SHELLFISH INVESTIGATION - PROGRESS REPORT NO. 21

October 10, 1950

Observations on Horseclams of the 1949-1950 Set in Yaquina Bay

Another sample of horseclams was taken from the study area in Yaquina Bay (see Shellfish Progress Report No. 20) on August 29, 1950, at a -0.5 foot tide. One-hundred-fifty-nine clams were obtained, brought back to the laboratory and measured for length and depth. Plotting a length frequency graph showed two distinct modes or age groups (Figure 1). The first mode averaging 13.8 millimeters represents the 1950 clam set, and the second mode averaging 61.1 millimeters represents last year's set (1949). This second mode shows a 27.2 millimeter increase in length or an increase of 80.2 percent in a little less than five months time--as compared with an April 7 sample of this year. The 1950 set was not evident in the April sample, which could be answered by several theories (1) either they were too small for detection or (2) they had not set as yet. To support this latter theory it was evident, as shown by the "condition" studies of the adult horseclams in Yaquina Bay (Progress Report No. 20), spawning was late and less complete, the last of spawning occurring in May. Consequently, it would seem that the horseclam larvae had not yet set in April.

The surprising length spread of the April sample, 13 to 60 millimeters, a spread of 47 millimeters made itself evident again in the August sample which had a length spread of 45 millimeters (41 mm. to 86 mm.). This year's set shows a smaller length spread of 32 millimeters (2 to 34 mm.), perhaps another indication of a retarded spawning this year.

Further length-depth data is presented (Figure2). The data is grouped in 5 millimeters length groups, the depth being averaged for each group. There appears to be a slight difference in the smaller clams (about 5 to 25 mm. length group) the curve climbing more rapidly as the length increases.

Sampling is continuing to determine growth and time of formation of growth rings on both the exterior of the valves and within the ligament bed.

On the Determination of the Age of the Horseclam, (Schizothaerus nuttallii)

With clams such as the razor clam, the cockle clam, and the butter clam it has been shown with certainty that the age of the clam can be read on the shell in the form of annual growth rings or check marks. It is the intention of this preliminary report to acquaint the reader with the methods this laboratory has devised in an attempt to read the age of the horseclam.

Growth lines are formed throughout the year but at a varying rate which is in direct relation with the growing period. By this it is meant that during a poor growth period the distance between growth lines is small. Similarly during a good growth period the distance between growth lines is large. A succession of retarded growth lines gives more lines per unit of length and shows up on the shell as a comparatively wide check mark or annual growth ring. These are the rings which are counted in the determination of the age of a shell by the shell-reading method.

Because there appears to be some difficulty in reading shells of the horseclam, especially the older specimens, another method has been sought. It was found that the ligament bed which is located directly beneath the umbone bore definite bluish rings. It is the purpose of this report to compare the readability of each of these methods.

Definite standards for reading each method were of necessity set up.

Shell Reading: Readings of growth rings were based on the following criteria which are listed in order of importance.

1. Definite changes in contour of the shell.
2. A close succession of lines causing growth rings.
3. Dark rings formed simultaneously with the growth rings by the periostracum.

Growth rings are usually associated with a change of contour of the shell. The third criteria listed is an aid in locating growth but is not always present. In younger clams, one to five years, dark rings are generally present for each annual growth ring but as the clam grows older these rings are worn off by constant contact with the sand and abrasives mixed with the sand. Therefore, a combination of the three criteria is generally used when reading a shell.

Age determination of the horseclam offers other difficulties. It appears that for the first three or four years the horseclam makes a more or less standard growth, this showing up quite clearly on the shell. As the clam grows progressively older age determination by this method becomes more uncertain. Annual growth rings are closer together thus increasing the chance for error in reading the shell. In older individuals contour lines are less pronounced and the periostracum rings become uncertain.

Ligament Bed Reading: Readings of ligament bed rings were based on the following criteria:

1. Only definite bluish lines were read.
2. Changes in contour of the ligament bed also included.

Because of the contour of the shell it is impossible to see the first check on older shells. Where this ring could not be seen it was assumed to be present and counted as such.

To compare these two methods, shell reading versus ligament scar reading, two groups of shells were examined, one group of 46 specimens from Yaquina Bay taken March 22, 1948, and another group of 23 specimens from Yaquina Bay taken May 25, 1948. For each group two readings were taken on each specimen, i.e., a shell reading and a ligament reading, and a sample correlation test was made between the two readings. These readings were taken independently from one another with no back reference.

The first group (46 clams from Yaquina Bay) was analyzed for age determination. The right and left valves were separated and numbered so that the two readings could be compared for an individual clam. For each valve two readings were made, (1) the number of annual rings showing on the exterior surface of the shell and, (2) the number of annual rings showing on the ligament bed. The same biologist read both sets of shells.

Statistical analysis of the derived data showed the following:

1. Ligament ring readings of one set (L_1) vs. ligament ring readings of the other set (L_2). Analysis of variance, using an "F Test", showed the variances to be equal ($\sigma_1^2 = \sigma_2^2$, $F = 1.0$ with 45, 45 d. f.). Further testing the difference between the two means by the "t test", the null hypothesis being that the two means are equal ($\mu_1 = \mu_2$), we accept the hypothesis (t=0.684 with 90 d. f.). Standard deviation for L_1 is 1.26, for L_2 is 1.27.

It is therefore concluded that either the right or the left ligament bed can be used for this work and, that a reader can, with a degree of certainty, duplicate his results. Any ligament readings in the future can be made regardless of which ligament is available.

2. Shell ring readings of one set (S_1) vs. shell ring readings of the other set (S_2). Analysis of variance showed the variances to be "equal" (F=1.31 with 45, 45 d. f). Testing the difference between the two means shows $\mu_1 \neq \mu_2$ the "t value" (t=2.79 with 90 d.f.) lying outside the one percent level. Standard deviation for S_1 is 1.02, for S_2 is 1.17.

In this instance the shell readings were not duplicated. This could mean one of several things--either there is a difference between the right and left valve, or the definition of the growth rings is such that it is difficult for an individual to duplicate his results, due to inexperience, obscure growth rings, etc. It is the writer's opinion the latter is the true concept. Both valves of the horseclam to all outward appearances are identical. (There is a difference in the hinge-teeth make-up.)

3. <u>The difference between ligament ring readings of one set (L_1) and the other set (L_2).</u>

Null hypothesis: $\mu_1 - \mu_2 = \mu_d = 0$
t=0.68 with 45 d.f.
We accept hypothesis $\mu_d = 0$
Standard deviation is 1.26

This test is more or less a duplication of No. 1 but the individual differences are compared here.

4. <u>The difference between shell ring readings of one set (S_1) and the other set (S_2).</u>

Null hypothesis: $\mu_1 - \mu_2 = \mu_d = 0$
t=2.69 with 45 d.f., right on 1% level
We reject hypothesis $\mu_d \neq 0$
Standard deviation is 1.15

5. <u>Ligament ring readings of one set (L_1, L_2) vs. shell ring readings of the same set (S_1, S_2).</u>

A. Analysis of variance (L_1 vs S_1)

Null hypothesis: $\sigma_1^2 = \sigma_2^2$
F=1.53 with 45, 45 d.f.
Accept hypothesis $\sigma_1^2 = \sigma_2^2$

B. Difference between two means (L_1 vs S_1)

Null hypothesis $\mu_1 = \mu_2$
t=2.44 with 90 d.f. falls between 1% and 5% level
The acceptance of the hypothesis is doubtful $\mu_1 = \mu_2$ (?)

C. Standard deviation (L_1)= 1.26

D. Standard deviation (S_1)= 1.02

E. Analysis of variance (L_2 vs S_2)

Null hypothesis: $\sigma_1^2 = \sigma_2^2$
F=1.17 with 45, 45 d.f.
Accept hypothesis $\sigma_1^2 = \sigma_2^2$

F. Difference between two means (L_2 vs S_2)

Null hypothesis $\mu_1 = \mu_2$
t=0.929 with 90 d.f.
Accept hypothesis $\mu_1 = \mu_2$

G. Standard deviation (L_2) = 1.27

H. Standard deviation (S_2) = 1.17

From the above tests in Section 5 it can be concluded:

<u>L_1 vs S_1</u>. Although the variances were statistically the same, the means were not. Referring to Section 2, the means in that case are again not equal. The common figures in Section 2 and the first part of Section 5 (5B) are those of S_1, the shell ring readings of the first set. Now referring to 5F where L_2 and S_2 are being compared it is found that both readings compare favorably. It appears, then, that the shell ring readings of the first set (S_1) are causing the difference. The cause of this can only be guessed at; however, the reasons listed in Section 2 may be applicable.

<u>L_2 vs S_2</u>. In this instance both the variances and the means were similar. The ligament rings could be read with the same degree of accuracy as the shell rings.

6. <u>Summary</u>: Assigning the symbols L_1, S_1 for the average ligament bed ring readings and average shell ring readings respectively of one shell set, and L_2, S_2 for the other set, the following relationship exists:

$$S_1 \pm S_2 \text{ and } L_1 = L_2 = S_2$$

The fact that $S_1 \pm S_2$ is disconcerting in that it was expected at the outset of the analysis that $L_1 = L_2 = S_1 = S_2$. The outcome indicates that the difficulty in reading the age in the horseclam lies in the interpretation of the annual rings on the exterior of the valves. Practice in reading probably will overcome this difference. It is interesting to note this difference did not exist between the two sets of ligament readings, the experience in reading being constant in both ligament and shell readings.

To test one reader against another and for detection of differences, if any, a group of 23 clams taken May 25, 1948, in Yaquina Bay was analyzed. Only one valve was used in this case irrespective of right or left valve. Readings were taken independently from one another with no back reference. The criteria followed in reading was the same as set up in the preceeding experiment.

1. First reader's figures--Ligament (L_1) vs shell (S_1).

   A. Analysis of variance

      Null hypothesis $\sigma_1^2 = \sigma_2^2$
      F=1.88 with 22, 22 d.f.
      Accept hypothesis $\sigma_1^2 = \sigma_2^2$

   B. Difference between two means

      Null hypothesis: $\mu_1 = \mu_2$
      t=2.015 with 44 d.f., right at 5% level
      Outcome doubtful.

2. Second reader's figures--Ligament (L_2) vs shell (S_2)

   A. Analysis of variance

      Null hypothesis: $\sigma_1^2 = \sigma_2^2$
      F=1.147 with 22, 22 d.f.
      Accept hypothesis $\sigma_1^2 = \sigma_2^2$

   B. Difference between two means

      Null hypothesis $\mu_1 = \mu_2$
      t=0.667 with 44 d.f.
      Accept hypothesis $\mu_1 = \mu_2$

3. Ligament (L_1) vs ligament (L_2)--First reader vs second reader

   A. Analysis of variance

      Null hypothesis: $\sigma_1^2 = \sigma_2^2$
      F=1.63 with 22, 22 d.f.
      Accept hypothesis $\sigma_1^2 = \sigma_2^2$

   B. Difference between two means

Null hypothesis: $\mu_1 = \mu_2$
t=0.266 with 44 d.f.
Accept hypothesis $\mu_1 = \mu_2$

C. Standard deviation (L_1) = 0.978

D. Standard deviation (L_2) = 1.25

4. Shell (S_1) vs shell (S_2)--First reader vs second reader

A. Analysis of variance

Null hypothesis: $\sigma_1^2 = \sigma_2^2$
F=3.53 with 22, 22 d.f.
Reject hypothesis $\sigma_1^2 \neq \sigma_2^2$

B. Difference between two means

Null hypothesis: $\mu_1 = \mu_2$
t=2.685 with 44 d.f.
Reject hypothesis $\mu_1 \neq \mu_2$

C. Standard deviation (S_1) = 0.71

D. Standard deviation (S_2) = 1.34

5. Summary: Ligament bed ring readings vs shell ring readings in one case proved to be the same, both in variances and arithmetic means. The other reader's (first reader) outcome was doubtful, the variances being closely alike but the means probably different.

Ligament readings vs ligament readings revealed no significant difference between the two sets of data. The variances were alike as were the means. The same set of shells can be read with the same results by two readers using the ligament rings in the ligament bed.

Shell readings vs shell readings showed differences in both variances and means. Thus, it appears that duplication of readings by two readers for the same set of shells, reading shell rings offers difficulty. Here again, as in the March 22 group, the reading of the growth rings on the exterior of the shell causes trouble.

