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OCEANOGRAPHICAL INVESTIGATIONS OFF THE PACIFIC COAST OF CANADA REPORT FOR 1934

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OCEANOGRAPHICAL INVESTIGATIONS OFF THE PACIFIC COAST OF CANADA
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by

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During the summer season, three cruises each of approximately one months's duration were made on board the Hydrographic Survey ship, "Wm. J. Stewart", and one cruise of five days on board the oceanographical vessel, "Catalyst" of the University of Washington.

The cruises on the "Stewart" were made in accordance with the plans submitted last spring and the work accomplished is outlined in the following pages.

The vital information regarding vessels, cruises, stations and observations is contained in Table I.

Table I

Vessel	"Wm. J. Stewart"			U.S.S. "Catalyst"	Totals
Cruise	I	II	III	IV	
Dates	April 29 to May 24	May 28 to June 30	July 4 to July 31	Aug. 12 to Aug. 17	111 days
Days at sea	25	33	26	5	95
Total stations	34	41	30	1	106
B Bottom sample	19	8	7	1	35
H Hydrographic Obs.	21	19	15	26	81
P Phyto-plankton Obs.	19	9	7	26	61
Z Zoo-plankton Obs.	18	10	7	26	61
T Trawling Operations	21	8	8	0	37
F Fishing Operations	1	0	0	0	1
S Shore Obs.	0	16	10	0	26

The location and character of the observations made at the various stations is contained in Table A appended to this report.

As has been explained in previous outlines of this summer's program, general observations were to be made at predetermined locations. These are shown on Biological Survey chart 2200-A which is appended. The territory under observation was divided into districts and the stations numbered in accordance with the international system now in use on the Pacific coast of North America.

The stations actually observed this summer are shown on Biological Survey chart 2200-B which is appended.

The general stations consisted of observations of the bottom, general chemical and physical observation of the water throughout its depth, quantitative samples of the phyto-plankton, and vertical net hauls for zoo-plankton. Thirty-three such stations were observed, eighteen on the first, eight on the second and seven on the third cruise of the "Stewart", and one on the cruise of the "Catalyst". Two of those taken from the "Stewart" consisted of tidal observations and the cruise of the "Catalyst" was for the express purpose of estimating tidal movements in Nootka sound. There were two hydrodynamic sections and several series of surface observations, as well as considerable trawling and shore collecting.

Biological Work

The collection of biological specimens was under the direct supervision of Mr. E.G. Hart, a voluntary worker at the Station.

Mr. Hart's interest and ability are worthy of high praise. At no time did he spare himself in the pursuance of his object and many times he worked through two days without rest that his work might all times be up to date. He seized every opportunity to gain material and information and improved the working

facilities by his own inventive genius. Descriptions of two devices of his design have been submitted for publication and several others should be forthcoming.

Complete records were kept of all material showing location, meteorological conditions, time and method of collection. There is a complete gazette of the observations and each specimen is clearly designated. Thanks to Mr. Hart's assiduity, these records are extremely clear.

Plankton.

Phyto-plankton was collected in one-litre Nekman deep sea-water bottles according to the procedure outlined in, "Oceanographical Investigations of the Pacific Coast of Canada, Strait of Georgia. I. Methods", now awaiting publication in "The Journal of the Biological Board" and concentrated to a small volume according to the procedure outlined in "Some Devices for the Collection of Marine Plankton", now awaiting publication in the "Journal du Conseil". This latter procedure was devised to fit the needs of the expedition by Mr. Hart.

The samples were preserved in formalin and returned to the Pacific Biological Station and are now awaiting identification and counting.

Zoo-plankton was collected by vertical net hauls with an apparatus described in the second paper mentioned above and designed by Mr. Hart. The samples collected were concentrated and preserved in a similar manner to the phyto-plankton.

As this material has not been inspected, no conclusions may be drawn at the present time.

Bottom Samples

A combined sounding and bottom sample was taken at each station observed, with a clam shell dredge. This machine, made in Nanaimo, was too light for ocean work and was very unsatisfactory in performance throughout the season. As a general rule two or three casts were necessary in order to obtain a sample which was generally very small.

