Case Inlet	1,396
North Bay proper	109
Oyster Bay (Totten Inlet)	337
Little Skookum	8
Mud Bay (Eld Inlet)	209
Oakland Bay	88
(to East entrance to Hammersley Inlet)	
South Bay (Henderson Inlet)	55

North Bay, which merely subtends Case Inlet, draws on the largest body of "enclosed" water while South Bay, at the other extreme, is susceptable to the greatest amount of flushing within a given tidal range and its beds lie the closest to the main tidal channels (Fig. 1).

Using the data of Hopkins (1937, P. 453) we can compute from vertical samples at various depths average monthly water temperatures at Mud Bay and Oyster Bay in 1932 and compare them with those of the large, more central mass of water at Seattle as recorded by the U. S. Coast and Geodetic Survery. This gives us the following table of --

AVERAGE WATER TEMPERATURES IN 1932

MONTH	SEATTLE	OYSTER BAY	MUD BAY
January	46.4	44.6	43.8
February	45.1	42.6	43.6
March	45.5	45.6	45.8
April	47.5	50.6	49.6
May	49.8	54.8	54.0
June	53.4	58.2	58.2
July	55.4	61.4	60.3
August	55.2	62.2	61.6
September	54.7	59.2	58.6
October	53.4	56.2	55.8
November	50.7	51.0	51.0
December	47.8	46.6	46.0

The above tabulation shows of course that the shallower, more inland waters of the bays are colder in winter and warmer in summer than waters more proximate to the main water mass of Puget Sound. More significantly, it is also shown that Mud Bay waters are somewhat cooler than those of Oyster Bay as is reasonable from the lesser volume of the former and its closer proximity to main tidal channels. Hence it is rendered reasonable, for example, that the Oyster Bay oysters spawn and set before those in Mud Bay and, on the same type of argument, that South Bay should "come in" last of all. As for North Bay, the great extent of water in Case Inlet probably balances the effect of the proximity of its mouth to main channels, leading to a timing of the reproductive cycle very similar to that of Oyster Bay.

It remains to ask why the prediction of the initial, ouvert stage of the reproductive cycle (spawning) should present a more involved problem than that of predicting the final stage (setting) which involves both the tempo of spawning and rate of larvae development. The reason is implied in what has already been suggested; namely, (1) that the development of the gonad, while dependent on water temperature, apparently does not follow pronounced deviations in air temperatures; but (2) that these deviations are reflected in the early summer temperatures attained in the bays which do influence the rate of development of the larvae to setting.

HOW INTENSITY OF SET IS PREDICTED

Even if cultching operations can be accurately timed, oystermen need to know also whether the set will be of sufficient magnitude to justify the expense of preparing the cultch. To approach a solution to this problem we analyze the data from the bay-year graphs of the setting seasons in order that we may uncover what factors contribute to a good set.

In the first place, we may discard at once certain factors which appear to have no relation to setting intensity. One of these is the early or late beginning of the reproductive season, for in 1946 setting began on June 18 while beginning spatfall did not occur until July 12 in 1950 and yet the catch was very similar, etc. A second is the percentage of gravid oysters during the first wave of spawning, for neither the maximum percentage nor the cumulative percentage by 10 day periods over the initial spawning peak is significantly related to success of set. It will be noted however that the total abundance of larvae and particularly the abundance of large larvae are directly related, as expected, to the magnitude of the rate of spatfall or Setting Index which, during the first wave of spatting, is correlated with the final surviving seasonal catch.

These relationships permit of certain general rules which guide us in the anticipation of over-all magnitude of spatfall. They have already been presented on Pp. 23 - 24.

Since Oyster Bay and North Bay seem now to yield consistantly good catches we conclude that prediction of intensity of spatfall in these bays is of little importance. In Mud Bay however, the set may be a complete failure, and this we desire to be able to foretell.

POSSIBLE CAUSES OF SPATTING FAILURES IN MUD BAY

(1) Abnormal Salinity

The situation in Mud Bay is unique among the areas of our study in that good plankton larvae populations may be present during the early part of the season without yielding significant spatfall. It would therefore be of great value to be able to foretell such setting failures in order that cultch may be withheld and not wasted; or transfered to other bays where good catches may be expected.

Although we had at first suspected that spat failures in Mud Bay may be due to the flushing of larvae out of the bay by spring tides, the plankton-tidal cycle study of 1950 (P. 82) rather conclusively demonstrates that this is not the case and that, if anything, the larvae in Mud Bay are even kept crowded up toward the head of the bay by the tidal currents. Hence it was necessary to look in other directions for a possible explanation.

We therefore focus our attention on the efficiency of conversion of larvae into spat or in other words, the relative proportion of the larvae that actually participate in the spatfall. To indicate this we could find what percentage of the larvae finally survive to large size, but still better it would seem is to determine the ratio of larvae abundance to rate of actual spatfall. To do this we divide the maximum Setting Index by the maximum larvae count preceeding the first setting peak. The resulting figure (here called an "index of setting efficiency") is at least a rough expression of the favorability of conditions for the development of larvae to setting, whatever may be the circumstances which determine their actual abundance.

When such calculations are made for the Mud Bay seasons we have the following:

YEAR	1944	1945	1946	1947	1948	1949	1950	1951
INDEX OF SETTING EFFICIENCY	.06	1.1	.04	1.1	.92	.16	.93	.02

Note that in the years of spat failure (1944, 1946, and 1951) the Index was lowest, in the low catch year of 1949 it was only slightly higher, while during good years we have a value near unity. Larvae size studies may therefore indicate whether lowered setting efficiency was due to disappearance of larvae before attaining full development.

In the years for which we have ~~adequate~~ available larvae-size studies (1944 - 1950) the setting seasons of 1944 and 1946 were complete failures in Mud Bay. An investigation of the problem in this bay may therefore begin with an analysis of the plankton larvae picture during these years, comparing the Mud Bay larva size measurements both with that of other bays during the same year and with Mud Bay itself during years of satisfactory spatfall.

It is clear from the bay-year graphs of 1944 (Figs. 9 through 11) that spawning and abundance of larvae in Mud Bay during this year did not differ in any striking way from the same in Oyster Bay and North Bay, but the spatfall was as nothing compared to that of the latter bays. Hence the spatting failure cannot be attributed to failure in the production of oyster larvae.

When we compare the larvae picture in these bays with reference to size of oyster larvae, however, a marked difference is manifest. Figures 66 through 68 show the proportionate distribution of larvae size groups in plankton samples during 1944 in the three bays, size in microns (1 micron = 0.000039 inches) being the maximum diameter of the larval shell parallel with the hing. This data has also been tabulated in Tables 59, 60 and 61.

By comparing the above charts it is apparent at once that no significant proportion of oyster larvae ever reached near setting size in Mud Bay during ~~the~~ this year (1944) of spat failure. The cause of spat failure may therefore be sought in whatever condition resulted in the demise of the larval oysters after they were half grown. New larvae were fairly continuously being supplied to the bay all during June and July but only a very few survived to setting size and the Setting Index never exceeded 42. It is further to be noted that all the larvae, both large and small, did not succumb at one time as in a mass killing. Only the large larvae dropped out. Hence we may further conclude that the causative condition was one that acted slowly and that the oyster larvae eventually died after being exposed to it for about a fortnight.

Is this conclusion confirmed by the data of other years? 1946 was also a year of set failure in Mud Bay. Proportions of large, medium and small larvae found in the plankton tows of the three principle bays during this year is graphically shown in Figure 69 . Again it will be noted that in Mud Bay no major group of large larvae was found in the plankton as was the case in the other two bays. In Oyster Bay expecially it is clear that the two setting peaks of the season were preceded by the attainment of near-setting size by a significant portion of the larvae population.

