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WIRE-DRAG WORK IN ALASKA

BY

L. O. COLBERT AND JOHN A. DANIELS

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CONTENTS.

	Page.
Introductory	5
Conditions peculiar to Alaska	8
Brief description of drag and methods of dragging	10
Vessels and launches	13
Importance of work accomplished and necessity for extension	13
Cost of wire-drag work in Alaska	18
General conditions affecting cost	18
Camp versus ship	21
Unit cost of wire-drag work	22
Summary of causes that interfere with the progress of wire-drag work	29

ILLUSTRATIONS.

Fig. 1.—Section of chart of southeastern Alaska	5
Fig. 2.—Drag set at different depths	7
Fig. 3.—Plan of drag under way	7
Fig. 4.—Plan of drag aground	7
Fig. 5.—Clearing drag	7
Fig. 6.—New Eddystone Rock	8
Fig. 7.—Cliff in Tracy Arm	8
Fig. 8.—Kayak Island and detached pinnacle rock	10
Fig. 9.—Rocky Relief	12
Fig. 10.—A dangerous shore	14
Fig. 11.—A pinnacle rock	14
Fig. 12.—Entrance to Resurrection Bay	18
Fig. 13.—Priest Rock	18
Fig. 14.—Remodeled steam schooner *Equator*	22
Fig. 15.—Power launch *Roosevelt*	22
Fig. 16.—Plan of *Roosevelt*	23
Fig. 17.—Section of chart of Shakan Bay	25

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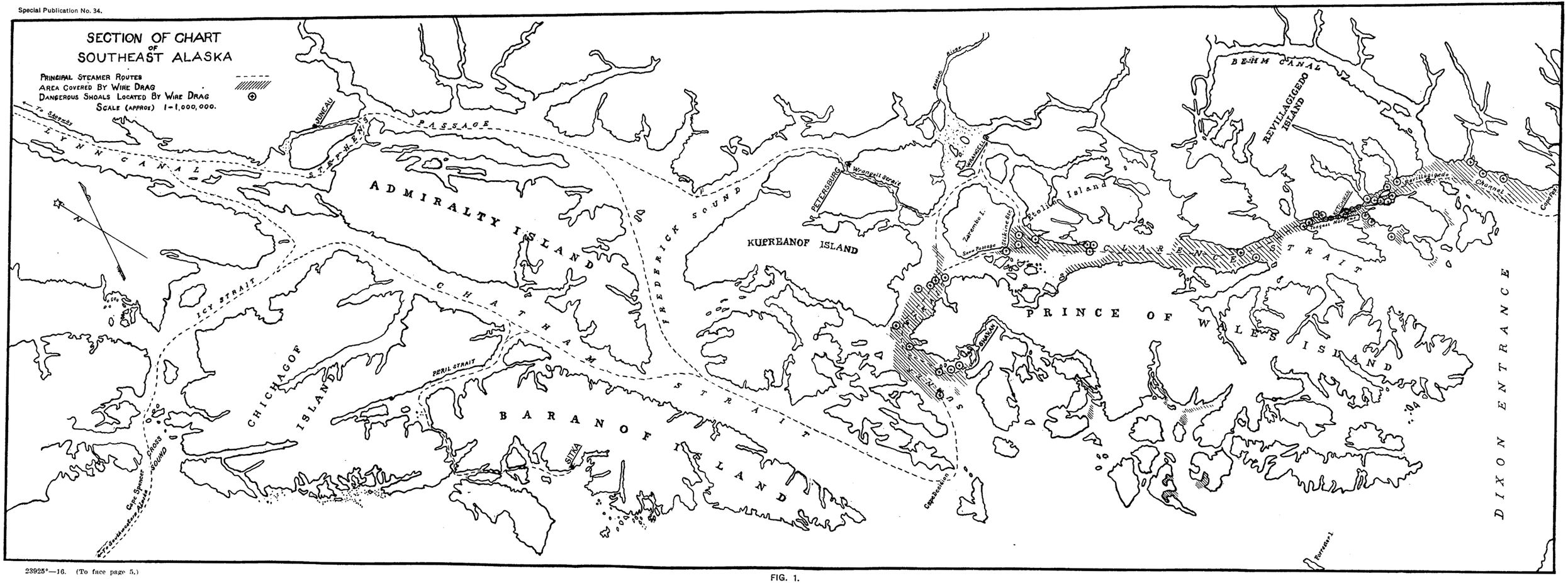

SECTION OF CHART
OF
SOUTHEAST ALASKA
PRINCIPAL STEAMER ROUTES
AREA COVERED BY WIRE DRAG
DANGEROUS SHOALS LOCATED BY WIRE DRAG
SCALE (APPROX) 1-1,000,000.
To Skagway
LYNN CANAL
JUNEAU
STEPHENS PASSAGE
ADMIRALTY ISLAND
CHATHAM STRAIT
FREDERICK SOUND
KUPREANOF ISLAND
PETERSBURG
Wrangell Narrows
WRANGELL
Stikine River
Zarembo I.
Sumner Strait
Etolin Island
REVILLAGIGEDO ISLAND
BEHM CANAL
Revillagigedo Channel
Tongass Narrows
KETCHIKAN
CLARENCE STRAIT
PRINCE OF WALES ISLAND
HYDAB
SHAKAN
Cape Bazaleon
DIXON ENTRANCE
Forrester I.
Cape Chacon
ICY STRAIT
CHICAGOF ISLAND
PERIL STRAIT
BARANOF ISLAND
SITKA
CROSS SOUND
Cape Spencer
To Yakutat
To Cordova

FIG. 1.

WIRE-DRAG WORK IN ALASKA.

INTRODUCTORY.

Since the purchase of Alaska by the United States, in 1867, the number of ships trading between the Territory and the western ports of the United States has steadily increased. Receiving great impetus from the Klondike, Nome, and Juneau gold strikes and the development of the mining and fishing industries, the importance of Alaska products has increased rapidly until the present value of commerce to and from the United States amounts to about $70,000,000 per year. For the same reasons immigration to the Territory has been stimulated and passenger traffic further augmented by tourists who frequent the region during the summer season. The natural wealth in coal and other minerals of the vast inland Territory of Alaska is deemed sufficiently important by the Government to justify appropriations for the construction of a railroad costing many millions of dollars. This project will undoubtedly bring to the Territory a much larger development of its natural resources and corresponding prosperity. In order to transport merchandise and passengers to and from Alaska a large and increasing number of vessels must pass through the inside passages of the British Columbia and Alaskan coasts.

These passages are deep and wide and lie between high ridges, so that they are sheltered from the heavy winds and seas of the open ocean, a condition that would seem to indicate security for navigation. This appearance of security is deceiving, however, for in many of these channels occurs what is now recognized as the greatest menace to coastwise shipping in Alaska, the pinnacle rock. Sometimes very sharp and rising from great depths, these dangers cover so small an area that it is only by chance that they are found by the ordinary methods of hydrographic surveying and they are often left undiscovered in apparently clear passages, ready to destroy the unfortunate vessel whose course lies near them.

In recent years, with increased navigation in Alaskan waters, the wrecking of vessels by striking uncharted pinnacle rocks has become appallingly frequent, even in the better surveyed waters. Disasters like that of the *Curaçao* and the *State of California,* costing about $200,000 and $350,000, respectively, and resulting in the loss of 31 lives in the latter case, directed the attention of the entire country to

the question of the safety of Alaska's ship channels. Were these disasters due to lack of care by navigators, lack of adequate charts, or to the unusually dangerous character of the waters? A consideration of the facts indicates a combination of the last two causes, as in both cases uncharted rocks were struck in channels where the existence of such unusual dangers proves the navigation of the channels to be very hazardous.

Surveys of Alaskan waters were begun by the Coast Survey in 1881 and have been carried on as rapidly and thoroughly as practicable since that time. Large areas have been surveyed and charted, but the universal method for making hydrographic surveys (that of using a leadline from a moving vessel) has not proved a certain means of locating pinnacle rocks, so that a large number of such dangers have remained undiscovered.

Until the introduction and perfection of the wire drag, surveyors and navigators were at a loss to devise an economical method for locating these dangers over wide areas, in a manner to insure safety for vessels. In fact the possibilities of the drag as a surveying instrument for extensive areas were not fully recognized until about 1910, after it had been used to a limited extent on the Atlantic coast. Since that time operations on the coasts of New England and Florida and in the vicinity of the Panama Canal have demonstrated its practical value through the large areas covered and the great number of dangers located.

With the increase in the commercial importance of Alaska and the number of ships plying its waters, there came a corresponding increase in accidents to vessels, with resultant loss of lives and property, due in many cases to the existence of uncharted rocks. This resulted in a just and insistent demand from navigators, shipowners, and the general public that some method be used for supplementing the usual hydrographic surveys so that all dangers could be discovered and their locations shown on Government charts or so that it could be proved that important channels and passages were free from such obstructions. To meet this demand wire-drag examinations were necessary, and this method was introduced in Alaska during the summer of 1914. In order to start this work, the Coast and Geodetic Survey was obliged to use money appropriated for the regular surveying ships, thus curtailing the progress of general surveys, already too long deferred, in order to meet a special condition. The wire drag had been used on the Atlantic coast for a number of years and, in general principles, was suitable for the work in Alaska. However, as will be explained hereafter, there were many local conditions to be considered, and it was necessary to solve various problems in order to meet these conditions. It was under these general handicaps that wire-drag work on the Alaskan coast was inaugurated.

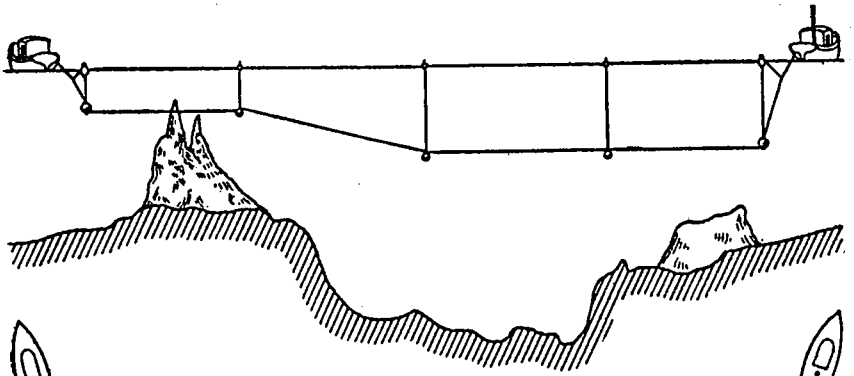


FIG. 2.—DRAG SET AT DIFFERENT DEPTHS.

