Practical Biology of the Olympia Oyster in Puget Sound

Vance Tarter

Introduction

The Bay Years

Spawning
Larval
Setting
Seasonal Catch
Review of Reproductive Seasons, By Bays & By Years

Prediction of Time of Spatfall
Prediction of Spawning Time
Predictions of Intensity of Set
Setting Failure in Mud Bay
Movement of Oyster Larvae by Tidal Currents
Cultching Experiments & Observations

Vertical Setting Studies
Floating Cultch
Bedded Cultch

Saturation of Cultch
Oyster Pests
Summary
Methods

← Spawning
← Planktonic Larvae
← Setting
← Larvae Size & Abundance
Distribution of Larvae During A Tide
Importance of Early Set and Insignificance of the Later
How Time of Oyster Sets can be Predicted
How Beginning Spawning is Predicted

105.

How Intensity of Spat is Predicted
Possible Causes of Spatting Failures in Mud Bay
Prospects for the Future (omit)

TABLE OF CONTENTS

Dedicated to

LOYD ROYAL

without his permission

3

TO WHOM IT MAY CONCERN:

It is the reasoned conclusion of the author that the paper, "Practical Biology of the Olympia Oyster in Puget Sound", should be published in its entirety because of the following considerations:

1) The paper summarizes the work of ten years by the entire staff of the State Shellfish Laboratory and it cannot be expected that so large an amount of work can be treated adequately in small compass.

2) The writing has been wholly compacted with no "padding" whatever and is designed to appeal both to practical oystermen and to biologists.

3) The figures are all essential to (a) locate geographical points, (b) give oystermen an immediate, visual portrayal of the performance of their bays, and (c) demonstrate the correlations arrived at.

4) The second section and all the tables constitute the essential scientific proof and argument supporting the conclusions advanced. Without them the statements offered would become mere opinions.

5) The Laboratory has followed a policy of few but substantial publications rather than frequent and minor notes and observations.

6) This is such a publication, for, as stated above, it brings together the work of ten years and presents the finest method of predicting oyster sets that has been developed in any part of the world, procedures which will in time be applicable to other oysters in other areas.

Hence it may be asserted that every part of the paper is essential and valuable, and that only its publication in entirety will complete the public return on the funds expended in pursuit of the Olympia oyster project.

Cordially yours,

Vance Tartar

Vance Tartar

Practical Biology of the Olympia Oyster,

Ostrea lurida, in Puget Sound

(Notes on present Introduction)

Condense acknowledgements & place in back or condense & leave in front after Introduction.

Omit reference ¶ to writer in paragraph 2 of page 1.

~~Put~~ Omit ¶ 2, p 3, ~~after ¶ 1, p. 1.~~

Reduce discussions of earlier workers.

Order of ¶'s indicated by number in right margin.

PRACTICAL BIOLOGY OF THE OLYMPIA OYSTER, *Ostrea lurida*, IN PUGET SOUND

VANCE TARTAR

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INTRODUCTION

This paper is a result of our wanting to know more about coastal fisheries in order that we may increase the productivity of the seas for human needs. In the bays of lower Puget Sound in the state of Washington, the Olympia oyster is the subject of the principal fishery. For many decades the State Department of Fisheries has promoted investigations concerning the problems of the Olympia oyster grower and since 1942 has issued a weekly series of Puget Sound Oyster Bulletins during the spring and summer months in order to supply oystermen promptly with information concerning the time and prospects of a catch of seed oysters and other matters of importance to them. These bulletins constitute the running account of which this paper is the summing-up.

Largely because he was connected with the Olympia oyster investigation for the longest period of years, it has fallen to the lot of the writer to tie these studies together in the present report of work in progress. As such he takes responsibility for the conclusions and speculations drawn therefrom; but it is not forgotten that we worked as a team and that the wealth of data herein summarized and interpreted could only have been the product of many contientious hands and heads supported by able and sagacious supervisors during the years involved.