The sample obtained was worked over for any life that was contained and this was preserved in formalin and where possible a sample of the bottom was also kept for future reference.

Trawling.

This operation was carried out by Captain J.J. Moore of the "Stewart", who has had considerable experience trawling in the North sea. Two beam trawls and one square-mouthed trawl were made under the direction of Captain Moore and kept in repair by the crew. The web used in the bag was begged from the canneries along the coast and was fitted and kept in repair by the crew and Captain Moore.

Seventy trawls were made at thirty-seven stations, the operations being carried out at the convenience of the survey and as the casts were made entirely at random, the material collected is representative of the area covered.

The collected material was sorted and preserved by Mr. Hart and on return to the Pacific Biological Station it was turned over to various authorities for identification.

The trawling operation was attended by many difficulties on a ship of this character and Captain Moore is to be sincerely thanked for his interest and skill in helping us throughout the season.

Had more trawls been available more work could have been done, but as constant repair was necessary both to the frame and the web, many opportunities for sampling were missed. All trawls were finally lost at sea and these operations ended about two weeks before the expedition returned.

Shore Collecting

During the months of June and July when the survey was observing the "low water features" of the coast-line, Mr. Hart took the opportunity to spend the periods of low water of the spring tides collecting shore forms. Collections were made along most of the coast from Kyuquot sound to Clayoquot sound. The specimens collected were divided into phyla, preserved and distributed amongst various authorities for identification.

The co-operation of Mr. H.D. Parizeau, commanding officer, cannot be too highly praised in this connection. He provided boats and landing parties for Mr. Hart and several times he established camps ashore expressly for this purpose. The service of two men and a boat was always available and at times as many as seven men and two boats were placed at his disposal.

Although this was not a major object of the expedition, the results obtained are amongst the most satisfactory observations made during the season.

Physical and Chemical Oceanography

This aspect of the expedition was under my personal direction and generally followed the procedure found most suitable in the Strait of Georgia.

General Observations of the Water.

The water was sampled from bottom to surface at thirty-three of the general stations and observations were made of the temperature, chlorinity, pH and dissolved oxygen, silicate and phosphate and in some instances analysis was made for nitrite. Analyses for nitrates was attempted but lack of equipment prevented this test from being consistently followed. From these analyses, the density and percentage saturation with dissolved oxygen was calculated.

The data have not been studied closely to date but cursory examination shows that the surface zone southward of Estevan point is colder and more dense than to the northward.

The location of the stations was planned in advance but the time of observation could not be predetermined and the samples were taken at the convenience of the Hydrographic Survey. Hence there was no logical sequence to the observations which were made at the stations nearest to the ship's position at the time. Due to this condition it is doubtful whether there is any value to these determinations other than to illustrate the general summer conditions.

Also the lack of accurate instruments impairs the value of the results obtained, particularly in the temperature observations and colorimetric analyses.

The thermometers in use have a variation of about two-tenths of a degree and an absolute error which in some cases amounts to seven-tenths of a degree. Hence it is impossible to determine the temperature closer than one-fifth of a degree Centigrade. This precludes hydrodynamic operations of any real value.

The colorimetric analyses are only approximate, as the colorimeter was very tiring to the eyes after several hours use. Also the external lighting conditions were found to affect the observer's sensitivity to an extent that would introduce an error of as much as fifty per cent in the phosphate and two hundred per cent in the silicate estimation. It is essential in this type of work that the observations be rapid, easy, accurate and with the analyst working long hours, as free as possible from personal errors. New thermometers are needed and a photo-electric colorimeter.

Hydro dynamics.

Two series of hydrodynamic observations were made, one on the flood and the other on the ebb of the neap tides, just outside of Nootka sound, as a test of the possibility of making such observations off the whole coast.

All corrections possible were applied to the thermometers and the operation was carried out with the greatest care. The data from the flood tide observation have been worked up and are plotted on chart 2231-A, appended to this report. This chart shows the current velocities at the surface, five, ten and twenty metres in relation to the water at thirty-five metres depth.

No direct observations of the current were possible as there was no equipment or opportunities to make any. It may be possible to check these data in another year but at the present time the diagram is fairly in accord with general observations.