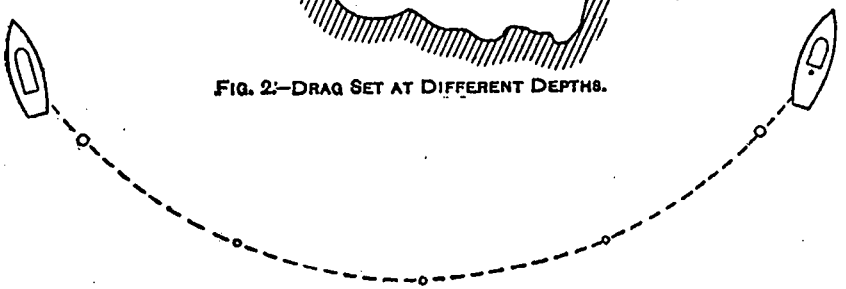


FIG. 3.—PLAN OF DRAG UNDER WAY.

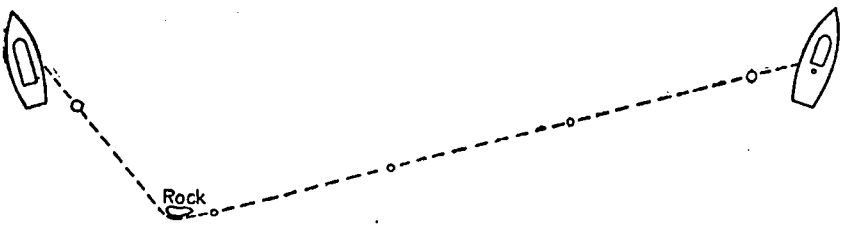


FIG. 4.—PLAN OF DRAG AGROUND.

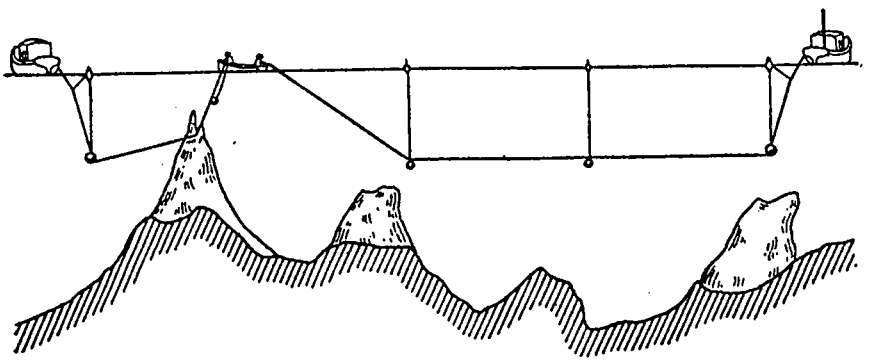


FIG. 5.—CLEARING DRAG.

The detailed mechanical construction of the wire drag as developed and perfected by the Coast Survey, since its adoption in 1906 from an apparatus used on the Great Lakes by the United States Engineers, is fully described in Special Publication No. 21, Department of Commerce. Its adaptation to the conditions on the Atlantic coast and the practical results obtained there are similarly described in Special Publication No. 29. These pamphlets may be obtained, by parties interested, upon application to the Division of Publications, Department of Commerce. Details of method and construction will therefore not be touched upon here, except where changes have been introduced to meet special conditions in Alaska. It is proper, however, to illustrate and briefly describe the fundamental operation of the drag as is done elsewhere in this paper.

Great differences exist between wire-drag work in Alaska and similar work on the Atlantic coast. A brief statement of the three distinctive features that hinder work in Alaska is as follows: First, marked increase in the range of tides with resulting stronger currents; second, widely divergent and more rugged physical features of the country, extending above and below the surface of the water; and, third, the comparatively few towns, affecting the conduct of the work with regard to supplies and living accommodations for the survey parties. It will be shown that these considerations render the wire-drag problem in Alaska as different from that on the Atlantic coast as the latter is different from that on the Great Lakes, and that these conditions require larger and more expensive launches with a consequent increase in the personnel of the party.

It will also be shown that the magnitude and importance of a complete wire-drag survey of Alaska justify and demand the expenditure of an amount sufficient to build and operate Government vessels, of the required type, equipped with special machinery necessary for carrying on this work. It should be stated that the work is not alone needed in Alaska, but that large areas along the western coast of the United States and in Puget Sound demand and must receive the additional safeguard for navigation that can be secured in no other way than by a wire-drag survey.

CONDITIONS PECULIAR TO ALASKA.

A large part of the Alaska coast is a land of high mountains, abrupt slopes, and deep channels. Jagged ridges, vertical cliffs, and sharp peaks unite to form scenery much admired by the tourist. Continuing below the water surface, however, the same relief forms shoals, ledges, and pinnacle rocks, and becomes a source of great anxiety to the navigator. The suddenness with which the sides of a valley may rise to a great height or the bed of a cañon be broken by a point of rock

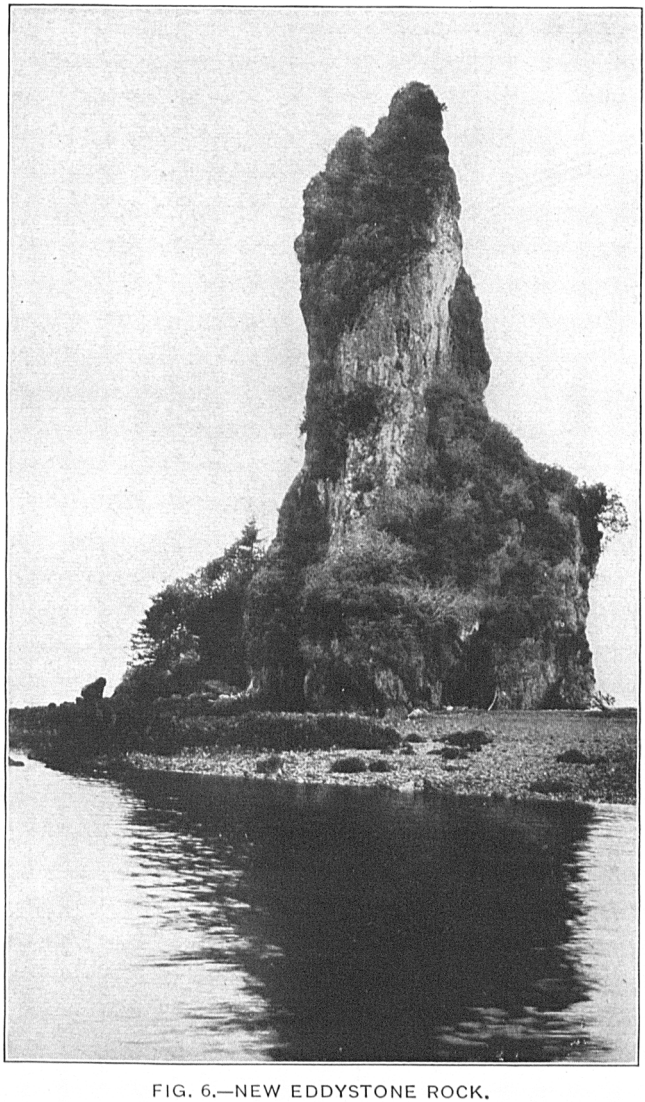


FIG. 6.—NEW EDDYSTONE ROCK.

Located in Behm Canal, southeastern Alaska; height, 234 feet; depths of 1,200 feet are found between this rock and the shore three-quarters of a mile distant.

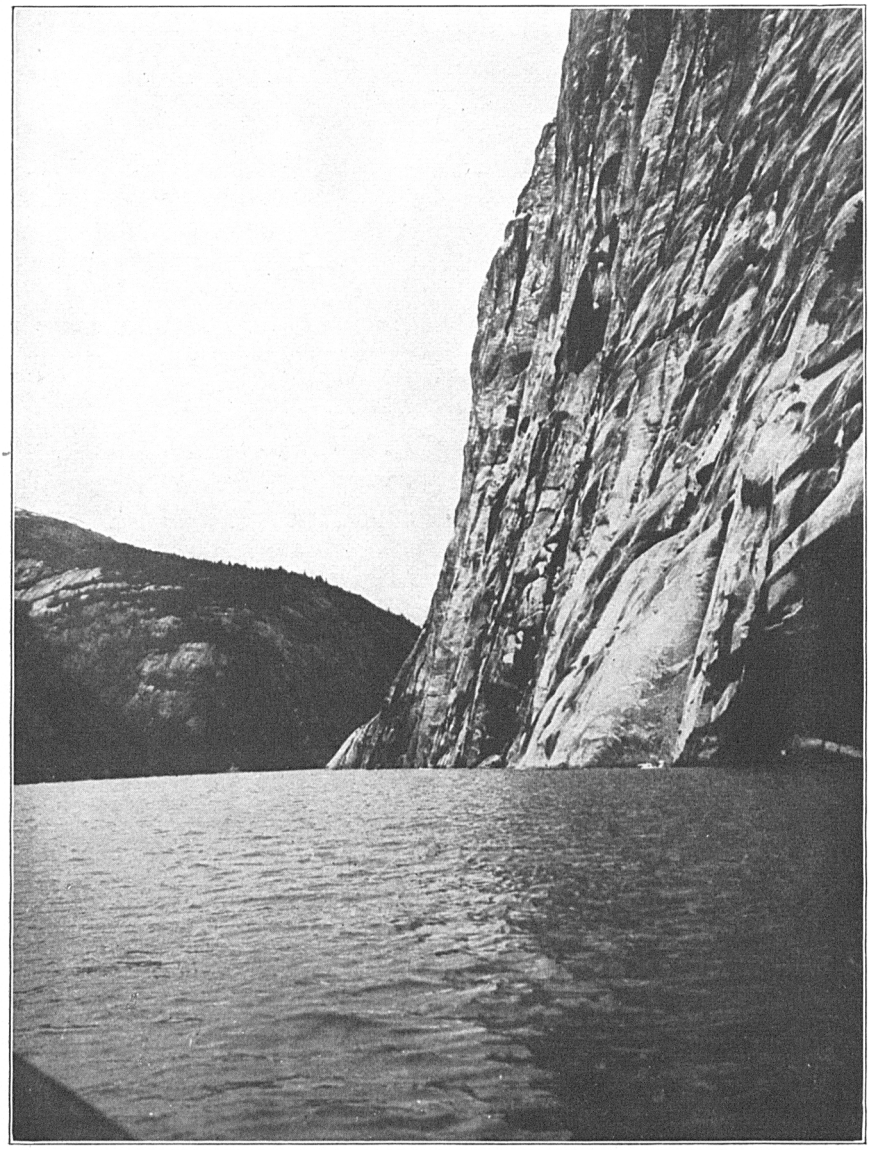


FIG. 7.—CLIFF IN TRACY ARM.