The relationship among the preceeding is:

$L_1 = L_2 = S_2$ and $S_1 \pm S_2$, where

L_1 = ligament reading of first reader

L_2 = ligament reading of second reader

S_1 = shell reading of first reader

S_2 = shell reading of second reader

Conclusion

Looking at the results of both the March 22 and the May 25 groups it is evident that:

1. Either ligament of the right or the left valve can be read with the assurance that there will be no significant difference in the results.

2. Two different readers can duplicate their results by both reading the same set of ligament beds.

3. The shell ring readings of the right valve cannot be substituted for the shell ring readings of the left valve. In this test they proved inequal ($\mu_1 \neq \mu_2$, but $\sigma_1^2 = \sigma_2^2$). It is believed by the writer that the difference was not in the number of annular rings per shell but in the difficulty in distinguishing the rings by the reader.

4. One reader cannot duplicate the shell reading results of another reader reading the same set of shells. This certainly indicates that shells are harder to read than ligament beds.

5. The results of the comparison of the ligament bed readings of the left valve against the shell reading of the same valve are various. In one instance there is no significant difference between the means and variances but in the other case there are significant differences.

6. The results of the comparison of one reader's readings between the ligament bed and the shell of the same valve are also various. In one case there is a significant difference in the means and in the other case there is no significant difference.

7. It was noted in reading the shells that there were varying degrees of readability, the degree of readability apparently closely related to the age of the clam. The older the clam the more difficult it was to read because of the crowding of the growth rings at the edge of the shell (slower growth rate on the older clams), and the fact that the shell becomes smooth (erosion, abrasion, etc.) with increasing age. As a result of the tests in this report and of more familiarity with the problems involved, methods of age determination will be used in the following order:

A. Read the outside of the shell when the annual rings are distinct. This is certainly the faster method.

B. Read the ligament bed when the annual rings on the outside of the shell are not clear.

C. If the ligament bed offers difficulty in reading, cross section it and examine under a misroscope. The growth rings show up very clearly when cross sectioned.

GENERAL ACTIVITIES

Another horseclam sample of adult clams was taken August 29, 1950, in Yaquina Bay for condition studies. This sample gave percent edible meat recovery from whole uncleaned clams of 26.2 percent, slightly less than the previous sample.

A survey of a proposed log boom area at Idaho Point in Yaquina Bay for shellfish populations was made September 1 at a 0.3 foot tide. No shellfish being present due to height of flats (+5 to +8 ft.) this proposed project was not objected to.

September 15 Tillamook and Netarts Bays were visited to pick up information on this summer's clamming activities. Apparently Netarts Bay had quite a successful season, all boat moorage operators reporting limits of clams for all diggers. All moorage operators consulted approved of existing clam regulations. Compilation of exact catch data is not complete and will be reported on at a later date for both bays.

A publication Edible Mollusca of the Oregon Coast by Charles H. Edmonson, Occasional Papers of the Bishop Museum of Natural History, Vol. VII, No. 9, 1920, was received from the state library and much interesting information was obtained therein on location of clam beds, theories on abundance, spawning periods, etc. This is being scanned for all information pertinent to this laboratory's work.

It is planned to read all back collections of horseclam shells in the near future now that the preliminary work on shell reading is completed.

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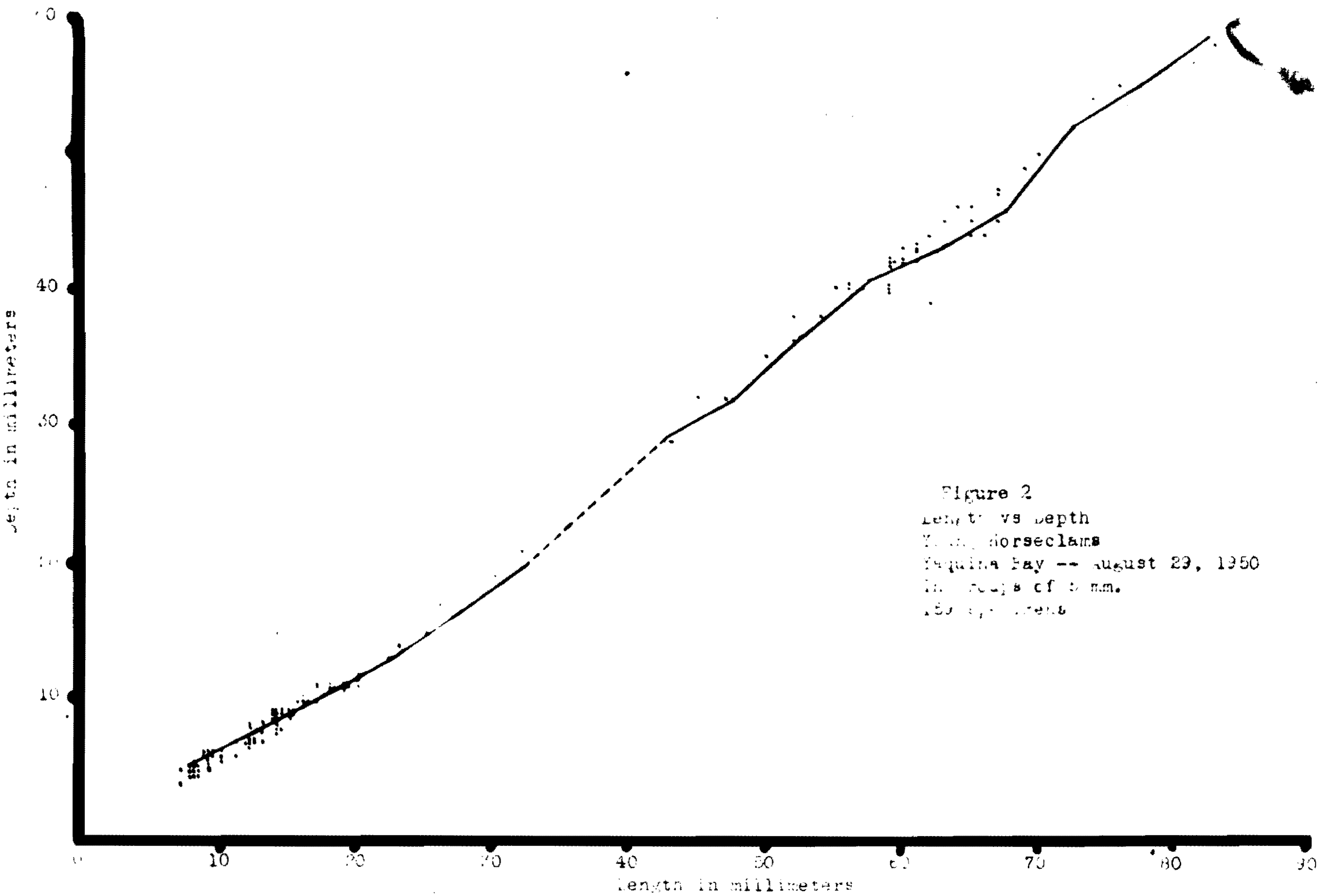

Figure 2
Length vs Depth
Young Horseclams
Yaquina Bay -- August 29, 1950
In groups of 5 mm.
150 specimens

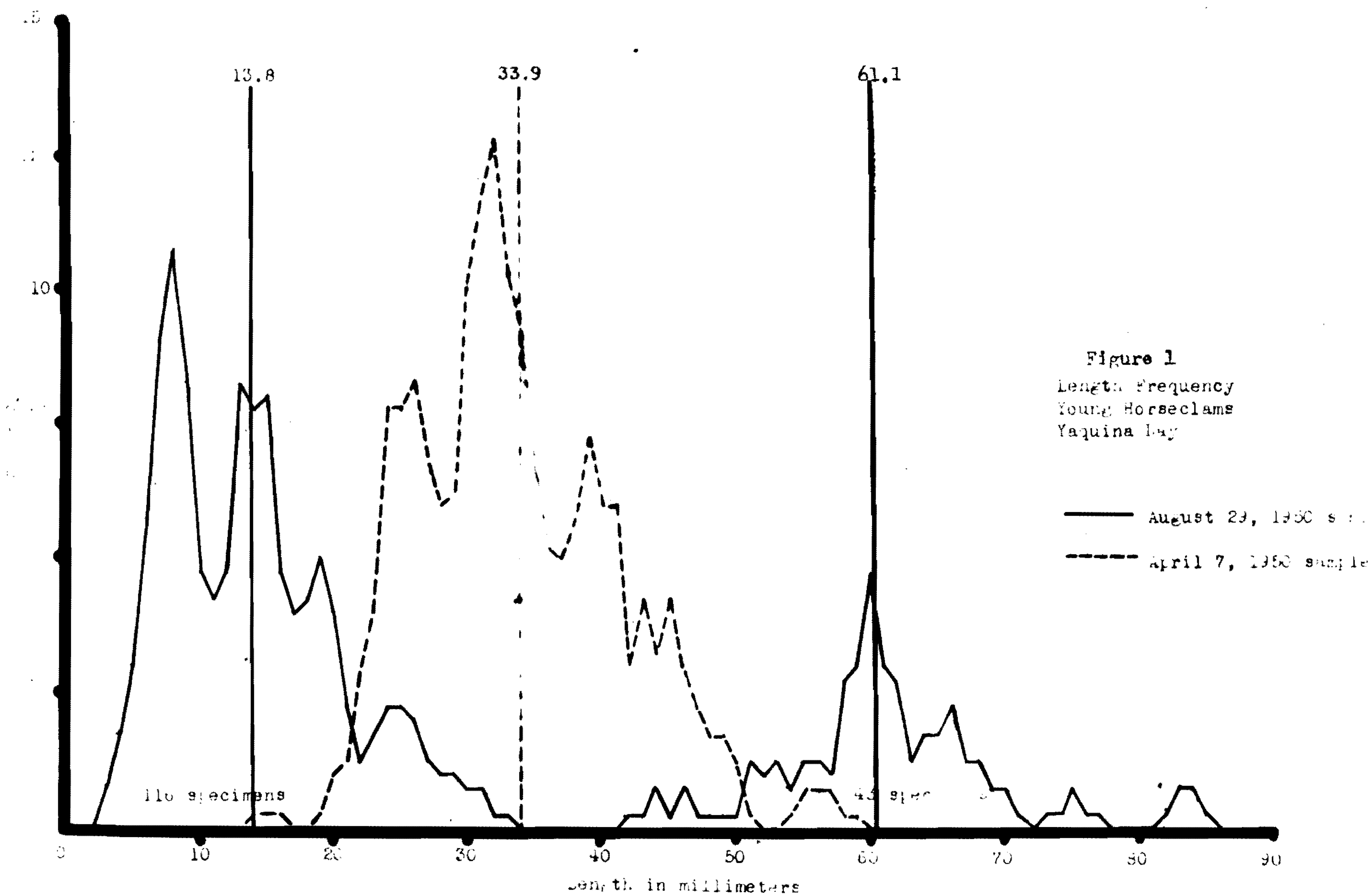
Figure 1
Length Frequency
Young Horseclams
Yaquina Bay
August 29, 1950
April 7, 1950 sample
13.8
33.9
61.1
10
0
10
20
30
40
50
60
70
80
90
Length in millimeters

RAZOR CLAM PROGRESS REPORT

June through September, 1950

All the major phases of the razor clam investigation were continued through the summer months. Routine counts of diggers and sampling of catches were continued. The magnitude of sport fishery on razor clams will be analyzed at a later date. Commercial shell samples were collected for each month and measured, awaiting only the process of age determination. Random samples were dug on various beach areas for growth studies, analysis of age classes present, and condition factors were taken progressively throughout the season.

A large number of plankton tows have been made to collect samples of the young larva for recognition of stages and to predict the time of setting. Almost a complete series of stages were obtained of the free swimming larva. At the same time temperature and salinities were taken. As soon as the first set of any magnitude occurred, sample screenings were begun and are being continued every time the weather permits.

During the last part of August a series of strips were set up, one meter wide and extending the width of the beach. These were dug routinely in an effort to dig them completely out. The work on this phase has only begun and is far from completion. At the same time a series of elevations were taken of the strips to form a sample contour of the beach. Comparison of these elevations from month to month have shown considerable changes in the slope and contour of the beach.

