- 0.1	34.68-34.69	2,485	441,880	-	-	4	10	49	-	21	16
79	1.8- 1.9	34.74-34.75	2,452	444,332	-	14	7	66	13	-	-	-
80	0.2- 0.3	34.69-34.70	2,449	446,781	-	-	16	17	44	-	15	8
81	1.9- 2.0	34.63-34.64	2,413	449,194	38	59	1	-	1	-	1	-
82	2.2- 2.4	34.92-34.93	4,788	453,982	-	-	-	-	-	89	11	-
83	2.2- 2.4	34.91-34.92	4,730	458,712	-	-	-	-	-	47	53	-
84	0.2- 0.3	34.70-34.71	2,361	461,073	-	23	50	6	2	-	19	-
85	1.8- 1.9	34.73-34.74	2,358	463,431	-	15	10	66	9	-	-	-
86	2.0- 2.2	34.91-34.92	4,671	468,102	-	-	-	-	-	95	5	-
87	0.8- 0.9	34.70-34.71	2,322	470,424	31	54	5	5	3	-	-	2
88	1.3- 1.4	34.72-34.73	2,319	472,743	-	16	20	59	-	-	2	3
89	0.4- 0.5	34.71-34.72	2,304	475,047	-	24	42	24	3	-	6	1
90	2.0- 2.2	34.88-34.89	4,597	479,644	-	-	-	-	-	2	98	-
91	1.7- 1.8	34.75-34.76	2,268	481,912	-	2	2	82	14	-	-	-
92	0.3- 0.4	34.69-34.70	2,195	484,107	-	-	17	24	32	-	12	15
93	1.6- 1.7	34.64-34.65	2,159	486,266	99	-	-	-	-	-	-	1
94	0.6- 0.7	34.70-34.71	2,157	488,423	-	23	30	14	20	-	7	6
95	1.6- 1.7	34.75-34.76	2,152	490,575	-	-	5	75	20	-	-	-
96	-0.3--0.2	34.66-34.67	2,145	492,720	-	-	-	1	-	-	35	64
97	2.0- 2.2	34.64-34.65	4,246	496,966	14	78	4	1	2	-	-	1
98	1.2- 1.3	34.74-34.75	2,116	499,082	-	8	18	43	24	-	7	-
99	-0.6--0.5	34.65-34.66	2,060	501,142	-	-	-	-	-	-	-	100
100	-0.3--0.2	34.67-34.68	2,037	503,179	-	-	1	5	45	-	38	11
101	0.1- 0.2	34.69-34.70	2,036	505,215	-	-	17	17	38	-	25	3
102	1.9- 2.0	34.90-34.91	2,014	507,229	-	-	-	-	-	97	3	-
103	1.1- 1.2	34.71-34.72	1,986	509,215	-	71	10	14	3	-	-	2
104	1.6- 1.7	34.63-34.64	1,974	511,189	99	-	1	-	-	-	-	-
105	2.0- 2.2	34.62-34.63	3,928	515,117	26	68	3	1	2	-	-	-
106	-0.1- 0.0	34.67-34.68	1,911	517,028	-	-	2	6	25	-	36	31
107	1.2- 1.3	34.71-34.72	1,909	518,937	-	85	7	7	-	-	-	1
108	-0.1- 0.0	34.68-34.69	1,900	520,837	-	-	4	11	58	-	20	7
109	1.6- 1.7	34.62-34.63	1,859	522,696	100	-	-	-	-	-	-	-
110	1.9- 2.0	34.73-34.74	1,857	524,553	-	21	9	60	10	-	-	-
111	-0.5--0.4	34.65-34.66	1,848	526,401	-	-	-	-	-	-	1	99
112	2.4- 2.6	34.93-34.94	3,691	530,092	-	-	-	-	-	84	16	-
113	0.1- 0.2	34.68-34.69	1,844	531,936	-	-	6	11	39	-	17	27
114	1.3- 1.4	34.70-34.71	1,836	533,772	-	97	1	-	-	-	-	2
115	0.9- 1.0	34.73-34.74	1,794	535,566	-	9	22	41	17	-	11	-
116	2.4- 2.6	34.92-34.93	3,547	539,113	-	-	-	-	-	33	67	-
117	2.2- 2.4	34.90-34.91	3,518	542,631	-	-	-	-	-	15	85	-
118	1.9- 2.0	34.72-34.73	1,744	544,375	-	16	11	67	6	-	-	-
119	-0.7--0.6	34.65-34.66	1,727	546,102	-	-	-	-	-	-	-	100
120	2.2- 2.4	34.62-34.63	3,440	549,542	27	67	3	2	1	-	-	-
121	1.4- 1.5	34.70-34.71	1,715	551,257	-	96	2	-	-	-	-	2
122	2.2- 2.4	34.61-34.62	3,396	554,653	22	72	4	1	1	-	-	-
123	1.8- 1.9	34.88-34.89	1,671	556,324	-	-	-	-	-	81	19	-
124	0.1- 0.2	34.70-34.71	1,644	557,968	-	-	79	5	-	-	16	-
125	1.8- 1.9	34.75-34.76	1,603	559,571	-	-	1	96	3	-	-	-
126	1.8- 1.9	34.89-34.90	1,564	561,135	-	-	-	-	-	98	2	-
127	2.4- 2.6	34.91-34.92	3,061	564,196	-	-	-	-	-	8	92	-
128	1.4- 1.5	34.72-34.73	1,515	565,711	-	16	21	54	-	-	3	6
129	0.0- 0.1	34.70-34.71	1,507	567,218	-	-	93	6	-	-	1	-
130	2.2- 2.4	34.60-34.61	2,998	570,216	24	69	4	1	1	-	-	1
131	-0.2--0.1	34.66-34.67	1,497	571,713	-	-	-	2	-	-	19	79
132	1.8- 1.9	34.72-34.73	1,489	573,202	-	23	18	50	9	-	-	-
133	2.6- 2.8	34.93-34.94	2,946	576,148	-	-	-	-	-	32	68	-
134	2.6- 2.8	34.94-34.95	2,939	579,087	-	-	-	-	-	82	18	-
135	1.7- 1.8	34.62-34.63	1,468	580,555	98	-	-	-	2	-	-	-
136	1.9- 2.0	34.66-34.67	1,459	582,014	9	83	3	-	2	-	1	2
137	1.9- 2.0	34.74-34.75	1,452	583,466	-	3	3	84	10	-	-	-
138	1.7- 1.8	34.64-34.65	1,448	584,914	90	8	1	-	1	-	-	-
139	1.5- 1.6	34.75-34.76	1,448	586,362	-	-	4	64	27	-	5	-

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
140	2.0- 2.2	34.72-34.73	2,872	589,234	-	11	3	81	5	-	-	-
141	1.1- 1.2	34.74-34.75	1,404	590,638	-	8	16	45	20	-	11	-
142	2.0- 2.2	34.65-34.66	2,807	593,445	13	74	8	1	3	-	-	1
143	1.7- 1.8	34.63-34.64	1,393	594,838	98	-	-	-	1	-	-	1
144	2.2- 2.4	34.59-34.60	2,778	597,616	35	58	4	1	1	-	-	1
145	1.3- 1.4	34.71-34.72	1,385	599,001	-	89	6	4	-	-	-	1
146	0.6- 0.7	34.72-34.73	1,353	600,354	-	1	37	36	2	-	24	-
147	1.6- 1.7	34.61-34.62	1,347	601,701	100	-	-	-	-	-	-	-
148	0.2- 0.3	34.71-34.72	1,306	603,007	-	-	54	8	-	-	38	-
149	2.2- 2.4	34.63-34.64	2,591	605,598	19	73	3	4	1	-	-	-
150	1.8- 1.9	34.87-34.88	1,288	606,886	-	-	-	-	-	53	47	-
151	-0.8--0.7	34.65-34.66	1,284	608,170	-	-	-	-	-	-	-	100
152	2.4- 2.6	34.94-34.95	2,526	610,696	-	-	-	-	-	99	1	-
153	-0.2--0.1	34.68-34.69	1,259	611,955	-	-	2	4	84	-	8	2
154	-0.4--0.3	34.66-34.67	1,251	613,206	-	-	-	3	-	-	2	95
155	2.0- 2.2	34.61-34.62	2,493	615,699	45	47	4	1	3	-	-	-
156	1.9- 2.0	34.87-34.88	1,240	616,939	-	-	-	-	-	1	99	-