Cliff rises to a height of about 2,000 feet; width of channel, one-half mile; depth of water, 1,000 feet.

rising sharply is often duplicated when the sides of a deep channel rise to form a dangerous shoal or the channel is obstructed by a pinnacle rock. The continuation of visible land features below the water surface is studied by the hydrographer and constitutes a useful means of determining where dangers are most likely to occur. To illustrate, ridges extend in well-defined directions in certain localities, and it is almost invariably true that the contours of the bottom of adjacent water areas show that these ridges recur below the water surface. These recurrences are strikingly apparent in Alaska waters, but their special feature there is the irregularity and uncertainty of the extent of their appearance. Nature has shown little system in placing obstructions in Alaska's channels, and the rocks already found either by ships striking them or by use of the wire drag, as well as the visible types that may be photographed, prove that entire confidence can not be placed in the completeness of the surveys of channels that have been charted without verification by the wire drag.

A part of the existing survey of Alaska was made in the eighties in response to a sudden demand occasioned by the discovery of gold at Sitka and Juneau. It is an interesting fact that within six years after the discovery of gold at Juneau the Treadwell mine there had become one of the great gold producers of the world. The magnitude of the area to be surveyed, the necessity for immediate results, the comparatively slight importance of the country except for its mines, and the limited means available, resulted in hurried surveys being made. Consequently this work was of a class that would now be termed reconnoissance, a fact that has a direct bearing on the present wire-drag problem. The topography of the old surveys was without detail and the triangulation points were in most cases left unmarked, making it necessary that new triangulation and topography be done in connection with the wire-drag work. At the time of the early surveys no one imagined that Alaska would ever have its present importance, and it was therefore thought unnecessary to do the work with great detail.

Except in a few regions, such as Cook Inlet and the estuaries of large rivers, almost the entire coast of Alaska is unchangeable unless from earthquake or similar disturbance. Present records show that shoals have formed in Yakutat Bay, southeast Alaska; seismic action causing the bottom of the bay to rise in places (a maximum of 40 feet observed). Occurrences of this nature are very rare, however, and it is safe to assume that if the present wire-drag surveys are made complete enough they will also be permanent. Regarding commercial importance it is safe only to assume that every locality will some time become important enough to justify its complete and detailed survey. It can be readily seen that the nature of the Alaskan country and the manner of its development have had a great bearing on the

present incomplete condition of the charts. That it is economical to complete if possible for all time, each area surveyed is evident from past experience.

It is therefore important that the present wire-drag surveys shall include such triangulation and topographic revisions as are necessary to insure the completeness and permanency of the charts. It is also plainly evident that the situation is largely peculiar to Alaska and has reached great importance only through the rapid commercial development of a frontier country.

BRIEF DESCRIPTION OF DRAG AND METHODS OF DRAGGING.

The wire drag consists primarily of a wire, called the bottom wire, towed at a certain distance below the surface of the water for the purpose of finding the location or proving the nonexistence of hidden dangers to navigation. The remaining apparatus consists of various parts whose objects are: First, to maintain the bottom wire at a constant known depth; second, to enable changes to be made in this depth to conform to the changes in tide or to pass over known shoals; third, to prevent the part of the wire not caught on the shoal from sinking to greater depths when an unknown shoal is found, the tension being removed from the wire by the stopping of the towing boats; and fourth, to float the two parts of the bottom wire in case of a break. The design of these parts is such that they can be readily removed and replaced in case of accident.

The drag is towed by a launch at each end, one of which is known as the guiding launch and the other as the end launch. These launches are equipped with suitable machinery and apparatus so that the drag can be quickly set out and taken up. When the drag is in operation, the course maintained on the guiding launch is such as will cause the near end of the drag to follow a certain, previously determined line. The function of the end launch is to stretch the drag to an effective length and, together with the guiding launch, advance it in the desired direction. To accomplish this, maneuvers are involved that require skill and experience in wire-drag work. When working in the inland passages of Alaska, where there is considerable current and uneven bottom, the heading of the two launches will vary as much as 60° from the course made good by the drag. This is caused by the current streams or swirls, varying in direction and velocity at several points on the surface and at the drag depth below the surface. In many places where fresh-water streams, fed by melting glaciers and recent rains, poured their vast volumes of water into the sea, it was found by observations that the surface currents were entirely different from those in the denser water 8 and 10 fathoms below. In addition to this, there were encountered in

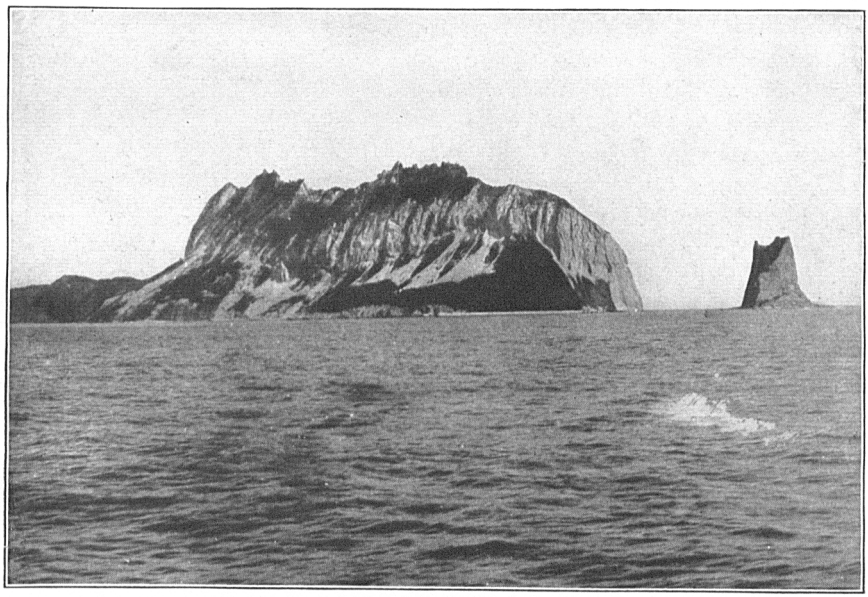


FIG. 8.—KAYAK ISLAND AND DETACHED PINNACLE ROCK.

Off Cape St. Elias, southwest Alaska.

Sumner Strait and Snow Passage circular tide swirls and tide rips. The former would force the launches together and prevent the covering of area economically, or throw them away from each other, the consequent heavy tension upon the gear causing it to part. For this reason in the vicinity of Point Baker it was found impossible to use a drag longer than 2,000 feet. When an attempt to use a 4,000-foot drag was made, the launches were powerless at critical moments against the influence of the swirls, and sections of the floating gear were submerged and sunk, pulling the entire drag down until it fouled the bottom in deep water. Invariably the wire parted at the surface when an attempt was made to clear it. In cases of this kind it is necessary to redrag the same area so that not only the equipment but the time spent on the first sweep is lost. When these tidal conditions occur over a large area, the cost of effective operation runs exceedingly high.

The third and fourth objects mentioned above are attained by the use of wooden floats, which are attached to the bottom wire at regular intervals and serve to balance its weight. To supply these floats and prevent them from water logging forms an important item of expense in Alaskan waters. In this region the depth verified is 50 feet at lower low water. In other words, it is desired to find all unknown obstructions that extend above this depth, or to prove that there are no such obstructions. The range of tide is as much as 35 feet in some places, and it is therefore necessary, at high water, to set the bottom wire 85 feet below the surface. The pressure at this depth is about 36 pounds per square inch and water is forced into the pores of the wooden floats until their weight is increased 33 to 50 per cent over that when dry, thus decreasing their buoyancy and rendering them useless for floating the ground wire. This is partially prevented by boiling the floats, when new, in paraffine or tallow, but in spite of this precaution they will last only about 10 days. At the end of this time it is necessary to dry and re-treat them. This means that two sets (as many as 250 or 300) must be kept on hand. During the past season the services of two men for two days were required on each occasion to dry and prepare the water-soaked floats. In order to overcome these objectionable features a new design of float is being considered and will be tested during the coming season. This float is to be made of steel, suitably reinforced, so that it may withstand the pressure of depths up to 20 fathoms. The first cost of these floats will be higher than of those now in use, but the added expense is necessary for satisfactory and accurate work and it is expected that they will prove more economical in the long run.

When the drag, being towed as described above, strikes a shoal the fact may be indicated in several ways: First, by the increased pull on the towline and consequent extra strain on the launch engine; second, by the drag stretching into a straight line between the launches and the shoal, the buoys on the surface tending to form an angle, with the shoal at the apex, as shown in figure 4; and third, by the capsizing of the buoys on or near the shoal, caused by the removal of tension on the uprights connecting the buoys with the bottom wire.

As soon as the drag catches, the small motor boats used as tenders, and frequently the launches as well, proceed to the spot indicated and sound with the hand lead. By drifting across the shoal area in parallel lines the shoalest points are noted, and these points are subjected to a closer examination by feeling over the immediate vicinity with the sounding lead on bottom. When the drag catches on a small pinnacle rock it is sometimes necessary to sound with the hand lead for a considerable length of time before the rock is found, and this notwithstanding the fact that the approximate location is known. The improbability of striking an obstruction of this nature with a lead thrown from a moving vessel is evident. After the examination is finished, the drag is pulled off the shoal and the bottom wire raised enough to clear the least depth found. Another sweep over the area is then made, and if the drag does not catch, it indicates that the least water was found and recorded during the first examination. Frequently, however, the wire catches again and a further investigation discloses the fact that another pinnacle exists, sometimes detached from the first one found. It is then necessary to repeat the operation described above with the drag drawing about a foot less than the last depth found, and this procedure is repeated until the wire clears the shoal and the least depth is determined beyond all doubt.

It is not always possible to redrag an area immediately after locating a shoal, for unfavorable conditions, due to weather, current, or loss of gear may prevent. In this case if the rock found is a dangerous one its location is advertised at once, but it may be several days before the highest pinnacle is found. Another notice is then published giving the new depth. Advance notices of this nature are sent out by the Inspector of Coast Surveys at Seattle, Wash., on receipt of a telegram from the field. These notices are mailed to interested parties, including the managers of all commercial companies operating vessels in Alaska, the Coast Guard, and Lighthouse Services, and the newspapers.

