ARCTIC STORM SURGE AND TIDAL EXPERIMENT

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Cover Page

Final Technical Report

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Final Technical Report

SUMMARY

ARPA has sponsored an on-going project to operate two tide gauges simultaneously on the Arctic coast of Alaska for one year. The project operated one gauge at Point Barrow throughout the contract period and under a no-cost 6-month extension of the contract operated a gauge at Oliktok Point. The original objectives of the experiment, to obtain simultaneous tide gauge data for the arctic alaskan coast were therefore fulfilled.

The project surpassed its original goals at no further cost other than time. A test of a bourdon tube "Filloux" type gauge was made at Point Barrow simultaneously with 'Bubbler' gauge measurements. Under the no-cost extension the original raw data were reduced to computer compatible form, plotted, checked and corrected. The corrected data are now stored on tape for further evaluation under other funding.

General Methodology

The main thrust of this project is in data acquisition in the Arctic. We had already made pioneering efforts to operate bubbler tide gauges in the Alaska arctic for extended periods (Matthews 1970) before this project began. The general principle invoked is to use equipment which is well tried and tested in temperate climates before attempting arctic work. The equipment should therefore be as simple and fool proof as possible.

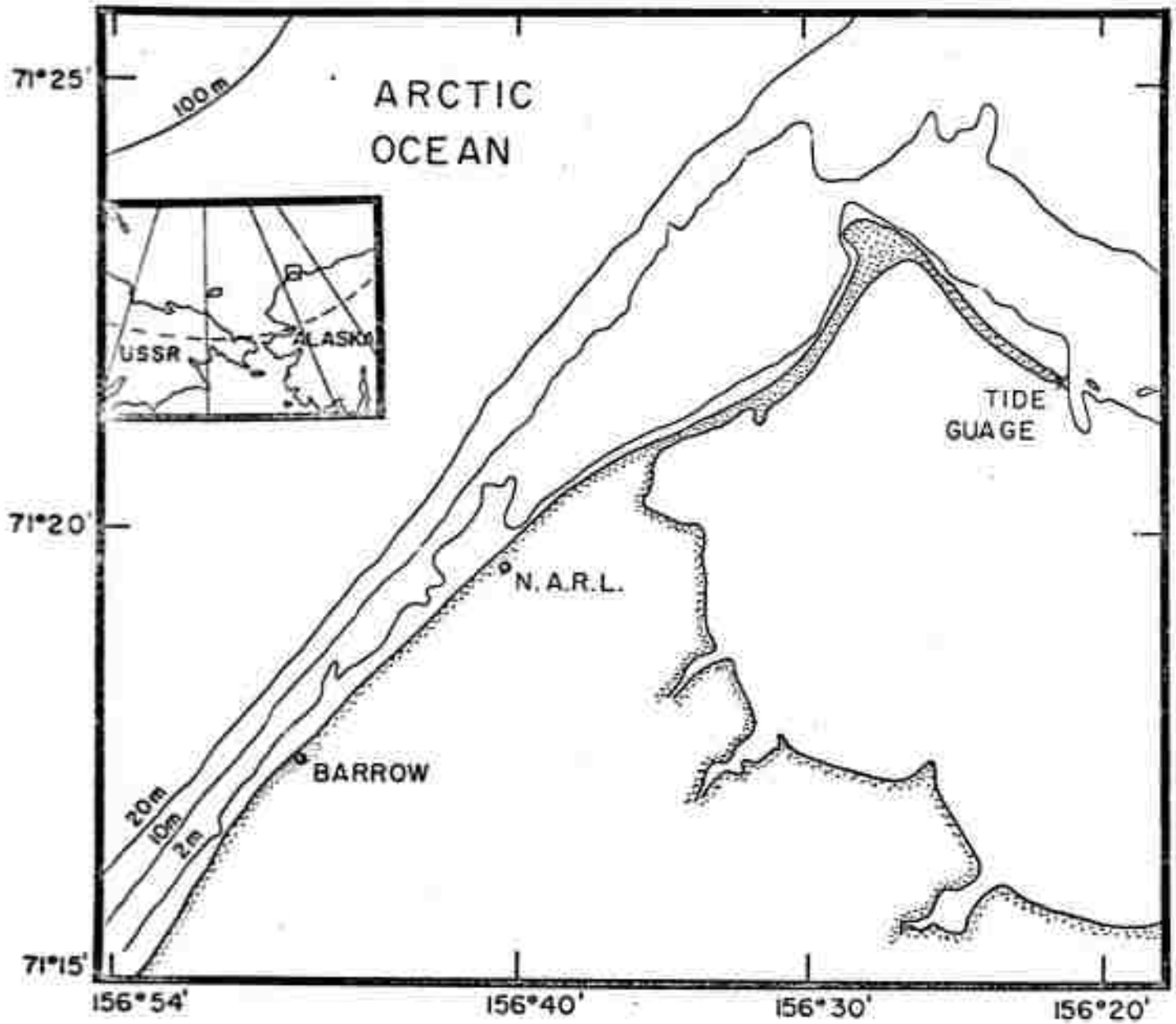

Figure 1. Location of the Point Barrow tide gauge.