(INSERT FIGS. 66
67
68
69)

Now 1945 was a year of good spatfall in Mud Bay, the Setting Index forming a smooth mode with a peak value of 3400 around July 11th (Fig. 15). Comparable spatting rate in Oyster Bay was 7400, and in North Bay, 9000 during this year. Some precise measurements on plankton larvae were made during June (Table 59), but for the most part we simply counted the number of obviously large larvae of around 250u diameter and over in the samples and calculated the percentages thereof. This is rather rough procedure to be sure, but it is sufficient to answer the question: In a year of good spatfall is the larvae picture different from that in a bad year? Reference to Table 14, p. 143 shows that during the 1945 season oyster larvae in Mud Bay survived to near-setting size in about the same degree as in the other bays, attaining a peak density of 240 per 20 gallon sample and a peak proportion of 15 per cent.

A comparison of the larvae picture in Mud Bay during years of spatting failure and of success therefore indicates that in Mud Bay setting failures ~~are~~ *may be* the direct result of failure of the larvae to survive to setting size. It is further indicated that the primary cause is a condition which acts with cumulative effect on the larvae, permitting them to survive ~~only~~ the early weeks of larval life but eventually resulting in their death before setting can take place. This condition may be such that when it occurs the larvae are always killed off soon after they pass the mid-point of their pelagic life in which case one could reliably foretell spatting failures by the larvae picture obtained through plankton samples; but it is also conceivable that if the hypothetical deleterious condition is of a somewhat lower intensity the larvae may not succumb to it until about the eve of their setting. In the latter case we will have to learn the nature of the unfavorable conditions in order for prediction of the spatting failure to become possible at all.

Now we do not yet know what causes eventual death of the larvae and consequent spatting failures in Mud Bay during certain years. The answer must be found through field investigations, but we need an hypothesis to guide our studies since a blind striking in the dark would probably get us nowhere. Until evidence proves otherwise we should procede on the simplest assumption that a single cause is responsible for this phenomenon. It has already been shown in the horizontal plankton sections during a tidal cycle that the large larvae are not swept out of any of the bays by tidal action. Our suggestion at the present time is that spatting failures in Mud Bay are due to abnormal salinities, whether above or below a certain optimum range.

That salinity may be the key to the problem in Mud Bay is a speculation arising from certain suggestive relationships between rainfall recorded at Priest Point Park, Olympia (Table 63), and spatting failures in this bay. If we assemble the precipitation data as in Table 61 , these relationships vaguely appear.

(INSERT Table 61)

In pursuing this possibility one seeks in every way for a correlation between peculiarities in rainfall and set failures; test and confirmation come later. Now reference to Table 61 will substantiate the following statements. Failure in spatfall occured in those years in which:

1) Winter precipitation was exceedingly low, (1944).

2) Precipitation during the "larvae months" of April through June was abnormally low even though that of the early months was high (1934, 1935, 1951); and

3) April through June precipitation was abnormally high, but did not compensate an abnormally low rainfall in the winter months.

TABLE 61 : SUMMATED DEVIATIONS FROM NORMAL RAINFALL IN RELATION TO SPATFALL IN MUD BAY

YEAR	MAXIMUM SETTING INDEX	RAINFALL DEVIATION FROM NORMAL December through March	April through June
1932	1150*	+5.19 inches	-1.12 inches
1933	4000*	+4.98	-1.91
1934	300* (failure)	+5.45	-4.86
1935	60 (failure)		
1944	42 (failure)	-11.77	+0.86
1945	3500	-4.94	-2.15
1946	14 (failure)	+0.34	+3.73
1947	1600	-3.67	-1.26
1948	5000	+4.74	+5.07
1949	600 (fair)	-8.83	-2.63
1950	2800	+8.98	-2.52
1951	70 (failure)	6.08	-4.28

* Number spat daily per bag of shell, Hopkins' data (1937).
For reminder, Setting Index equals number spat per 100 Japanese oyster shell faces per day.

(1946, as contrasted with 1948).

In pursuing this speculation we assume that the only way rainfall could affect survival of larvae is through decreasing salinity by diluting a bay with rainwater or by increasing it in dry spells when evaporation from the bay is not compensated. We further note that the effect of rainfall and run-off should be most noticeable in the upper half of the bays where the water is shallow and major stream inflow received, which is just the part of the bay to which the oyster larvae are confined. Now we add the further notion that a bay may behave somewhat like a bowl: if it is filled to overflowing additional water poured in merely spills out[1] and we remain at a constant, full bowl; but if the bowl is warmed and evaporation encouraged no equilibrium is reached and the level of water in the receptacle becomes lower and lower.

Applying these hypotheses to the above statements we come out with the following interpretations of them in terms of salinity:

1) If winter precipitation is extremely low and April through June does not compensate for this by high precipitation, then salinity is abnormally high and affects the larvae adversely (1944).

2) If winter rainfall is high it will "spillout" of the bay and an abnormally low precipitation in the "larval months"[2] will still result in abnormally high salinity detremental to larvae (1951, 1934, 1935).

3) If April through June precipitation is abnormally high but does not compensate an abnormally low rainfall in the winter months (i.e. merely "filling up the bay" to normal), then salinity will be abnormally low and larvae will be affected thereby.

Hence it may be possible that rainfall can affect salinity of the bay water in either direction of increase or decrease to such an extent that the survival of larvae is affected.

It is interesting to note the setting season of 1949 in Mud Bay in this connection. Maximum rate of spatfall attained was equivalent to a

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1 This is a hydrographical speculation, but it <u>may</u> in time be discovered that salinity of tidal bays is more affected by decreased than by increased rainfall.

2 April and May are included in the "larvae months" on the assumption that rainfall during these months carries over as a salinity difference effective during the months (May and/or June and/or July) in which the larvae which produce the initial set are present in the bays.

Setting Index of 600. Hence this set was "betwixt and between", neither a failure nor half the magnitude of the spatting in good years. Now it can be seen in Table 61 that the winter months deviation from normal in precipitation was - 8.83 inches and that of the later months - 2.52 inches, giving a total of - 11.46 inches which is only a bit more rainfall than in 1944 in which the set was a failure and the comparable figure was - 12.63 inches. Thus 1949 precipitation may have been just on the borderline as regards adverse effect on survival of oyster larvae.

If the circumstances are such that the set in Mud Bay can be wiped out by abnormal precipitation, then we might expect that the other bays would be affected also at least to a minor extent. That such may be the case is indicated in the following table of setting maxima in the three principal bays during the years of our survey:

MAXIMUM SETTING INDEX
first peak of setting

Year	MUD BAY	OYSTER BAY	NORTH BAY
1944	42	2300	6500
1945	3500	9000	9000
1946	14	2700	1300
1947	1600	17500	3500+
1948	5000+	7000	9500
1949	600	9000	2500
1950	2800	4000	4200
1951	50	4000	1200

It will be seen from this table of comparative setting figures that, in general, the years of spatting failure in Mud Bay were also years of decreased setting intensity in other bays. In this connection it should be noted that Oyster Bay had a lower over-all spatfall in 1946 than in 1944 even though the maximum Setting Index for the former year was higher, for the area under the setting curve (i.e. the cumulative set regardless of "peaks"; see Figs. 9 and 19) was greater in 1944. Hence the diminution in setting in Oyster Bay paralleled that in Mud Bay for these two years, though at a far higher level.