Dr. A. H. Banner and his assistant Mr. Charles E. Woelke contributed the data for the years 1942 and 1943. Many interesting and significant special studies were conceived and executed by Mr. Roger Tollefson and are so designated in the text. Mr. John B. Glud was for several years head of the laboratory and responded nobly beyond the call of duty to assure the success and continuity of this work. During the years of his ~~supervision of~~ concern with the project Mr. David C. McMillin contributed much toward the gathering of data and increasing the precision of oyster set predictions. The able and enthusiastic assistance of Mr. Harold Wicksten, Mr. Charles Woelke and Mr. Frank Henry is gratefully acknowledged.

We owe a special debt to Mr. Donald L. McKernan who made the objectives of this study his own and in 1944 set up the Olympia oyster investigation in essentially its present form. Much of the completeness of our data was due to his tireless energy and unflagging zeal. McKernan also saw through to completion the first experiments on the effects upon oysters of minimal concentrations of sulfite waste liquor from wood-pulp mills, the results of which have already been published (McKernan, Tartar, and Tollefson, 1942).

Finally, the present account of the practical biology of the Olympia oyster appears under the auspices of Mr. Cedric E. Lindsay, Supervisor of Shellfish Researches of the State Department of Fisheries, who himself collected valuable data on the Olympia oyster at the Gig Harbor laboratory besides generously placing all information at our disposal and fostering and supporting the project with abundant helpfulness in every way.

The State Department of Fisheries and the U. S. Fish and Wildlife Service have on many occasions cooperated in Olympia oyster studies, and during several years of our investigation the Service provided a boat for our use.

To the oystermen themselves we express our gratitude for their indulgence and their help and encouragement. Only if our work has resulted in useful contributions to their fishery will it have justified itself.

The plan of this paper will be to present a continuous and compacted account of our findings on the Olympia oyster and the conclusions tentative or otherwise which can be deduced from them. In bold-faced type within this account are given page references to later portions of the publication wherein tables of data and further discussion and substantiation of the points of the main story are to be found. This will relieve the reader of groping around among tedious ~~charts and~~ tabulations and, we trust, contribute something to remedy the situation whereby in their scientific papers oyster biologists often argue with each other while the practical oysterman can only stand by and hope that some useful morsels of information may chance to shake out of the discussion.

The great predecessor of this paper was the study of the Olympia oyster by Dr. A. E. Hopkins during the period of 1931 through 1935, published in 1937. Hopkins' paper may be consulted for references to earlier researches and observations on <u>Ostrea lurida</u>. Although we have taken exception to several of Hopkins' suggestions we realize that they were put forth provisionally, as befits the scientist, and require emendation largely because he did not have time in his extensive and under-staffed investigations to make quantitative studies on the larval stage of the oyster and because he did not employ over-all seasonal cultch. And we appreciate also how much we are indebted to this biologist for his pioneer work on lower Puget Sound. To Hopkins the industry owes the demonstration of the importance of angle of cultch surface for efficiency of spatting and the possibility of floating cultch, with all the vast practical gains that have followed therefrom.

Important contributions of more distant source stem from Dr. H. F. Prytherch's introduction of the cemented cardboard egg-case filler cultch (1924?) which is the best that we know for Olympia oysters; and his observations on the actual process of setting of Eastern oyster larvae in the laboratory are of importance and great potentiality in visualizing the relevant factors in spatfall. Cole and Knight Jones (1939) also contributed to our knowledge of the setting of oyster larvae in vitro.

We are indebted to Dr. P. Korringa for a recent, comprehensive, logically comparative and intelligently critical review of the oyster literature of eight languages. His publication (1940) has as its central theme a thorough study of the reproductive cycle of the European flat oyster in Holland from which he and his co-workers are able to predict time and intensity of oyster setting on short notice and to locate the most favorable areas for cultching. Conditions in the Oostershelde are however quite different from those in the Olympia oyster bays of lower Puget Sound. In this work we miss an investigation of over-winter mortality in relation to time of setting and a quantitative study of surviving spatfall (seasonal catch) which is most relevant to the actual, practical recruitment of seed oysters from year to year.