Preliminary Summary of the Marked Razor Clam Program

A marking program on razor clams was undertaken during the spring months of 1950. A total of 658 marked clams were planted in the Cove and the beach in front of Seaside extending north to the Necanicum River. The releases can be summarized as follows.

Date	Number of clams planted	Where planted	Source
April 19	182	Off "A" Ave. to the Necanicum River	Dug by commercial diggers on 8th Ave. Bar
April 20	87	"A" Ave. through the Cove area	Dug by commercial diggers on 8th Ave. Bar
April 21	278	1st Ave. through the Cove area	Dug by biologists and by comm. digger on bar in the Cove area
May 17	111	"T" Ave. Bar north to 14th Ave.	Dug by biologist in Cove and by comm. digger from 12th Ave. Bar

Total planted 658

The majority of the clams were purchased from commercial diggers with whom advance arrangements had been made. This led to at least two difficulties. The clams purchased were not representative of the over-all size distribution on the beach, since the diggers were after the maximum poundage and the larger clams meant more pounds. The bar on which they dug yielded a predominance of larger clams, except for April 21 when a bar in the Cove area was dug. The diggers did not deliver the clams to us until shortly after low water (the single exception was April 21 again when all the clams were marked and the planting began at low water). This meant that the clams were planted too high on the beach. Also it meant that the most favorable outer bars could not be planted.

The errors in the experiment during planting can be summarized as follows.

1. The clams were not distributed equally over the entire beach area subject to digging. This was a result of the manner and time of procurement

of the clams, the lack of a boat to go on to the outer exposed bars, and the poorer tides during which planting was undertaken.

2. The size distribution of clams planted was not representative of the over-all size distribution on the beach, also a partial result of the manner of obtaining the clams. As a result we were forced to plant a predominance of large clams on beach levels where smaller clams composed by far the majority of the population.

The technique of marking was to carve a number on each valve of the shell with the aid of a rotary electric carving drill. Each shell was then measured. The clams were planted in groups of 25 to 50 recording the over-all area of planting for each group. All planting was done in the surf in from 2 ft. to 6 in. of water (waist deep on the bars that could be waded) taking successive trips up and down the beach as the tide came in to distribute the clams evenly over the entire beach. Each clam was planted well below the surface of the sand to ensure it didn't wash out. This involved a little practice and a technique in itself. All planting was done by the biologists.

Sampling and Checking for Recoveries

In an effort to determine the intensity of the fishery routine sampling was undertaken on both sport diggers and commercial diggers. The commercial diggers were checked at the clam markets while the sports diggers were sampled at the same time samples were taken of the catch per digger. Also a program of voluntary returns was initiated and publicized through the local newspapers.

By far the greater number of the total 164 recoveries (a few of which were doubtful) were obtained from voluntary returns. Sampling yielded a very minor number of clams. The data on this sampling will be analyzed when the total take for the months is summarized.

Figure 3 shows the total size distribution planted in comparison with the size distribution recovered, based on length measurements of the recovered clams when planted. A smaller percentage of the smaller clams were recovered as compared to the larger clams.

The last marked clam recovered was in July. Since then not one clam has come in. The rate of recovery dropped very rapidly during the month of June. (See figure 4). The total returns including reports of clams where no shell was turned in was 24.8 percent of the clams planted. This seems like a fair percentage of recovery in consideration of the character of the fishery where such a large percentage of the clams were dug by tourists that the publicity campaign did not reach.

Recommendations for Future Marking Programs

Any future marking program on razor clams should embody a few changes in methods and proceedure. Either commercial diggers can be hired to dig where an average size range of clam can be found and to deliver the clams at least in part before the change of tide, or the digging should be done by the biologists. To obtain satisfactory commercial diggers under the above conditions would entail hiring on an hourly basis. There it is doubtful if even at a very high hourly rate diggers could be obtained, since whenever tides are satisfactory for planting purposes the diggers can make a fairly large profit digging for commercial houses in a very short period of time. To dig them ourselves would require a longer period over which the planting program would have to take place.

The clams should not be planted on the poorer spring tides when the outermost reaches of the beach are not accessible. A low fall tide when the ocean is reasonably calm might prove to be a better time for planting.

Sampling for marked clams, because of the many purchasers for clams and the many individual sports and commercial diggers, takes considerable time. Any errors that may have been made in technique can be better seen when the sampling data areanalyzed.

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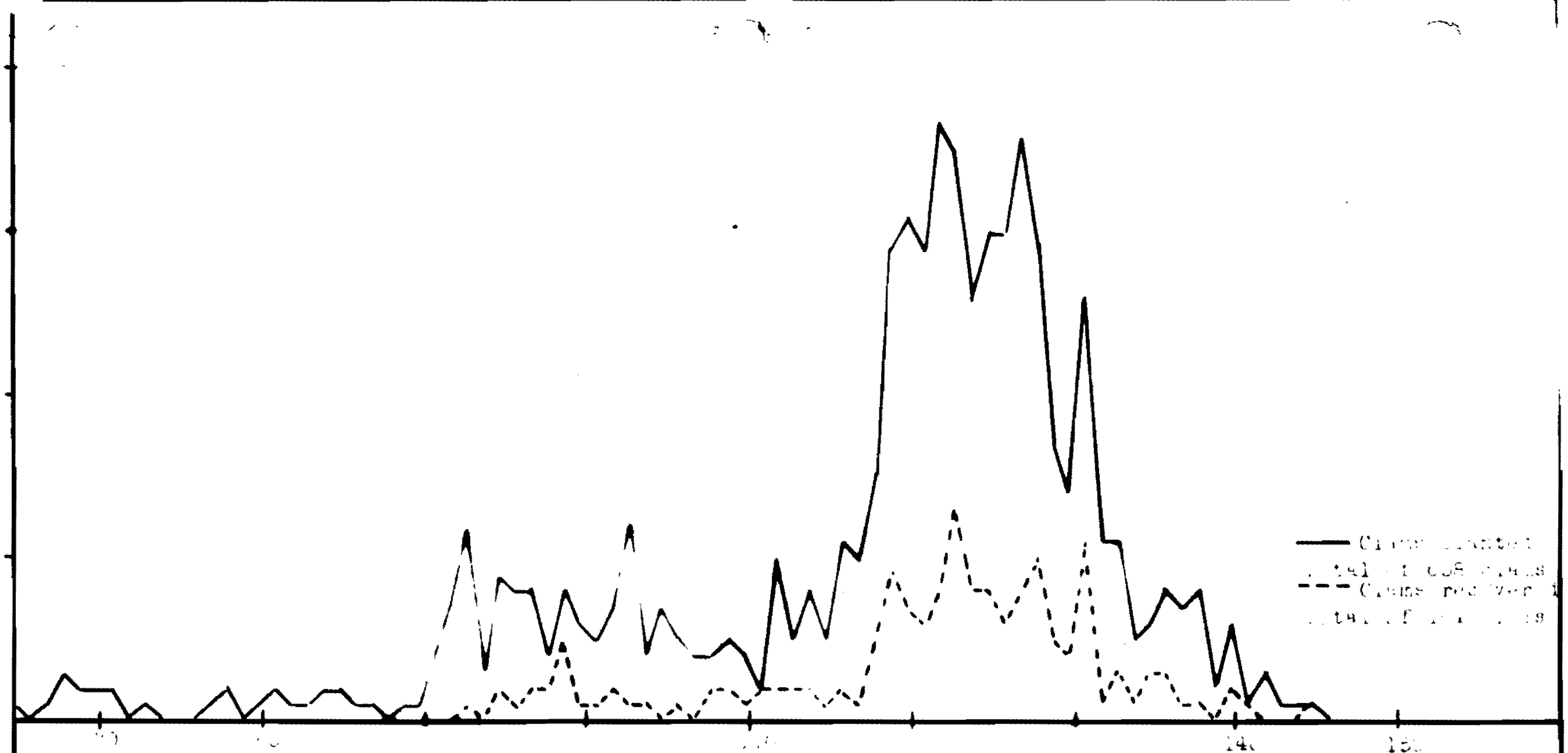

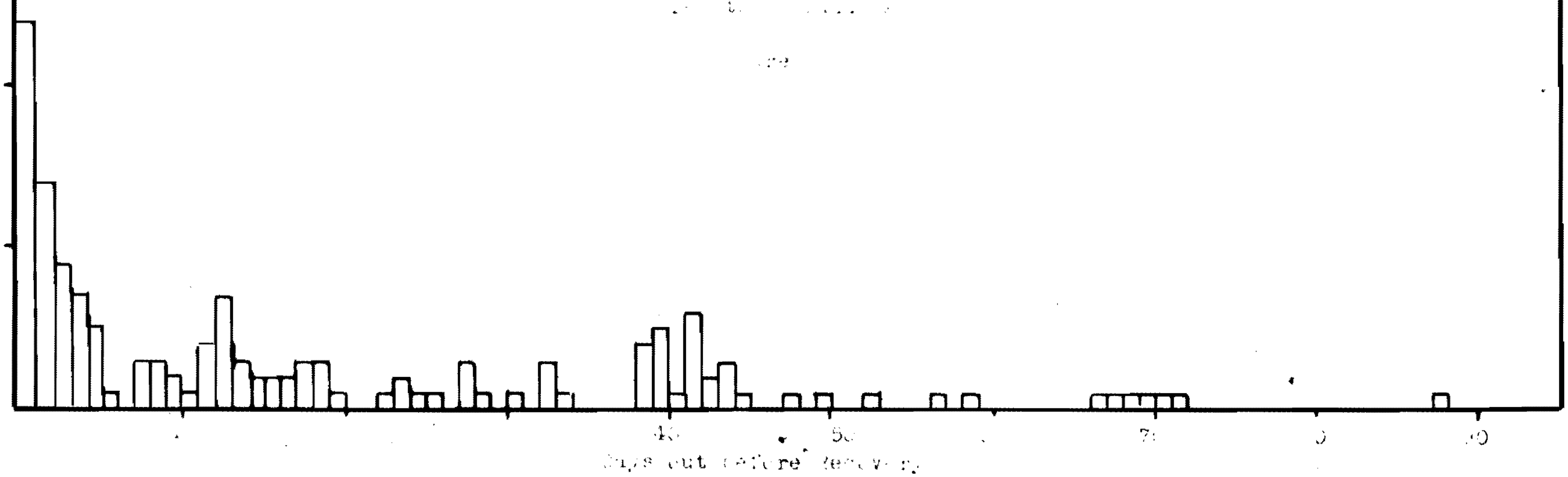

Figure ... clams planted during ... of clams planted

Figure ... of clams recovered for each day after release (days out ...) ... a total recovery of ... clams.

Preliminary Report on Hydrographic Work

A comparatively new project which the shellfish investigation is undertaking, is a hydrographic s rvey of the bays, coastal rivers, and adjacent coastal waters of Oregon. For the present, this work consists solely of determining salinities and water temperatures. When sufficient data have been gathered, salinity and temperature patterns for the various coastal rivers and bays can be determined. It is believed that this information will prove beneficial to the various other studies of the shellfish investigation as well as to the other investigations carried on by the research division. For example, this knowledge will aid in explaining the occurrence and relative densities in populations of clams and crabs in these areas, the spawning areas of striped bass, etc. The work to date has primarily been carried out in the bays and rivers with the lone exception being some work done along the open ocean beaches of Clatsop County in conjunction with the razor clam investigation.

The Work So Far

To date, three major items have been accomplished:

First, all of the unfinished back work has been brought up to date. All of the water samples accumulated by the laboratory were tested for salinity by titrating with silver nitrate and the results were worked up into presentable form and recorded chronologically by area. In addition some new samples were received from the razor clam investigation and were worked up as above.

Second, considerable time was expended in building and assembling the gear which is being used currently in the water sampling operations. Four boxes were constructed, each of which holds 135 glass vials. These vials (capacity 40 ml) have numbered labels, water-proofed with varnish, on both the vial and the cap. The remainder of the equipment used in the field is composed of an armored thermometer and a home-made weighted depth bottle. The depth bottle makes it possible for obtaining water samples at any reasonable desired depth. In the laboratory an automatic burette has been set up and is now being used in titrating the water samples.

Last, and most important, the actual water sampling in the bays and rivers has been started. So far, a day has been spent collecting samples in each of the following bays: The Alsea, the Siletz, and the Yaquina. Since it is quite obvious that the results of one day's sampling would not be very significant, the value of these preliminary surveys at the moment lies mainly in determining the location and number of sampling stations which would be necessary to present a true picuure of the salinity and temperature patterns for each area. These first trips are of considerable value from the familiarization standpoint as well.