157	1.2- 1.3	34.70-34.71	1,236	618,175	-	90	2	-	5	-	-	3
158	2.6- 2.8	34.95-34.96	2,463	620,638	-	-	-	-	-	98	2	-
159	0.4- 0.5	34.69-34.70	1,226	621,864	-	-	17	13	31	-	10	29
160	1.7- 1.8	34.60-34.61	1,216	623,080	98	-	-	-	2	-	-	-
161	-0.4--0.3	34.67-34.68	1,205	624,285	-	-	-	6	85	-	-	9
162	-0.4--0.3	34.65-34.66	1,194	625,479	-	-	-	-	-	-	-	100
163	1.9- 2.0	34.75-34.76	1,177	626,656	-	-	-	100	-	-	-	-
164	2.6- 2.8	34.92-34.93	2,343	628,999	-	-	-	-	-	10	90	-
165	2.8- 3.0	34.94-34.95	2,339	631,338	-	-	-	-	-	56	44	-
166	1.7- 1.8	34.87-34.88	1,149	632,487	-	-	-	-	-	73	27	-
167	0.3- 0.4	34.71-34.72	1,134	633,621	-	2	57	9	-	-	32	-
168	0.2- 0.3	34.68-34.69	1,128	634,749	-	-	7	2	29	-	14	48
169	1.7- 1.8	34.68-34.69	1,120	635,869	-	94	2	-	3	-	-	1
170	1.6- 1.7	34.69-34.70	1,114	636,983	-	94	4	-	1	-	-	1
171	0.0- 0.1	34.69-34.70	1,109	638,092	-	-	35	16	32	-	17	-
172	1.7- 1.8	34.72-34.73	1,105	639,197	-	26	23	39	10	-	-	2
173	2.4- 2.6	34.60-34.61	2,202	641,399	33	55	-	10	-	-	2	-
174	2.4- 2.6	34.57-34.58	2,200	643,599	29	62	-	6	-	-	3	-
175	2.8- 3.0	34.95-34.96	2,194	645,793	-	-	-	-	-	87	13	-
176	1.5- 1.6	34.72-34.73	1,096	646,889	-	26	23	35	5	-	3	8
177	2.8- 3.0	34.93-34.94	2,190	649,079	-	-	-	-	-	11	89	-
178	1.6- 1.7	34.72-34.73	1,037	650,116	-	23	21	38	11	-	1	6
179	2.0- 2.2	34.71-34.72	2,062	652,178	-	19	7	66	8	-	-	-
180	1.5- 1.6	34.70-34.71	1,026	653,204	-	94	4	-	1	-	-	1
181	1.8- 1.9	34.67-34.68	1,019	654,223	-	93	4	-	2	-	1	-
182	1.4- 1.5	34.75-34.76	1,019	655,242	-	-	1	66	24	-	9	-
183	1.7- 1.8	34.61-34.62	1,018	656,260	97	-	-	-	2	-	-	1
184	0.0- 0.1	34.67-34.68	1,003	657,263	-	-	1	2	13	-	14	70
185	2.4- 2.6	34.61-34.62	1,996	659,259	35	48	-	14	-	-	3	-
186	1.8- 1.9	34.62-34.63	980	660,239	96	2	1	-	1	-	-	-
187	1.8- 1.9	34.63-34.64	975	661,214	88	9	2	-	1	-	-	-
188	2.2- 2.4	34.93-34.94	1,922	663,136	-	-	-	-	-	100	-	-
189	2.4- 2.6	34.58-34.59	1,892	665,028	37	51	-	8	-	-	4	-
190	1.8- 1.9	34.61-34.62	931	665,959	98	-	1	-	1	-	-	-
191	-0.1- 0.0	34.70-34.71	930	666,889	-	-	97	3	-	-	-	-
192	1.5- 1.6	34.62-34.63	925	667,814	99	-	1	-	-	-	-	-
193	-0.5--0.4	34.66-34.67	908	668,722	-	-	-	3	2	-	-	95
194	1.4- 1.5	34.71-34.72	889	669,611	-	84	9	4	-	-	-	3
195	1.9- 2.0	34.62-34.63	887	670,498	81	13	3	-	1	-	1	1
196	1.7- 1.8	34.59-34.60	877	671,375	97	-	1	-	2	-	-	-
197	2.2- 2.4	34.58-34.59	1,742	673,117	33	56	7	2	1	-	-	1
198	1.8- 1.9	34.90-34.91	869	673,986	-	-	-	-	-	100	-	-
199	1.8- 1.9	34.58-34.59	864	674,850	97	-	1	-	1	-	-	1
200	-0.3--0.2	34.68-34.69	857	675,707	-	-	1	-	99	-	-	-
201	0.7- 0.8	34.70-34.71	855	676,562	-	22	36	14	10	-	7	11
202	2.4- 2.6	34.59-34.60	1,710	678,272	27	59	-	11	-	-	3	-
203	2.8- 3.0	34.96-34.97	1,706	679,978	-	-	-	-	-	98	2	-
204	2.4- 2.6	34.56-34.57	1,679	681,657	17	72	-	7	-	-	4	-
205	1.9- 2.0	34.71-34.72	828	682,485	-	39	29	16	16	-	-	-
206	3.0- 3.2	34.94-34.96	3,289	685,774	-	-	-	-	-	60	40	-
207	1.8- 1.9	34.76-34.77	820	686,594	-	-	-	100	-	-	-	-
208	2.6- 2.8	34.59-34.60	1,638	688,232	35	50	-	9	-	-	6	-
209	0.1- 0.2	34.71-34.72	817	689,049	-	-	95	3	-	-	2	-
210	2.0- 2.2	34.60-34.61	1,611	690,660	70	18	5	2	4	-	-	1

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
211	1.9- 2.0	34.76-34.77	801	691,461	-	-	-	100	-	-	-	-
212	1.8- 1.9	34.60-34.61	800	692,261	96	-	2	-	2	-	-	-
213	1.5- 1.6	34.85-34.86	798	693,059	-	-	-	-	-	87	13	-
214	2.2- 2.4	34.64-34.65	1,595	694,654	21	61	4	12	2	-	-	-
215	2.4- 2.6	34.62-34.63	1,582	696,236	21	54	-	21	-	-	4	-
216	1.8- 1.9	34.59-34.60	790	697,026	97	-	2	-	1	-	-	-
217	2.4- 2.6	34.90-34.91	1,578	698,604	-	-	-	-	-	-	100	-
218	1.9- 2.0	34.91-34.92	788	699,392	-	-	-	-	-	100	-	-
219	2.2- 2.4	34.89-34.90	1,563	700,955	-	-	-	-	-	-	100	-
220	2.0- 2.2	34.73-34.74	1,545	702,500	-	5	1	91	3	-	-	-
221	3.2- 3.4	34.96-34.98	3,062	705,562	-	-	-	-	-	71	29	-
222	2.2- 2.4	34.88-34.89	1,530	707,092	-	-	-	-	-	-	100	-
223	2.0- 2.2	34.74-34.75	1,477	708,569	-	-	-	97	-	-	3	-
224	2.4- 2.6	34.63-34.64	1,475	710,044	27	44	-	25	-	-	4	-
225	1.7- 1.8	34.88-34.89	732	710,776	-	-	-	-	-	98	2	-
226	1.9- 2.0	34.56-34.57	729	711,505	96	-	2	-	1	-	1	-
227	-0.1- 0.0	34.66-34.67	720	712,225	-	-	-	-	-	-	-	100
228	2.0- 2.2	34.70-34.71	1,433	713,658	-	37	16	36	11	-	-	-
229	0.3- 0.4	34.68-34.69	714	714,372	-	-	5	-	17	-	10	68
230	3.0- 3.2	34.96-34.98	2,745	717,117	-	-	-	-	-	89	11	-
231	2.4- 2.6	34.55-34.56	1,372	718,489	22	67	1	6	-	-	4	-
232	2.6- 2.8	34.60-34.61	1,367	719,856	45	37	-	10	-	-	8	-
233	1.9- 2.0	34.61-34.62	679	720,535	93	-	3	-	1	-	2	1
234	2.0- 2.2	34.92-34.93	1,332	721,867	-	-	-	-	-	98	2	-
235	1.6- 1.7	34.86-34.87	664	722,531	-	-	-	-	-	76	24	-