All these remarks are presented as and clearly stated to be mere speculation. They may be wholly invalidated by further investigations. It is not claimed that they make a convincing argument nor a clear picture. All that is asserted is that in the absence of any other or better clues to the setting failures in Mud Bay which stand out as an anomaly in the oyster situation in lower Puget Sound, there is sufficient probability that salinity is the significant factor to justify expenditures in time and equipment to settle the question one way or another. Such a study could reveal that the weaknesses in "the case for rainfall" here presented are due to the fact that rainfall at Priest Point Park, Olympia, is not always characteristic also of Mud Bay and its watershed, and that evaporation and other factors complicate the picture so that the relationship between Priest Point precipitation, and salinity of Mud Bay is a complex one. Direct and adequate study of the primary factor, the salinity of the water itself to which the oyster larvae are subjected during their pelagic life, may cut through all these difficulties and eventually allow one to predict spatting failures in Mud Bay on the basis of abnormal salinity. If this proves to be the case, then these speculations will have amply justified themselves in originating such a study. Furthermore it could appear that optimum salinity is a vital secret in the culture of oyster larvae to setting in the laboratory and in artificial ponds. In the meantime, one may be on the lookout for setting failure in Mud Bay in any year in which early spring rainfall is markedly abnormal.

If abnormal salinities are the cause of collapse of setting during certain years in Mud Bay, then these failures should be more closely correlated with the actual salinity of the bay water than with rainfall which affects salinity far more indirectly than air temperature affects water temperature. For rainfall is generally more sharply localized than air temperature and, as mentioned, precipitation recorded at Priest Point Park may be different from that at Mud Bay itself which in turn may be different from rainfall on the watershed of streams emptying into Mud Bay. Factors determining evaporation no doubt further complicate the relationship between rainfall and salinity.

What then of the salinities (or chlorinities) of the water relative both to rainfall and to spatfall failure in Mud Bay? We have made large series of chlorinity determinations on water samples from the bays of lower Puget Sound and Hopkins (1937) presents many tables of such data. A contientious and laborious review of the salinity data however has not proved rewarding. After careful analysis we can at most conclude the following:

1) There is an annual cycle of salinity but the variation is not great, During the rainy early months of the year salinity is lowest and rises to a peak late in the summer, thereupon decreasing through the winter to the spring low.

2) Salinity does not contradict rainfall, for seasons of high rainfall never show high salinity; but the correlation between rainfall as recorded at Priest Point Park, Olympia, and salinity is very inexact, doubtless owing to the multiple factors mentioned above. Thus there is a very general relationship between rainfall data and available bay water salinities, as one would expect from the diluting action of precipitation, but the correlation appears to be so loose that one cannot obtain a precise indication of salinities from rainfall record.

3) Since good oyster sets occur regularly in Oyster Bay and North Bay salinity data from these waters can be of little value anyway and it is probable

that spat failures in Oakland Bay and South Bay are due to other factors.

4) Hopkins' extensive salinity data unfortunately does not extend to 1934 and 1935 in Mud Bay which were just the years of setting failure during the period of his investigation. His studies, did, however, lead him to remark that "The salinity on the oyster grounds in Mud Bay is more variable than in Oyster Bay------and heavy rains affect the water more quickly in the former" (1937, p. 449). That greater variability occurs in salinity of off-shore waters in Mud Bay than in Oyster Bay was also noted. In this place it may also be mentioned that although Hopkins found lower prevailing salinites in Little Skookum and Oakland Bay than in Mud Bay, this fact does not render untenable the hypothesis that spat failure in Mud Bay may be due to abnormal (eg. low) salinity, for it must be remembered that each bay is a genetically isolated population of oysters which do not interbreed with oysters of other bays. Hence the oysters in any one of these bays may have physiological, as they undoubtedly have morphological, differences from those of other bays. In a manner of speaking, this means of course that oyster larvae of Oakland Bay (but not of Little Skookum?) could have "learned" to tolerate lower salinities. In any event the sets in Oakland Bay and Little Skookum have in our time and in that of Hopkins been much lower than those of the major oystering bays.

6) Water bottle samples as usually taken are simply inadequate to a determination of the summated average effective salinity to which oyster larvae are subjected from week to week during their pelagic life. Certain general cycles and trends as mentioned above are evident, but the variation in such samples is much too "jumpy" to permit correlation with events in the life cycle of the oyster. Either a <u>very extensive</u> water-bottle survey should be made of salinity in Mud Bay during the larvae season or some sort of integrating electrical conductivity recorder might be set up

to determine the average over-all salinity changes in the water mass of the upper half of the bay to which the larvae are mostly confined. Only such a study might demonstrate that salinity is a crucial factor in success of setting in Mud Bay and permit one, from a precise knowledge of the water salinity during the two weeks following initial major liberation of larvae from spawning, to forecast whether those larvae may be expected to survive through to setting. In the meantime we shall have to be guided as best we may be the empirical rules (given on P. 118) derived from the apparent relationship between abnormal rainfall and spat failure.

2) Range and Stage of Tide in Reference to Setting

The demonstration of a Larvae Mass which moves back and forth in the bay with the ebb and flooding of the tide enables one to clear up very simply a question concerning the relation of stages of tide to rate of setting brought up by Hopkins in his 1937 paper (pp. 489 - 493). Hopkins determined the spat caught hourly during a complete tidal cycle at three locations in Oyster Bay and found a marked change in spatfall from hour to hour. Heaviest setting occured generally during "half-tides", ie. during mid-flooding water, mid-ebbing or during a low high-tide. Water temperature, pH, salinity and current-velocity were also determined along with setting rate because it was assumed that the variation in the spatfall was due to <u>conditions of the water</u> as such. However, no satisfactory correlation between any of these factors and intensity of setting was shown.

Turning to one of the studies on variation in larvae abundance with stage of tide (Fig. 45) we note that the abundance of larvae and therefore of setting larvae at Station 9 (near Dike 5) presents a curve strikingly similar to Hopkins' histograms of setting rate in ~~height~~

relation to height of tide. Hence it follows that the very simple and reasonable explanation of Hopkins' results is that larvae set more when there are more larvae to set! That is to say, the center of the Larvae Mass passes over a given spot like Station 9 or Dike 5 at a certain stage of the tide, in this case during half-ebb and especially at half-flood tide. Setting still occurs at high or ebb tide not in spite of changes in physical or chemical state of the water but simply because the outer fringe of the Larvae Mass is still over the station and so some larvae are available for setting.

If this reasoning be valid then setting intensity at down-bay stations like Hopkins' designated Dike S on the Steele grounds should show maximum spatting on late ebb and early flood tide according to the larvae counts there during these stages of the tide (Station H-6 in Fig. 50 and Station G in Figure 52). This expectation is not confirmed by Hopkins' findings (see his Fig. 35, P.490) which showed instead highest setting at the peak of the highest high tide in Dike S. But this east shore location was not included among the sampling stations in any of our plankton tidal cycles so it is possible that local off-channel, in-shore eddies may determine hourly fluctuations in larvae abundance at this particular point somewhat different from the back and forth movement of the Larvae Mass of the bay in general. Since larvae abundance so simply explains the fluctuations in setting rates at Hopkins' up-bay stations it is considered likely that a local study of larvae density over Dike S in reference to tide would clear up the discrepancy. At any rate the markedly lower intensity of spatting which he continually observed at Dike S as compared to Dike 5 shows that by reason of its location down-bay Dike S fails to tap the major Larvae Mass.

The possibility of this interpretation of Hopkins' results was anticipated by Korringa (1940, p. 200) who noted that Hopkins neglected the all-important factor of abundance of setting larvae in connection with both his hourly setting studies and his tests of vertical distribution of spatting intensity. Investigations in variation in larvae abundance at different stages of the tide specifically confirm that this abundance and not water conditions is one of the most important factors in determining rate of spatfall.

Attention to the fluctuation in larvae abundance at any point in relation to the stages of the tide thus clearly indicates that this is the major factor in hourly rate of setting and that conditions of the water, if influential, play but a minor part. Hopkins' experiments can then be used in a different manner, namely, to demonstrate that cultch over which the Larvae Mass passes draws on the maximum density of setting larvae in the mass for its cumulative spatfall, picking up spat as the mass passes over it going up-bay on the flood and again as it comes down the bay on ebbing tide.