For the benefit of distant readers who may not be familiar with the Olympia oyster, a few orienting remarks are made in passing. Ostrea lurida is the oyster native to the northwest coast of North America and is similar to O. edulis of the northwest coast of Europe, being a small, larviparous oyster subject to intensive cultivation as a high-valued food item. Once abundant in all our deep bays from San Francisco to British Columbia, its distribution has now been markedly curtailed by depletion of natural beds and competition of the introduced Japanese species, O. gigas, with the result that now the only really extensive area of native oyster culture is in the bays of southern Puget Sound near the city of Olympia. These long inlets (Fig. 1) radiating out like the fingers of a hand are ideal locations for oysters since their upper reaches flatten into wide tidelands and each bay is sufficiently attenuated so that it confines and retains its own spawn. ~~It results that~~ each bay is to a large extent an independent oystering unit and has been treated as such in the present work. (7)

The area of oyster land has been greatly increased by the building of dikes which have the twofold purpose of retaining 6 or more inches of water over the oysters at low tide in order to protect them from freezing and over-heating, and to extend the area of usable tideland by providing appropriate gravel substrate in places where only soft mud was encountered before. In many places the dike wall facing the incoming tidal current is made lower than that of the remaining sides with the result that the dike is filled after low tide seepage ~~only~~ by water flowing in one direction. In such "current dikes" the directed inflow efficiently cleans oysters and cultch and washes away the silt.

At the proper time cultch in the form usually of clean oyster shells or cemented egg-case fillers is placed in the dikes and seed is caught. Here the dikes may be said to have the additional function of keeping the cultch submerged, for exposure is inimical to permanent attachment of the seed oysters. After the spatting season the seed are scattered and allowed to grow until 4 or 5 years old when they are large enough for marketing. One or more periods of take-up and culling may intervene between these terminal operations.

The publications of Galtsoff (1929) and of Hopkins (1937) may be consulted for discussions of procedures of the Olympia oyster industry.

Marketing of oysters and care of the beds involve well-established operations wherein improvement depends largely on the industry and cost-accounting of the grower; and simple methods for the control of oyster pests have not been forthcoming due to the extreme difficulty of this type of problem. For the growth and fattening of oysters we are still largely at the mercy of the provender of the seas. Hence the most immediately effective point at which one can aid the fishery is by helping in every way possible to assure a continued abundant supply of seed oysters through attention to the reproductive cycle of the oyster.

The Olympia oyster begins spawning usually some time during the month of May. Sexually mature after one year, the oyster spawns first as a male and later as a female, alternating thereafter even within a given year (Coe, 1931, ~~a, b,~~ 1932); and the developing eggs are retained within the mantle cavity for about 10 days until the larvae are shelled. Liberated larvae spend a pelagic life of around 30 days and then metamorphose into oysters on attaching to suitable surfaces. The reproductive cycle through the spring and summer season may therefore be followed by contact at these points: (1) time, number and proportion of spawning oysters, (2) abundance and size of pelagic larvae, (3) time and rate of spatfall, and, (4) magnitude of effective, surviving set, for each year and each bay.

Season after season we obtained frequent spawning and plankton samples and put out weekly, bi-weekly and seasonal test cultch in as many as 5 separate breeding populations of oysters. Within this coverage we tried of course to have our data be as accurate and as representative as possible. A description of the methods employed together with an assessment of their accuracy and representative character are given in detail on ~~elsewhere in this paper~~ (P. 52). The result was that we now have a quantitative picture, usually quite complete, of the reproductive season in each bay for each year during ~~the past~~ nine consecutive years. Since these representations are the substance of our field observations, we turn to them now for a view of what occurs bay-wise during the reproductive cycle of our Olympia oyster.

THE BAY-YEARS

I prefer a title like
Explanation of Figures — to —.
and condense each explanation as much as possible.

Put REVIEW OF REPRODUCTIVE SEASONS, BY BAYS & BY YEARS at beginning of this section & leave off this specific title.

Detail about ~~[illegible]~~ relative rank of the various bays as given on p.11 seems out of place here.

THE BAY - YEARS

We want first of all to say what needs to be said about how the bay-year graphs were set up, referring to a typical example like Figure 14. The graphs show successive waves of spawning leading to blooms of oyster larvae eventuating in waves of spatfall. The temporal sequence of spawning, larvae production and setting are evident from the uniform date line at the top of the graph, while at the bottom are shown the periods of spring tides with the predicted tidal run-out indicated by height of the black pyramids.