236	1.8- 1.9	34.57-34.58	663	723,194	98	-	1	-	1	-	-	-
237	2.6- 2.8	34.91-34.92	1,313	724,507	-	-	-	-	-	-	100	-
238	0.1- 0.2	34.67-34.68	656	725,163	-	-	-	1	8	-	15	76
239	1.4- 1.5	34.63-34.64	652	725,815	100	-	-	-	-	-	-	-
240	1.9- 2.0	34.60-34.61	649	726,464	95	-	2	-	1	-	1	1
241	1.9- 2.0	34.57-34.58	645	727,109	96	-	2	-	1	-	1	-
242	1.7- 1.8	34.71-34.72	642	727,751	-	33	34	-	16	-	4	13
243	3.4- 3.6	34.96-34.98	2,566	730,317	-	-	-	-	-	64	36	-
244	1.3- 1.4	34.75-34.76	639	730,956	-	-	2	64	11	-	23	-
245	-0.5--0.4	34.67-34.68	638	731,594	-	-	-	-	96	-	-	4
246	2.0- 2.2	34.75-34.76	1,275	732,869	-	-	-	99	-	-	1	-
247	-0.9--0.8	34.65-34.66	635	733,504	-	-	-	-	-	-	-	100
248	2.6- 2.8	34.56-34.57	1,247	734,751	53	30	-	11	-	-	6	-
249	1.9- 2.0	34.70-34.71	620	735,371	-	47	37	2	12	-	-	2
250	1.7- 1.8	34.69-34.70	620	735,991	-	82	6	-	9	-	2	1
251	-0.4--0.3	34.68-34.69	613	736,604	-	-	-	-	100	-	-	-
252	1.8- 1.9	34.71-34.72	613	737,217	-	40	48	-	9	-	-	3
253	2.6- 2.8	34.58-34.59	1,221	738,438	25	54	-	13	-	-	8	-
254	2.8- 3.0	34.92-34.93	1,208	739,646	-	-	-	-	-	1	99	-
255	0.3- 0.4	34.72-34.73	592	740,238	-	-	12	9	-	-	79	-
256	0.0- 0.1	34.71-34.72	576	740,814	-	-	100	-	-	-	-	-
257	2.6- 2.8	34.53-34.54	1,146	741,960	23	58	-	11	-	-	8	-
258	2.0- 2.2	34.68-34.69	1,144	743,104	-	56	24	6	13	-	-	1
259	2.0- 2.2	34.69-34.70	1,139	744,243	-	47	22	16	14	-	-	1
260	1.6- 1.7	34.71-34.72	567	744,810	-	40	35	-	6	-	7	12
261	2.6- 2.8	34.57-34.58	1,124	745,934	36	42	-	14	-	-	8	-
262	2.0- 2.2	34.54-34.55	1,112	747,046	92	-	2	2	4	-	-	-
263	2.6- 2.8	34.61-34.62	1,102	748,148	29	50	-	11	-	-	10	-
264	0.8- 0.9	34.73-34.74	550	748,698	-	10	14	53	8	-	15	-
265	2.8- 3.0	34.58-34.59	1,098	749,796	42	51	-	5	-	-	2	-
266	1.9- 2.0	34.69-34.70	548	750,344	-	42	41	-	10	-	1	6
267	2.0- 2.2	34.76-34.77	1,084	751,428	-	-	-	93	-	-	7	-
268	3.2- 3.4	34.94-34.96	2,148	753,576	-	-	-	-	-	60	40	-
269	1.9- 2.0	34.58-34.59	535	754,111	96	-	2	-	-	-	1	1
270	2.6- 2.8	34.54-34.55	1,059	755,170	18	61	-	12	-	-	9	-
271	2.6- 2.8	34.55-34.56	1,055	756,225	34	46	-	12	-	-	8	-
272	-0.9--0.8	34.64-34.65	527	756,752	-	-	-	-	-	-	-	100
273	3.0- 3.2	34.92-34.94	2,091	758,843	-	-	-	-	-	13	87	-
274	0.7- 0.8	34.76-34.77	522	759,365	-	-	-	-	-	1	99	-
275	1.6- 1.7	34.60-34.61	517	759,882	99	-	-	-	-	-	-	1
276	2.2- 2.4	34.70-34.71	1,032	760,914	-	2	-	98	-	-	-	-
277	1.2- 1.3	34.65-34.66	514	761,428	100	-	-	-	-	-	-	-
278	2.6- 2.8	34.52-34.53	1,026	762,454	17	62	-	12	-	-	9	-
279	2.0- 2.2	34.53-34.54	1,026	763,480	92	-	2	2	4	-	-	-
280	1.7- 1.8	34.86-34.87	503	763,983	-	-	-	-	-	25	75	-
281	1.1- 1.2	34.66-34.67	503	764,486	97	-	2	-	1	-	-	-

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
282	1.9- 2.0	34.55-34.56	503	764,989	93	–	3	1	1	–	1	1
283	1.8- 1.9	34.68-34.69	501	765,490	–	85	8	–	5	–	2	–
284	1.9- 2.0	34.59-34.60	499	765,989	94	–	2	–	1	–	2	1
285	0.4- 0.5	34.72-34.73	496	766,485	–	–	21	25	–	–	54	–
286	0.6- 0.7	34.75-34.76	495	766,980	–	–	–	–	–	3	97	–
287	2.0- 2.2	34.67-34.68	989	767,969	–	53	29	4	13	–	–	1
288	2.6- 2.8	34.96-34.97	989	768,958	–	–	–	–	–	100	–	–
289	2.8- 3.0	34.97-34.98	986	769,944	–	–	–	–	–	100	–	–
290	2.2- 2.4	34.71-34.72	986	770,930	–	–	–	100	–	–	–	–
291	1.9- 2.0	34.67-34.68	491	771,421	–	66	15	–	8	–	2	9
292	0.5- 0.6	34.69-34.70	489	771,910	–	–	27	–	26	–	18	29
293	2.4- 2.6	34.54-34.55	967	772,877	26	63	1	6	–	–	4	–
294	3.2- 3.4	34.92-34.94	1,933	774,810	–	–	–	–	–	62	38	–
295	1.3- 1.4	34.64-34.65	482	775,292	100	–	–	–	–	–	–	–
296	2.0- 2.2	34.55-34.56	963	776,255	90	–	3	2	4	–	–	1
297	1.8- 1.9	34.70-34.71	478	776,733	–	35	36	–	8	–	3	18
298	1.5- 1.6	34.71-34.72	475	777,208	–	56	24	4	6	–	3	7
299	2.0- 2.2	34.77-34.78	938	778,146	–	–	–	91	–	–	9	–
300	2.8- 3.0	34.59-34.60	937	779,083	52	37	–	8	–	–	3	–
301	1.6- 1.7	34.70-34.71	468	779,551	–	78	13	–	7	–	–	2
302	2.2- 2.4	34.50-34.51	933	780,484	90	–	6	2	1	–	1	–
303	1.7- 1.8	34.76-34.77	465	780,949	–	–	–	93	–	–	7	–
304	1.6- 1.7	34.87-34.88	463	781,412	–	–	–	–	–	97	3	–
305	3.6- 3.8	34.96-34.98	1,845	783,257	–	–	–	–	–	62	38	–
306	2.2- 2.4	34.69-34.70	919	784,176	–	7	–	92	1	–	–	–
307	2.0- 2.2	34.66-34.67	918	785,094	1	54	26	4	12	–	–	3
308	-0.1- 0.0	34.69-34.70	454	785,548	–	–	40	26	34	–	–	–
309	2.6- 2.8	34.62-34.63	908	786,456	38	40	–	9	–	–	13	–
310	0.4- 0.5	34.68-34.69	453	786,909	–	–	3	–	17	–	11	69
311	2.0- 2.2	34.59-34.60	852	787,761	80	–	8	3	7	–	–	2
312	2.2- 2.4	34.72-34.73	849	788,610	–	–	–	89	–	–	11	–
313	2.8- 3.0	34.56-34.57	847	789,457	28	57	–	11	–	–	4	–
314	2.8- 3.0	34.55-34.56	828	790,285	44	37	–	15	–	–	4	–
315	0.4- 0.5	34.73-34.74	413	790,698	–	–	–	1	–	–	99	–