We conclude that physical factors like current velocity, correlated with stage and range of the tides themselves, are probably not relevant to the problem of spat failure in Mud Bay. Prevailing salinities, at any stage or range of tide may be involved as discussed above. Yet range of tide may possibly account for cultching failures in certain years, not through conditions of the water but with reference to distribution of the setting larvae, as will now be developed.

In his paper on the Olympia oyster (1937), Hopkins considered that there was sufficient correlation between spatting intensity and range of tides to permit the conclusion that "times of maximum frequency of setting fall within periods of spring tides when tidal range is greatest". His figure 33 (p. 489) is stated to show this relationship most clearly since 2 to 3 day test cultch was used for the data therein visualized, and the ambiguities in his other bay-year diagrams are attributed to the fouling of 7 - day test cultch resulting in a less definite location of the precise peaks in spatfall. We shall see again, however, that certain of Hopkins' conclusions are vitiated by the incompleteness of his data;

for he did not make quantitative studies of the planktonic oyster larvae and a reliable correlation between range of tide and setting cannot be established unless one can show, for example, that setting on neap tides is low even though there is an abundance of setting larvae available at the time.

It has just been shown how Hopkins' results on setting intensity in relation to stage of tide are most simply explainable by the fact that only at half-tide are the larvae brought up to Dike 5, Oyster Bay, in near their maximum abundance. On this basis it was suggested by Mr. Cedric Lindsay that range of tide at time of setting might affect delivery of setting larvae to the cultch in Mud Bay and therefore have a bearing on success or failure of the set in that bay. This possibility was therefore surveyed as follows:

Reference is made to Figure 53 showing a horizontal plankton section through Mud Bay on a cycle of tides. It will be noticed that maximum larvae counts were obtained at Station A, fartherest up toward the head of the bay and that they appeared at this location in maximum abundance only after the height of the tide was 12 1/2 feet or higher. Although from this one study it remains a mystery where the larvae are at low tide, it may be a general rule that only tides of height + 12 1/2 feet* or greater will bring the larvae in the region of Station A. Now this is just the area of the bulk of commercial cultching in Mud Bay as it is also the location of our station for test cultch.

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* Since there is no reference tide station for Mud Bay we use the +3.6 feet correction factor for Burns Point, Oyster Bay, applied to Seattle tide tables.

Although the 1951 season is not included in this review paper, we wish to refer to it in the present connection. Suffice it to say that in 1951 the larvae abundance reached a satisfactory maximum of over 3000 per 20 gallons in Mud Bay and somewhere between 2% and 5% of these attained near-setting size in July 9th samples. Nevertheless the setting intensity never exceeded 70 spat per 100 Pacific oyster shells per day, which is poor.

That is to say, according to the larvae data the peak of spatting in Mud Bay should have been reached around July 9th. Refering to 1951 tide tables we see however that on July 8 through July 13 only half of the high tides attained a height of +12 1/2 feet or greater. On the hypothesis suggested this would mean that the larvae which were apparently ready to set had only half a chance of reaching the cultching area though it is difficult to explain why the set was not therefore at least half as good as normal instead of being in fact unusually low.

Turning how to the other years of our study in Mud Bay we may analyze them with reference to whether (1) the larvae picture was favorable, ie., showed a thousand or so larvae in the samples and growth toward setting size, (2) the tides were favorable or not when the larvae were ready to set in abundance i.e. whether both daily high tides were of height + 12 1/2 feet or greater, or whether only one high tide a day reached this height, and (3) whether the rainfall of the season was normal or abnormal and therefore the salinity presumably altered accordingly (see Table 62). This survey reveals the following:

(INSERT Table 62)

TABLE 62 :

SPATFALL SUCCESS IN MUD BAY IN RELATION TO CERTAIN FACTORS

YEAR	MAXIMUM SETTING INDEX	LARVAE PICTURE	TIDES AT LARVAE PEAK	RAINFALL
1944	42	insufficient large larvae	good	very abnormal
1945	3500	good	good	not very abnormal
1946	14	insufficient large larvae	good	abnormally high June precipitation
1947	1600	fair	poor only for a few days, then good	not very abnormal
1948	5000+	good	good	early dry season balanced by later rain
1949	600	good	poor	quite abnormal
1950	2800	good	good	not very abnormal
1951	70	good	poor	early rain possibly balanced by later dry months

From this review of the setting seasons in Mud Bay we see that spatting failures can be accounted for either by abnormal rainfall (1944, 1946, and possibly 1951) or by the occurence of neap tides at the time of setting (possibly 1949 and 1951).

When we return to Hopkins' observations on Mud Bay, we find that his Figure 33, P. 486, shows that in 1935 the setting peak in Mud Bay did coincide sharply with a run of spring tides. The same is the case with the set in all the other seasons of his study of this bay (1931 - 1934). In fact we note that Hopkins' principle of maximum setting at spring tides holds very well for Mud Bay, although perhaps for different reasons than he thought (ie. "Frequency of setting appears to be associated with swiftness of current"), while the case for this rule does not seem to me at all clear-cut with reference to Oyster Bay. Of course we do not know the larvae picture for Mud Bay, 1931 through 1935, and so can never in any instance tell whether the larvae happened to be ready to set on a spring tide or were picked up on the cultch because there was a spring tide maximum. It is improbable however that this relation of setting maxima to spring tides was in every case a coincidence and therfore Hopkins' observations do add some evidence for the idea that two daily high high-tides were necessary to bring the setting larvae to his Mud Bay setting stations, which were even farther up the bay than ours.

If absence of spring tides in Mud Bay at the time when the larvae are prepared to set in abundance may explain setting failures during some years, why then are sets in Oyster Bay and in North Bay so generally successful in spite of the fact that during some years neap tides come during the setting maxima? To answer this question we refer to plankton studies in these bays during a tidal cycle. In the case of Oyster Bay we note that the maximum larvae abundance was found at just up-bay from Station 9 (station C in Fig. 52).during the second half of flooding tide and that the larvae never appeared in great abundance farther up the bay. If one can generalize from this one study it may be said that in Oyster Bay the larvae are not carried all the way up to the head of the inlet as is the case in Mud Bay. Practice confirms this, for the seed grounds in Oyster Bay are relatively down-bay, in the region of Station 9 or Dike 5 and Burns Point. This being the case, Oyster Bay should not be affected by tidal range in this area and it is not. This circumstance rather than imprecise location of dates of maximum setting due to fouling of 7-day cultch explains the exceptions to his rule in the case of Oyster Bay which Hopkins could not otherwise account for.

Refering now to the one tidal study in North Bay (Fig. 55) we find that there is not much difference between larvae abundance at the three stations in North Bay proper at the end of Case Inlet and therefore again we do not have in this bay, as in Mud Bay, any indication of the concentrating of the larvae toward the head of the bay at high water. Hence in North Bay, too, the set appears to be largely independent of range of tides as can be seen by noting setting peaks in relation to spring tides which is shown in the bay-year graphs.

Let it be repeated that Mud Bay setting failures represents the one anomaly in the picture of the bays of lower Puget Sound. Poor spatting in Oakland Bay and South Bay are due to the failure for one reason or another to produce sufficient abundance of setting larvae. Variation in spatfall from year to year in Oyster Bay and North Bay is probably correlated with changes in spawning population due to marketing of oysters as well as to changes in weather, abundance of larvae predators (eg. Noctiluca, Pleurobrachia), etc., and in any case a satisfactory catch now seems always possible. But in Mud Bay there may be poor sets although larvae are annually produced in rather favorable numbers. Now we have <u>only three years</u> during our study in which distinct Mud Bay set failures occured; two of these (1944 and 1946) were toward the beginning of our investigations and the third (1951) almost falls outside the perview of this paper. Hence at this time the best we can do on the basis of these three cases is to conjecture the reasons for spat failures in Mud Bay in the hope of providing <u>some</u> degree of probability in anticipating such bad seasons when cultching is unprofitable. Future studies, based on these suggestions, may then in time lead to a thorough knowledge of the conditions for a satisfactory set in Mud Bay.