Results

The old data (see Table 1) which was worked up consists of samples taken from the salt water system (intake at the -3.0 to -4.0 foot tide level) in the shellfish laboratory and from just off the Port Dock in Yaquina Bay. These were taken from October 23 to November 4, 1947, a period of extreme fresh water. The results show the salinity range for the salt water system to be from 22.1 to 34.3 with a mean of 28.8, while the range for the surface samples taken off the Port Dock over this same period was from 11.6 to 34.0 with a mean of 24.8. These figures show that the salt water system not only has a higher comparative mean but also a much higher minimum salinity which indicates that freshets cause no great fluctuation in the salinity for the laboratory aquaria.

The few samples taken on the razor clam beaches of Clatsop County show a salinity range of 19.2 to 32.3 0/00 with a mean of 28.6 (refer to Table 2).

Table 1

YAQUINA BAY WATER SAMPLES

Old Data

Standard 23.60 Blank .29 Chlorinity of Standard 19.42

Date	Station**	Time	Depth	Chlorinity	Salinity	
Oct. 23, 1947	3	14:30	Surface	6.6	11.9	*
"	3	14:30	1/3	6.6	11.9	*
"	3	15:00	Surface	6.4	11.6	*
"	11	15:10		13.7	24.8	
"	3	17:00	Surface	9.2	16.6	
"	11	17:00		16.6	30.0	
Oct. 24, 1947	11	9:00		17.1	30.9	
"	3	9:00	Surface	17.1	30.9	
"	3	15:00	Surface	10.3	18.6	
"	11	15:00		13.7	24.8	
"	3	17:15	Surface	13.1	23.7	
"	11	17:15		15.6	28.2	
Oct. 25, 1947	11	9:30		17.1	30.9	
"	3	17:15	Surface	13.9	25.1	
Oct. 26, 1947	11	16:00		15.1	27.3	
"	3	16:00	Surface	14.9	26.9	
"	11	17:15		14.5	26.2	
Oct. 27, 1947	11	9:30		18.0	32.5	
"	3	9:30	Surface	17.5	31.6	
"	11	13:00		15.7	28.4	
"	3	13:00	Surface	15.5	28.0	
"	11	18:30		15.0	27.1	
"	3	18:30	Surface	14.4	26.0	
Oct. 28, 1947	11	9:00		17.6	31.8	
"	3	9:00	Surface	18.8	34.0	
"	11	12:00		17.7	32.0	
"	3	12:00	Surface	17.5	31.6	
"	11	15:00		16.5	29.8	
"	3	15:00	Surface	16.2	29.3	
"	11	17:00		14.9	26.9	
"	3	17:00	Surface	15.9	28.7	
Nov. 3, 1947	11	9:30		12.2	22.1	
"	3	9:30	Surface	11.4	20.6	
"	3	13:00	Surface	16.9	30.5	*
"	11	13:00		19.0	34.3	*
Nov. 4, 1947	3	9:00	Surface	13.9	24.6	
"	11	9:00		13.4	24.2	*
"	11	12:30		17.6	31.8	*
"	3	12:30	Surface	14.4	26.0	*
"	11	16:30		17.7	32.0	*
"	3	16:30	Surface	18.4	33.2	*

* Standard 22.65 Blank .23 Chlorinity of Standard 19.42

** See Table 4

The minimum salinity seems quite low and the range quite wide, especially for an open ocean beach. Even though no definite conclusion can be made with such a small amount of data, it is certainly feasible that a large influx of fresh water could have severe effects on the razor clam population of this area.

All of the preliminary surveys (see Tables 3, 4, and 5) show that sampling should be done further up bay, at least to a point which is beyond the upper limits of clam and crab habitat.

Nothing definite has been decided about the number and location of sampling stations in the bays surveyed (Tables 3, 4, and 5). For the present it looks as if the jetty and bridge stations in Yaquina Bay might be eliminated but another check will be made to be certain. As soon as maps are available, copies will be made showing the location of the sampling stations.

As mentioned previously the small amount of data obtained from one day's sampling cannot be regarded as very significant, yet it is interesting to note that when these samples were tested, some rather striking dissimilarities in the three bays sampled came to light even in view of this meager amount of data. For example, these first checks show considerable stratification in Alsea Bay which was not true of either the Siletz or the Yaquina. This could be indicative that a larger comparative volume of fresh water is present in Alsea Bay than the other two which were sampled. However, much more information is needed before anything definite can be stated.

What Is Needed

In view of the evidence of very low salinities during some periods on the Clatsop beaches, it would be desirable to sample that area steadily to see how frequently these heavy influxes of fresh water occur and to see how low the salinities actually to go.

Table 2

SALINITY AND TEMPERATURE DATA

1950

In Surf off Northern Clatsop Beaches

Date	Location	Depth of Surf	Time PST	Height of Tide L.W.	Height of Tide H.W.	Hours After L.W.	Air Temp.°C	Water Temp.°C	Chlorinity	Salinity	Sal. Bottle
4/25/50	Cove area	1 ft.	18:00	0.6	6.3	5	8.5	11.5	15.9	28.7	1
"	12th Ave.	1	19:10	"	"	6 1/6		11.2	16.4	29.6	2
"	"	2-3	"	"	"	"		"	16.6	30.0	3
"	.2 S. Necanicum River	1	19:30	"	"	6 1/2		10.5	17.0	30.7	4
"	"	2-3	"	"	"	"		"	17.1	30.9	5
"	Sunset Beach	1	20:00	"	"	1/3 after hi water		10.3	17.1	30.9	6
"	"	2-3	20:00	"	"	"		"	17.9	32.3	7
6/22/50	2nd Ave.		18:20	2.0	7.8	"	14.6	14.4	11.7	21.2	1
6/27/50	"S" Ave.		7:10	-1.1	6.3	2 1/2	17.7	15.7	10.6	19.2	2
"	Gearhart Hotel		7:30	"	"	2 4/5	17.5	15.6	11.3	20.4	4
"	Sunset Beach		8:00	"	"	3 1/3	17.3	15.6	10.6	19.2	5
"	Peter Iredale		8:25	"	"	3 3/4		15.9	10.7	19.3	6
6/30/50	Sunset Beach		11:00	-1.9	7.0	3 3/4		13.4	16.5	29.8	7
"	Gearhart Hotel		10:35	"	"	3 1/3		13.5	16.4	29.6	8
"	"S" Ave.		10:00	"	"	2 3/4	14.7	16.0	15.3	27.7	9
"	Peter Iredale		11:20	"	"	4 1/12		12.7	17.0	30.7	10
7/3/50	Gearhart Hotel		11:00	-.9	7.4	1 1/2	13.7	12.6	17.4	31.4	1
"	Sunset Beach		11:23	"	"	2	13.6	12.8	18.3	33.1	2
"	Peter Iredale		11:44	"	"	2 1/4	13.4	12.7	17.6	31.8	3
7/13/50	12th Ave.		8:40	-.7	6.2	2 5/6	14.8	11.9	16.9	30.5	1
"	Gearhart Hotel		9:10	"	"	3 1/3	14.4	9.4	17.6	31.8	2
"	Sunset Beach		9:35	"	"	3 3/4	14.1	9.9	17.2	31.1	3
"	Peter Iredale		9:55	"	"	4 1/12	13.2	10.2	17.2	31.1	4

Table 3

SILETZ BAY WATER SAMPLES

September 21, 1950

Standard 21.95 Blank .3 Chlorinity of Standard 19.42

Station	Time	Depth-Fath.	Temp.-°C	Chlorinity	Salinity
9	8:36	2	10.0	18.0	32.5
9	8:36	Surface	9.1	18.0	32.5
8	9:02	1	9.3	18.4	33.2
8	9:02	Surface	9.5	18.3	33.1
7	9:17	2/3	9.2	18.4	33.2
7	9:17	Surface	8.9	18.4	33.2
6	9:35	2	9.1	18.5	33.4
6	9:35	Surface	8.8	18.4	33.2
4	9:46	1	9.5	18.5	33.4
4	9:46	Surface	9.5	17.8	32.2
3	10:02	2/3	9.7	18.0	32.5
3	10:02	Surface	9.5	18.0	32.5
2	10:09	3	9.0	18.0	32.5
2	10:09	Surface	9.9	18.1	32.7
1	10:17	2 1/2	9.0	18.1	32.7
1	10:17	Surface	8.5	17.9	32.3
1	11:01	2 1/2	9.0	18.0	32.5
1	11:01	Surface	8.7	18.1	32.7
3	11:46	1/2	12.8	15.4	27.8
2	11:50	2 2/3	9.9	18.1	32.7
2	11:50	Surface	9.4	18.0	32.5
1	12:01	2 1/2	9.3	18.1	32.7
1	12:01	Surface	9.0	18.0	32.5
4	12:15	1 1/3	10.0	18.0	32.5
4	12:15	Surface	10.4	18.1	32.7
6	12:46	1 1/2	10.9	18.1	32.7
6	12:46	Surface	11.2	18.0	32.5
7	13:01	1/2	12.2	17.3	31.3
7	13:01	Surface	12.0	17.2	31.1
8	13:12	1	13.3	17.0	30.7
8	13:12	Surface	13.6	16.9	30.5
5	13:23	Surface	13.6	8.8	15.9
9	13:45	1 1/2	11.3	16.3	29.4
9	13:45	Surface	12.2	14.3	25.8

WATER SAMPLE TAKING STATIONS
SILETZ BAY

No.	Location
1.	Just off tip of South spit
2.	Straight out from Bailey's Moorage
3.	Under bridge over Schooner Creek
4.	Right off Cutler City dock
5.	Halfway up Drift Creek channel
6.	Straight down Siletz River from Kernville on spit
7.	Just off South Timberline
8.	Dolfin at bend in main channel
9.	Just off Siletz moorage

Table 4

YAQUINA BAY WATER SAMPLES

August 25, 1950

Standard 21.95 Blank .3 Chlorinity of Standard 19.42

Station	Time	Depth-Fath.	Temp.-°C	Chlorinity	Salinity
11	4:36	SWS	14.9	17.2	31.1
3	8:12	Surface	14.0	17.4	31.4
3	8:12	3 1/2	13.9	17.5	31.6
1	8:45	Surface	13.6	17.4	31.4
1	8:45	4	13.7	17.5	31.6
2	9:13	Surface	13.6	17.4	31.4
2	9:13	5 1/2	13.9	17.4	31.4
3	9:25	Surface	14.0	17.4	31.4
3	9:25	4 1/2	13.9	17.3	31.3
4	9:45	Surface	14.8	17.3	31.3
4	9:45	5	14.6	17.3	31.3
5	10:10	Surface	14.4	17.3	31.3
5	10:10	1	14.7	17.4	31.4
6	10:42	Surface	15.7	17.3	31.3
6	10:42	2	15.0	17.3	31.3
7	11:07	Surface	15.5	17.3	31.3
7	11:07	1	15.3	17.2	31.1
8	12:15	Surface	15.3	17.2	31.1
8	12:15	6 1/2	14.4	17.3	31.3
10	12:53	Surface	16.7	16.6	30.0
10	12:53	2	14.8	17.1	30.9
9	13:05	Surface	15.8	17.3	31.3
9	13:05	4	14.4	17.3	31.3
8	13:25	Surface	15.3	17.2	31.1
8	13:25	2 1/2	15.4	17.0	30.7
7	13:50	Surface	16.5	17.1	30.9
7	13:50	1	16.1	17.0	30.7
6	14:13	Surface	18.2	17.0	30.7
6	14:13	1	17.9	17.2	31.1
5	14:31	Surface	17.2	16.9	30.5
5	14:31	2	16.3	17.3	31.3
4	15:11	Surface	16.9	16.7	30.2
4	15:11	4	15.4	17.0	30.7
3	15:40	Surface	14.7	17.3	31.3
3	15:40	1 1/3	14.9	17.4	31.4

WATER SAMPLE TAKING STATIONS
YAQUINA BAY

No.	Location	No.	Location
1.	Just inside North jetty at end	8.	Off Yaquina dock
2.	Under North side of Yaquina Bay bridge	9.	By C.D. Johnson's dolphins
3.	Just off Port Dock	10.	By CMC boat repair dock
4.	Off cement ships	11.	Salt water system in lab
5.	End of channel by oyster barge		
6.	First boat landing on West side of King slough		
7.	Bend of channel by Walker's oyster bed		