Tidal Stations.

Two tidal observations were made from the "Stewart" similar in all respects to those of the Strait of Georgia expedition of 1932. One was in Clayoquot sound and the other just outside of Nootka sound. The station

observed from the "Catalyst" consisted of twenty-six complete observations made at two-hour intervals, just inside of Nootka sound. These data were taken to further the study of an apparent dual circulation, noted last year and outlined in "Oceanographical Investigations off the Pacific Coast of Canada, A Preliminary Chemical and Physical Investigation of Nootka Sound and the Adjacent Sea Waters", now awaiting publication in the "Journal of the Biological Board of Canada".

Surface Observations.

While lines of soundings were being run by the survey, surface samples and temperatures were taken at four-minute intervals while the ship was steaming at twelve knots. The surveyors plotted the position at each observation and data were mapped with regard to the position of the ship. It is hoped that further examination of these results will show the tendencies of surface movement.

Daily Water Samples.

In order to determine the annual cycle of temperatures and densities, arrangements have been made with the keepers of six lighthouses on the Canadian coast to measure the surface temperature and to take a sample of the water each day. The lighthouses are: Amphitrite, Estevan, Nootka, Kains Island, Cape St. James and Green Island. The samples and temperatures are to be returned to the Pacific Biological Station where analysis for chlorides will be made and the densities calculated and the data from the whole coast correlated to the fisheries problems.

Contour Chart.

One of the most outstanding contributions of the season's expedition is the contour chart of the sea bottom of the west coast of Vancouver island which is appended to this report. The contours shown were interpreted from the original data on board the "Stewart" and the chart contains the latest information regarding this section of Canadian waters.

The preparation of this chart, which has already attracted much favorable comment, is entirely due to the courtesy, interest and co-operation of Mr. Parizeau and his associates who spared no pains in aiding the scientists in the preparation and interpretation of the data. Most of the contours were interpreted on board, but the surveyors prepared the coastline and the contours between forty metres depth and the shore-line for tracing and have done the printing.

It is hoped that blue prints will be made for use in fishing stations and by scientists and that a reproduction on one-quarter scale may be prepared for use by fishermen and investigators.

The practical value of this chart lies in the bold relief that is given to bottom detail, the fishing banks being clearly indicated by the sixty-metre contours. The scientific value is enormous where correlation between habits, habitat, and species of marine life is being considered. Also an understanding of the behaviour of water currents and of fish migration is considerably simplified by this chart which is probably the most accurate of its kind for the American Pacific coast.

Facilities for Oceanographic Work

The accommodation and treatment accorded to the scientists on board the ship was of the best and every possible provision was made for their comfort.

The laboratory space was in the forepeak of the ship over the chain locker and was ample in size. Mr. Parizeau undertook the construction of work benches and shelves, the laying of a floor, the installation of lights and a radiator so that the place would be livable. It should be pointed out that all the labour and much of the material was supplied by the Hydrographic Survey at considerable trouble and expense.

In spite of these efforts and due to its position in the ship, this laboratory was untenable in heavy weather, due to the fact that the forward hatch had to be battened down, which cut off all source of ventilation. It sometimes occurred that analysis of water samples had to be left for several days so that the determinations of the dissolved nutrient salts were worthless and that for dissolved oxygen of doubtful value.

The use of formalin in the laboratory was discontinued after the first day as the fumes drove every one from that part of the ship. This operation was carried out behind a canvas wind screen on the main deck which was kindly erected by Mr. Parizeau. The deck laboratory was adequate for most of the preserving operations except in the heaviest weather.

As there was no power winch the sounding line was wound on a hand-operated sounding machine, loaned by Mr. Parizeau for the purpose. This machine was necessarily slow and after two attempts, the examination of deep water was abandoned due to the fact that too many men were required for the operation.

Mr. Parizeau delegated two men of the crew to the service of the scientific staff and this number was later increased to three. These men would the winch, cleaned the laboratory, fetched water, emptied waste, acted as the nucleus of the landing parties and performed the countless tasks that the lack of proper facilities rendered essential.