It has already been described how in 1944 and 1946 the larvae in Mud Bay apparently failed to develop in sufficient numbers to setting size and how this might be attributed indirectly to abnormal rainfall.

The notion regarding the relation of range of tide to spatting success complicates the picture in Mud Bay but this complexity is by no means unmanageable. We can cut right through it by stating that, until we have more certain knowledge from further cases of spat failures in Mud Bay, one may be on the lookout for such failures when-------

1) the total abundance of larvae is less than 1000 per 20 gallons and the number of near-setting size larvae less than 100, and/or

2) the precipitation as recorded at Priest Point Park, Olympia is definitely abnormal in the manner discussed on P. 118 , and / or

3) a period of neap tides follows the predicted date for the beginning of the first wave of setting. When any one or any combination of these circumstances is the case, xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx then the spatting possibilities are precarious and the chances are small that a profitable catch will be obtained in commercial cultch according to the observations so far accumulated.

TABLE 4 : FIELD DATA, 1942

	DATE	PERCENT OF OYSTERS SPAWNING* AS FEMALES White-sick	Gray-sick	Total	MID-DATE	RATE OF SPATFALL**
OYSTER BAY (Dike 5, Olympia Oyster Co.)	May 5	8	0	8		
	May 8	16	0	16		
	May 12	14	0	14		
	May 15	17	0	17		
	May 18	16	0	16		
	May 23	31	1	32		
	May 29	12	9	21		
	June 1	11	4	15		
	June 5	9	0	9		
	June 8	7	0	7		
	June 12	2	4	6	June 12	0
	June 15	10	7	17	June 15	0
	June 19	6	1	7	June 19	3
	June 23	0	0	0	June 23	13
	June 26	3	2	5	June 26	19
	June 29	1	0	1	June 29	2
	July 3	4	0	4	July 3	1
	July 7	3	0	3	July 7	10
	July 10	0	0	0	July 10	2
	July 13	4	1	5	July 13	10
	July 17	4	3	7	July 17	17
	July 20	2	0	2	July 20	23
	July 24	0	0	0	July 24	22
	July 31	0	0	0	July 31	16
	Aug. 3	0	0	0	Aug. 3	9
	Aug. 7	0	0	0	Aug. 7	0
	Aug. 10	0	1	0	Aug. 11	0
	Aug. 14	0	0	0	Aug. 14	0
	Aug. 17	0	0	0	Aug. 17	5
	Aug. 21	0	0	0	Aug. 21	0
	Aug. 24	0	0	0	Aug. 24	0
MUD BAY (Dike B, Brenner Oyster Co.)	May 23	19	3	22		
	May 29	11	8	19		
	June 5	4	5	9		
	June 12	10	1	11	June 12	0
	June 19	9	0	9	June 19	12
	June 26	4	6	10	June 26	1
	July 3	2	5	7	July 3	0
	July 31	0	2	2	July 10	7
					July 17	21
					July 24	2
					July 31	3
	Aug. 7	1	0	1	Aug. 7	0
	Aug. 14	0	0	0	Aug. 14	0
	Aug. 21	0	0	0	Aug. 21	0

TABLE 4 : FIELD DATA, 1942 (cont'd)

	DATE	PERCENT OF OYSTERS SPAWNING* AS FEMALES White-sick	Gray sick	Total	MID-DATE	RATE OF SPATFALL**
OAKLAND BAY (State Dike)	May 29	5	0	5		
	June 5	15	2	17		
	June 12	3	5	8	June 12	0
	June 19	9	0	9	June 19	0
	June 26	5	2	7	June 26	2
	July 3	1	0	1	July 3	1
	July 10	13	0	13	July 10	4
	July 13	3	2	5		
	July 17	0	2	2	July 17	4
					July 24	0
	July 31	0	0	0	July 31	0
	Aug. 7	0	0	0	Aug. 7	0
	Aug. 14	0	0	0	Aug. 14	0
	Aug. 21	0	0	0	Aug. 21	0

*Percentage of oysters in a sample of 100 mature individuals bearing unshelled (White-sick) and conchivarous larvae (Gray-sick).

**Number of spat per 20 _Ostrea gigas_ shells per week. Mid-date of the 7-day period is given. Sample of 20 shells from a chicken wire bag containing about 100 were examined for spat.

TABLE 5: FIELD DATA, 1943

	DATE	PERCENT OF OYSTERS SPAWNING* AS FEMALES			MID*DATE	NO. DAYS CULTCH EMERSED	RELATIVE RATE OF SPATFALL**
		White-sick	Gray-sick	Total			
OYSTER BAY (Dike 5, Olympia Oyster Co.)	May 3	0	0	0			
	13	2	0	2			
	18	4	0	4			
	21	3	1	4			
	25	8	1	9			
	29	11	6	17			
	June 2	8	10	18			
	4	20	4	24			
	8	21	6	27	June 10	3	1.7
	11	8	15	23	13	4	0.5
	15	12	16	28	17	3	2.0
	18	4	9	13	20	4	0.3
	22	2	10	12	24	3	0.2
	25	7	1	8	27	4	10.8
	29	2	2	4	July 1	3	0.7
	July 2	0	7	7	4	4	0.3
	6	2	0	2	8	4	0.1
	10	3	1	4	12	3	0.5
	13	0	3	3	15	3	0
	16	0	1	1	18	4	1.0
	20	2	0	2	22	4	1.3
	24	1	1	2	26	3	7.5
	27	0	1	1	29	3	3.3
	30	1	0	1	Aug. 1	4	1.4
	Aug. 3	0	1	1	7	8	0
					15	7	3.9
					22	?	7.9
MUD BAY	May 3	0	0	0			
	13	2	0	2			
	18	3	0	3			
	21	8	2	10			
	24	16	1	17			
	29	16	5	21			
	June 2	15	9	24			
	4	20	9	29			
	8	17	5	22	June 10	3	1.7
	11	12	16	28	13	4	0.5
	15	7	19	26	17	3	1.3
	18	11	16	27	20	4	0.2
	22	2	10	12	24	3	0.5
	25	7	13	20	27	4	0
	29	4	1	5	July 1	3	1.7
	July 2	5	1	6	4	4	0
	6	6	6	12	8	4	0
	10	8	3	11	12	3	0.7
	13	1	4	5	15	3	0
	16	11	5	16	18	4	0.8
	20	3	1	4	22	4	0.1
	24	0	6	6	26	3	0.3
	27	0	0	0	29	3	3.3
	30	0	0	0	Aug. 1	4	1.1
	Aug. 4	1	0	1	15	7	6.1
					22	8	0.9

TABLE 5 : FIELD DATA, 1943 (cont'd)

	DATE	PERCENT OF OYSTERS SPAWNING* AS FEMALES White-sick	Gray-sick	Total	MID-DATE	NO. DAYS CULTCH EMERSED	RELATIVE RATE OF SPATFALL
NORTH BAY (State Dike)	May 15	3	0	3			
	19	4	1	5			
	23	12	4	16			
	26	17	5	22			
	29	9	8	17			
	June 2	11	15	26			
	5	5	13	18			
	9	13	8	21	June 11	3	0
	12	4	9	13	14	4	0.1
	16	1	20	21	18	3	0.2
	19	8	9	17	21	4	0
	23	6	6	12	27	5	0
	26	6	3	9	28	3	0.8
	30	2	2	4	July 2	4	0.1
	July 3	4	1	5	5	4	0
	7	3	2	5	9	3	0
	10	4	2	6	12	4	0
	14	0	1	1	16	3	0.1
	17	4	0	4	20	3	0.4
	21	4	0	4	23	3	0
	24	0	4	4	26	4	0.1
	27	0	1	1	30	3	0.8
	31	1	0	1	Aug. 2	5	0
					16	7	0
					23	8	0.05
OAKLAND BAY	May 29	0	0	0			
	June 2	1	0	1			
	4	1	0	1			
	8	0	0	0	June 10	3	0
	11	0	0	0	13	4	0.4
	15	1	0	1	17	3	0
	18	9	1	10	20	4	0
	22	2	2	4	24	3	0
	25	5	3	8	27	4	0
	29	2	2	4	July 1	3	0
	July 2	1	3	4	4	4	0
	6	11	1	12	8	4	0
	10	5	0	5	12	3	0
	13	1	2	3	15	3	0
	16	5	1	6	18	4	0.1
	20	2	0	2	22	4	0
	24	0	0	0	26	3	0.1
	27	0	0	0	29	3	0
	30	0	0	0	Aug. 1	4	0
	Aug. 3	0	1	1	15	7	0.2
					22	8	0

* Percentage of oysters in a sample of 100 mature individuals bearing unshelled (White-sick) and conchivarous larvae (Gray-sick).