316	-0.3--0.2	34.65-34.66	410	791,108	–	–	–	–	–	–	–	100
317	2.6- 2.8	34.51-34.52	818	791,926	17	62	–	11	–	–	10	–
318	2.8- 3.0	34.60-34.61	818	792,744	37	51	–	9	–	–	3	–
319	2.2- 2.4	34.49-34.50	816	793,560	89	–	6	3	1	–	1	–
320	0.5- 0.6	34.74-34.75	405	793,965	–	–	–	–	–	–	100	–
321	2.8- 3.0	34.54-34.55	808	794,773	62	21	–	14	–	–	3	–
322	2.2- 2.4	34.57-34.58	802	795,575	45	32	14	4	3	–	1	1
323	2.2- 2.4	34.66-34.67	801	796,376	–	45	5	48	2	–	–	–
324	2.2- 2.4	34.65-34.66	799	797,175	1	52	8	36	3	–	–	–
325	-0.6--0.5	34.66-34.67	398	797,573	–	–	–	4	–	–	–	96
326	2.2- 2.4	34.51-34.52	796	798,369	88	–	7	3	1	–	1	–
327	2.8- 3.0	34.57-34.58	792	799,161	32	59	–	6	–	–	3	–
328	2.0- 2.2	34.56-34.57	790	799,951	86	–	5	3	5	–	–	1
329	2.4- 2.6	34.46-34.47	786	800,737	81	7	5	1	–	–	5	1
330	1.0- 1.1	34.74-34.75	393	801,130	–	–	13	50	13	–	24	–
331	2.6- 2.8	34.50-34.51	782	801,912	24	56	–	10	–	–	10	–
332	0.9- 1.0	34.68-34.69	390	802,302	88	–	1	–	8	–	–	3
333	3.0- 3.2	34.56-34.58	1,514	803,816	37	51	–	8	–	–	4	–
334	2.2- 2.4	34.76-34.77	756	804,572	–	–	–	97	–	–	3	–
335	0.5- 0.6	34.72-34.73	377	804,949	–	–	51	28	–	–	21	–
336	2.2- 2.4	34.67-34.68	754	805,703	–	29	1	69	1	–	–	–
337	1.7- 1.8	34.58-34.59	374	806,077	94	–	2	–	3	–	–	1
338	2.0- 2.2	34.52-34.53	747	806,824	89	–	3	3	4	–	–	1
339	1.9- 2.0	34.68-34.69	373	807,197	–	31	38	–	12	–	3	16
340	2.2- 2.4	34.68-34.69	739	807,936	–	10	–	89	1	–	–	–
341	3.0- 3.2	34.58-34.60	1,475	809,411	48	43	–	5	–	–	4	–
342	2.0- 2.2	34.58-34.59	734	810,145	80	–	7	4	7	–	–	2
343	1.4- 1.5	34.84-34.85	365	810,510	–	–	–	–	–	76	24	–
344	2.8- 3.0	34.51-34.52	715	811,225	28	56	–	13	–	–	3	–
345	-0.5--0.4	34.68-34.69	357	811,582	–	–	–	–	100	–	–	–
346	2.8- 3.0	34.61-34.62	706	812,288	43	45	–	9	–	–	3	–
347	0.5- 0.6	34.73-34.74	353	812,641	–	–	3	22	–	–	75	–
348	2.0- 2.2	34.57-34.58	705	813,346	82	–	6	4	6	–	–	2
349	1.8- 1.9	34.69-34.70	352	813,698	–	44	23	–	15	–	3	15
350	2.6- 2.8	34.42-34.43	701	814,399	76	11	3	2	–	–	7	1
351	2.4- 2.6	34.45-34.46	699	815,098	84	3	5	1	–	–	6	1
352	2.4- 2.6	34.53-34.54	697	815,795	28	57	2	6	–	–	6	1

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
353	2.4- 2.6	34.88-34.89	697	816,492	-	-	-	-	-	-	100	-
354	-0.2--0.1	34.71-34.72	343	816,835	-	-	100	-	-	-	-	-
355	2.6- 2.8	34.43-34.44	686	817,521	70	16	3	2	-	-	8	1
356	2.6- 2.8	34.49-34.50	680	818,201	18	61	-	12	-	-	9	-
357	2.4- 2.6	34.47-34.48	678	818,879	77	10	5	1	-	-	6	1
358	3.2- 3.4	34.56-34.58	1,355	820,234	50	38	-	5	-	-	7	-
359	2.8- 3.0	34.50-34.51	677	820,911	16	67	-	13	-	-	4	-
360	2.4- 2.6	34.95-34.96	671	821,582	-	-	-	-	-	100	-	-
361	0.8- 0.9	34.77-34.78	333	821,915	-	-	-	-	-	2	98	-
362	2.2- 2.4	34.74-34.75	658	822,573	-	-	-	87	-	-	13	-
363	2.8- 3.0	34.53-34.54	653	823,226	46	33	-	17	-	-	4	-
364	-0.2--0.1	34.70-34.71	326	823,552	-	-	100	-	-	-	-	-
365	0.2- 0.3	34.67-34.68	326	823,878	-	-	-	-	2	-	15	83
366	2.8- 3.0	34.49-34.50	645	824,523	17	64	-	14	-	-	5	-
367	3.4- 3.6	34.92-34.94	1,286	825,809	-	-	-	-	-	55	45	-
368	0.6- 0.7	34.73-34.74	320	826,129	-	-	3	26	-	-	71	-
369	3.2- 3.4	34.58-34.60	1,280	827,409	42	42	-	9	-	-	7	-
370	-0.8--0.7	34.64-34.65	320	827,729	-	-	-	-	-	-	-	100
371	1.7- 1.8	34.70-34.71	319	828,048	-	40	19	-	24	-	6	11
372	2.2- 2.4	34.48-34.49	634	828,682	87	-	7	3	1	-	1	1
373	2.4- 2.6	34.76-34.77	633	829,315	-	-	-	89	-	-	11	-
374	2.6- 2.8	34.41-34.42	629	829,944	78	9	3	1	-	-	8	1
375	2.2- 2.4	34.52-34.53	615	830,559	81	-	11	4	2	-	1	1
376	2.2- 2.4	34.56-34.57	614	831,173	57	14	18	5	3	-	1	2
377	2.2- 2.4	34.78-34.79	612	831,785	-	-	-	95	-	-	5	-
378	1.4- 1.5	34.83-34.84	305	832,090	-	-	-	-	-	33	67	-
379	0.7- 0.8	34.73-34.74	302	832,392	-	-	5	14	-	-	81	-
380	3.8- 4.0	34.96-34.98	1,204	833,596	-	-	-	-	-	58	42	-
381	3.0- 3.2	34.98-35.00	1,192	834,788	-	-	-	-	-	99	1	-
382	2.8- 3.0	34.52-34.53	595	835,383	33	45	-	18	-	-	4	-
383	0.9- 1.0	34.78-34.79	297	835,680	-	-	-	-	-	2	98	-
384	-0.2--0.1	34.69-34.70	297	835,977	-	-	40	57	3	-	-	-
385	2.4- 2.6	34.52-34.53	591	836,568	30	51	5	4	-	-	8	2
386	2.8- 3.0	34.38-34.39	590	837,158	73	13	3	2	-	-	9	-
387	1.2- 1.3	34.75-34.76	295	837,453	-	-	-	67	4	-	29	-
388	1.6- 1.7	34.76-34.77	293	837,746	-	-	-	70	-	-	30	-
389	1.9- 2.0	34.77-34.78	289	838,035	-	-	-	90	-	-	10	-
390	2.6- 2.8	34.48-34.49	576	838,611	16	61	-	11	-	-	11	1
391	3.0- 3.2	34.54-34.56	1,147	839,758	33	56	-	7	-	-	4	-
392	2.8- 3.0	34.48-34.49	572	840,330	26	56	-	13	-	-	5	-
393	0.6- 0.7	34.74-34.75	284	840,614	-	-	-	2	-	-	98	-
394	2.2- 2.4	34.77-34.78	568	841,182	-	-	-	95	-	-	5	-
395	3.0- 3.2	34.46-34.48	1,135	842,317	17	63	-	14	-	-	6	-
396	0.7- 0.8	34.74-34.75	283	842,600	-	-	-	27	-	-	73	-