The engineering facilities of the ship were placed at the disposal of the scientists, and without this almost continuous aid in constructing new or makeshift equipment and in repairing the old, the survey would never have been accomplished.

In brief the Hydrographic Survey, through the interest of Mr. Parizeau, supplied the equipment and personnel necessary for the operations of observation while the Biological Board contributed the laboratory supplies and technical staff. Mr. Parizeau's keen interest and unlimited co-operation was reflected in all on board the ship, so that the survey finally attained an unhoped for degree of success.

Plans for the Future

The expedition this year may be likened to a reconnaisance of the territory, and when considered in that light it has been eminently successful. The personnel of the biological staff is fully aware of the problems of manipulation to be encountered and the scope and relation of the work to be done. Sufficient results have been obtained to indicate the most suitable course of action in the future and it is now a matter of obtaining the essential information in the most efficient manner.

Such a survey should consist of complete observations at a series of co-related stations. These would need to include all the physical, chemical and biological data necessary to define the distribution of densities, water movements, the occurrence and distribution of the food elements, phyto- and zoo-plankton and the physical and chemical character of the bottom together with the flora and fauna present. For the systematic collection of these data it would be necessary not only to plan the location of the stations in advance but to observe them in an orderly sequence so that the information obtained might be co-related to the tides, season and year.

In addition, current measurement by means of log, current meter and drift bottles are necessary to standardize the hydrodynamic calculations.

From the data so collected, the tidal and non-tidal water movements could be charted, the hydrodynamic features could be calculated and plotted, the distribution and classification of the plankton and its relation to the physical and chemical characteristics of the water could be ascertained and a description of the bottom flora and fauna could be made. All these could be related to diurnal and seasonal changes and in this way a thorough understanding of the conditions affecting the ocean fisheries off this coast would be obtained.

Required Facilities

An efficient survey of the Pacific coast waters requires the use of a vessel that is free to sail at the direction of the scientist in charge of the work. This is particularly true in the study of hydrodynamics, plankton, and fish movements which have to be considered in relation to season as well as location.

For the purpose of hydrodynamic observations, the use of one of the

navy cruisers, similar to the U.S.S. "Hannibal" off the coast of United States, would be possible.

For all purposes the use of one of the fisheries patrol boats at selected seasons would be suitable. By this means a cruise could be made for a month entirely in the interests of the Biological Survey and all the information available in that interval could be collected.

The motor cruiser "A.P. Knight" could be used in this service admirably. A moderate amount of refitting would make this vessel seaworthy and adapt her to the work in hand. By carefully considering the weather a very complete survey could be made of all waters within twenty-five miles off the coast which is all that is at present necessary. The use of this boat has the further advantage that it would form a base for further operations on the West coast.

The best interests of the Biological Board might best be served by operating from the "Stewart" during May and from the "Knight" during the rest of the summer season and from a fisheries patrol boat in the winter. Some such arrangement would enable your staff to completely describe the annual meteorological and life cycle off the West coast.

Some other equipment is required for the coming year regardless of what vessel is used. For further operations on the "Stewart" or any vessel other than the "Knight", a suitable winch assembly is required to haul the sounding line.

The instruments urgently required include a photo-electric colorimeter, six deep-sea thermometers, six open-tube thermometers, three standard burettes, a current meter, a stop watch, a sextant. Some gear is also required, namely, some beam trawls, a clam shell dredge and a set of plankton nets.

The price and total cost of this equipment is listed and appended to this report.

If operations are to be carried out on the "Stewart", it is essential that

a system of ventilation and a water supply be installed in the laboratory. The former so that the scientist may work with some more regularity and the latter so that he may work with some more efficiency.

Conclusion

This year's expedition on board the "Stewart" has been eminently successful as a reconnaisance survey of these waters. It is known that from the material worked over, several new species have been discovered and the range of many more has been extended. A general idea of the summer oceanographical conditions off the coast has been obtained and pertinent notes as to the general circulation of the water have been made. An accurate contour chart containing the latest information from the hydrographic surveys of United States and Canada has been prepared.

The results, when completely analysed and correlated, will give a comprehensive sketch of the area covered.