** Maximum spat per day per glass plate (70 square inches, under surface only).

TABLE 6 : SPAWNING, 1944

OYSTER BAY

DATE	PERCENT OF OYSTERS SPAWNING AS FEMALES: White-sick	Gray-sick	Total
May 5	0	0	0
11	32	0	32
19	16	12	28
22	20.7	10.3	31.0
26	14.5	26.1	40.6
June 3	9.3	2.9	11.6
6	1.6	8.1	9.7
10	0	4	4
14	0	3.2	3.2
17	5	0	5
20	7.3	1.8	9.1
23	4.0	11.8	15.8
28	3.5	1.8	5.3
30	4.0	11.8	15.8
July 4	7.1	3.6	10.7
7	6.0	4.0	10.0
11	7.3	1.8	9.1

MUD BAY

DATE	PERCENT OF OYSTERS SPAWNING AS FEMALES: White-sick	Gray-sick	Total
May 4	0	0	0
11	7.6?	0	7.6
19	13.8	1.1	14.9
22	10.9	0	10.9
26	18.0	3.9	21.9
June 3	16.7	6.7	23.4
6	8.6	8.6	17.2
10	20.0	6.0	26.0
14	1.5	7.5	9.0
17	1.7	8.3	10.0
20	6.8	1.7	8.5
23	6.0	0	6.0
28	0	5	5
July 1	2	8	10
4	3.4	0	3.4
7	3.2	1.6	4.8
11	5.3	0	5.3

NORTH BAY

DATE	PERCENT of OYSTERS SPAWNING AS FEMALES: White-sick	Gray-sick	Total
May 4	0	0	0
11	0	0	0
19	18.8	6.2	25.0
26	8.2	8.2	16.4
June 3	4.4	4.4	8.8
6	8.6	10.3	18.9
10	28.0	0	28.0
17	0	5.7	5.7
20	0	3.0	3.0
23	3.8	3.8	7.6
30	2.8	1.4	4.2
July 4	5.1	0	5.1
7	8.9	0	8.9
11	3.3	0	3.3

SOUTH BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	12	0	0	0
	19	0	1.5	1.5
	26	3.1	0	3.1
June	3	5.7	3.6	9.3
	6	1.9	0	1.9
	10	6.0	2.0	8.0
	17	0	3.6	3.6
	20	6.8	3.4	10.2
	23	6.0	0	6.0
July	1	1.6	3.2	4.8
	4	6.0	2.0	8.0
	7	1.8	1.8	3.6
	11	0	0	0

OAKLAND BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	11	0	0	0
	19	3.9	0	3.9
	22	6.5	0	6.5
	26	10.0	4.0	14.0
June	3	6.6	11.5	18.1
	6	5.4	5.4	10.8
	10	6.8	8.5	15.3
	14	0	10.3	10.3
	17	0	3.2	3.2
	20	3.3	1.7	5.0
	23	1.9	5.8	7.7
	28	0	0	0
	30	1.2	7.1	8.3
July	4	7.1	3.6	10.7
	7	4.8	6.5	11.3 3
	11	0	3.8	3.8

TABLE 7 : SPAWNING, 1945

OYSTER BAY (Dike 5b, Olympia Oyster Co.)

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	11	7.3	0	7.3
	22	9.0	0	9.0
	26	13.0	9.3	22.3
	30	10.2	10.2	20.4
June	4	10.0	14.0	24.0
	9	8.3	5.6	13.9
	12	1.9	9.4	11.3
	16	1.7	1.7	3.4
	19	3.4	1.7	5.1
	24	3.5	7.4	10.9
	27	3.1	9.2	12.3
	30	1.7	8.4	10.1

MUD BAY (Bremner Dike)

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	11	0	0	0
	26	12.3	0	12.3
	30	20.6	3.2	23.8
June	4	10.0	16.7	26.7
	12	8.8	7.0	15.8
	16	1.5	13.4	14.9
	19	5.0	8.4	13.4
	24	2.7	11.0	13.7
	27	1.4	9.6	11.0
	30	0	3.4	3.4

NORTH BAY (Nelson Dike)

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	26	4.7	9.3	14.0
	30	5.7	8.6	14.3
June	4	4.7	10.6	15.3
	12	1.3	3.8	5.1
	16	2.9	10.1	13.0
	19	1.8	5.4	7.2
	24	1.4	1.4	2.8
	27	2.6	2.6	5.2

SOUTH BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	30	12.5	12.5	25.0
June	12	3.8	17.0	20.8
	16	4.8	2.4	7.2
	19	2.0	5.9	7.9
	24	3.7	3.7	7.4
	27	0	3.2	3.2
	30	10.0	4.0	14.0

OAKLAND BAY
(State Dike)

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	4	0	0	0
	11	0	0	0
	22	5.4	0	5.4
	26	18.5	0	18.5
	30	1.7	10.3	12.0
June	2	3.6	1.8	5.4
	9	15.9	9.5	25.4
	12	21.2	0	21.2
	16	3.6	7.1	10.7
	19	7.5	6.7	14.2
	24	6.1	4.6	10.7
	27	2.9	2.9	5.8
	30	3.2	6.3	9.5

TABLE 8 : SPAWNING, 1946

OYSTER BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	8	0	0	0
	20	14	8	22
	27	0	4	4
June	4	8	0	8
	11	0	10	10
	18	6	0	6
	25	0	4	4
July	2	4	2	6
	9	0	0	0
	15	12	0	12
	23	2	2	4

MUD BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	8	0	0	0
	20	6	0	6
	27	6	2	8
June	4	18	8	26
	11	2	4	6
	18	8	2	10
	25	6	4	10
July	2	6	0	6
	9	2	0	2
	15	4	8	12
	23	2	0	2

NORTH BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	8	0	0	0
	20	8	0	8
	27	30	2	32
June	4	12	0	12
	11	10	4	14
	18	4	0	4
	25	6	6	12
July	2	16	0	16
	9	0	4	4
	15	6	0	6
	23	0	0	0

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SOUTH BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	8	0	0	0
	20	4	0	4
	27	20	0	20
June	4	20	8	28
	11	10	12	22
	18	4	14	18
	25	0	4	4
July	2	2	2	4
	9	8	2	10
	15	6	4	10
	23	2	0	2

OAKLAND BAY

DATE		PERCENT OF OYSTERS SPAWNING AS FEMALES		
		White-sick	Gray-sick	Total
May	8	0	0	0
	20	0	0	0
	27	4	0	4
June	4	12	2	14
	11	6	6	12
	18	16	2	18
	25	0	4	4
July	2	6	0	6
	9	4	2	6
	15	4	0	4
	23	2	0	2