Table 5
ALSEA BAY WATER SAMPLES

September 19, 1950

Standard 21.95 Blank .3 Chlorinity of Standard 19.42

Station	Time	Depth-Fath.	Temp.°C	Chlorinity	Salinity
2	9:37	2	9.8	18.4	33.2
2	9:37	Surface	9.6	18.3	33.1
1	9:50	7	9.6	18.4	33.2
1	9:50	Surface	9.4	18.4	33.2
2	10:09	5	10.0	18.2	32.9
2	10:09	Surface	9.9	18.1	32.7
3	10:47	1	11.2	17.9	32.3
3	10:47	Surface	11.7	18.4	33.2
4	11:03	1	10.9	17.9	32.3
4	11:03	Surface	12.7	16.1	29.1
5	11:25	1 1/2	11.3	17.4	31.4
5	11:2	Surface	14.2	13.6	24.6
6	11:39	1/2	13.8	14.8	26.7
7	12:00	1 1/3	14.1	13.7	24.8
7	12:00	Surface	16.2	8.0	14.5
8	12:16	1	14.4	13.4	24.2
8	12:16	Surface	16.2	9.1	16.5
6	12:30	1/2	15.8	11.1	20.1
6	12:30	Surface	15.8	10.8	19.5
5	12:45	1 1/3	11.9	17.2	31.1
5	12:45	Surface	15.9	11.9	21.5
4	14:23	1	11.5	17.9	23.3
4	14:23	Surface	11.0	18.0	32.5
3	14:34	1	11.6	18.4	33.2
3	14:34	Surface	11.4	18.3	33.1
2	14:50	2 1/2	10.7	18.3	33.1
2	14:50	Surface	10.2	18.5	33.4
1	15:01	3	10.6	18.4	33.2
1	15:01	Surface	10.2	18.5	33.4
2	15:26	3	10.4	18.4	33.2
2	15:26	Surface	10.2	18.5	33.4
3	15:47	1 1/2	11.2	18.3	33.1
3	15:47	Surface	11.0	18.4	33.2

WATER SAMPLE TAKING STATIONS
ALSEA BAY

No.	Location
1.	Between cabins on knoll and spit
2.	By North light on bridge
3.	Just off Fisherman's Inn dock
4.	Even with old trestle in middle of South or main channel
5.	Straight out from mill by oil company
6.	Just off of upriver end of small island off of Eckman's slough
7.	Just off Curtiss' Landing opposite mouth of Drift Creek
8.	At mouth of North channel

As to the bays and rivers, the ideal thing would be to sample through complete tide cycles in all areas at approximately the same time. However, the time and manpower expended would make a venture of this scope prohibitive.

The chief difficulties encountered in taking water samples so far have been (1) the lack of knowledge of the geography of the areas and (2) the amount of time it takes to travel from one station to the next. When it is possible, the latest maps are checked for channels, but in some cases maps are not available, so considerable delay is often encountered in an unfamiliar bay or river. This problem will be solved as more trips are made to these areas. There seems to be no remedy for the time lost between stations except that this may be alleviated somewhat by using a vehicle on the upper reaches of the bays and streams where there are adjacent roads.

What Will Be Done

The razor clam investigation is instituting a more regular sampling program which should present a much more complete picture of salinity fluctuation on the Clatsop beaches.

Preliminary sampling will be continued until at least one complete sample is obtained from each of the more important coastal rivers and bays. In addition to those previously mentioned these include: the Nehalem River, Tillamook Bay, Netarts Bay, the Nestucca River, the Siuslaw River, the Umpqua River, Coos Bay, and the Coquille River. Possibly surveys will be conducted on some of the lesser important streams and bays at a later date.

When the preliminary sampling is finished, the required number and location of sampling stations will be ascertained from the salinity and temperature results, and then further samplings will take place as time allows. It will be only after considerable data have been accumulated, however, that real value can be derived from the results.

Stanley N. Wilkes
Aquatic Biologist

SALINITY DETERMINATIONS

MOHR'S METHOD

With Density and Salinity Tables

The following brief discussion (with tables) regarding the determination of chlorinity, salinity, and density of sea water was compiled from a number of references to serve as an aid for those in the Commission who might be concerned with such, and who might not have easy access to the various references.

Mohr's method of titrating with silver nitrate against a chloride standared was selected for normal use at this laboratory. The method as used here is as follows:

Slightly more than 32 grams of freshly fused and cooled C.P. sodium chloride are weighed out on an analytical balance, correct to the fourth decimal place. This is then dissolved and made up to one liter with distilled water in a volumetric flask at 20°C. The parts chloride per liter (expressed Cl^-/L) are then calculated from the original weight on the basis of the atomic weights (Cl = 35.457, NaCl = 58.454) as:

$$\text{weight} \times 0.60657 = Cl^-/L$$

It is then necessary to convert Cl^-/L (volumetric basis) to the parts chloride per kilogram, or Cl- 0/00 (gravimetric basis). This may be done by substituting in the formula (Thompson, 1928):

$$Cl_w = 0.008 + 0.99980\ Cl_v - 0.001228\ Cl_v^2$$

where Cl_w = parts chloride per kilogram (Cl- 0/00) and Cl_v = the parts chloride per liter at 20°C (Cl^-/L). This product, Cl- 0/00, is the figure that prior to 1940 was equivalent to chlorinity, but which because of changes in atomic weights and subsequent redefinition of chlorinity is now known as the chlorine equivalent. Rather than using the above formula, Cl^-/L may also be corrected to Cl^{-}0/00 by use of a table (Thompson and VanCleve, 1930), a portion of which is given here to cover the normal ranges of a prepared standard solution:

Table- 6*

Cl^{-}/L	Correction (subtract from Cl^{-}/L to give Cl^{-}0/00)
15.69-15.87	-0.30
16.18-16.32	-0.32
16.63-16.82	-0.34
17.12-17.32	-0.36
17.58-17.82	-0.38
18.03-18.27	-0.40
18.48-18.67	-0.42
18.98-19.17	-0.44
19.33-19.52	-0.46
19.78-19.97	-0.48

* Numbers, inclusive, alternate divisions with odd numbered correction factors ommitted.

The chlorine equivalent (Cl^{-}0/00) is then divided by the correction factor of 1.00045 to give the true chlorinity as defined by the International Commission.

Thus to give a typical example of a prepared standard salt solution, the following determinations are made:

Example of One Solution

Sodium chloride/liter 20°C-32.9740 gm
Chloride/liter 20°C---------20.001 gm Cl^{-}/L
Chlorine equivalent---------19.51 gm Cl^{-}0/00
Chlorinity------------------19.42 0/00
Salinity--------------------35.08 0/00
(Chlorosity-----------------19.90 gm/L 20°)

The last figure, that of chlorosity, is mentioned here only to show that this is a different unit than any of the preceeding terms and should not be confused with them. It is the defined chlorinity converted back to a volumetric basis (by multiplying the chlorinity by its density at 20°C), referring to defined chlorinity rather than to chloride ions as is the case in

Cl^-/L. A brief table of some corresponding values of chlorinity and chlorosity is found in "The Oceans", 1946.

The proceedure used at this laboratory to determine chlorinity of a given water sample is as follows:

Approximately 20 grams of C.P. silver nitrate are weighed out on a triple beam balance and dissolved in one liter of distilled water. Since this solution is standardized against the prepared standard salt solution it is not necessary to have undue accuracy in the weighing. The only requirement is that the solution be of such strength (it may be adjusted if need be) as to require the use of from 15 to 25 millilitres for titrating an average sample (approximately 1 ml per unit of chlorinity). (For extremely accurate determinations, it would be of course necessary to hold this more constant in order to insure exact equivalent end point determinations.)

This solution is then standardized by titrating from a 25 millilitres automatic buret against 5 millilitres samples (taken with a volumetric pipette) of the standard salt solution to which 50 millilitres of tap water have been added (by use of a graduate). Four to six drops of a standard potassium chromate indicator solution are used for end point determination. It is naturally necessary to also run a blank on the tap water but the amount required is almost negligible in the water supply used here. After standardization of the silver nitrate the water samples are run exactly as were the standards. Not only must each new solution of silver nitrate be standardized, but this should also be repeated before running any new group of samples if any considerable time has elapsed to detect possible slight changes that might have occurred.

The chlorinity of the sample can then be determined by the simple proportion:

$$\text{Chlorinity of sample} = \frac{\text{chlorinity of standard} \times \text{ml } AgNO_3 \text{ required for sample}}{\text{ml } AgNO_3 \text{ required for standard}}$$

Should the results be desired in terms of salinity, the comparable figures could be substituted in the above formula; or the salinity can be calculated by the formula:

$$\text{Salinity} = 0.03 + 1.805 \times \text{chlorinity}$$

For convenience, the respective values are given in Table 7 where chlorinity is carried to the tenths, and in Table 8, where chlorinity is carried to the hundredths.

It should be remembered that determination of salinity by Mohr's method is subject to possible slight errors where the chlorinity is below 5 or so 0/00.

Some investigations are now using, or might wish to use, hydrometers for salinity determinations. The advantage here is the greater speed and less trouble with which determinations may be made. The disadvantage is much lower accuracy.

Should such readings be made the observed densities can be converted to salinity by means of the Tables (U.S. Coast and Geodetic Survey, 1941) presented here. Table 9 gives the direct comparative values at 15°C. For temperatures other than 15°C the required correction to 15° shown on Table 10 may be either added or subtracted as the case may be, to the observed density, the resulting figure then located on Table 9 to give the salinity.

Table 11 was originally drawn up before the location of the foregoing density table. This may also be used for determination of salinity if the temperature is at or near 0°C. This table was calculated from the formula as listed in "The Oceans", 1946:

$$\text{Density } 0°\text{C} = -0.069 + 1.4708\ Cl - 0.001570\ Cl^2 + 0.0000398\ Cl^3.$$

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Table 7

CHLORINITY TO SALINITY

(Using formula: Salinity = 0.03 + 1.805 Chl)

Chlor-inity	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.21	.39	.57	.75	.93	1.11	1.29	1.47	1.65
1	1.84	2.02	2.20	2.38	2.56	2.74	2.92	3.10	3.28	3.46
2	3.64	3.82	4.00	4.18	4.36	4.54	4.72	4.90	5.08	5.26
3	5.45	5.63	5.81	5.99	6.17	6.35	6.53	6.71	6.89	7.07
4	7.25	7.43	7.61	7.79	7.97	8.15	8.33	8.51	8.69	8.87
5	9.06	9.24	9.42	9.60	9.78	9.96	10.14	10.32	10.50	10.68
6	10.86	11.04	11.22	11.40	11.58	11.76	11.94	12.12	12.30	12.48
7	12.67	12.84	13.03	13.21	13.39	13.57	13.75	13.93	14.11	14.29
8	14.47	14.65	14.83	15.01	15.19	15.37	15.55	15.73	15.91	16.09
9	16.28	16.46	16.64	16.82	16.98	17.17	17.36	17.54	17.72	17.90
10	18.08	18.26	18.44	18.62	18.80	18.98	19.16	19.34	19.52	19.70
11	19.89	20.07	20.25	20.43	20.61	20.79	20.97	21.15	21.33	21.51
12	21.69	21.87	22.05	22.23	22.41	22.59	22.77	22.95	23.13	23.31
13	23.50	23.68	23.86	24.04	24.22	24.40	24.58	24.76	29.94	25.12
14	25.30	25.48	25.66	25.84	26.02	26.20	26.38	26.56	26.74	26.92
15	27.11	27.29	27.47	27.65	27.83	28.01	28.19	28.37	28.55	28.73
16	28.91	29.09	29.27	29.45	29.63	29.81	29.99	30.17	30.35	30.53
17	30.72	30.90	31.08	31.26	31.44	31.62	31.80	31.98	32.16	32.34
18	32.52	32.70	32.88	33.06	33.24	33.42	33.60	33.78	33.96	34.14
19	34.33	34.51	34.69	34.87	35.05	35.23	35.41	35.59	35.77	35.95
20	36.13	36.31	36.49	36.67	36.85	37.03	37.21	37.39	37.57	37.85
21	37.94	38.12	38.30	38.48	38.66	38.84	39.02	39.20	39.38	39.56
22	39.74	39.92	40.10	40.28	40.46	40.64	40.82	41.00	41.18	41.36
23	41.55									