A telescoping scale is employed for the abundance of larvae and magnitude of spatfall, the points where the scale "breaks" being clearly indicated by horizontal lines. This compromise arrangement is to be fully kept in mind in studying the graphs because increments within the telescoped bands are greatly minimized in relation to increases within lower portions of the curves. The use of broken - line histograms would have been more legitimate; but data points have been joined to form curves and no broken lines are used in passing from one scale to another in order to eliminate confusion, to compact all the data for one bay-year in a single figure, and to enable oystermen to make immediate, visual comparisons of the performance of the bays from year to year. Furthermore, the telescoping scale permits all graphs to be of identical scale and emphasizes miniral, critical values of spawning, larvae abundance, and spatting intensity essential to a successful catch of seed oysters. Excesses above these thresholds may be generally discounted for practical purposes as contributing little to an already saturated cultch (see P. 41).

The only exception to this uniformity of presentation is that the spatfall of 1942 and 1943 is expressed in different terms since an entirely different type of test cultch was used during these years.

It is to be emphasized that the graphs do not necessarily represent what actually occured in the bays, but rather are to be viewed as the best approximations to these real events which we were able to obtain with the time and means at our disposal.

SPAWNING

Points on the spawning curves represent percentages of mature female-functioning oysters found to be "incubating" larvae, on successive days in one patch of oysters in each bay which was thought to be representative of the whole bay. Intensity of spawning ~~at a given time~~ rises more or less rapidly to a peak and then falls off. Steepness of the curve may depend upon the prevailing temperature of the water at the time of spawning.

Since the larvae are retained by the parent for about 9 1/2 days it can be assumed that at 10-day intervals throughout the curve the spawners encountered will contain none of those found previously and that after the peak of spawning the individuals not gravid will contain both those which have not yet spawned and those which have already completed spawning. Hence cumulative percentages at 10-day intervals will give a measure of the total proportion of the sampled oysters which have spawned as females. This value may vary from 35% to 121%, the higher figure demonstrating that individuals which spawned as males may later spawn as females during the same season. But the spawning curve is chiefly of importance in indicating the time of commencement of the reproductive cycle. Being a matter of percentage, its magnitude has little to do with the actual abundance of larvae produced since this depends on other factors as well, such as the sise of the broods, early survival of larvae, and, chiefly, the number of mature oysters in the bay. When the aggregate percentage of female spawners was unusually high during the first wave of spawning (83% and 80% for Oyster and Mud Bays, respectively, in 1945) the abundance of larvae produced was phenominal; but at lower values no significant correlation appears between the aggregate percentage and size of the larval mass. Hence we have not charted these cumulative percentages but plotted only the week-to-week proportion of gravid oysters.

LARVAE

Points on the larvae curves represent maximum numbers of pelagic, swimming larvae found on any one day by filtering 20 gallons of bay water. The reasons for using the maximum number will be discussed more fully later (P. 61), but for the present it suffices to say that maximum counts are the best substitute for such a valid average density of larvae as could be obtained only in more time than was at our disposal.

Secondary spawning curves are also reflected in second peaks of larval abundance.

Since a wave of spawning occurs over a 20 to 30-day period, a variety of sizes of larvae is present at most times. In addition to counting the number of larvae per 20 gallon water sample, we noted the percentage of those which were near setting, or roughly 270 to 330 microns in diameter (see also P. 67). The percentages from all samples measured on a given bay-day were averaged and multiplied by the maximum count to give the ~~number~~ density of large larvae near setting. These values are plotted within the over-all larvae curves and show the ~~actual~~ number of larvae contributing to the set at a given time.

SETTING

Points on the setting curve represent the number of spat caught on 100 Pacific oyster (O. gigas) shell faces per day averaged during a period of from 3 to 7 days, a value which we call in our bulletins the Setting Index. Test cultch was made by stringing a dozen flat Pacific oyster shell "lids" on a wire with face downward and in a horizontal position. Hence the setting surface was maximal, being the underside of a horizontal shell surface (Hopkins, 1937). The strings were placed in one or two areas considered to be typical in each bay.