During the 1915 season one shoal patch was encountered that required three separate attempts before it was cleared and the least

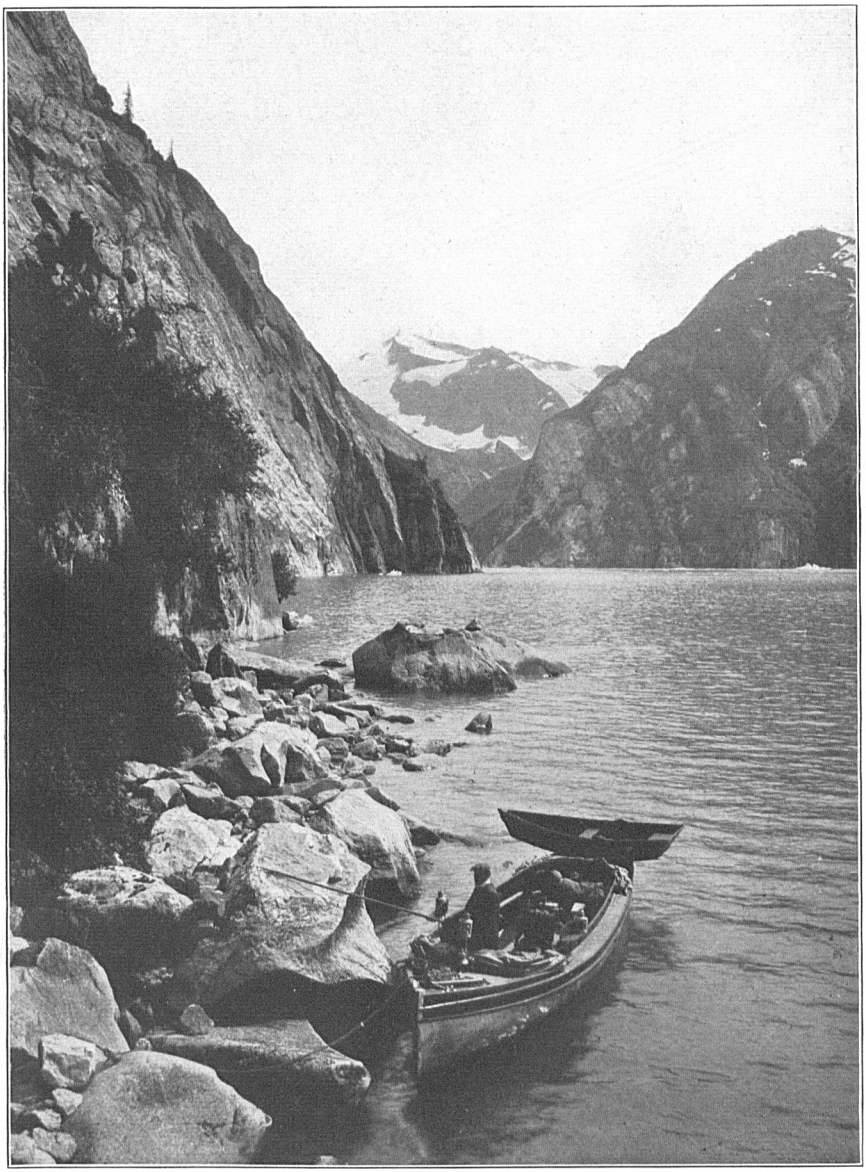


FIG. 9.—ROCK RELIEF.

Holkham Bay, Tracy Arm, southeast Alaska.

water found. The first time the shoal was located it appeared to be a flat reef 22 feet below the surface. On the second attempt a pinnacle rock 10 feet below the surface was found near one end of the reef. This depth was reported immediately, a special trip being made to the cable office for the purpose. Weather conditions for the next seven days prevented a reexamination of the locality and work was done elsewhere. At the third trial an 8-foot rock was found close by, and this proved to be the least depth in the vicinity, as the drag set at 7 feet was taken over the shoal immediately afterwards. This is a good illustration of the difficulty of locating pinnacles even when the reef from which they project is found. It is well known that the action of a current against an obstacle of this kind is to bank up, divide, and flow aside, thus deflecting a sounding lead from it. With the precautions taken in sounding on this shoal it is certain that the lead passed close to these pinnacles at various times during the previous examinations, but the fact that they were missed is easily explained when one considers the difficulties that exist.

VESSELS AND LAUNCHES.

The illustrations of vessels and launches represent the two types of boats that are required for the Alaska work, those shown having been used with success.

The *King and Winge*, a power schooner 110 feet long by 20 feet beam, and the *Equator*, a steam schooner 90 feet long by 22 feet beam, were successfully used as house vessels during the 1915 season. The charter price of the *King and Winge* and of the *Equator* included the cost of repairs but not the pay of the crew or cost of fuel.

The *Roosevelt* represents the type of launch used most effectively for towing the drag, she being shown by photograph and in plan with dimensions and arrangements.

It should be stated that the launches are employed to a considerable extent outside of the wire-drag work proper. Triangulation and topography are necessarily carried on in connection with the operations to the extent that one of the three boats is likely to be busy at this work for the greater part of the time. This is an important consideration in connection with the design or selection for charter of wire-drag boats.

IMPORTANCE OF WORK ACCOMPLISHED AND NECESSITY FOR EXTENSION.

Forty-five uncharted dangers to navigation and 301 separate shoals have been located with the wire drag. The operations extend over an area of 570 square miles of main ship channel, comprising roughly

one-third of the principal inside passage through southeastern Alaska. The foregoing is a statement of the net results obtained by two wire-drag parties operating in Alaska waters during five months of the past season, and of one party during three months in 1914.

That 45 dangers have been located is important, but hardly less so is the possession of positive knowledge that in a region of pinnacle rocks 570 square miles of much-frequented waters are free of uncharted obstructions. The result is large, but that the greatest value of such information is not readily appreciated is made clear by the following discussion.

The importance of surveys to a frontier coast is not in a direct ratio to the development of the adjoining country. That the value of the local shipments and property invested will form a certain factor is true, but the real value of a new country is measured by the amount and accessibility of its undeveloped resources. The vastness and richness of the resources of Alaska are unquestioned. The accessibility of these riches is the point that will, in a large measure, retard or advance the development and prosperity of the country. This is the subject in which we are especially interested, because the necessity of detailed surveys, supplemented by wire-drag examinations, is an important point in the problem of water transportation. It is also a factor, in a less degree, in determining the points and methods of assembling products and distributing supplies.

In order to make Alaska's known riches more accessible, the Government is now engaged, at tremendous expense, in building a railroad. As this link to interior points reaches completion and becomes important commercially, the water routes leading to it must become more frequented by larger and deeper draft vessels.

The development of certain sections of Alaska has reached its present stage largely through the ability of the managers of steamship companies to promote their trade. During the past year shipments to and from the Territory taxed the capacity of the carriers. Further developments will be met by increased tonnage, and this must ultimately mean an increase in the draft of ships, the present maximum draft being 25 feet. An increase over this will increase the risk of striking rocks that are not dangerous to the present draft, and insurance rates on large deep-draft steamers will be prohibitive until charts, with contemplated surveys of the principal channels, are obtainable.

Fig. 1 is a copy of the chart of southeastern Alaska, from which will be seen at a glance the large number of navigable waterways. The principal steamer route is marked by a dotted line. The distance over this route from Cape Fox, near the British Columbia boundary, to Cape Spencer is 547 miles, as great a distance as from New York City to Wilmington, N. C., or to Halifax, N. S., on the

FIG. 10.—A DANGEROUS SHORE.

Off Cape St. Elias.

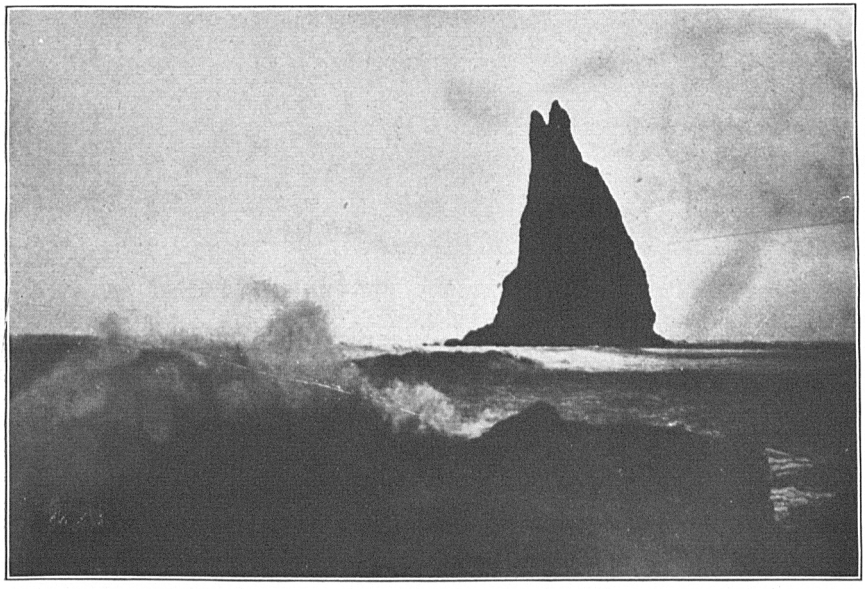


FIG. 11.—A PINNACLE ROCK.

Near Cape St. Elias; height, 500 feet.

Atlantic coast. Many of the larger boats avoid the shoal water in Wrangell Strait by continuing out through Sumner Strait and rounding Cape Decision, which course adds 150 miles to the distance. As the above route is used by the steamers bound to the westward as well as by those on the southeast Alaska run, any hidden dangers along it would jeopardize the largest number of ships. For this reason it should have the first consideration, and it is the present plan of the Coast Survey to sweep immediately this entire route with the wire drag. Pending the completion of this, all regular survey parties are now equipped with a small drag for examining critical areas.

Important as the main channels are on account of the greater traffic through them, the subsidiary channels are no less so when we realize our duty of preventing loss of life and property. Such excursions are made at great risk to the ships, yet the demand is so insistent that the danger, which is unknown to the majority of the passengers, is disregarded by the steamship companies and their navigators. Passenger steamers like the *Jefferson*, *Spokane*, *City of Seattle*, and *Dolphin* with local pilots go 30 to 65 miles off the main route to call at various salmon canneries. Freighters such as the *Paraiso*, *Redondo*, and *Northland* visit points on the west coast of Prince of Wales Island which lie 85 miles away from the nearest point on the main route.