Table 8

Chlorinity	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
10.0	18.08	18.10	18.12	18.13	18.15	18.17	18.19	18.21	18.22	18.24
.1	18.26	18.28	18.30	18.31	18.33	18.35	18.37	18.39	18.40	18.42
.2	18.44	18.46	18.48	18.50	18.51	18.53	18.55	18.57	18.59	18.60
.3	18.62	18.64	18.66	18.68	18.69	18.71	18.73	18.75	18.77	18.78
.4	18.80	18.82	18.84	18.86	18.87	18.89	18.91	18.93	18.95	18.96
.5	18.98	19.00	19.02	19.04	19.05	19.07	19.09	19.11	19.13	19.14
.6	19.16	19.18	19.20	19.22	19.24	19.25	19.27	19.29	19.31	19.33
.7	19.34	19.36	19.38	19.40	19.42	19.43	19.45	19.47	19.49	19.51
.8	19.52	19.54	19.56	19.58	19.60	19.61	19.63	19.65	19.67	19.69
.9	19.70	19.72	19.74	19.76	19.78	19.79	19.81	19.83	19.85	19.87
11.0	19.89	19.90	19.92	19.94	19.96	19.98	19.99	20.01	20.03	20.05
.1	20.07	20.08	20.10	20.12	20.14	20.16	20.17	20.19	20.21	20.23
.2	20.25	20.26	20.28	20.30	20.32	20.34	20.35	20.37	20.39	20.41
.3	20.43	20.44	20.46	20.48	20.50	20.52	20.53	20.55	20.57	20.59
.4	20.61	20.63	20.64	20.66	20.68	20.70	20.72	20.73	20.75	20.77
.5	20.79	20.81	20.82	20.84	20.86	20.88	20.90	20.91	20.93	20.95
.6	20.97	20.99	21.00	21.02	21.04	21.06	21.08	21.09	21.11	21.13
.7	21.15	21.17	21.18	21.20	21.22	21.24	21.26	21.27	21.29	21.31
.8	21.33	21.35	21.37	21.38	21.40	21.42	21.44	21.46	21.47	21.49
.9	21.51	21.53	21.55	21.56	21.58	21.60	21.62	21.64	21.65	21.67
12.0	21.69	21.71	21.73	21.74	21.76	21.78	21.80	21.82	21.83	21.85
.1	21.87	21.89	21.91	21.92	21.94	21.96	21.98	22.00	22.01	22.03
.2	22.05	22.07	22.09	22.11	22.12	22.14	22.16	22.18	22.20	22.21
.3	22.23	22.25	22.27	22.29	22.30	22.32	22.34	22.36	22.38	22.40
.4	22.41	22.43	22.45	22.47	22.48	22.50	22.52	22.54	22.56	22.58
.5	22.59	22.61	22.63	22.65	22.66	22.68	22.70	22.72	22.74	22.75
.6	22.77	22.79	22.81	22.83	22.85	22.86	22.88	22.90	22.92	22.94
.7	22.95	22.97	22.99	23.01	23.03	23.04	23.06	23.08	23.10	23.12
.8	23.13	23.15	23.17	23.19	23.21	23.22	23.24	23.26	23.28	23.30
.9	23.31	23.33	23.35	23.37	23.39	23.40	23.42	23.44	23.46	23.48
13.0	23.50	23.51	23.53	23.55	23.57	23.59	23.60	23.62	23.64	23.66
.1	23.68	23.70	23.71	23.73	23.75	23.77	23.78	23.80	23.82	23.84
.2	23.86	23.87	23.89	23.91	23.93	23.95	23.97	23.98	24.00	24.02
.3	24.04	24.05	24.07	24.09	24.11	24.13	24.14	24.16	24.18	24.20
.4	24.22	24.24	24.25	24.27	24.29	24.31	24.33	24.34	24.36	24.38
.5	24.40	24.42	24.43	24.45	24.47	24.49	24.51	24.52	24.54	24.56
.6	24.58	24.60	24.61	24.63	24.65	24.67	24.69	24.70	24.72	24.74
.7	24.76	24.78	24.79	24.81	24.83	24.85	24.87	24.88	24.90	24.92
.8	24.94	24.96	24.98	25.00	25.01	25.03	25.05	25.07	25.08	25.10
.9	25.12	25.14	25.16	25.17	25.19	25.21	25.23	25.25	25.26	25.28

Table 8 (Cont.)

Chlor- inity	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
14.0	25.30	25.32	25.34	25.35	25.37	25.39	25.41	25.43	25.44	25.46
.1	25.48	25.50	25.52	25.53	25.55	25.57	25.59	25.61	25.62	25.64
.2	25.66	25.68	25.70	25.72	25.73	25.75	25.77	25.79	25.81	25.82
.3	25.84	25.86	25.88	25.90	25.91	25.93	25.95	25.97	25.99	26.00
.4	26.02	26.04	26.06	26.08	26.09	26.11	26.13	26.15	26.17	26.18
.5	26.20	26.22	26.24	26.26	26.27	26.29	26.31	26.33	26.35	26.36
.6	26.38	26.40	26.42	26.44	26.46	26.47	26.49	26.51	26.53	26.55
.7	26.56	26.58	26.60	26.62	26.64	26.65	26.67	26.69	26.71	26.73
.8	26.74	26.76	26.78	26.80	26.82	26.83	26.85	26.87	26.89	26.91
.9	26.92	26.94	26.96	26.98	27.00	27.01	27.03	27.05	27.07	27.09
15.0	27.11	27.12	27.14	27.16	21.18	27.20	27.21	27.23	27.25	27.27
.1	27.29	27.30	27.32	27.34	27.36	27.38	27.39	27.41	27.43	27.45
.2	27.47	27.48	27.50	27.52	27.54	27.56	27.57	27.59	27.61	27.63
.3	27.65	27.66	27.68	27.70	27.72	27.74	27.75	27.77	27.79	27.81
.4	27.83	27.85	27.86	27.88	27.90	27.92	27.94	27.95	27.97	27.99
.5	28.01	28.03	28.04	28.06	28.08	28.10	28.12	28.13	28.15	28.17
.6	28.19	28.21	28.22	28.24	28.26	28.28	28.30	28.31	28.33	28.35
.7	28.37	28.39	28.40	28.42	28.44	28.46	28.48	28.49	28.51	28.53
.8	28.55	28.57	28.59	28.60	28.62	28.64	28.66	28.68	28.69	28.71
.9	28.73	28.75	28.77	28.78	28.80	28.82	28.84	28.86	28.87	28.89
16.0	28.91	28.93	28.95	28.96	28.98	29.00	29.02	29.04	29.05	29.07
.1	29.09	29.11	29.13	29.14	29.16	29.18	29.20	29.22	29.23	29.25
.2	29.27	29.29	29.31	29.33	29.34	29.36	29.38	29.40	29.42	29.43
.3	29.45	29.47	29.49	29.51	29.52	29.54	29.56	29.58	29.60	29.61
.4	29.63	29.65	29.67	29.69	29.70	29.72	29.74	29.76	29.78	29.79
.5	29.81	29.83	29.85	29.87	29.88	29.90	29.92	29.94	29.96	29.97
.6	29.99	30.01	30.03	30.05	30.07	30.08	30.10	30.12	30.14	30.16
.7	30.17	30.19	30.21	30.23	30.25	30.26	30.28	30.30	30.32	30.34
.8	30.35	30.37	30.39	30.41	30.43	30.44	30.46	30.48	30.50	30.52
.9	30.53	30.55	30.57	30.59	30.61	30.62	30.64	30.66	30.68	30.70
17.0	30.72	30.73	30.75	30.77	30.79	30.81	30.82	30.84	30.86	30.88
.1	30.90	30.91	30.93	30.95	30.97	30.99	31.00	31.02	31.04	31.06
.2	31.08	31.09	31.11	31.13	31.15	31.17	31.18	31.20	31.22	31.24
.3	31.26	31.27	31.29	31.31	31.33	31.35	31.36	31.38	31.40	31.42
.4	31.44	31.46	31.47	31.49	31.51	31.53	31.55	31.56	31.58	31.60
.5	31.62	31.64	31.65	31.67	31.69	31.70	31.73	31.74	31.76	31.78
.6	31.80	31.82	31.83	31.85	31.87	31.89	31.91	31.92	31.94	31.96
.7	31.98	32.00	32.01	32.03	32.05	32.07	32.09	32.10	32.12	32.14
.8	32.16	32.18	32.20	32.21	32.23	32.25	32.27	32.29	32.30	32.32
.9	32.34	32.36	32.38	32.39	32.41	32.43	32.45	32.47	32.48	32.50

Table 8 (Cont.)

Chlorinity	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
18.0	32.52	32.54	32.56	32.57	32.59	32.61	32.63	32.65	32.66	32.68
.1	32.70	32.72	32.74	32.75	32.77	32.79	32.81	32.83	32.84	32.86
.2	32.88	32.90	32.92	32.94	32.95	32.97	32.99	33.01	33.03	33.04
.3	33.06	33.08	33.10	33.12	33.13	33.15	33.17	33.19	33.21	33.22
.4	33.24	33.26	33.28	33.30	33.31	33.33	33.35	33.37	33.39	33.40
.5	33.42	33.44	33.46	33.48	33.49	33.51	33.53	33.55	33.57	33.58
.6	33.60	33.62	33.64	33.66	33.68	33.69	33.71	33.73	33.75	33.77
.7	33.78	33.80	33.82	33.84	33.86	33.87	33.89	33.91	33.93	33.95
.8	33.96	33.98	34.00	34.02	34.04	34.05	34.07	34.09	34.11	34.13
.9	34.14	34.16	34.18	34.20	34.22	34.23	34.25	34.27	34.29	34.31
19.0	34.33	34.34	34.36	34.38	34.40	34.42	34.43	34.45	34.47	34.49
.1	34.51	34.52	34.54	34.56	34.58	34.60	34.61	34.63	34.65	34.67
.2	34.69	34.70	34.72	34.74	34.76	34.78	34.79	34.81	34.83	34.85
.3	34.87	34.88	34.90	34.92	34.94	34.96	34.97	34.99	35.01	35.03
.4	35.05	35.07	35.08	35.10	35.12	35.14	35.16	35.17	35.19	35.21
.5	35.23	35.25	35.26	35.28	35.30	35.32	35.34	35.35	35.37	35.39
.6	35.41	35.43	35.44	35.46	35.48	35.50	35.52	35.53	35.55	35.57
.7	35.59	35.61	35.62	35.64	35.66	35.68	35.70	35.71	35.73	35.75
.8	35.77	35.79	35.81	35.82	35.84	35.86	35.88	35.90	35.91	35.93
.9	35.95	35.97	35.99	36.00	36.02	36.04	36.06	36.08	36.09	36.11
20.0	36.13	36.15	36.17	36.18	36.20	36.22	36.24	36.26	36.27	36.29
.1	36.31	36.33	36.35	36.36	36.38	36.40	36.42	36.44	36.45	36.47
.2	36.49	36.51	36.53	36.55	36.56	36.58	36.60	36.62	36.64	36.65
.3	36.67	36.69	36.71	36.73	36.74	36.76	36.78	36.80	36.82	36.83
.4	36.85	36.87	36.89	36.91	36.92	36.94	36.96	36.98	37.00	37.01
.5	37.03	37.05	37.07	37.09	37.10	37.12	37.14	37.16	37.18	37.19
.6	37.21	37.23	37.25	37.27	37.29	37.30	37.32	37.34	37.36	37.38
.7	37.39	37.41	37.43	37.45	37.47	37.48	37.50	37.52	37.54	37.56
.8	37.57	37.59	37.61	37.63	37.65	37.66	37.68	37.70	37.72	37.74
.9	37.75	37.77	37.79	37.81	37.83	37.84	37.86	37.88	37.90	37.92
21.0	37.94	37.95	37.97	37.99	38.01	38.03	38.04	38.06	38.08	38.10
.1	38.12	38.13	38.15	38.17	38.19	38.21	38.22	38.24	38.26	38.28
.2	38.30	38.31	38.33	38.35	38.37	38.39	38.40	38.42	38.44	38.46
.3	38.48	38.49	38.51	38.53	38.55	38.57	38.58	38.60	38.62	38.64
.4	38.66	38.68	38.69	38.71	38.73	38.75	38.77	38.78	38.80	38.82
.5	38.84	38.86	38.87	38.89	38.91	38.93	38.95	38.96	38.98	39.00
.6	39.02	39.04	39.05	39.07	39.09	39.11	39.13	39.14	39.16	39.18
.7	39.20	39.22	39.23	39.25	39.27	39.29	39.31	39.32	39.34	39.36
.8	39.38	39.40	39.42	39.43	39.45	39.47	39.49	39.51	39.52	39.54
.9	39.56	39.58	39.60	39.61	39.63	39.65	39.67	39.69	39.70	39.72

Table 8 (Cont.)