It is evident from the above discussion that there are some facilities lacking in the present method of investigation. Although the Hydrographic Survey has done everything in its power to indicate its co-operation, the observations were necessarily made at random and have often been curtailed or insufficient due to lack of equipment.

In the further prosecution of this survey, the general reconnaisance attitude must give way to an exact procedure and all observations must be precise measurements taken with due consideration of all the factors. This necessitates the appointment of a vessel to this service for several months of the year at least, a number of instruments, and some extra gear.

Under the present circumstances, it is probable that a month spent on

board the "Stewart" during the rough weather in the spring, followed by the summer months on the "Knight" would be the most efficient procedure and this course is sincerely recommended.

TABLE A.

"Wm. J. Stewart" I.

Date	Station	Latitude	Longitude	Character B	H	P	Z	T	F	S	Remarks
April 30	2221-12	49°02'	126°01'	B	H	P	Z				
	2221-10	48 53½	126 09	B	H	P	Z				
May 1	2221-11	48 52	126 11	B				T			
1	-16	48 59½	126 07					T_1			
1	-17	49 00½	126 07½					$2T_1$			
1	-18	49 02½	126 08½					2_{T_1}			
2	2221-15	48 53½	125 49	B	H	P	Z				Rough
2	2212- 1	48 56 35	125 08 37	B	H	P	Z				
5	2221- 2	48 56½	126 40½	B	H	P					
7	2212- 2	48 51	125 16	B	H	P	Z	1_{T_1}	F		
7	2213- 1	49 00	124 52½	B	H	P	Z				
7	- 2	49 00½	124 48	B'	H	P	Z				
7	- 3	49 12½	124 49½					$2S_1$			
8	2211- 2	48 47	125 41	B	H	P	Z				
8	- 1	48 39	125 46	B	H	P	Z	$2T_1$			
8	2221-19	49 04½	126 05½					$2T_2$			
9	2221- 7	49 00½	126 19	B	H	P'	Z				
10	2221- 6	48 52	126 26	B	H	P	Z				
10	2222- 1	49 15½	126 01½					$3T_1$			
11	2221-20	49 00½	125 44½					$1S_1$			
14	2221- 8	49 10½	126 13½	B	H	P	Z	$3T_2$ $3T_1$			
15	- 4	49 26	126 23½	B	H	P	Z				
	- 3	49 07½	126 31½	B	H	P	Z	$2T_1$			
16	-21	49 20½	126 18½					$1T_1$			
	-22	49 19½	126 21½					$1T_1$			

Date	Station	Latitude	Longitude	Character B	H	P	Z	T	F	S	Remarks
May 18	2222- 2	49°14½'	126°03½'	1_B	4_H	2_P	2_Z				Tidal Series
19	2222- 3	49 21½	126 14½					2_{T_2}			
22	2221- 5	48 43½	126 33½	B	H	P	Z				
	-23	49 10½	126 25½					2_{T_2}			
	-24	49 15½	126 20½					1_{T_2}			
	-25	49 14	126 20					1_{T_1}			
22	2221-26	49 11	126 11					1_{T_1}			
22	-27	49 10½	126 10½					1_{T_1}			
24	2211- 6	48 36	124 55	B	H	P	Z				
Days 25	34			19	21	19	18	21	1	-	Totals

"Wm. J. Stewart" II.

May 28	2211- 5	48 41½	125 08	B	H	P	Z				
29	2223- 1	49 28½	126 23½							S	
31	2231-14	49 23½	126 34½							S	
	2223- 2	49 27½	126 27							S	
June 1	2223- 3	49 22½	126 28½							S	
2	2231-15	49 23½	126 34½								
5	2231- 6	49 08½	126 49	B	H	P	Z	1_{T_1}			
	- 9	49 10	126 43					1_{T_1}			
	2221-28	49 11½	126 39					1_{T_3}			
	2231-10	49 13½	126 43					1_{T_3}			
	2231-11	49 19	126 36					2_{T_3}			
6	2232-10	Ocean de informe								S	
	2231- 8	49 22½	126 34½	B	H	P	Z				