In order that such ports might be approached by steamers, reconnaissance surveys of all these waters were started in 1881, and these were supplemented by more detailed work beginning about 1909. Commerce under private individuals, however, has advanced ahead of these surveys. The discovery of natural resources, such as gold and coal, and the development of the fishing and lumbering industries have resulted in the establishing of plants for exploitation where they will be close to these resources, no matter how remote they may be from the nearest distributing point or how much their development may depend on the courage and determination of the pioneers. A cannery is built where the salmon run most abundantly, a mine is located where the ore lies, and its bunkers are built in the nearest protected bight of the shore line. A minimum amount of time and money is expended in examining the approaches to the selected site, and practically all the available energy and capital are used in overcoming local obstacles and in developing the enterprise. In order that steamers may call to deliver supplies and machinery and take away the local product, detailed surveys are needed. The development of such places has advanced to the point where the original reconnaissance is not only insufficient but possibly dangerous. It will require years of work to complete the hydrographic survey of the approaches to these places, and wire-drag work alone will not be sufficient. It must be supplemented by a delineation of the shore line and an investigation into the tidal, magnetic, and current condi-

tions. Consequently there are increasingly numerous needs for extending the completed work as far and as rapidly as possible in order that commerce may proceed to take full advantage of the resources of the Territory with the definite assurance that all dangers to navigation and advantages of location are marked out for them.

From Tongass Narrows to Stikine Strait there are 12 buoys placed on dangerous rocks that exist directly in the main path of vessels. Five of these mark rocks that were unknown until struck by steamers. When it is considered that ships have been plying these waters for 50 years, the recent results of wire-drag work are emphasized by the fact that no less than five more mark equally dangerous rocks that have been discovered by this method during the two seasons that work has been done.

Following is a list of some of the more noted examples of ships that have been damaged or lost by striking unknown pinnacle rocks in Alaska. In each of these cases it is an established fact that the damage sustained was due soleiy to the fact that they were pinnacles, no indication of which had been found when the original surveys were made.

Date.	Ship.	Locality.	Date.	Ship.	Locality.
——	Tsaritza	Sitka Harbor.	——	Portland	Landlocked Bay.
1881	California	Tongass Narrows.	1903	Potter (barge)	Tongass Narrows.
1886	Ancon	Icy Strait.	1909	Ohio	Do.
——	Idaho	Tongass Narrows.	1912	Mariposa	Sumner Strait.
1895	Portland (schr.)	Off Dundas Island.	1913	Independence	Icy Strait.
1900	Wolcott (schr.)	Uyak Bay.	1913	State of California	Gambier Bay.
1901	Queen	Frederick Sound.			

There are many reasons why it is important that the charts should show all the dangers to navigation. Many vessels keep very close to the same courses when constantly navigating a region, but it must be remembered that there is no requirement that vessels shall follow beaten tracks. A vessel may go in any place where the charts show sufficient water, and the navigator can not be held responsible if he strikes an uncharted rock. Very often strangers will be off their reckoning when running in a fog. If a chart appears clear they will take a chance and continue on their course, while if dangers are shown they will anchor until it clears. There is no means of estimating how many vessels are saved from disaster on a dangerous shoal because the shoal is located on the chart. Furthermore navigators are accustomed to pass all dangers at a safe distance. If a danger is uncharted, a vessel in the act of avoiding a charted danger may strike it, for shoals often occur in groups.

The legal status of the charts, in settling the responsibility for the grounding of vessels, is an important matter. In every such case an investigation is made by the steamboat inspectors, or, in case of naval vessels, a court of inquiry is held. If negligence is proved,

the penalty may be so severe as to suspend or withdraw the license, and with it practically the means of livelihood of the offending master or pilot. There are corresponding penalties in the Navy. Of course, if a shoal is uncharted there is no blame or penalty. In all doubtful cases where the vessel, though damaged, succeeds in getting off before the facts can be ascertained by the proper authority, the claim that a rock is uncharted may be made or, what amounts to the same thing, a wrong location of the accident may be given. As the whole purpose of licensing navigators is to protect the safety and interests of the traveling and shipping public, it is important that the plea of an uncharted rock should everywhere be made untenable. Even under present conditions the wire drag is a valuable agent for settling such questions, as any such claim can be proved or disproved beyond all doubt by its use.

Of almost equal importance to showing all the dangers on the charts is the assurance that a known safe depth exists over an area clear from obstruction. The depth of drag used during the 1915 season as a maximum for Alaskan waters was 50 feet at lower low water. This depth was adopted after considering the maximum draft, while at rest, of the largest steamers afloat, and adding to this an allowance for increased draft while at full speed (the allowance being obtained from the best available sources of information), an allowance for abnormally low tides which occur during storms, and an allowance for the possible effects of ocean swell on a vessel. In dragging, the depth of the bottom wire below the surface may at times be as much as 88 feet, as an allowance is made for the possible effect of swell on the drag as well as for tide. The cost of the work increases with the depth of drag used, but the extra expense and all precautions are justified when we consider the fact that a serious accident, even to a small vessel and without loss of life, would cover the cost of years of wire-drag work. A fast-moving liner striking a pinnacle rock in just the right way would suffer the fate of the *Titanic*, no matter what precautions might be taken.

The advent of the submarine and its recent exploits have brought a new factor into this discussion. One of their greatest dangers is undoubtedly the pinnacle rock, and it can be readily seen that there is little chance for saving one damaged by such a rock while submerged. When the present war in Europe is ended and the list of submarines sunk by various hostile means is compiled, there will be a number unaccounted for, and one of the main causes assigned will undoubtedly be the supposition that they struck unknown pinnacle rocks while attempting to escape observation by submerging. In finished surveys, depths up to 40 and 45 feet have been the subject of close examination in previous years. Now the maximum depth must be

increased to insure the safety of this newer type of craft. The draft of the largest type, when at rest on the surface with deck awash, is 24 feet. When submerged and underway, with the periscope showing, it amounts to 28 feet, and when submerged deep enough to hide from aeroplanes, they may be forced to go to depths between 75 and 100 feet. Full consideration of this new factor will fix a new danger depth in some localities of at least 75 feet, and to this limit all dangers must be determined and located as accurately as they were a few years ago to a depth of 30 feet.

COST OF WIRE-DRAG WORK IN ALASKA.

GENERAL CONDITIONS AFFECTING COST.

The cost of operating a wire-drag party in Alaska is much greater than upon the Great Lakes or upon the Atlantic coast, for the following reasons:

1. More expensive equipment required.
2. Larger and more expensive boats used.
3. Larger and more expensive party needed.

The necessity for these variations involving increased expense will be briefly pointed out.

1. The necessity for more expensive equipment is due to the greater range of tide, stronger currents, and the greater isolation of working grounds from points where equipment can be purchased. The ranges of tide for different parts of Alaska are shown by the following table:

Place.	Locality in Alaska.	Average range.	Extreme range.
		Feet.	*Feet.*
Ketchikan	Southeast Alaska	13.1	18.6
Petersburg	do	13.8	20.8
Juneau	do	13.8	25.8
Skagway	do	14.1	27.7
Seward	Southwest Alaska	8.4	16.8
La Touche	Southwest Alaska (Prince William Sound)	9.2	15.9
Seldovia	Southwest Alaska (Cook Inlet)	15.4	28.4
Anchorage	do	27.2	35.6
Kodiak	Western Alaska	6.9	16.8

The table shows that in order to secure an effective depth of 50 feet at all times, it is necessary to set the drag to depths of from 60 to 85 feet. The heavy water pressure at the lower depths causes frequent loss of floats and buoys, as described in another section of this article. The high cost of supplies, as shown in the Table of Party Expenses, 1915, is in a large measure due to this cause. This loss of equipment is very serious in an isolated country like Alaska, and serious delays can be avoided only by keeping large amounts on

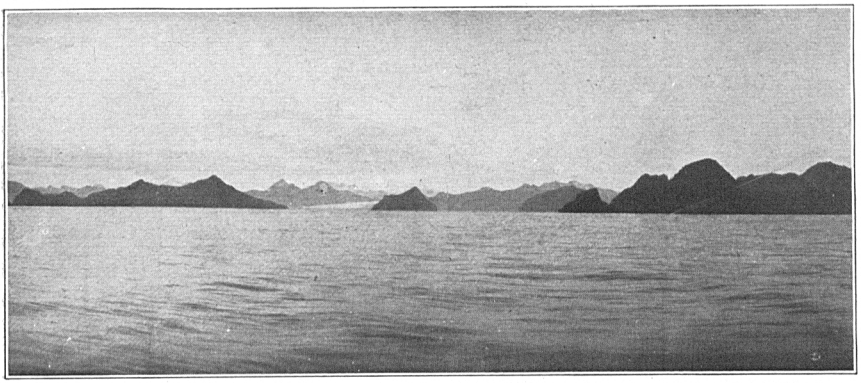


FIG. 12.—ENTRANCE TO RESURRECTION BAY.

Near Seward, southwest Alaska.

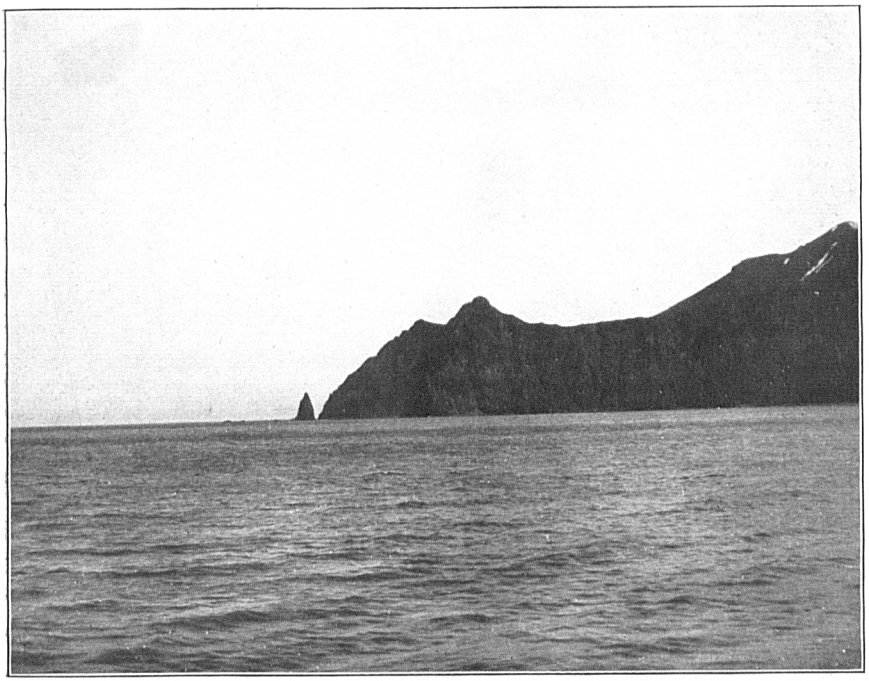


FIG. 13.—PRIEST ROCK.