TABLE 9 : SPAWNING, 1947

DATE	OYSTER BAY PERCENT OF OYSTERS SPAWNING AS FEMALES			MUD BAY PERCENT OF OYSTERS SPAWNING AS FEMALES			NORTH BAY PERCENT OF OYSTERS SPAWNING AS FEMALES		
	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total
May 21	6.7	8.3	15.0	5.3	0	5.3	3.4	0.8	4.2
June 4	6.0	1.2	7.2	--	--	--	4.5	7.5	12.0
7	--	--	--	9.2	3.4	12.6	--	--	--
10	4.8	7.9	12.7	--	--	--	5.9	7.8	13.7
16	3.7	1.8	5.5	7.8	15.7	23.5	0	3.9	3.9
25	0	8.3	8.3	0	2.5	2.5	0	10.6	10.6
July 1	6.8	0	6.8	3.0	0	3.0	0	0	0

SOUTH BAY			OAKLAND BAY		
PERCENT OF OYSTERS SPAWNING AS FEMALES			PERCENT OF OYSTERS SPAWNING AS FEMALES		
White-sick	Gray-sick	Total	White-sick	Gray-sick	Total
3.0	0	3.0	2	0	2
--	--	--			
--	--	--			
--	--	--			
16.7	0	16.7			
0	7.3	7.3			
9.4	6.2	15.6			

TABLE 10: SPAWNING, 1948

DATE	OYSTER BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES			MUD BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES			NORTH BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES			PERCEN…
	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total	White-…
May 27*	0	0	0	0	0	0	0	0	0	0
June 3	1.9	0	1.9	4.4	0	4.4	16.3	0	16.3	2.6
7	16.2	0	16.2	3.9	0	3.9	19.0	1.9	20.9	3.2
10	15.9	8.2	24.1	2.4	0	2.4	16.5	8.6	25.1	
14	19.6	5.4	25.0	10.6	5.6	16.2	5.3	14.0	19.3	9.6
18	11.1	1.6	12.7	13.4	1.2	14.6	17.3	6.7	24.0	14.
21	16.3	2.5	18.8	21.4	2.9	24.3	5.8	5.8	11.6	0.8
24	7.2	16.4	23.6	10.0	10.0	20.0	9.5	1.6	11.1	8.9
28				4.1	8.2	12.3				13.

* Adequate samples of both May 24 and May 27 showed no spawning. This is quite interesting in showing a preciptous development of spawn, especially in the always precipitous North Bay.

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SOUTH BAY			OAKLAND BAY		
PERCENT OF OYSTERS SPAWNING AS FEMALES			PERCENT OF OYSTERS SPAWNING AS FEMALES		
White-sick	Gray-sick	Total	White-sick	Gray-sick	Total
0	0	0	0	0	0
2.6	0	2.6			
3.3	0	3.3	0	0	0
			0	0	0
9.6	0	9.6			
14.0	2.3	16.3	3.0	1.0	4.0
0.8	4.2	5.0			
8.9	0	8.9	0	0	0
13.5	0.9	14.4			

TABLE 11: SPAWNING, 1949

DATE	OYSTER BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES			MUD BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES			NORTH BAY — PERCENT OF OYSTERS SPAWNING AS FEMALES		
	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total
May 27	8.0	0	8.0	12.3	0	12.3	6.4	0	6.4
June 2	11.5	1.2	12.7	21.3	0	21.3	7.9	0	7.9
8	14.6	13.3	27.9	16.0	4.0	20.0	6.6	5.3	11.9
13	18.7	2.7	21.4	12.0	10.7	22.7	6.6	1.3	7.9
16				2.7	6.7	9.4	10.7	6.7	17.4

TABLE 12: SPAWNING, 1950

DATE	OYSTER BAY PERCENT OF OYSTERS SPAWNING AS FEMALES			MUD BAY PERCENT OF OYSTERS SPAWNING AS FEMALES			NORTH BAY PERCENT OF OYSTERS SPAWNING AS FEMALES		
	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total	White-sick	Gray-sick	Total
June 3	10.0	0	10.0	4.0	0	4.0	6.0	0	6.0
8	15.0	0	15.0	12.0	0	12.0	3.0	0	3.0

TABLE 13: PELAGIC LARVAE, 1944

OYSTER BAY (Combined Stations 7, 8 & 9)

DATE	MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May 10	0	0	0
17	32	0	0
25	252	0	0
June 2	1,152	0	0
12	17,400		
15	7,040	2.7	90
19	3.840	2.6	100
26	7,896	6.5	434
July 3	836	3.7	31
17	7,152	6.9	493
27	2,000*	4.7	94
Aug. 7	100*	13.1	13
14	2*	0	0
28	200*	7.0	14
Sep. 5	5*	5.9	0

MUD BAY (Combined Stations 3 & 4)

DATE	MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May 10	44	0	0
17	36	0	0
June 2	544	0	0
15	700	0	0
26	563	1.6	9
July 3	3,200	3.2	102
17	1,472	0.4	6
24	512	0	0
27	300	0.8	2
31	36	0	0
Aug. 7	8	0	0
9	44	0	0
14	0	0	0

(

DATE
May 11
17
25
June 2
12
15
19
20
July 3
20
24
27
31
Aug. 7
14
28
Sep. 5
12
Oct. 9

*Average, plus.

142 Cont.

VAE, 1944

NORTH BAY
(Combined Stations 10, 11, 12)

DATE	MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May 11	36	0	0
17	4	0	0
25	12	0	0
June 2	568	0	0
12	360	0	0
15	3,884	4.6	179
19	2,884	9.6	277
20	456	15.3	70
July 3	700	11.2	78
20	496	4.5	22
24	184	9.7	18
27	212	7.7	16
31	40		
Aug. 7	80	5.0	4
14	12		
28	20		
Sep. 5	4		
12	4		
Oct. 9	0		

SOUTH BAY

DATE	MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May 17	0	0	0
June 2	8	0	0
15	28	0	0
26	252	0.8	2
July 3	2,132	4.9	104
7	676	1.8	12
24	56	0	0
27	24		
31	172	13.9	24
Aug. 7	0		
8	32		
9	16		
14	20		
28	0		
Sep. 2	0		

OAKLAND BAY
(Combined stations 19 & 20)

DATE	MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May 17	0	0	0
25	8	0	0
June 2	144	0	0
12	904	0	0
15	1,316	0	0
19	1,036	0.8	8
July 3	180	1.1	2
20	520		
24	656	1.4	9
27	1,200	1,8	22
31	1,800	4.0	72
Aug. 7	160	14	22
14	12		
21	8		
28	16		
Sep. 5	32		
12	12		
Oct. 9	0	0	0

E 14 : PELAGIC LARVAE, 1945

NORTH BAY
(Combined Stations 11, 12, 12A)

DATE		MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May	29	4	0	0
June	8	1,012	0	0
	20	1,348	36	485
	29	648	15	97
July	10	600	1	6
	20	416	4.5	19
Aug.	3	56	17.5	10
	8	44	43	19

SOUTH BAY
Combined Stations 15, 15A & 15B)

DATE		MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMBER LARGE LARVAE
May	23	0	0	0
June	2	12	0	0
	15	0	0	0
	22	176	0	0
	26	956	2	19
July	3	1,060	0.1	1
	6	868	1.4	12
	9	552		
	10	816	2.5	20
	13	336	19	64
	17	236	9	21
	24	132	7.5	10
	30	144	3	4
Aug.	3	168	7	12
	8	32	0	0
	30	12	33	4
Sep.	8	0	0	0

OAKLAND BAY
(Combined Stations)

DATE		MAXIMUM TOTAL COUNT	% LARGE LARVAE	NUMB LARG LARV
May	18	0	0	0
	23	0	0	0
	29	4	0	0
June	2	36	0	0
	8	616	0	0
	15	(8)	0	0
	20	9,304	0	0
	22	1,084	0	0
	26	216	0	0
	29	28	16	4
July	3	488	0.2	1
	6	288	1.7	5
	9	256		
	13	104	0	0
	17	572	6	34
	20	332	0	0
	24	232	1.7	4
	27	512	0	0
	30	124	0	0
Aug.	3	600	11	66
	8	124	9	11
	15	16	25	4
	24	0	0	0

143 cont.