397	2.0- 2.2	34.78-34.79	560	843,160	-	-	-	75	-	-	25	-
398	2.4- 2.6	34.44-34.45	558	843,718	83	3	4	1	-	-	8	1
399	2.8- 3.0	34.91-34.92	556	844,274	-	-	-	-	-	-	100	-
400	1.5- 1.6	34.84-34.85	277	844,551	-	-	-	-	-	26	74	-
401	3.4- 3.6	34.94-34.96	1,108	845,659	-	-	-	-	-	53	47	-
402	1.3- 1.4	34.83-34.84	276	845,935	-	-	-	-	-	73	27	-
403	2.2- 2.4	34.75-34.76	552	846,487	-	-	-	93	-	-	7	-
404	2.8- 3.0	34.39-34.40	549	847,036	70	17	1	4	-	-	8	-
405	1.6- 1.7	34.85-34.86	271	847,307	-	-	-	-	-	20	80	-
406	2.4- 2.6	34.77-34.78	540	847,847	-	-	-	88	-	-	12	-
407	0.3- 0.4	34.67-34.68	269	848,116	-	-	-	-	3	-	-	97
408	2.4- 2.6	34.48-34.49	537	848,653	69	13	7	1	1	-	8	1
409	3.6- 3.8	34.98-35.00	1,068	849,721	-	-	-	-	-	96	4	-
410	2.2- 2.4	34.73-34.74	533	850,254	-	-	-	89	-	-	11	-
411	3.6- 3.8	34.56-34.58	1,054	851,308	37	44	-	11	-	-	8	-
412	3.2- 3.4	34.54-34.56	1,048	852,356	25	57	-	8	-	-	10	-
413	1.0- 1.1	34.79-34.80	261	852,617	-	-	-	-	-	1	99	-
414	2.2- 2.4	34.55-34.56	520	853,137	54	15	19	6	3	-	1	2
415	2.4- 2.6	34.89-34.90	517	853,654	-	-	-	-	-	-	100	-
416	3.2- 3.4	34.90-34.92	1,032	854,686	-	-	-	1	-	35	64	-
417	3.0- 3.2	34.52-34.54	1,031	855,717	58	30	-	8	-	-	4	-
418	3.4- 3.6	34.56-34.58	1,030	856,747	53	36	-	8	-	-	3	-
419	2.8- 3.0	34.45-34.46	514	857,261	16	66	-	14	-	-	4	-
420	2.8- 3.0	34.37-34.38	508	857,769	73	10	3	2	-	-	11	1
421	3.4- 3.6	34.54-34.56	1,015	858,784	36	54	-	6	-	-	4	-
422	2.6- 2.8	34.47-34.48	507	859,291	24	51	1	12	-	-	11	1
423	2.6- 2.8	34.76-34.77	505	859,796	-	-	-	69	-	-	31	-

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
424	3.2– 3.4	34.44–34.46	1,010	860,806	19	57	–	16	–	–	8	–
425	1.3– 1.4	34.82–34.83	252	861,058	–	–	–	–	–	14	86	–
426	-0.1– 0.0	34.71–34.72	251	861,309	–	–	100	–	–	–	–	–
427	1.8– 1.9	34.56–34.57	248	861,557	95	–	2	–	3	–	–	–
428	3.4– 3.6	34.98–35.00	988	862,545	–	–	–	–	–	98	2	–
429	3.8– 4.0	34.56–34.58	986	863,531	39	42	–	6	–	–	13	–
430	1.5– 1.6	34.61–34.62	245	863,776	98	–	1	–	1	–	–	–
431	2.4– 2.6	34.87–34.88	490	864,266	–	–	–	–	–	–	100	–
432	2.8– 3.0	34.44–34.45	489	864,755	22	62	–	12	–	–	4	–
433	2.6– 2.8	34.40–34.41	485	865,240	77	6	4	1	–	–	11	1
434	3.0– 3.2	34.50–34.52	969	866,209	52	28	–	16	–	–	4	–
435	2.8– 3.0	34.46–34.47	482	866,691	18	63	–	15	–	–	4	–
436	2.2– 2.4	34.79–34.80	480	867,171	–	–	–	93	–	–	7	–
437	2.4– 2.6	34.79–34.80	479	867,650	–	–	–	74	–	–	26	–
438	2.8– 3.0	34.47–34.48	475	868,125	28	55	–	13	–	–	4	–
439	1.2– 1.3	34.81–34.82	237	868,362	–	–	–	–	–	6	94	–
440	1.8– 1.9	34.91–34.92	236	868,598	–	–	–	–	–	100	–	–
441	1.1– 1.2	34.80–34.81	235	868,833	–	–	–	–	–	1	99	–
442	2.2– 2.4	34.54–34.55	466	869,299	55	11	19	7	3	–	3	2
443	3.8– 4.0	34.94–34.96	928	870,227	–	–	–	2	–	50	48	–
444	1.7– 1.8	34.89–34.90	232	870,459	–	–	–	–	–	100	–	–
445	2.8– 3.0	34.43–34.44	463	870,922	19	65	–	12	–	–	4	–
446	0.7– 0.8	34.75–34.76	231	871,153	–	–	–	–	–	–	100	–
447	0.8– 0.9	34.76–34.77	230	871,383	–	–	–	–	–	1	99	
448	3.4– 3.6	34.42–34.44	919	872,302	18	51	–	20	–	–	11	–
449	3.2– 3.4	34.52–34.54	911	873,213	32	48	–	7	–	–	13	–
450	3.2– 3.4	34.98–35.00	907	874,120	–	–	–	–	–	100	–	–
451	1.5– 1.6	34.76–34.77	223	874,343	–	–	–	48	–	–	52	–
452	2.2– 2.4	34.53–34.54	444	874,787	62	3	19	6	3	–	6	1
453	2.8– 3.0	34.36–34.37	441	875,228	74	5	4	2	–	–	14	1
454	2.4– 2.6	34.78–34.79	439	875,667	–	–	–	82	–	–	18	–
455	0.5– 0.6	34.68–34.69	219	875,886	–	–	2	–	2	–	–	96
456	2.4– 2.6	34.51–34.52	436	876,322	31	43	9	4	1	–	10	2
457	0.6– 0.7	34.69–34.70	218	876,540	–	–	32	–	3	–	11	54
458	3.4– 3.6	34.58–34.60	868	877,408	37	40	–	19	–	–	4	–
459	1.6– 1.7	34.77–34.78	217	877,625	–	–	–	47	–	–	53	–
460	1.9– 2.0	34.85–34.86	215	877,840	–	–	–	–	–	–	100	–
461	2.6– 2.8	34.85–34.86	430	878,270	–	–	–	1	–	–	99	–
462	2.6– 2.8	34.44–34.45	430	878,700	57	22	4	4	–	–	12	1
463	3.0– 3.2	34.34–34.36	856	879,556	72	15	1	5	–	–	7	–
464	2.4– 2.6	34.80–34.81	427	879,983	–	–	–	62	–	–	38	–
465	2.6– 2.8	34.80–34.81	426	880,409	–	–	–	61	–	–	39	–
466	3.0– 3.2	34.48–34.50	851	881,260	30	45	–	19	–	–	6	–
467	2.0– 2.2	34.51–34.52	425	881,685	82	–	5	5	7	–	–	1
468	3.2– 3.4	34.48–34.50	843	882,528	49	28	–	9	–	–	14	–
469	3.0– 3.2	34.60–34.62	835	883,363	38	38	–	18	–	–	6	–
470	2.4– 2.6	34.74–34.75	416	883,779	–	–	–	81	–	–	19	–
471	2.4– 2.6	34.49–34.50	415	884,194	56	20	10	2	1	–	10	1
472	3.2– 3.4	34.88–34.90	829	885,023	–	–	–	9	–	51	40	–
473	3.2– 3.4	34.38–34.40	829	885,852	15	75	–	8	–	–	2	–
474	1.0– 1.1	34.67–34.68	206	886,058	87	–	4	–	1	–	–	8
475	3.0– 3.2	34.40–34.42	820	886,878	17	72	–	10	–	–	1	–
476	0.9– 1.0	34.77–34.78	205	887,083	–	–	–	–	–	–	100	–
477	2.4– 2.6	34.64–34.65	410	887,493	3	12	–	70	–	–	15	–