At entrance to Unalaska Harbor, western Alaska. Note low rocks just outside of pinnacle.

hand. Seattle, 700 or more miles distant, is the nearest point where new equipment can be obtained, and the following table shows the actual time that was required to secure equipment in the summer of 1915:

Kind of equipment.	Party No.	Ordered.	Received	Time required.	
				Months.	*Days.*
Small weights	3	June 21	July 21	1	0
Do	4	July 24	Sept. 2	1	9
Small buoys	4	June 26	July 30	1	4
Do	3	June 21	July 21	1	0
Do	4	July 24	Sept. 2	1	7
Wire[1]	3	July 5	Oct. 13	2	8
Fittings	4	July 24	Sept. 15	1	19

[1] Wire of special make brought from Trenton, N. J.

Party No. 3 was working from Ketchikan as a base and party No. 4 from Wrangell, both in southeastern Alaska. The obvious necessity of keeping large reserve supplies of equipment on hand entails additional expense for transportation, storage, and deterioration.

2. Large able boats are required for the Alaska work in order that the parties may be safely housed, and that the greater reliability demanded in isolated localities may be secured. It is impossible to quarter the parties in towns because of the distances, as shown in the table of Alaska towns and distances between them. It will be shown later that it is not practical to maintain a wire-drag party in camp, and therefore boats, large enough to provide living quarters, are chartered at considerable expense, but with satisfactory results. On the Atlantic coast, in Florida, and New England, where wire-drag operations are being carried on, it has always been possible to secure a working base ashore, thus eliminating the complications and extra expense incident to quartering and messing the party on board.

Table showing distances between Alaska towns.

	Nautical miles.		Nautical miles.
Seattle to Ketchikan	660	Yakutat to Katalla	170
Ketchikan to Wrangell	89	Katalla to Cordova	120
Wrangell to Petersburg	40	Katalla to Valdez	130
Petersburg to Juneau	108	Valdez to Seward	150
Juneau to Skagway	100	Seward to Seldovia	140
Juneau to Sitka	155	Seward to Kodiak	175
Juneau to Yakutat	250	Seward to Unalaska	757

The isolation of the working grounds from well-protected harbors makes it imperative that the boats be capable of reaching shelter in rough weather. All parts of Alaska are subject to strong gales at all seasons, and, even in the inside passages, gales and strong tides produce dangerous seas. Frequently unexpected gales raise high

seas in a very short time. Vessels of 1,000 tons or more have often been obliged to seek shelter because of danger, or of their inability to proceed against wind and sea. An example is the *City of Seattle*, a vessel of 1,462 gross tons, that lay at anchor in the shelter of Mary Island, southeast Alaska, because of a storm on Dixon Entrance on the night of October 14, 1915. In this connection it is an interesting fact that the area from Mary Island across Dixon Entrance was surveyed with a wire drag during the past season. This feature of the weather is even more pronounced in western and southwestern Alaska, where much of the future work lies. That fairly able steamships are not secure in this region is shown by the well-known record of the *Dora*, a vessel of 320 tons and a speed of 7 to 8 knots. While anchored in Shelikof Strait, western Alaska, in December, 1905, she was struck by a heavy gale, and to escape driving ashore was compelled to put to sea, where she encountered a still more violent storm, against which she was unable to make headway. Blown to sea with a small coal supply and her sails useless because embedded in ice, she was buffeted helplessly about the North Pacific for 60 days. By almost a miracle she finally drifted inshore sufficiently to make port in Puget Sound, at a point more than 2,000 miles from her original destination.

It is true that private individuals own and operate in Alaska almost every conceivable type of launch, but that many of these are unsafe has been proven by the record of accidents to unseaworthy boats. An example fresh in mind is that of the *Francis R.*, a 38-foot launch, not unlike several that have been used for wire-drag work. This launch left Ketchikan in October, 1915. She was swamped in a heavy blow in Behm Canal and the two young men with her were drowned. Private individuals assume the responsibility and expect to abide by the results when working with unsafe equipment, but, in case of accident, the Government can not escape severe and just censure if the safest possible boats and equipment are not provided for parties doing the Government work.

When operations are carried on at a great distance from a machine shop, expensive delays in waiting for repairs are avoided only by the employment of launches with the most up-to-date and reliable machinery. Because of the inability to secure try outs for launches offered for charter from distant or inaccessible points, it is the policy to select only recently built launches with engines of standard make and proven merit. The small amount of suitable working weather, about 15 days per month, makes it very important that all good weather be utilized in actual wire-drag work. If the engine of a launch be disabled so as to require a machine shop for repairs, and the shop is located one or two days' run from the working grounds,

an accident that might mean only a day's delay for one boat if working from a shore base may require several days' loss of time for two boats. It is therefore probable that in the charter of boats the greatest economy is obtained by selection of boats whose reliability is unquestioned.

Because of incompleteness of the charts, of isolation, and of dangerous weather conditions, all boats are subjected to exceptional risks in Alaskan waters. This fact is recognized by insurance underwriters and owners who contemplate chartering vessels for Alaska work, with the resulting high prices for insurance and charters. The table of expenses for an Atlantic coast and an Alaska wire-drag party will show that it is in the charter of launches that the greatest difference in cost lies.

3. As explained elsewhere, the Alaska wire-drag party must carry on topography and triangulation in connection with the wire-drag work proper; it must care for and be responsible for the expensive boats used, and also maintain living quarters and mess for the party. In order to accomplish this, from four to six additional officers and men are required, with the attendent expense of their maintenance and salaries. In addition it is a well-known fact that the scale of wages in Alaska is from 10 to 20 per cent higher than in the States. These differences account for the fact that the pay and subsistence of the Alaska party is more than 20 per cent higher than that of the Atlantic coast party.

A general conclusion may here be drawn that the increase in cost of wire-drag parties in Alaska over those upon the Atlantic coast is due to such natural and unpreventable causes as excessive tides, currents, and isolation, with their attendant effects on the size of the launches and personnel of the party and on the amount and durability of the equipment.

CAMP VERSUS SHIP.

It has been suggested that the high cost of chartering vessels could be reduced by using a camp as a working base. Three launches are the minimum possible for a party where triangulation and topography are necessary. The only difference in the expense of a party in camp would be in the price of the boats, which would amount to about $20 per day, as shown below.

Daily cost of boats.

Ship party:		
Two 50-foot launches, at $12	24	
One 100-foot vessel, at $32	32	
		$56
Camp party:		
Three 50-foot launches, at $12		36
		20

Twenty dollars per day equals $600 per month excess for ship party.

Past experience shows that it would be necessary to move camp about once a month. To break, move, and make camp, transporting outfit and supplies would require about two working days for the entire party. During the past season the cost of a ship party for each day upon which work was done was $285; figured upon a camp basis this would be $244. Moving camp would therefore cost about $500 per month.

It is estimated that through the greater mobility of the ship party the available part of a working day is increased at least an average of three-quarters of an hour over that of a camp party. An hour of effective working time during the past season cost one party $54.70, which if reduced to a camp basis would amount to $46.83. Thus three-quarters of an hour per day for the average of 16 working days per month amounts to $562.

It is therefore evident that although the camp party would be $600 per month less expensive, it would be more than $1,000 per month less efficient in its ability to get results.

The section of chart (Fig. 17) shows in Shakan Bay, southeast Alaska, an actual condition of the past season, where the ability to anchor at a point too exposed for a camp site saved a daily run of 11 miles for a period of about six weeks. The best available camp site for work in this vicinity is at or near Shakan Village, about 5½ miles from the point at the entrance of the bay, where anchorage was found. The anchorage is exposed, but with a ship it is easy to run to better shelter in case of bad weather, while with a camp the site must be selected where the small boats may be safely moored in any weather. With a ship it is also possible to plan the work so as to run lines between anchorages, thus saving much time that would otherwise be taken up in running back to the point of the morning's start.

UNIT COST OF WIRE-DRAG WORK.[1]

This is a complex matter. Wire-drag work consists of two antagonistic operations—that of covering area, or sweeping, and that of finding shoals. The apparatus best adapted to the first operation is not that which is most effective in the second, and that actually used is a compromise between the two requirements. Covering area proceeds most rapidly when the shoals are few in number, and shoals can be located and developed most satisfactorily when the purpose of covering area rapidly is temporarily subordinated.

The actual cost of wire-drag work in the past has varied through a wide range from between $125 and $667 per square mile on the Atlantic coast, where shoals are numerous, to between $52 and $171

[1] This discussion is taken from Special Publication No. 29 with certain alterations to adapt it to the work in Alaska.

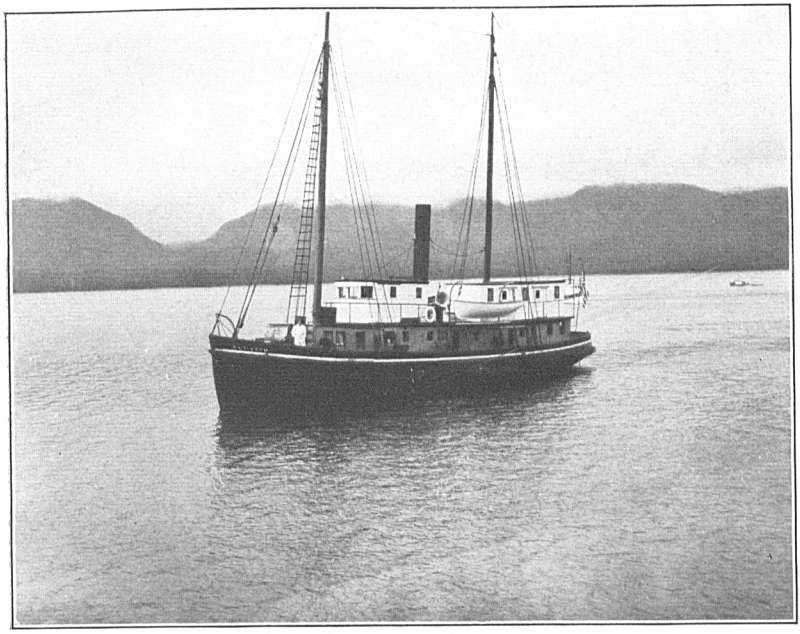


FIG. 14.—REMODELED STEAM SCHOONER "EQUATOR."

Used as house vessel in southeast Alaska, 1915. Length, 90 feet; beam, 22 feet.

