SURFACE CATCHES OF MARINE DIATOMS AND
DINOFLAGELLATES MADE BY U.S.S. PIONEER
BETWEEN SAN DIEGO AND SEATTLE IN 1923

BY
WINFRED EMORY ALLEN

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WINFRED EMORY ALLEN

(Contribution from Scripps Institution for Biological Research of the University of California) *

In the latter part of February, 1923, the United States Coast and Geodetic Survey Steamer *Pioneer* ended her winter work in the San Diego region and turned northward to prepare for summer work in Alaskan waters. On the northward trip, hourly collections were taken in the same way that they had been taken in the San Diego region (Allen, 1923). This series of collections was continuous to San Francisco. Collecting was resumed the first week in April and was again continuous as far as Seattle. It comprises a total of 119 catches from fifteen miles north of San Diego to a point near Seattle in Puget Sound.

On account of the uniform frequency of sampling in this series, it has seemed desirable to make somewhat different designations of regional units from those formerly used (Allen, 1922). Although arbitrarily selected, the limits of these regions have been largely determined by the more prominent coastal topographic features. (See map, fig. 1.) The position of the last catch in each region has been taken as the distal boundary of that region.

In seven out of the eleven regions designated, at least a few diatoms were recorded for every catch. Of dinoflagellates, this was true in only two regions. In five regions, the largest catch of diatoms, and in four regions the average number of diatoms to the catch, were greater than 50,000 to the liter. In only two regions did catches of dinoflagellates reach 1000 to the liter, and in no region was the average to the catch so great as 1000 to the liter. (See table 1.)

Fifty-one species of diatoms, representing twenty-two genera, were recorded between San Diego and Seattle. The more important of

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TABLE 1
TO SHOW GROSS FEATURES OF REGIONAL DISTRIBUTION

Region (see map)	Diatoms			Surface Temp. C.			Dinoflagellates		
	Largest catch*	Average per catch*	Number blank catches	Maximum catch	Average for region	Number catches	Largest catch*	Average per catch*	Number blank catches
Santa Catalina Island.....	32,627	6,122		13.89	14.00	12	110	40	2
Santa Barbara Channel.....	10,384	3,096		13.33	12.95	10	638	143	1
Piedras Blancas.....	3,164	368	2	12.22	12.00	13	22	3	11
Monterey.....	238,312	34,469		10.56	11.00	7	264	37	6
San Francisco.....	2,220,748	434,502		10.56	10.95	7	1958	693	
Point Arena.....	816,598	53,837	2	11.39	10.11	16	1246	136	8
Point St. George.....	594	157	2	9.44	9.56	13	594	2	12
Yakina Head.....	330	100	6	8.8	8.8	14	88	8	12
Columbia River.....	33,968	14,407		8.77	8.9	8	220	74	1
Destruction Island.....	682,017	444,507		8.60	8.60	9	801	231	
Puget Sound.....	595,104	159,030		7.60	7.8	10	356	131	2

* Numbers per liter.

these had already been observed in the catches made by McEwen and Mortensen in 1920 (Allen, 1922). In the main, the same forms tended to prominence, although *Nitzschia seriata* Cl. was much less conspicuous than in the catches of 1920. Only in the Santa Barbara region did this species attain a place in the list of five most abundant forms.

Eight genera represented by ten species were found to be among the five most numerous forms in one or more regions. Of these, the most prominent numerically was *Skeletonema costatum* (Grev), which occupied first place in four regions out of the six in which it was conspicuous. The genus *Chaetoceras* was second to *Skeletonema* only in numbers. In constancy of representation, it was, as usual, first. The specimens of this genus were mostly small and difficult to segregate, for which reasons the record is somewhat unsatisfactory. Small forms listed as *Chaetoceras* sp. were found in all regions. In addition, *Chaetoceras debile* Cl. (sometimes including *Ch. curvisetum* Cl.) and *Chaetoceras scolopendra* (Cl.) were notable in some regions. In this particular series, the genus *Chaetoceras* appears to be relatively much more prominent south of Monterey than in any region farther north.

The genus third in prominence in this series was *Thalassiosira*. Identification of the species was not fully satisfactory. Only two, *Thalassiosira baltica* (Grun) and *Th. gravida* Cl., were recorded although there may have been as many as four or five species present in some catches. This genus showed some prominence in the southerly regions, but it was so very abundant in the regions of Columbia River, Destruction Island, and Puget Sound as to suggest the idea that northerly conditions especially favor it.