478	2.6– 2.8	34.77–34.78	408	887,901	–	–	–	63	–	–	37	–
479	2.4– 2.6	34.68–34.69	407	888,308	–	–	–	83	–	–	17	–
480	2.0– 2.2	34.87–34.88	406	888,714	–	–	–	–	–	–	100	–
481	2.4– 2.6	34.72–34.73	403	889,117	–	–	–	65	–	–	35	–
482	2.0– 2.2	34.85–34.86	403	889,520	–	–	–	–	–	–	100	–
483	2.4– 2.6	34.75–34.76	403	889,923	–	–	–	80	–	–	20	–
484	2.8– 3.0	34.40–34.41	403	890,326	57	23	1	9	–	–	9	1
485	2.4– 2.6	34.71–34.72	401	890,727	–	–	–	79	–	–	21	–
486	2.4– 2.6	34.69–34.70	400	891,127	–	–	–	80	–	–	20	–
487	3.2– 3.4	34.50–34.52	797	891,924	47	28	–	9	–	–	16	–
488	2.6– 2.8	34.81–34.82	396	892,320	–	–	–	56	–	–	44	–
489	3.6– 3.8	34.40–34.42	792	893,112	8	55	–	21	–	–	16	–
490	1.9– 2.0	34.54–34.55	197	893,309	85	–	6	1	3	–	3	2
491	1.5– 1.6	34.86–34.87	197	893,506	–	–	–	–	–	97	3	–
492	3.8– 4.0	34.98–35.00	785	894,291	–	–	–	–	–	99	1	–
493	2.6– 2.8	34.75–34.76	392	894,683	–	–	–	60	–	–	40	–
494	3.6– 3.8	34.52–34.54	782	895,465	22	65	–	6	–	–	7	–

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
495	-0.6--0.5	34.68-34.69	195	895,660	-	-	-	-	100	-	-	-
496	3.0- 3.2	34.42-34.44	779	896,439	29	58	-	12	-	-	1	-
497	2.6- 2.8	34.79-34.80	388	896,827	-	-	-	61	-	-	39	-
498	2.8- 3.0	34.98-34.99	388	897,215	-	-	-	-	-	100	-	-
499	0.8- 0.9	34.74-34.75	194	897,409	-	-	-	38	-	-	62	-
500	2.6- 2.8	34.78-34.79	387	897,796	-	-	-	64	-	-	36	-
501	2.6- 2.8	34.46-34.47	385	898,181	34	40	1	10	-	-	14	1
502	2.6- 2.8	34.71-34.72	384	898,565	-	-	-	57	-	-	43	-
503	3.0- 3.2	34.44-34.46	767	899,332	29	48	-	17	-	-	6	-
504	2.8- 3.0	34.42-34.43	382	899,714	39	41	-	13	-	-	7	-
505	2.4- 2.6	34.86-34.87	381	900,095	-	-	-	-	-	-	100	-
506	2.6- 2.8	34.45-34.46	381	900,476	43	32	2	8	-	-	14	1
507	3.6- 3.8	34.54-34.56	757	901,233	62	21	-	9	-	-	8	-
508	2.2- 2.4	34.80-34.81	378	901,611	-	-	-	56	-	-	44	-
509	2.2- 2.4	34.87-34.88	376	901,987	-	-	-	-	-	-	100	-
510	3.8- 4.0	34.54-34.56	749	902,736	50	22	-	10	-	-	18	-
511	1.8- 1.9	34.78-34.79	186	902,922	-	-	-	24	-	-	76	-
512	3.6- 3.8	34.94-34.96	744	903,666	-	-	-	-	-	56	44	-
513	-0.3--0.2	34.71-34.72	186	903,852	-	-	100	-	-	-	-	-
514	1.0- 1.1	34.78-34.79	186	904,038	-	-	-	-	-	-	100	-
515	1.7- 1.8	34.77-34.78	185	904,223	-	-	-	60	-	-	40	-
516	3.6- 3.8	34.90-34.92	735	904,958	-	-	-	18	-	35	47	-
517	3.4- 3.6	34.36-34.38	732	905,690	12	69	1	12	-	-	6	-
518	0.7- 0.8	34.69-34.70	183	905,873	-	-	45	-	7	-	-	48
519	2.2- 2.4	34.47-34.48	365	906,238	79	-	11	5	2	-	2	1
520	2.6- 2.8	34.74-34.75	361	906,599	-	-	-	60	-	-	40	-
521	2.4- 2.6	34.50-34.51	361	906,960	37	33	11	4	1	-	12	2
522	1.4- 1.5	34.76-34.77	179	907,139	-	-	-	38	-	-	62	-
523	1.1- 1.2	34.79-34.80	179	907,318	-	-	-	-	-	-	100	-
524	2.6- 2.8	34.66-34.67	358	907,676	-	-	-	64	-	-	36	-
525	2.4- 2.6	34.67-34.68	355	908,031	-	-	-	82	-	-	18	-
526	2.6- 2.8	34.73-34.74	354	908,385	-	-	-	61	-	-	39	-
527	3.8- 4.0	34.40-34.42	708	909,093	23	32	-	22	-	-	23	-
528	2.4- 2.6	34.65-34.66	353	909,446	-	1	-	81	-	-	18	-
529	3.2- 3.4	34.46-34.48	690	910,136	35	34	-	19	-	-	12	-
530	3.4- 3.6	34.88-34.90	689	910,825	-	-	-	21	-	46	33	-
531	1.8- 1.9	34.84-34.85	172	910,997	-	-	-	-	-	-	100	-
532	3.6- 3.8	34.42-34.44	688	911,685	32	29	-	20	-	-	19	-
533	2.6- 2.8	34.82-34.83	343	912,028	-	-	-	43	-	-	57	-
534	3.8- 4.0	34.38-34.40	683	912,711	15	59	-	13	-	-	13	-
535	2.2- 2.4	34.85-34.86	341	913,052	-	-	-	-	-	-	100	-
536	3.0- 3.2	34.36-34.38	681	913,733	56	28	1	10	-	-	5	-
537	2.4- 2.6	34.66-34.67	340	914,073	-	-	-	81	-	-	19	-
538	1.9- 2.0	34.84-34.85	170	914,243	-	-	-	-	-	-	100	-
539	3.2- 3.4	34.42-34.44	677	914,920	25	38	-	23	-	-	14	-
540	2.6- 2.8	34.70-34.71	337	915,257	-	-	-	55	-	-	45	-
541	1.2- 1.3	34.80-34.81	168	915,425	-	-	-	-	-	-	100	-
542	2.6- 2.8	34.86-34.87	335	915,760	-	-	-	-	-	-	100	-
543	3.2- 3.4	35.00-35.02	670	916,430	-	-	-	-	-	100	-	-
544	2.2- 2.4	34.81-34.82	334	916,764	-	-	-	14	-	-	86	-
545	3.4- 3.6	34.52-34.54	666	917,430	39	45	-	10	-	-	6	-
546	2.0- 2.2	34.80-34.81	332	917,762	-	-	-	49	-	-	51	-
547	2.8- 3.0	34.82-34.83	332	918,094	-	-	-	60	-	-	40	-
548	2.4- 2.6	34.70-34.71	331	918,425	-	-	-	77	-	-	23	-
549	3.4- 3.6	34.40-34.42	656	919,081	30	38	-	19	-	-	13	-
550	1.1- 1.2	34.75-34.76	164	919,245	-	-	-	55	-	-	45	-
551	3.8- 4.0	34.52-34.54	653	919,898	21	56	-	10	-	-	13	-
552	1.4- 1.5	34.82-34.83	163	920,061	-	-	-	-	-	-	100	-
553	3.4- 3.6	34.90-34.92	652	920,713	-	-	-	7	-	62	31	-
554	2.6- 2.8	34.90-34.91	319	921,032	-	-	-	-	-	-	100	-
555	0.0- 0.1	34.66-34.67	159	921,191	-	-	-	-	-	-	10	90
556	3.4- 3.6	34.50-34.52	631	921,822	38	46	-	8	-	-	8	-
557	1.3- 1.4	34.81-34.82	157	921,979	-	-	-	-	-	-	100	-