Arctic environmental conditions provide sufficient problems without the need to import problems from more temperate climates.

To measure sea level variations and relate these to weather conditions both sea level and tidal records are required. The project was simplified by using sites for which meteorological data is already being recorded by the National Weather service. We have acquired the three-hourly pressure and wind records for our chosen sites, Point Barrow (Figure 1) and Oliktok Point (Figure 2) and put these in a form compatible with our sea-level records data bank.

The recording of sea level in the Arctic is a problem because of the ice interface which is present for most of the year. Canadian experiences with stilling well gauges on the St. Lawrence River have proved that the maintenance of such gauges can be very expensive. Ideally one requires an instrument which can measure sea level without crossing the air-ice-water interface.

No bottom-mounted long term tide gauge was available when this project was mooted. Moreover our initial premise of requiring well-tried equipment would preclude the use of new equipment to form the mainstay of our experiment.

The main piece of equipment for this experiment is a gas-purged bubbler tide gauge or bubbler gauge. This instrument consists of a calibrated downwards-pointing brass tube rigidly mounted to the sea floor. It is connected by plastic pressure hose to an instrument on land. The pressure hose is the only part of the equipment which crosses the destructive ice-water interface. Because the hose and orifice are relatively inexpensive redundancy can be built into the system to obtain fairly good continuous records.