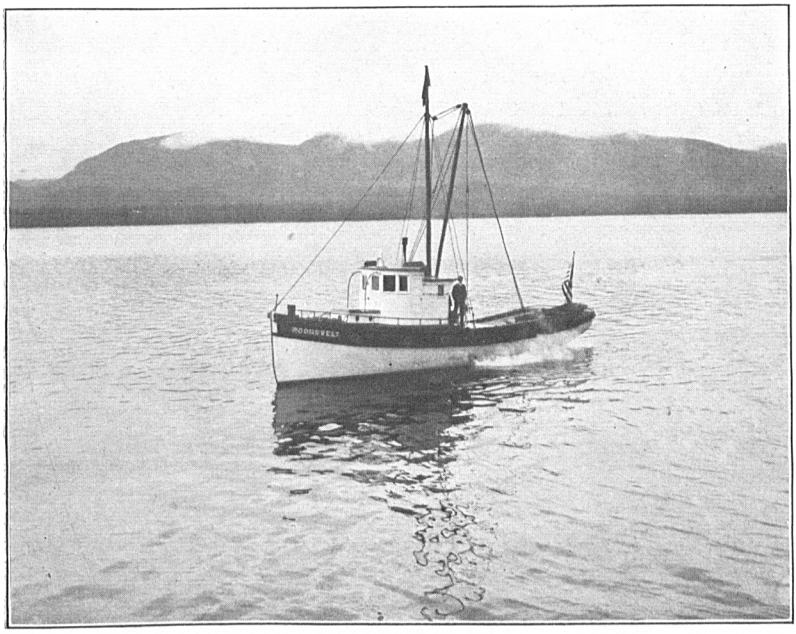
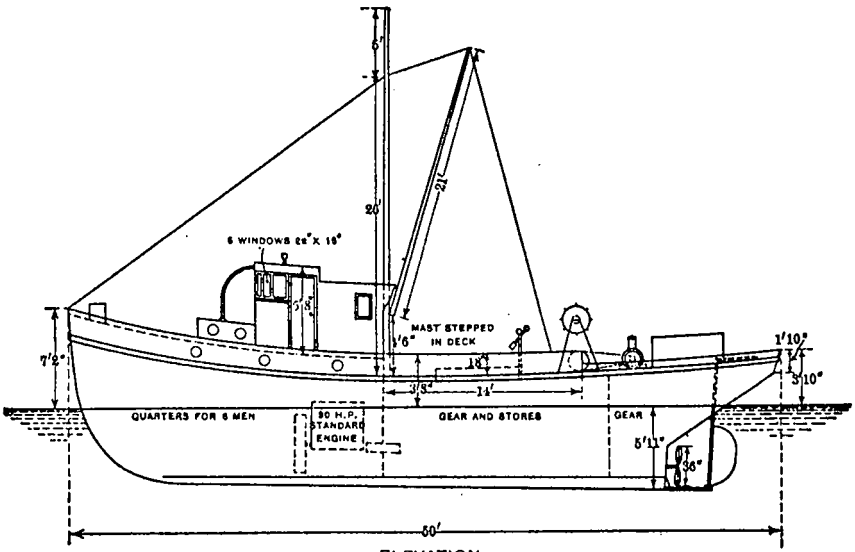
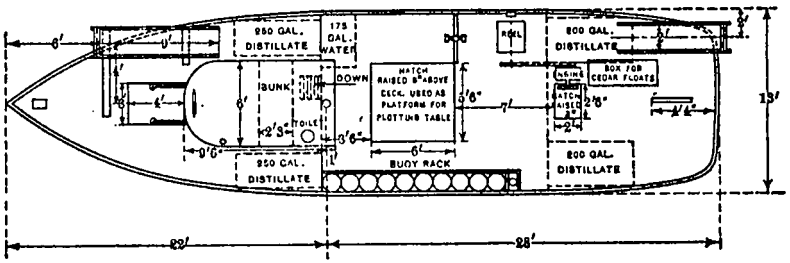


FIG. 15.—POWER LAUNCH "ROOSEVELT."

An excellent type for wire-drag work. Length, 50 feet; beam, 13 feet.



ELEVATION



DECK PLAN

FIG. 16.—PLAN OF LAUNCH "ROOSEVELT."
Showing arrangements.

in Alaska, where shoals are few. It is proposed to analyze the cost in such a way that it will be evident why the costs are so large and why they vary so much.

The principal factors that increase the cost will be listed more completely later; they include weather, tides, currents, bottom conditions, isolation of working grounds, failure of equipment, and inexperience on part of members of party.

It may be said, with reference to very expensive work, that usually the very factors that increase the cost of the work are those that make navigation dangerous, and that usually if the work is more costly the results are likewise of greater value.

The following method of analyzing unit cost has been adopted: The statute square mile has been used as the unit of area. The cost per unit of area will be considered without effort to distinguish between cost of sweeping and cost of locating shoals.

In order to have a unit which will be practically common to all operations, the *basic cost per linear mile* will be defined (b in formula). This is the cost of moving a drag 1 mile under conditions that are theoretically possible, but which are rarely if ever obtained. It is the cost of operating through a linear mile a drag of such length as to cover a statute mile at a single sweep, moving at the rate of 1.5 statute miles per hour for five hours each day, every day except Sundays and legal holidays, from the first day's dragging to the last day of the season. This unit cost can be obtained by dividing the total cost of the season's work by the total number of days just mentioned (d') and then by 7.5. This is very nearly the same on the coast of New England as on the coast of Florida, and differs from that in Alaska only with the increased total cost. It will be slightly less for a long season than for a short one, as transportation and other charges that are not monthly are relatively smaller. For a carefully analyzed season in Alaska, the value of b was about $20. It is evident that it will cost just as much to operate a 1,200-foot drag as a 4,000-foot drag, provided the velocity is the same.

Now, in order to reach the desired unit cost per square mile from this basic cost per linear mile, it is necessary to multiply the latter by certain factors.

The first factor, L, is obtained by dividing the number of linear miles (l') by the area (A). It is evident that if 4 linear miles are required for each square mile finished the cost will be four times as great as when only one mile is required. This factor includes the drag length, the overlap whether necessary or excessive, and repetition whether because of shoals or area missed.

The second factor, V, is obtained by dividing the standard velocity 1.5 (v') miles per hour, by the actual velocity (v). The necessary increase or decrease due to this factor is obvious.

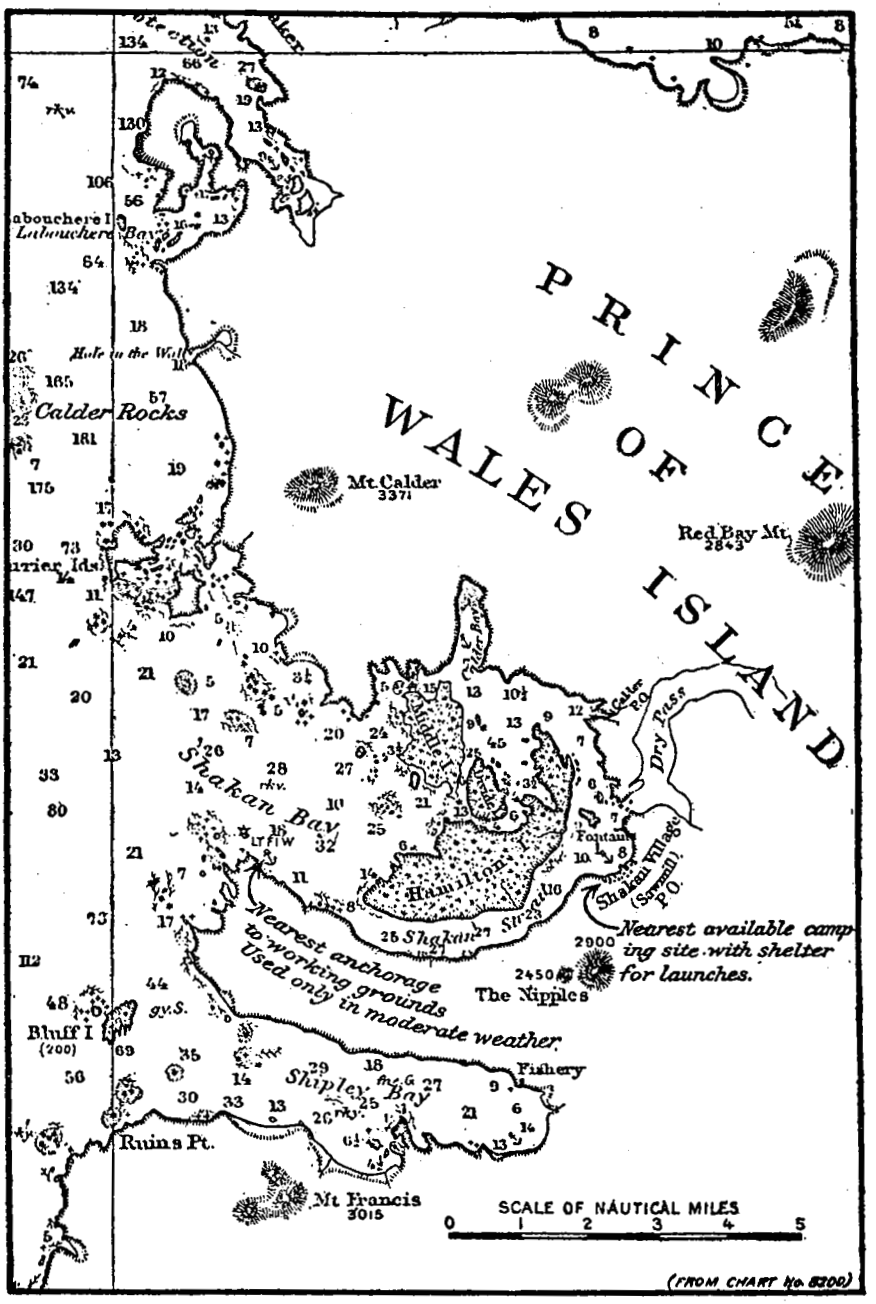


FIG. 17.—SECTION OF CHART OF SHAKAN BAY.
Showing difference in distance from working grounds to anchorage and to nearest available camp site.

The third factor, D, is obtained by dividing the number of days, exclusive of Sundays and legal holidays, from the first day of dragging to the last (d') by the actual number of days on which work was done during this period (d). This is the weather factor and includes the effects of wind, sea, swell, and conditions which make signals invisible, such as fog, haze, and smoke. The amount of exposure to the open sea enters into this, as work can be done in protected regions when impracticable in the open sea. The factor decreases with the ability of the boats.

The fourth factor, T, is obtained by dividing the standard day, five hours (t'), by the actual time spent in dragging (t). This takes into account time lost from dragging for every cause except running to and from the harbor, setting out and taking up the drag, and bad weather, and includes time usefully spent in locating shoals as well as that lost through drag failure or failure of the engines. It is not an efficiency factor directly, as much of the time lost from dragging may be useful in other ways. The standard day of five hours represents about the best average that is possible under Atlantic coast conditions, and takes into account the relation of the working area to the base or bases and high efficiency in setting out and taking up the drag.