558	2.6- 2.8	34.67-34.68	312	922,291	-	-	-	58	-	-	42	-
559	3.6- 3.8	34.92-34.94	624	922,915	-	-	-	5	-	50	45	-
560	3.4- 3.6	34.46-34.48	623	923,538	47	29	-	9	-	-	15	-
561	3.4- 3.6	34.48-34.50	619	924,157	46	33	-	8	-	-	13	-
562	2.4- 2.6	34.73-34.74	309	924,466	-	-	-	66	-	-	34	-
563	2.8- 3.0	34.84-34.85	306	924,772	-	-	-	34	-	-	66	-
564	1.8- 1.9	34.86-34.87	153	924,925	-	-	-	-	-	-	100	-
565	3.0- 3.2	34.32-34.34	610	925,535	80	4	5	-	-	-	11	-

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
566	3.2- 3.4	34.32-34.34	606	926,141	56	26	–	8	–	–	10	–
567	2.8- 3.0	34.77-34.78	302	926,443	–	–	–	74	–	–	26	–
568	2.4- 2.6	34.43-34.44	301	926,744	75	1	5	2	1	–	16	–
569	2.6- 2.8	34.39-34.40	300	927,044	69	2	8	4	–	–	17	–
570	3.4- 3.6	35.00-35.02	598	927,642	–	–	–	–	–	100	–	–
571	2.8- 3.0	34.79-34.80	298	927,940	–	–	–	66	–	–	34	–
572	2.0- 2.2	34.86-34.87	298	928,238	–	–	–	–	–	–	100	–
573	3.4- 3.6	34.44-34.46	594	928,832	31	31	–	17	–	–	21	–
574	1.8- 1.9	34.77-34.78	148	928,980	–	–	–	71	–	–	29	–
575	2.6- 2.8	34.63-34.64	296	929,276	27	1	–	32	–	–	40	–
576	1.0- 1.1	34.76-34.77	148	929,424	–	–	–	19	–	–	81	–
577	2.6- 2.8	34.89-34.90	295	929,719	–	–	–	–	–	–	100	–
578	1.7- 1.8	34.83-34.84	147	929,866	–	–	–	–	–	–	100	–
579	0.9- 1.0	34.75-34.76	147	930,013	–	–	–	33	–	–	67	–
580	2.8- 3.0	34.81-34.82	293	930,306	–	–	–	63	–	–	37	–
581	3.8- 4.0	34.50-34.52	583	930,889	36	49	–	6	–	–	9	–
582	1.5- 1.6	34.83-34.84	145	931,034	–	–	–	–	–	–	100	–
583	1.6- 1.7	34.59-34.60	144	931,178	94	–	1	–	4	–	–	1
584	2.6- 2.8	34.65-34.66	287	931,465	–	–	–	55	–	–	45	–
585	3.2- 3.4	34.40-34.42	573	932,038	25	56	1	9	–	–	9	–
586	4.0- 4.5	34.50-34.55	3,574	935,612	33	32	–	7	–	1	27	–
587	1.6- 1.7	34.84-34.85	141	935,753	–	–	–	–	–	–	100	–
588	2.8- 3.0	34.76-34.77	282	936,035	–	–	–	77	–	–	23	–
589	1.9- 2.0	34.78-34.79	141	936,176	–	–	–	46	–	–	54	–
590	2.8- 3.0	34.83-34.84	282	936,458	–	–	–	42	–	–	58	–
591	1.3- 1.4	34.76-34.77	140	936,598	–	–	–	27	–	–	73	–
592	1.5- 1.6	34.77-34.78	140	936,738	–	–	–	37	–	–	63	–
593	2.8- 3.0	34.78-34.79	278	937,016	–	–	–	66	–	–	34	–
594	2.2- 2.4	34.94-34.95	278	937,294	–	–	–	–	–	100	–	–
595	2.8- 3.0	34.80-34.81	278	937,572	–	–	–	57	–	–	43	–
596	3.2- 3.4	34.60-34.62	553	938,125	31	12	–	40	–	–	17	–
597	2.6- 2.8	34.68-34.69	276	938,401	–	–	–	51	–	–	49	–
598	3.2- 3.4	34.30-34.32	550	938,951	82	4	1	2	–	–	11	–
599	2.8- 3.0	34.41-34.42	275	939,226	42	29	1	15	–	–	12	1
600	1.7- 1.8	34.85-34.86	137	939,363	–	–	–	–	–	–	100	–
601	3.6- 3.8	34.46-34.48	548	939,911	42	43	–	7	–	–	8	–
602	3.8- 4.0	34.36-34.38	546	940,457	23	58	–	10	–	–	9	–
603	0.8- 0.9	34.75-34.76	136	940,593	–	–	–	17	–	–	83	–
604	2.6- 2.8	34.69-34.70	272	940,865	–	–	–	50	–	–	50	–
605	2.8- 3.0	34.35-34.36	272	941,137	70	4	5	2	–	–	17	2
606	2.6- 2.8	34.84-34.85	271	941,408	–	–	–	11	–	–	89	–
607	1.7- 1.8	34.78-34.79	135	941,543	–	–	–	21	–	–	79	–
608	2.4- 2.6	34.84-34.85	269	941,812	–	–	–	1	–	–	99	–
609	4.5- 5.0	34.50-34.55	3,356	945,168	33	31	–	2	–	7	27	–
610	1.4- 1.5	34.77-34.78	134	945,302	–	–	–	18	–	–	82	–
611	-0.7--0.6	34.64-34.65	134	945,436	–	–	–	–	–	–	–	100
612	2.4- 2.6	34.81-34.82	266	945,702	–	–	–	61	–	–	39	–
613	2.6- 2.8	34.97-34.98	266	945,968	–	–	–	–	–	100	–	–
614	1.6- 1.7	34.82-34.83	133	946,101	–	–	–	–	–	–	100	–
615	1.5- 1.6	34.81-34.82	133	946,234	–	–	–	–	–	–	100	–
616	3.6- 3.8	34.34-34.36	523	946,757	14	73	1	3	–	–	9	–
617	-0.3--0.2	34.69-34.70	129	946,886	–	–	10	87	3	–	–	–
618	2.6- 2.8	34.83-34.84	257	947,143	–	–	–	32	–	–	68	–
619	4.0- 4.5	34.35-34.40	3,210	950,353	18	52	–	16	–	–	14	–
620	3.6- 3.8	34.38-34.40	512	950,865	30	47	–	10	–	–	13	–
621	2.0- 2.2	34.84-34.85	256	951,121	–	–	–	–	–	–	100	–
622	0.8- 0.9	34.69-34.70	128	951,249	–	–	21	–	7	–	–	72
623	1.1- 1.2	34.77-34.78	128	951,377	–	–	–	13	–	–	87	–
624	3.6- 3.8	34.36-34.38	509	951,886	27	50	–	14	–	–	9	–
625	3.6- 3.8	34.58-34.60	509	952,395	50	21	–	14	–	–	15	–
626	3.6- 3.8	34.44-34.46	508	952,903	45	33	–	8	–	–	14	–
627	3.4- 3.6	34.24-34.26	508	953,411	70	1	5	–	–	–	24	–
628	2.8- 3.0	34.89-34.90	254	953,665	–	–	–	–	–	–	100	–
629	3.0- 3.2	34.38-34.40	507	954,172	27	51	–	18	–	–	4	–
630	3.2- 3.4	34.28-34.30	499	954,671	74	6	4	–	–	–	16	–
631	4.0- 4.5	34.55-34.60	3,116	957,787	40	31	–	4	–	3	22	–
632	3.6- 3.8	34.50-34.52	498	958,285	35	44	–	10	–	–	11	–
633	3.2- 3.4	34.34-34.36	498	958,783	33	46	–	13	–	–	8	–
634	2.2- 2.4	34.86-34.87	247	959,030	–	–	–	–	–	–	100	–
635	1.9- 2.0	34.79-34.80	123	959,153	–	–	–	25	–	–	75	–
636	3.0- 3.2	34.76-34.78	492	959,645	–	–	–	70	–	1	29	–

Rank	T°	S, ‰	Volume	Total Volume	N. Pac.	S. Pac.	So. O. Pac.	Ind.	So. O. Ind.	N. Atl.	S. Atl.	So. O. Atl.