Chlorinity	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
22.0	39.74	39.76	39.78	39.79	39.81	39.83	39.85	39.87	39.88	39.90
.1	39.92	39.94	39.96	39.97	39.99	40.01	40.03	40.05	40.06	40.08
.2	40.10	40.12	40.14	40.16	40.17	40.19	40.21	40.23	40.25	40.26
.3	40.28	40.30	40.32	40.34	40.35	40.37	40.39	40.41	40.43	40.44
.4	40.46	40.48	40.50	40.52	40.53	40.55	40.57	40.59	40.61	40.62
.5	40.64	40.66	40.68	40.70	40.71	40.73	40.75	40.77	40.79	40.80
.6	40.82	40.84	40.86	40.88	40.90	40.91	40.93	40.95	40.97	40.99
.7	41.00	41.02	41.04	41.06	41.08	41.10	41.11	41.13	41.15	41.17
.8	41.18	41.20	41.22	41.24	41.26	41.27	41.29	41.31	41.33	41.35
.9	41.36	41.38	41.40	41.42	41.44	41.45	41.47	41.49	41.51	41.53

Table 9

CORRESPONDING DENSITIES AND SALINITIES

Density	Sal.	Density	Sal.	Density	Sal.	Density	Sal.
0.9991	0.0	1.0042	6.6	1.0093	13.2	1.0144	19.9
0.9992	0.0	1.0043	6.7	1.0094	13.3	1.0145	20.0
0.9993	0.1	1.0044	6.8	1.0095	13.5	1.0146	20.1
0.9994	0.3	1.0045	7.0	1.0096	13.6	1.0147	20.3
0.9995	0.4	1.0046	7.1	1.0097	13.7	1.0148	20.4
0.9996	0.5	1.0047	7.2	1.0098	13.9	1.0149	20.5
0.9997	0.7	1.0048	7.3	1.0099	14.0	1.0150	20.6
0.9998	0.8	1.0049	7.5	1.0100	14.1	1.0151	20.8
0.9999	0.9	1.0050	7.6	1.0101	14.2	1.0152	20.9
1.0000	1.1	1.0051	7.7	1.0102	14.4	1.0153	21.0
1.0001	1.2	1.0052	7.9	1.0103	14.5	1.0154	21.2
1.0002	1.3	1.0053	8.0	1.0104	14.6	1.0155	21.3
1.0003	1.4	1.0054	8.1	1.0105	14.8	1.0156	21.4
1.0004	1.6	1.0055	8.2	1.0106	14.9	1.0157	21.6
1.0005	1.7	1.0056	8.4	1.0107	15.0	1.0158	21.7
1.0006	1.8	1.0057	8.5	1.0108	15.2	1.0159	21.8
1.0007	2.0	1.0058	8.6	1.0109	15.3	1.0160	22.0
1.0008	2.1	1.0059	8.8	1.0110	15.4	1.0161	22.1
1.0009	2.2	1.0060	8.9	1.0111	15.6	1.0162	22.2
1.0010	2.4	1.0061	9.0	1.0112	15.7	1.0163	22.4
1.0011	2.5	1.0062	9.2	1.0113	15.8	1.0164	22.5
1.0012	2.6	1.0063	9.3	1.0114	16.0	1.0165	22.6
1.0013	2.8	1.0064	9.4	1.0115	16.1	1.0166	22.7
1.0014	2.9	1.0065	9.6	1.0116	16.2	1.0167	22.9
1.0015	3.0	1.0066	9.7	1.0117	16.3	1.0168	23.0
1.0016	3.2	1.0067	9.8	1.0118	16.5	1.0169	23.1
1.0017	3.3	1.0068	9.9	1.0119	16.6	1.0170	23.3
1.0018	3.4	1.0069	10.1	1.0120	16.7	1.0171	23.4
1.0019	3.5	1.0070	10.2	1.0121	16.9	1.0172	23.5
1.0020	3.7	1.0071	10.3	1.0122	17.0	1.0173	23.7
1.0021	3.8	1.0072	10.5	1.0123	17.1	1.0174	23.8
1.0022	3.9	1.0073	10.6	1.0124	17.3	1.0175	23.9
1.0023	4.1	1.0074	10.7	1.0125	17.4	1.0176	24.0
1.0024	4.2	1.0075	10.8	1.0126	17.5	1.0177	24.2
1.0025	4.3	1.0076	11.0	1.0127	17.6	1.0178	24.3
1.0026	4.5	1.0077	11.1	1.0128	17.8	1.0179	24.4
1.0027	4.6	1.0078	11.2	1.0129	17.9	1.0180	24.6
1.0028	4.7	1.0079	11.4	1.0130	18.0	1.0181	24.7
1.0029	4.8	1.0080	11.5	1.0131	18.2	1.0182	24.8
1.0030	5.0	1.0081	11.6	1.0132	18.3	1.0183	25.0
1.0031	5.1	1.0082	11.8	1.0133	18.4	1.0184	25.1
1.0032	5.2	1.0083	11.9	1.0134	18.6	1.0185	25.2
1.0033	5.4	1.0084	12.0	1.0135	18.7	1.0186	25.4
1.0034	5.5	1.0085	12.2	1.0136	18.8	1.0187	25.5
1.0035	5.6	1.0086	12.3	1.0137	19.0	1.0188	25.6
1.0036	5.8	1.0087	12.4	1.0138	19.1	1.0189	25.8
1.0037	5.9	1.0088	12.6	1.0139	19.2	1.0190	25.9
1.0038	6.0	1.0089	12.7	1.0140	19.4	1.0191	26.0
1.0039	6.2	1.0090	12.8	1.0141	19.5	1.0192	26.1
1.0040	6.3	1.0091	12.9	1.0142	19.6	1.0193	26.3
1.0041	6.4	1.0092	13.1	1.0143	19.7	1.0194	26.4

Density at 15°C   Salinity in Parts per thousand

Table 9 (Cont.)

Density	Sal.	Density	Sal.	Density	Sal.
1.0195	26.5	1.0246	33.2	1.0297	39.8
1.0196	26.7	1.0247	33.3	1.0298	39.9
1.0197	26.8	1.0248	33.4	1.0299	40.1
1.0198	26.9	1.0249	33.6	1.0300	40.2
1.0199	27.1	1.0250	33.7	1.0301	40.3
1.0200	27.2	1.0251	33.8	1.0302	40.4
1.0201	27.3	1.0252	34.0	1.0303	40.6
1.0202	27.4	1.0253	34.1	1.0304	40.7
1.0203	27.6	1.0254	34.2	1.0305	40.8
1.0204	27.7	1.0255	34.4	1.0306	41.0
1.0205	27.8	1.0256	34.5	1.0307	41.1
1.0206	28.0	1.0257	34.6	1.0308	41.2
1.0207	28.1	1.0258	34.7	1.0309	41.4
1.0208	28.2	1.0259	34.9	1.0310	41.5
1.0209	28.4	1.0260	35.0	1.0311	41.6
1.0210	28.5	1.0261	35.1	1.0312	41.8
1.0211	28.6	1.0262	35.3	1.0313	41.9
1.0212	28.8	1.0263	35.4	1.0314	4 .0
1.0213	28.9	1.0264	35.5	1.0315	42.1
1.0214	29.0	1.0265	35.6	1.0316	42.3
1.0215	29.1	1.0266	35.8	1.0317	42.4
1.0216	29.3	1.0267	35.9	1.0318	42.5
1.0217	29.4	1.0268	36.0	1.0319	42.7
1.0218	29.5	1.0269	36.2	1.0320	42.8
1.0219	29.7	1.0270	36.3		
1.0220	29.8	1.0271	36.4		
1.0221	29.9	1.0272	36.6		
1.0222	30.0	1.0273	36.7		
1.0223	30.2	1.0274	36.8		
1.0224	30.3	1.0275	37.0		
1.0225	30.4	1.0276	37.1		
1.0226	30.6	1.0277	37.2		
1.0227	30.7	1.0278	37.3		
1.0228	30.8	1.0279	37.5		
1.0229	31.0	1.0280	37.6		
1.0230	31.1	1.0281	37.7		
1.0231	31.2	1.0282	37.9		
1.0232	31.4	1.0283	38.0		
1.0233	31.5	1.0284	38.1		
1.0234	31.6	1.0285	38.2		
1.0235	31.8	1.0286	38.4		
1.0236	31.9	1.0287	38.5		
1.0237	32.0	1.0288	38.6		
1.0238	32.1	1.0289	38.8		
1.0239	32.3	1.0290	38.9		
1.0240	32.4	1.0291	39.0		
1.0241	32.5	1.0292	39.2		
1.0242	32.7	1.0293	39.3		
1.0243	32.8	1.0294	39.4		
1.0244	32.9	1.0295	39.6		
1.0245	33.0	1.0296	39.7		

Density at 15°C   Salinity in Parts per thousand

Table 10

DIFFERENCES FOR REDUCING DENSITIES OF SEA WATER TO 15°C

Observed Density	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	Observed Density
1.0000	-3	-4	-5	-5	-6	-6	-6	-6	-6	-5	-5	-4	-3	-2	-1	0	1	3	4	6	8	10	12	14	16	19	1.0000
1.0010	-4	-5	-6	-6	-6	-6	-6	-6	-6	-5	-5	-4	-3	-2	-1	0	1	3	4	6	8	10	12	14	16	19	1.0010
1.0020	-4	-5	-6	-6	-7	-7	-6	-6	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	7	8	10	12	14	17	19	1.0020
1.0030	-5	-6	-6	-7	-7	-7	-7	-6	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	7	8	10	13	15	17	19	1.0030
1.0040	-5	-6	-7	-7	-7	-7	-7	-7	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	7	9	11	13	15	17	19	1.0040
1.0050	-6	-7	-7	-7	-8	-7	-7	-7	-7	-6	-5	-5	-4	-3	-1	0	1	3	5	7	9	11	13	15	17	20	1.0050
1.0060	-6	-7	-8	-8	-8	-8	-8	-7	-7	-6	-6	-5	-4	-3	-1	0	2	3	5	7	9	11	13	15	17	20	1.0060
1.0070	-7	-7	-8	-8	-8	-8	-8	-7	-7	-6	-6	-5	-4	-3	-1	0	2	3	5	7	9	11	13	13	18	20	1.0070
1.0080	-7	-8	-8	-8	-9	-8	-8	-8	-7	-7	-6	-5	-4	-3	-1	0	2	3	5	7	9	11	13	15	18	20	1.0080
1.0090	-8	-8	-9	-9	-9	-9	-8	-8	-7	-7	-6	-5	-4	-3	-1	0	2	3	5	7	9	11	13	16	18	20	1.0090
1.0100	-8	-9	-9	-9	-9	-9	-9	-8	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	7	9	11	14	16	18	21	1.0100
1.0110	-9	-9	-10	-10	-10	-9	-9	-8	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	7	9	12	14	16	18	21	1.0110
1.0120	-9	-10	-10	-10	-10	-10	-9	-9	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	7	9	12	14	16	19	21	1.0120
1.0130	-10	-10	-10	-10	-10	-10	-9	-9	-8	-7	-6	-6	-4	-3	-2	0	2	3	5	8	10	12	14	16	19	21	1.0130
1.0140	-10	-11	-11	-11	-11	-10	-10	-9	-8	-7	-7	-6	-4	-3	-2	0	2	3	5	8	10	12	14	17	19	22	1.0140
1.0150	-11	-11	-11	-11	-11	-10	-10	-9	-9	-8	-7	-6	-4	-3	-2	0	2	3	5	8	10	12	14	17	19	22	1.0150
1.0160	-11	-11	-12	-11	-11	-11	-10	-10	-9	-8	-7	-6	-4	-3	-2	0	2	4	6	8	10	12	15	17	19	22	1.0160
1.0170	-12	-12	-12	-12	-12	-11	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	8	10	12	15	17	20	22	1.0170
1.0180	-12	-12	-12	-12	-12	-11	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	8	10	12	15	17	20	22	1.0180
1.0190	-13	-13	-13	-13	-12	-12	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	8	10	13	15	17	20	23	1.0190
1.0200	-13	-13	-13	-13	-13	-12	-11	-11	-10	-9	-7	-6	-5	-3	-2	0	2	4	6	8	10	13	15	18	20	23	1.0200
1.0210	-14	-14	-14	-13	-13	-12	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	8	10	13	15	18	20	23	1.0210
1.0220	-14	-14	-14	-14	-13	-13	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	8	11	13	15	18	21	23	1.0220
1.0230	-15	-15	-14	-14	-14	-13	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	8	11	13	16	18	21	24	1.0230
1.0240	-15	-15	-15	-14	-14	-13	-12	-12	-10	-9	-8	-7	-5	-3	-2	0	2	4	6	8	11	13	16	18	21	24	1.0240
1.0250	-16	-15	-15	-15	-14	-13	-13	-12	-11	-9	-8	-7	-5	-4	-2	0	2	4	6	9	11	13	16	19	21	24	1.0250
1.0260	-16	-16	-16	-15	-15	-14	-13	-12	-11	-10	-8	-7	-5	-4	-2	0	2	4	6	9	11	13	16	19	21	24	1.0260
1.0270	-17	-16	-16	-15	-15	-14	-13	-12	-11	-10	-8	-7	-5	-4	-2	0	2	4	6	9	11	14	16	19	22	24	1.0270
1.0280	-17	-17	-16	-16	-15	-14	-13	-12	-11	-10	-9	-7	-5	-4	-2	0	2	4	6	9	11	14	16	19	22	25	1.0280
1.0290	-18	-17	-17	-16	-16	-15	-14	-13	-12	-10	-9	-7	-5	-4	-2	0	2	4	6	9	11	14	16	19	22	25	1.0290
1.0300	-18	-18	-17	-17	-16	-15	-14	-13	-12	-10	-9	-7	-6	-4	-2	0	2	4	6	9	11	14	17	19	22	25	1.0300
1.0310	-19	-18	-18	-17	-16	-15	-14	-13	-12	-10	-9	-7	-6	-4	-2	0	2	4	7	9	12	14	17	20	22	25	1.0310