Asterionella was more conspicuous than in most series and it was especially noticeable near San Francisco. Heretofore, only one species of this genus had been noticed, *Asterionella japonica* Cl., but in the course of study it became evident that another species, *Asterionella kariana* Grun, was also present. This species seems to be very fragile in many colonies, all the distal points of the cells being broken. This breakage probably led to more or less error in identification even after the presence of a second (and possibly a third) species was recognized, but it is very probable that *A. japonica* Cl. is, in this series, more prominent in the southerly regions, while *A. kariana* Grun is more prominent in the northerly regions.

Bacteriastrum, *Grammatophora*, and *Eucampia* are the other three genera which had representatives among the five most prominent

forms in some regions, but there is nothing in the showing made by them which requires particular attention in this connection.

The catches of 1920 (Allen, 1922) did not give any strong indication that the species studied were peculiar to any particular section between San Diego and Puget Sound. It is therefore especially interesting to note that this more continuous series at a different season does give some evidence of restricted geographic range of some pelagic diatoms; e.g., the greater prominence of the genus *Chaetoceras* southerly, of *Skeletonema* medially, and of *Thalassiosira* northerly, and the possible difference in range of the two species of *Asterionella*, just mentioned.

As to geographic difference in quantity production, there are some interesting points. In 1920, the largest individual catches were made in the regions near to or north of Cape Mendocino. In this series, the largest catches were made in the San Francisco region, considerably south of that point (table 1 and fig. 1). Furthermore, the average production of catches in the San Francisco region is only slightly less than in the region of Destruction Island. On the other hand, only thirteen out of the sixty-five catches south of Cape Mendocino contained more than 10,000 to the liter while thirty-three of the fifty-four catches north of Cape Mendocino exceeded that number. Superficially, this seems to be strong indication that productivity is greater in higher latitudes. It is, however, one thing to say that higher latitudes are places of greater production and quite another thing to say that they cause greater production in the sea. For example, they may merely mark the region in which land drainage most favorably influences marine productivity. The showing in the San Francisco region makes it desirable to delay the statement of a conclusion until we are sure that latitude exerts a determining influence instead of merely accompanying such an influence. (Allen, 1922, p. 143.)

Although it was not possible to make hydrographic observations to accompany this series of collections, records of temperatures at times of collecting were regularly made. These temperature records are partly summarized in the middle columns of table 1. As might be expected, this summary shows a steady lowering of temperatures toward the north. Six out of eleven maximum catches were taken in temperatures slightly below the average for the region, but there is no special significance in this isolated fact. The fact that the two most consistently productive regions were those of lowest temperature while that of largest production was of a somewhat higher temperature

is important because it adds to the evidence that, under ordinary circumstances, temperature is not a directly determining factor in productivity of marine diatoms.

In considering the evidence of productivity in this series of catches, it should be remembered that the southerly regions were traversed in late February (not usually a highly productive month), while the northerly regions were traversed in April (in some years the most productive month). For that reason, direct comparison of areas south of San Francisco with areas north of that point is rather unsatisfactory. So far as we really know, the southerly sections may also have been heavily productive in April. Still, it is not probable that the relative conditions of temperature were very different in the two months, since it is known that southerly sections get some of their coldest water in March and early April.

At this time of year, the greatest change in any single environmental condition is supposed to be in the effect of the sun's rays. There are excellent general and theoretic reasons for connecting vernal increase in productivity with solar influence, but, unfortunately, that is one factor concerning which marine researches are almost entirely lacking.

Comparison of productivity of regions in this series with that of those in the 1920 series shows that the Destruction Island and San Francisco regions were highly productive in all three cases (McEwen in summer, Mortensen through fall, and the *Pioneer* in early spring). The Point St. George region was poorly productive in all cases while the Yakina Head region was most productive in Mortensen's catches and very poor in McEwen's and those of the *Pioneer*. Thus we find additional evidence that some regions may be highly variable in productivity according to season or circumstance. On the other hand, it seems probable that some regions, e.g., Destruction Island, may always show relatively high productivity as compared with other regions.

It is not possible at present to make a conclusive statement essentially different from that concerning the 1920 series (Allen, 1922). This is, however, an appropriate place to emphasize the fact that, with such vessels as the *Pioneer*, plankton collecting of very high value can be done, and that the spirit of coöperation shown by the officers and men of the U.S.S. *Pioneer* is exceedingly encouraging for more rapid and effective advances in oceanic research. The enthusiasm of the administrative officers of the U. S. Coast and Geodetic Survey in Washington is also encouraging and deserving of high commendation.

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Fig. 1. Map Diagram of Pacific Coast of United States. Regional Boundaries indicated by dotted lines.

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