637	1.4- 1.5	34.80-34.81	121	959,766	-	-	-	1	-	-	99	-
638	1.8- 1.9	34.80-34.81	121	959,887	-	-	-	48	-	-	52	-
639	2.6- 2.8	34.64-34.65	242	960,129	-	-	-	49	-	-	51	-
640	1.2- 1.3	34.78-34.79	121	960,250	-	-	-	9	-	-	91	-
641	1.4- 1.5	34.85-34.86	120	960,370	-	-	-	-	-	97	3	-
642	3.4- 3.6	34.26-34.28	478	960,848	75	7	1	2	-	-	15	-
643	0.4- 0.5	34.67-34.68	119	960,967	-	-	-	-	12	-	-	88
644	3.8- 4.0	34.34-34.36	476	961,443	33	57	-	6	-	-	4	-
645	1.4- 1.5	34.62-34.63	118	961,561	94	-	2	-	3	-	-	1
646	3.2- 3.4	34.36-34.38	468	962,029	22	61	-	13	-	-	4	-
647	3.0- 3.2	34.90-34.92	465	962,494	-	-	-	-	-	-	100	-
648	3.0- 3.2	34.78-34.80	464	962,958	-	-	-	58	-	12	30	-
649	3.0- 3.2	34.80-34.82	464	963,422	-	-	-	56	-	9	35	-
650	2.0- 2.2	34.83-34.84	232	963,654	-	-	-	19	-	-	81	-
651	1.3- 1.4	34.79-34.80	116	963,770	-	-	-	2	-	-	98	-
652	2.8- 3.0	34.75-34.76	231	964,001	-	-	-	76	-	-	24	-
653	3.0- 3.2	34.82-34.84	462	964,463	-	-	-	66	-	2	32	-
654	-0.7--0.6	34.66-34.67	114	964,577	-	-	-	11	-	-	-	89
655	2.8- 3.0	34.62-34.63	227	964,804	56	-	-	34	-	-	10	-
656	0.0- 0.1	34.65-34.66	113	964,917	-	-	-	-	4	-	-	96
657	3.8- 4.0	34.92-34.94	450	965,367	-	-	-	23	-	44	33	-
658	2.6- 2.8	34.72-34.73	225	965,592	-	-	-	43	-	-	57	-
659	5.5- 6.0	34.30-34.35	2,806	968,398	2	92	-	2	-	-	4	-
660	3.6- 3.8	34.88-34.90	444	968,842	-	-	-	20	-	25	55	-
661	3.8- 4.0	35.00-35.02	440	969,282	-	-	-	-	-	100	-	-
662	0.9- 1.0	34.74-34.75	110	969,392	-	-	-	65	-	-	35	-
663	3.8- 4.0	34.32-34.34	438	969,830	26	54	-	8	-	-	12	-
664	3.4- 3.6	34.38-34.40	437	970,267	26	45	1	7	-	-	21	-
665	3.2- 3.4	34.86-34.88	436	970,703	-	-	-	37	-	39	24	-
666	2.4- 2.6	34.85-34.86	217	970,920	-	-	-	-	-	-	100	-
667	2.8- 3.0	34.88-34.89	214	971,134	-	-	-	-	-	-	100	-
668	2.8- 3.0	34.74-34.75	214	971,348	-	-	-	76	-	-	24	-
669	4.5- 5.0	34.30-34.35	2,675	974,023	13	80	-	3	-	-	4	-
670	3.0- 3.2	34.62-34.64	426	974,449	23	-	-	61	-	-	16	-
671	3.0- 3.2	34.74-34.76	422	974,871	-	-	-	65	-	-	35	-
672	3.6- 3.8	34.48-34.50	422	975,293	39	41	-	9	-	-	11	-
673	3.0- 3.2	34.30-34.32	421	975,714	68	3	7	-	-	-	22	-
674	2.8- 3.0	34.34-34.35	208	975,922	62	4	8	2	-	-	22	2
675	3.2- 3.4	34.26-34.28	416	976,338	58	-	7	-	-	-	35	-
676	3.4- 3.6	34.86-34.88	414	976,752	-	-	-	32	-	19	49	-
677	5.0- 5.5	34.50-34.55	2,586	979,338	30	30	-	3	-	7	30	-
678	2.8- 3.0	34.87-34.88	203	979,541	-	-	-	-	-	-	100	-
679	3.4- 3.6	34.30-34.32	405	979,946	33	51	-	6	-	-	10	-
680	4.0- 4.5	34.30-34.35	2,513	982,459	25	67	-	4	-	-	4	-
681	1.0- 1.1	34.75-34.76	101	982,560	-	-	-	72	-	-	28	-
682	3.6- 3.8	35.02-35.04	402	982,962	-	-	-	-	-	100	-	-
683	3.8- 4.0	34.80-34.82	402	983,364	-	-	-	32	-	1	67	-
684	-0.3--0.2	34.70-34.71	100	983,464	-	-	100	-	-	-	-	-
685	2.8- 3.0	34.64-34.65	198	983,662	-	-	-	89	-	-	11	-
686	3.8- 4.0	34.42-34.44	395	984,057	38	37	-	18	-	-	7	-
687	3.4- 3.6	34.34-34.36	394	984,451	27	63	-	8	-	-	2	-
688	6.5- 7.0	34.35-34.40	2,456	986,907	3	94	-	1	-	-	2	-
689	3.4- 3.6	35.02-35.04	392	987,299	-	-	-	-	-	100	-	-
690	3.8- 4.0	34.44-34.46	392	987,691	36	49	-	7	-	-	8	-
691	4.0- 4.5	34.45-34.50	2,431	990,122	25	38	-	11	-	-	26	-
692	2.0- 2.2	34.50-34.51	194	990,316	62	-	11	10	15	-	-	2
693	2.8- 3.0	34.65-34.66	192	990,508	-	-	-	86	-	-	14	-