Then the product $b \times L \times V \times D \times T$ equals C, the *cost per square mile.* A little study will show that the numerators and denominators of the various factors cancel out until total cost divided by area is left, as should be the case.

$\frac{C}{t'} \frac{l'}{A} \frac{v'}{v} \frac{d'}{d} \frac{t'}{t} = \frac{C l'}{A v d t}$. It is clear that $v\ d\ t$ is the number of actual linear miles and equals l'.

It is evident from the above discussion that time is the one important factor in wire-drag work. On the Atlantic coast there is no division of labor, as the party does no other work except wire-drag work, while in Alaska triangulation and topography are regularly carried on so that the amount representing the total cost of wire-drag work must be deduced from the total cost of the party, giving each class of work its share of the expense.

This deduction may be made in the following manner: Find the total amount of wages and subsistence of officers and men. Divide the total cost of the party for the season by this amount and the result is a factor of the cost, the portion of the total cost to be given each class being found by multiplying the above factor by the amount of the wages and subsistence expended in each case. This gives a proportionate share of the total cost to each class of work done, the size of the share depending upon the amount of time spent upon it by members of the party.

Now what is the usefulness of this analysis? First it serves as a basis for comparing and determining the cost or probable cost in various localities, thus being useful for making estimates for projected work. Further it shows an analytic statement of the effects of different conditions upon cost, thus serving as a comprehensive basis of study for reducing cost, which is the important object of any cost analysis.

In order to get the value of the constants it is necessary to make a very careful analysis of a season's work. The 1915 season in Revillagigedo Channel and Clarence Strait has been selected, as it was a full-length season under good conditions, though the unit cost was lower than usual because of the few shoals found. There was a large proportion of open area, but no larger than can generally be expected upon the Alaskan coast. The records were so kept that a complete analysis is shown. The period of dragging extended from May 11 to October 11; the party arrived in the field upon May 1 and left the field upon October 18. In this case d' equaled 128, d equaled 80, 31 before June 30 and 49 after. The total cost of the party was $22,910. Of this 44 per cent represented pay and subsistence of party, 37½ per cent cost of launches, 13 per cent net supplies used and depreciation of outfit, 5 per cent transportation, and ½ per cent incidentals. About one-third of the supplies consisted of wire-drag equipment, while the remainder were general supplies necessary for maintaining combined operations. The cost of supplies used exclusively for the wire drag were deducted from the total cost in deducing the cost of each kind of work and added to the cost of the wire-drag work after the deduction had been made. The large item for transportation is principally due to the expense of the officers' travel from Washington, D. C., to Alaska. The cost of the wire-drag work alone was found to be $17,637; this amount included the total cost of all wire-drag equipment, and a proportionate share of all overhead expenses.

During this season 339 square miles of area were dragged, 105 before June 30 and 214 after that date.

Average time occupied in wire-drag work.

	h.	*m.*		*h.*	*m.*
Run to working grounds	1	24	Return from working grounds	1	12
Setting out drag	0	41	Taking up drag	0	43
Spent in dragging	4	35	On shoals	0	27
Parted drag, dead lines	0	17			
Drag day	5	19	Total day	9	19

Number of separate soundings, 81; per square mile, 0.24; per day, 1.0.
Number of linear miles, 418; before June 30, 140; per day, 5.2.
Average length of drag used, 6,455 feet.

Analysis of unit cost.

	Entire season.	Before June 30.	July 1 to Oct. 11.
b	18.37	22.20	16.44
L	1.23	1.34	1.30
V	1.31	1.35	1.27
D	1.60	1.39	1.73
T	1.09	1.29	1.04
Product of LVDT	2.80	3.25	2.99
C	52.00	67.00	49.00
Total cost	$17,637.00	$7,159.00	$10,478.00

COMPARISON OF TWO PARTS OF SEASON.

First part. Considerable shoal area was examined. The open area around Cape Fox was very exposed, making work possible only in the best weather.

Second part. Very large percentage of open water and few shoals were found.

To show the difference in the cost factors in various localities, the following comparisons are shown:

	Atlantic coast.		Pacific coast.			
	New England and Florida.		Panama Bay and southeastern Alaska.			
	Portland, 1914.	Key West, 1915.	Panama, 1912.	Tongass Narrows, 1914.	Sumner Strait, 1915.	Revillagigedo Channel, Clarence Strait, 1915.
b	15.9	17.0	22.0	18.7	24.67	18.37
L	2.96	4.3	2.0	3.45	2.44	1.23
V	1.05	1.1	1.0	1.35	1.07	1.31
D	1.54	2.0	1.1	1.50	1.67	1.60
T	2.27	4.0	1.2	1.31	1.25	1.09
Product LVDT	10.85	38.0	2.6	9.26	5.45	2.80
C	$175.00	667.00	60.00	171.00	134.00	52.00
n	3.3	10.00	.2	2.0	.68	.24
Mean drag length (feet)	3,655	2,653	5,564	3,000	3,970	6,455

In order to decrease the factors, it is evident that it is necessary to increase the time spent in dragging, the length of the drag, and the speed. There are serious objections or obstacles in the way of increasing each. The run to and from the working grounds with given launches is fixed, with advantages in having fast launches. The time of setting out and taking up the drag can be decreased little, as an average of 40 minutes for a 6,500-foot drag sufficed for each operation during the past season. Losses through failure of drag are studied and every effort made to remedy the defects. Large launches make it possible to work in rougher seas and decrease the weather factor.

The length of drag is kept as great as possible, but a number of elements keep this down. In work close to bottom the time required for the tender or tenders to make a depth change fixes the length. The length of drag in Alaska is generally governed by the width of the channel. In narrow channels, or in regions obstructed by ledges or buoys, or where there is much current, the drag length is obviously restricted.

The velocity in deep-water long-drag work could with advantage be greater than 1.5 miles per hour if enough power could be used to gain this extra velocity without endangering the effective depth through lift. In shoal water a greater velocity is a serious disadvantage. The tenders can not make the changes in the drag depth fast enough either on approaching a shoal or in setting the drag deeper after passing it, and the area of doubtful depth is increased. At a high speed the likelihood of parting the wire when the drag strikes is greatly increased, and there is danger that the drag will not catch firmly. A few instances have been noted where the drag has lifted or bounced over smooth bowlders 1 or 2 feet shoaler than the effective depth of the wire, probably due to excessive speed of the launches or to abnormal currents combined with the smoothness of the obstructions.

As to the repetition involved in factor L, it should be remembered that the effective width of the drag is important. This may be reduced, either by failure to keep the launches heading at sufficient angles to each other to get the required tension, by the launches failing to keep the drag normal to the direction of progress, or by the action of tidal swirls and cross currents. A curious feature is that the amount of repetition necessary does not increase directly with the number of shoals, but in a much smaller ratio, as when the shoals are closely grouped a single sweep may be sufficient to pass over them all.

It should be remembered that the cost of covering area has a more definite meaning than the cost of triangulation or ordinary hydrography. The wire is actually passed over an area, and no imaginary horizontal or vertical lines enter into the operation. In other words, the operation involves three dimensions instead of two, in that a definite volume of water is actually separated, so to speak.

SUMMARY OF CAUSES THAT INTERFERE WITH THE PROGRESS OF WIRE-DRAG WORK.

1. *Weather.*—(*a*) Wind; (*b*) sea; (*c*) swell; (*d*) fog; (*e*) haze; (*f*) smoke.

2. *Bottom conditions.*—(*a*) High percentage of area of a depth less than the maximum depth to be verified; (*b*) broken relief of bottom;

(*c*) number of uncharted shoals found, total soundings minus those which are too close to others to be considered separate or of less than charted depth; (*d*) small size of shoals—hard to get lead on small pinnacles; (*e*) large size of shoals—difficult to find all points of such shoals and harder to clear drag; (*f*) large areas of kelp; (*g*) excessive depths in the vicinity of dangerous areas make it impossible to anchor in a favorable position, and sinking of one buoy may cause sinking and loss of entire drag.

3. *Current conditions.*—(*a*) Head tide reduces speed of drag; (*b*) cross tides make it difficult to control drag; (*c*) fair tide may make the drag go too fast for best results and drag may part if it catches bottom suddenly; (*d*) excessive currents may cause tide rips and so make it possible to work only during slack water; (*e*) current running against sea or swell makes them much greater; (*f*) reversal of current with the tide usually makes it impossible to utilize a fair tide throughout the working day, sometimes more economical to stop work than to run against tide; (*g*) currents running contrary to expectation, often due to wind. As the effort is made to select favorable currents, opposite conditions if found have disastrous results in reducing the output of work.

4. *Tide conditions.*—(*a*) A great range makes it hard to keep the drag at the desired depth—tends to be too great on ebb, too small on flood; (*b*) when drag is aground or delayed for any reason falling tide may place all of drag aground instead of a part ; (*c*) difference between actual and predicted tides may cause drag to catch or pass too far above shoals.

5. *Location.*—(*a*) Distance of harbor used for shelter from working grounds; (*b*) distance from working grounds to nearest port from which mail and supplies can be obtained; (*c*) amount of exposure to sea and winds; (*d*) islands, ledges, etc., which make it necessary to shorten drag.

6. *Fishing gear.*—(*a*) Causes delay in fouling drag or in securing its removal.

7. *Lack of experience in party,*—(*a*) in keeping drag in desired position—may result in unsatisfactory depths, striking shoals or charted depths when not desired, in leaving "splits," or in making excessive and unnecessary overlap in adjoining areas. These failures require that additional time be spent in running over finished area to reach them or in taking up and setting out the drag several times in a day; (*b*) in keeping depth correct, especially in judging tide and speed of drag; (*c*) in properly predicting amount of wind, sea, and swell; (*d*) in finding shoals promptly; (*e*) in removing drag promptly after shoals are located; (*f*) in getting the parts of the drag together if the wire breaks; (*g*) in keeping the drag parts out of the

propellers; (*h*) in observations—may put in error the position of the launches or the shoals; (*i*) in compiling correctly preliminary data; (*j*) in constructing properly and caring for drag gear.

8. *Equipment and apparatus.*—(*a*) Breaking of the wire in setting out or when dragging; (*b*) failure of buoys; (*c*) water-logging of floats; (*d*) failure of engines,—these include those propelling the launches engaged in towing, those on the tenders, and the auxiliary engines, operating anchor hoists, dynamo, and reels. Failure of any of these may stop the work or delay it. In most cases these are gasoline engines, which are perhaps more likely to get out of order than others.

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