TABLE 14

OYSTER BAY
(Combination of Stations 8 & 9)

DATE		MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May	18	0	0	0
	23	16	0	0
	29	420	0	0
June	2	2,836	0	0
	8	6,484	0	0
	15	4,216	0	0
	20	38,578	Under 1	-
	22	2,588	6	155
	29	15,880	3	476
July	3	7,784		
	13	13,104	4,5	590
	17	9,816	9.7	952
	20	3,628	21	762
	24	3,532	7	247
	30	3,896	9.7	378
Aug.	3	7,472	9	672
	7	1,868	16	299
	15	644	31	200
	30	52	13	7
Sep.	8	16	25	4

MUD BAY
(Average of Stations 3 & 4)

DATE		MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May	23	0	0	0
June	2	12	0	0
	15	324	0	0
	22	1,152	0.3	3
	26	1,760	2	35
	29	2,792	1.8	50
July	3	2.432	4	97
	6	516	3.3	9
	10	572	3	17
	13	4,812	5	240
	17	1,076	7	75
	24	152	15	23
	30	248	1.5	4
Aug.	3	48	8	4
	8	124	2	2
	30	0	0	0
Sep.	8	12	33	4

TABLE 15 : PELAGIC LARVAE, 1946

OYSTER BAY
(Combined Stations 7, 8 and 9)

DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May 28	1744	0	0
June 4	7816	0	0
14	14832		80
19	2940		44
27	636		50
July 1	3120		416
9	11432		288
23	1652		32
Aug. 1	1292		16
7	1352		32
14	312		96
20	6680	7.0	496
29	76		4

MUD BAY
(Combined stations 3 and 4)

DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May 28	4	0	0
June 4	0	0	0
16	272	0	0
19	2748	0	0
27	468	0	0
July 2	(36)	0	0
9	412	1.5	6
23	524	0	0
Aug. 1	24	0	0
7	4	0	0

NORTH BAY
(Combined, Allyn Dock & Station 12)

DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
June 4	20	0	0
14	400	0	0
21	884	0	0
25	128	3.1	4
July 2	64	0	0
9	96	12.5	12
17	32	0	0
23	40	0	0
30	40	0	0
Aug. 1	856	0	0
14	4	0	0

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SOUTH BAY

DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
June 4	0	0	0
13	0	0	0
19	240	0	0
25	344	0	0
July 2	416	0	0
9	260	0	0
17	952		4
23	56	0	0
Aug. 1	96	0	0
7	96	10	10
14	0	0	0

OAKLAND BAY
(Combined stations 19 and 20)

DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May 28	0	0	0
June 4	36	0	0
13	656		4
19	424	0	0
27	172	0	0
July 2	132		4
9	80	0	0
17	44	0	0
23	8	0	0
Aug. 1	56	0	0
7	32	0	0

TABLE 16: PELAGIC LARVAE, 1

OYSTER BAY				MUD BAY			
DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May 27	520	0	0	June 7	116	0	0
June 12	7472	6.7	501	12	184	0	0
19	10880	12.3	1338	19	164	0	0
30	1096	22	241	30	1452	9.5	138

1947

	NORTH BAY				SOUTH BAY		
DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	DATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
May 27	220	0	0	June 19	616	0	0
June 12	92	0	0	30	1336	2	27
19	128	3.7	5				
30	388	20	78				

TABLE 17: PELAGIC LARVAE, 1948

DATE	OYSTER BAY MAXIMUM TOTAL COUNT	OYSTER BAY AVERAGE % LARGE LARVAE	OYSTER BAY NUMBER LARGE LARVAE	MUD BAY MAXIMUM TOTAL COUNT	MUD BAY AVERAGE % LARGE LARVAE	MUD BAY NUMBER LARGE LARVAE	NORTH BAY MAXIMUM TOTAL COUNT	NORTH BAY AVERAGE % LARGE LARVAE	NORTH BAY NUMBER LARGE LARVAE
June 15	1124	0	0				620	0	0
22	3824	0	0	1224	0	0	3216	0	0
28	2088	0	0	4912	0	0	112	1	1
July 1	6320	1	63	804	0	0	4364	4	175
5	12,224	9	1100	6416	0	0	5440	4	218
12				192	50	96			
15				2424	33	808			
19	2472	?	?	5200	?	?			

146 com.

SOUTH BAY			OAKLAND BAY		
MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
148	0	0			
112	0	0			
724	0	0	108	0	0
1168	0	0			
40	5	2			
328	12	39	0	0	0
832	?	?			

TABLE 18: PELAGIC LARVAE, 1949

	OYSTER BAY			MUD BAY			NORTH BAY			SOUTH BAY		
ATE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
ay 27	16	0	0	8	0	0	0	0	0			
une 2	416	0	0	0	0	0	72	0	0			
8	8032	0	0	712	0	0	688	0	0	32	0	0
13	12928	0	0	1592	0	0	1208	0	0	8	0	0
16	16256	?	?	1280	0	0						
17							344	0	0			
20	3096	?	?	1376	0	0	976	4	39	216	0	0
23	8736	?	?	584	?	?	112	?	?	68	0	0
26	10864	9	978	3552	?	?	228	4	9	152	0	0
30	3976	19	755	608	10	61	112	7	8			
uly 5	13536	3.5	474	3632	[illegible]	145	1016	11	112	368	0	0
8	11856	5	593	384	6	23	1488	8	119			
11	8640	1.5	130	768	19	146	344	25	86	250	0	0
18	6960	10?	696	448	2	9	384	16	61	96	0	0
21	2088	25	522	1192	2.5	30	400	13	52			
27	2632	16	421	328	7	23	128	11	14	144	0	0

TABLE 19: PELAGIC LARVAE, 1950

DATE	OYSTER BAY MAXIMUM TOTAL COUNT	OYSTER BAY AVERAGE % LARGE LARVAE	OYSTER BAY NUMBER LARGE LARVAE	MUD BAY MAXIMUM TOTAL COUNT	MUD BAY AVERAGE % LARGE LARVAE	MUD BAY NUMBER LARGE LARVAE	NORTH BAY MAXIMUM TOTAL COUNT	NORTH BAY AVERAGE % LARGE LARVAE	NORTH BAY NUMBER LARGE LARVAE
June 3	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
12	36	0	0	0	0	0	0	0	0
15	604	0	0	0	0	0	0	0	0
19	556	0	0	0	0	0	0	0	0
22	1164	0	0	44	0	0			
23							24	0	0
26	7656	0	0	352	0	0	2544	0	0
29	5200	0	0	960	0	0	4936	0	0
July 3	(548)	0	0	1396	0	0	(40)	0	0
6	10400	5	520	3328	0	0	(136)	0	0
10	6112	13	795	(172)	0	0	1640	11	180
13	7368	26	1916	1440	2	29	420	20	42
17	4776	33	1576	712	36	250	352	5	18
20	2836	66	1872	1416	22	312	1048	20	210
24	6928	9	2161	2472	8.5	210	1008	14	141
27	9046	20	1809	2144	29	622	5360	22	1179
31	2216	39	864	572	7	40	1097	30	328
Aug. 3	2312	0.7	16	52	38	20			

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SOUTH BAY			OAKLAND BAY		
MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE	MAXIMUM TOTAL COUNT	AVERAGE % LARGE LARVAE	NUMBER LARGE LARVAE
0	0	0	0	0	0
0	0	0			
4	0	0	4 per 5 minute tow		
88	0	0	16 " " " "		
548	0	0	20 " " " "		
(14)	0	0	18	0	0
648	0	0	34	12	4
416	8	33			
240	18.5	44	8	0	0

Blank