Table 11

DENSITY OF SEA WATER AT 0°C

Chlorinity	Salinity	Density	Chlorinity	Salinity	Density
1	1.84	1.00140	13.2	23.86	1.01917
1.5	2.74	1.00213	13.4	24.22	1.01946
2	3.64	1.00287	13.6	24.58	1.01974
2.5	4.54	1.00360	13.8	29.94	1.02004
3	5.45	1.00433	14.0	25.30	1.02032
3.5	6.35	1.00506	14.2	25.66	1.02061
4	7.25	1.00579	14.4	26.02	1.02093
4.5	8.15	1.00652	14.6	26.38	1.02119
5	9.06	1.00725	14.8	26.74	1.02148
5.2	9.42	1.00754	15.0	27.11	1.02177
5.4	9.78	1.00783	15.2	27.47	1.02207
5.6	10.14	1.00813	15.4	27.83	1.02235
5.8	10.50	1.00842	15.6	28.19	1.02264
6	10.86	1.00871	15.8	28.55	1.02294
6.2	11.22	1.00900	16.0	28.91	1.02323
6.4	11.58	1.00929	16.2	29.27	1.02352
6.6	11.94	1.00958	16.4	29.63	1.02381
6.8	12.30	1.00987	16.6	29.99	1.02410
7	12.67	1.01016	16.8	30.35	1.02439
7.2	13.03	1.01046	17.0	30.72	1.02468
7.4	13.39	1.01075	17.2	31.08	1.02507
7.6	13.75	1.01104	17.4	31.44	1.02526
7.8	14.11	1.01133	17.6	31.80	1.02555
8.0	14.47	1.01162	17.8	32.16	1.02584
8.2	14.83	1.01191	18.0	32.52	1.02613
8.4	15.19	1.01220	18.2	32.88	1.02642
8.6	15.55	1.01249	18.4	33.24	1.02671
8.8	15.91	1.01278	18.6	33.60	1.02700
9.	16.28	1.01307	18.8	33.96	1.02729
9.2	16.64	1.01336	19.0	34.33	1.02758
9.4	16.93	1.01365	19.2	34.69	1.02787
9.6	17.36	1.01394	19.4	35.05	1.02817
9.8	17.72	1.01423	19.6	35.41	1.02846
10	18.08	1.01452	19.8	35.77	1.02875
10.2	18.44	1.01481	20.0	36.13	1.02994
10.4	18.80	1.01510	20.2	36.49	1.02933
10.6	19.16	1.01539	20.4	36.85	1.02962
10.8	19.52	1.01568	20.6	37.21	1.02991
11.0	19.88	1.01597	20.8	37.57	1.03021
11.2	20.25	1.01626	21.0	37.94	1.03050
11.4	20.61	1.01655	21.2	38.30	1.03079
11.6	20.97	1.01684	21.4	38.66	1.03108
11.8	21.33	1.01713	21.6	39.02	1.03137
12.0	21.69	1.01742	21.8	39.38	1.03166
12.2	22.05	1.01771	22.0	39.74	1.03195
12.4	22.41	1.01800	22.2	40.10	1.03224
12.6	22.77	1.01829	22.4	40.46	1.03254
12.8	23.13	1.01858	22.6	40.82	1.03283
13	23.50	1.01887	22.8	41.18	1.03312
			23.0	41.55	1.03341

PUNCH CARD SYSTEM

for

Crab Tagging Data

The following is the system set up for recording and punching out the desired data for all crab tagging material. Green inked cards only are to be used.

Recording

To facilitate reference to the various headings, consider the central data lines as numbered from 1 through 19 starting at the top line (species, etc.) and going down to number 19 (Research Division OFC). Unless otherwise specified all headings will be filled in with the data called for, providing such is known. The exceptions are:

Line 1. Species: not necessary, leave blank

" 1. Maturity: use instead for back width in mm.

" 2. Condition when tagged: use for missing appendages (0 if none missing) followed by shell condition; hyphen between

" 4. Condition when recovered: rarely known in enough detail to be pertinent; leave blank

" 5. Distance migrated: record in nautical miles

" 5. Direction of migration: North, South, inshore, offshore

" 5. Length and weight: leave blank

" 6. Length when tagged: use instead for latitude in degrees and minutes of area tagged; in case of a bay give latitude of mouth of bay followed by the number of nautical miles upbay to point of release.

" 6. Length when recovered: use instead for latitude in degrees and minutes of area recovered as above.

Line 6. Growth: leave blank

" 6. Days or years out: record as number of days out

" 7. Depth released: may be left blank if normal pot depth; fill in if unusual

" 7. Depth recovered: same as depth released

" 8 through 19. Leave blank except for any pertinent remarks.

Punching

To facilitate reference, consider the upper right hand cut corner as starting base, then work counter clockwise around the card with each major division (separated by double lines in the margin) being given a letter from A through P (with the letters I and O ommitted).

A. (Species)--"Tens" division

#1. Crustacea (all following applies only when this hole punched)
#2. Mollusca

A. "Units" division (for Crustacea only)

#1. Crab tagging (all following applies only when this hole punched)
#2. Crab catch statistics
#3-7 Undesignated as yet

B. (Sex and maturity)--all three divisions to be males if punched, female if none are punched

#1. (Unknown)--Male under 5 3/4" back measurement (6" point measurement -144 mm. and less)
#2. (Immature)--Male between 5 3/4" and 6 1/4" width (145 through 157 mm.)
#3. (Female)--Male over 6 1/4" (158 mm. and over)

C. (Date tagged) --partially as listed

Day and month as listed
Year--last digit of year only; to be punched out in unit division of year block

C. (Date tagged)--month of year in which recovered

Use tens division in year block.

#1-12 Sequence number of the month in which recovered
#13. Unknown or uncertain

D. (Condition when tagged)--over-all condition of release

#1. Crab apparently o. k. in vitality
#2. Very weak or "dead"
#3. Cracked or broken back, etc. (may be punched in conjunction with #1 or especially #2.)

E. (Type of gear used in capture)--top row (no punch in 2nd row hole)

#1. Pots--commercial
#2. Rings--commercial
#3. Sports recovery
#4. Miscellaneous
#5. Unknown

Second row (punch 2nd row hole): for tagging re-release

F. (Tagging locality)--as listed

Offshore releases.

All offshore releases to have latitude of area punched out in degrees and minutes, dropping the 4 from the forty degrees in which all releases were made. (Example: 45°37' = 537 to be punched out in the hundreds, tens, and units divisions). No punch to be made in the thousands hole for offshore releases.

Bay releases

Punch out thousands hole and use following area code:

Units div.	#1.	Columbia
	#2.	Nehalem
	#4.	Tillamook
	#7.	Netarts
Tens div.	#1.	Siletz
	#2.	Yaquina
	#4.	Alsea
	#7.	Siuslaw
Hundreds div.	#1.	Umpqua
	#2.	Coos Bay
	#4.	Misc. (Coquille, Nestucca, etc.)
	#7.	Area unknown--inshore or offshore

G. (length of boat)--use for shell condition when tagged

#1.	#1 old and #1 old barnacled
#2.	#1 shell
#3.	#1 new shell
#4.	#2B shell
#5.	#2 shell
no punch.	#3 shell

I. (Tonnage of boat)--use for missing appendages

- #1. No appendages missing
- #2. 1 claw only missing (#1 appendage)
- #3. 1 leg only missing (#2, 3, 4 or 5 appendage)
- #4. 2 legs only missing
- #2 & #3. 1 claw and 1 leg missing
- #2 & #4. 1 claw and 2 legs missing
- No punch. 2 claws missing or combination thereof, or more than 1 claw and 2 legs missing

J. (Recovery area)--as listed

Punch same as "F" (tagging locality).
Punch out thousands hole and #7 in hundreds division for unknowns.

K. (Weight of catch)--tag number

Units, tens, and hundreds divisions: punch out tag number (last three numbers only in case of tags numbered over 999)
Thousands division: use series number as follows:

	No punch in last div.	#1 hole punched in last div.
#1.	Astoria A	Newport A
#2.	Astoria B	Newport B
#3.		Newport C
#4.	Astoria C	Newport J
#5.		Newport K
#6.		Newport R, 6000 series
#7.	Misc. series	Newport R, 7000 series
#8.		Newport R, 8000 series

L. (Distance migrated)--use as such; regardless of direction

#1. 0-5 miles (nautical)	#10. 46-50 miles
#2. 6-10 "	#11. 51-60 "
#3. 11-15 "	#12. 61-70 "
#4. 16-20 "	#13. 71-80 "
#5. 21-25 "	#14. 81-90 "
#6. 26-30 "	#15. 91-100 "
#7. 31-35 "	#16. 101-120 "
#8. 36-40 "	#17. 121-140 "
#9. 41-45 "	#18. Over 140
	#19. Unknown (also applies to direction of migration)

M. (Direction of migration)--use as such

- #1. (Up No. division)--punch for North, i.e. movement from south to north; leave unpunched for South, i.e. from north to south
- #2. (West division)--punch for movement offshore, i.e. to the west; leave unpunched for movement inshore, i.e. to the east

M. (Boat number)--as listed to thousands division

Punch out code number (from code to be set up) of man, boat, or plant recovering tag.

N. (Boat number)--thousands hole only; completion of card

Punch only when card is complete as will be possible to make. Leave unpunched if card requires further data.

P. (Number of annuli)--Units or total age: Use for elapsed time out

#1. less than 10 days
#2. 10- 19 days
#3. 20- 39 "
#4. 40- 59 "
#5. 60- 79 "
#6. 80- 99 "
#7. 100-119 "
#8. 120-139 "
#9. 140-159 "
#10. 160-179 "
#11. 180-199 "
#12. 200-249 "
#13. 250-300 "
#14. over 300 "

P. (Number of annuli)--Tens or fresh water: year recovered

#1. 1947
#2. 1948
#3. 1949
#4. 1950
#5. 1951
#6. 1952
#7. 1953

(Report not Complete)

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