Date	Station	Latitude	Longitude	Character							Remarks
				B	H	P	Z	T	F	S	
June 6	2231- 7	49°15'	126°42½	B	H	P	Z				
7	2243- 1	49 52½	126 59½							S	
7	2231-12	49 23½	126 38½		H						
9	2231-13	49 21	126 43½					1_{T_1}			
11	2224- 4	49 09½	126 00							S	
12	2223- 5	49 15½	126 07							S	
13	2231-16	49 34½	126 40½							S	
14	2231-17	49 36½	126 40½							S	
15	2251-13	49 57½	127 21½							S	
16	2241- 9	Bajo point								S	
18	2231-18	49 53½	126 38½	1_B	4_H	2_P	2_Z				Tidal Station Flounders
19	2231-19	49 31½	126 42½					5_{T_3}			
20	2241-10	49 46½	127 03					4_{T_3}			
23	2242- 1	49 50½	127 02½				Z				
25	2242- 2	49 51½	127 04½							S	
26	2231-20	49 36½	126 49							S	
27	2241-11	49 40½	126 53½							S	
28	2241-12	49 51	127 06½							S	
29	2231-21	49 35	126 34½		H						
	-22	49 35½	126 36½		H						
	-23	49 33½	126 41		H						
	-24	49 33½	126 37		H						
	-25	49 27½	126 39		H						
	-26	49 28½	126 43		H						
	-27	49 30½	126 46½		H						
	2211- 4	48 48½	125 19	B	H	P	Z				

Date	Station	Latitude	Longitude	Character B	H	P	Z	T	F	S	Remarks
June 29	2211- 3	48°39½'	125°27'	B	H	P	Z				
	2211- 6	48 36	124 55	B	H	P	Z				
Days 33	41			8	19	9	10	8	-	16	Totals
July 5	2221-14	48 46½	125 57	B	H	P	Z	$^{1}T_{1}$			
9	2231- 4	49 30½	126 46½	B	H	P	Z	$^{2}T_{3}$			
	2231-28	49 36	126 43½							S	
10	2231-29	49 36	126 43½							S	
11	2231-30	49 37½	126 49½							S	
12	2231-31	49 26½	126 51					$^{2}T_{1}$			
13	2231-32	49 31½	126 34½					$^{1}T_{1}$			
14	2231-13	49 45	126 59							S	
17	2231-33	49 22½	126 55					$^{3}T_{1}$			
	2231-34	49 30	126 51					$^{1}T_{1}$			
	2231- 3	49 22½	126 54	B	H	P	Z				
18	2241- 8	49 39½	126 57½	B	H	P	Z				
19	2241-14	49 37½	127 01½					$^{1}T_{1}$			
	2241-15	49 38½	127 00					$^{1}T_{1}$			
24	2242- 3	49 44	126 57							S	
25	2241- 4	49 45½	127 09½	B	H	P	Z				
	2242- 4	49 44	126 57							S	
	2242- 5	49 44	126 57		H					S	
27	2242- 6	49 48	126 50½							S	
	2244- 4	49 57½	126 54½							S	
29	2251-12	49 52½	127 20½	B	H	P	Z				
30	2231-35	49 35½	126 37		H					S	

Date	Station	Latitude	Longitude	Character B	H	P	Z	T	F	S	Remarks
July 30	2231-36	49°31½'	126°46½'		H						
	-37	49 29	126 43		H						
	-38	49 27½	126 39		H						
	-39	49 33½	126 41		H						
July 27	2231-40	49 32	126 37		H						
	-41	49 35½	126 36½		H						
	-42	49 35	126 34½		H						
31	2231- 8	48 36	124 55	B	H	P	Z				
Days 26	30			7	15	7	7	8	-	10	Totals

"Dr. J. Stewart" Totals

Days 90	105 stations			34	55	35	35	37	1	26	

"Catalyst" IV.

Date	Station	Latitude	Longitude	Character B	H	P	Z	T	F	S	Remarks
Aug. 13-35	2232-11	49°36½'	126°36½'	B	H	P	Z				52 hr. series
Days 5	1			1	26	26	26				Totals

Grand Totals

Days 95	106 stations			35	81	61	61	37	1	26	