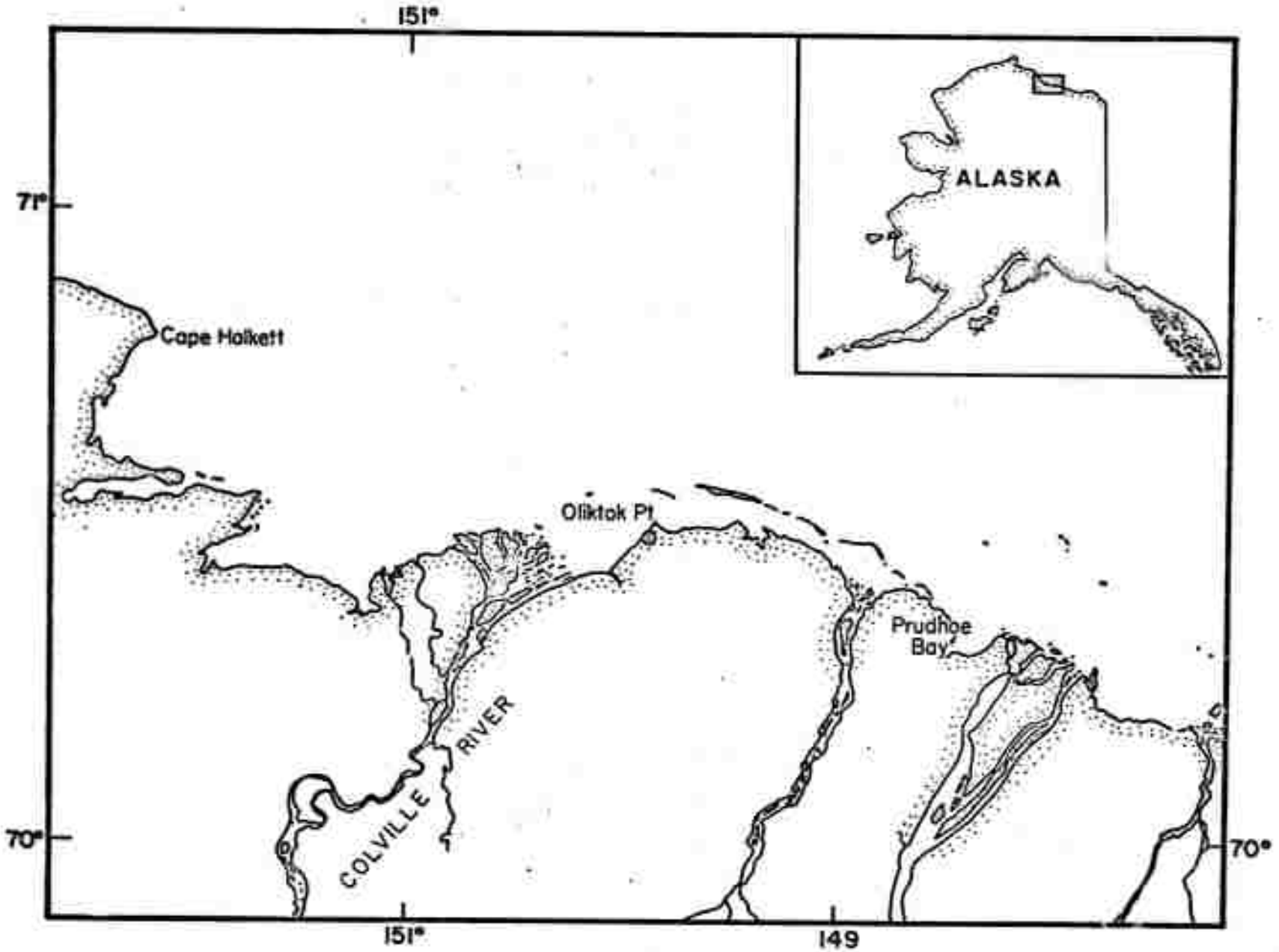

Figure 2. Oliktok Point tide gauge location.

The instrument on land provides a constant dry-nitrogen bubble rate and measures and records the back pressure on the submerged orifice. The land based equipment uses a 6" wide paper tape recorder which though anachronistic in this age of digital recorders is non-the-less reliable. This is more important for remote arctic stations where reliability is vital and normal electrical service is scarce. The operation of a clock-driven paper tape recorder in the arctic environment is difficult enough as will be outlined below.

The gas purged bubbler tide gauge uses a Bristol pen recorder and a nitrogen gas system. It is designed to operate in temperate climates in temperature ranges from 5°C to 40°C. It is therefore essential to have an enclosure which can maintain these temperatures when local conditions may be -60°C with 40 Kt winds. The instrument requires attention preferrably daily but more reasonably every two or three days.

We chose a site on Eluikak Pass, 8 miles from the Naval Arctic Research Laboratory at Point Barrow for our main site (Figure 1). This point affords water depths up to 30 feet close to shore. A propane heated hut supplied by NARL provided the instrument enclosure. Propane had to be hauled from Pt. Barrow by truck, weasel or preferrably snow-machine. When the propane supply failed the gauge recorder's ink froze as did the grease on its bearings. By attending the gauge on a bi-daily basis such faults could be held to a minimum. Never-the-less considerable difficulty was encountered in finding reliable gauge operators prepared to journey 8 miles across sastrugi-ridged trackless snow and ice and usually in total darkness.

Rather than dwell on the problems of the operation a letter from the gauge-operator is reprinted below. This is from Don Schell who devoted a great deal of time and effort to maintaining the gauges and surveying

them to Coast Survey bench marks. Without his valiant efforts the project would not have been possible. The following letter will explain typical conditions explicitly, Schell's wife Ann has operated the gauge much of the time and is mentioned in the narrative.

Naval Arctic Research Laboratory
Point Barrow, Alaska 99701

October 16, 1972

Dr. J. B. Matthews
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Dear Brian:

I'm writing out of sheer frustration. The Eluitkak gauge has been and is still under severe assault that is stymieing all attempts to get it leveled.

We have had a series of the damndest blows that have shoved the ice around and onto the gauge almost continuously. The first problems after my return here came with strong westerly winds that washed across the spit and broke up the 8" of new ice that had formed on the lagoon. This new ice was then driven onto the spit with sufficient force that in places the sheet travelled clear across the spit. In most places the ice piled in colossal jumbles along the shore. At Eluitkak Pass this onslaught was especially severe and was the source of near disaster of an Eskimo whaling boat and crew that had taken refuge in the open water lead between the ice and the spit. When the west wind swung into the south and the lagoon ice broke free, it caught the boat against the beach. The crew got a block and tackle on the pipe tower out there and managed to drag the boat up onto the beach. The ice purused them inland for over 50' and actually ended up passing alongside their lost boat for over half its length. Having been denied the opportunity to crush the ship it then piled an awesome wall of ice 5' high and 15' thick behind the boat and along the beach. This epic is further significant in that if one looks closely, the tide gauge line can be seen where it passes under the leading edge alongside of the above mentioned boat. The sensor did <u>not</u> emerge from that unscathed but miraculously it <u>does</u> still work although it was dragged into much shallower water.

I got out the day after this occurred by carefully timing the arrival of the large breakers and charging the truck through the low spots in the spit. A few times as seawater swirled around the axles and splashed over

the hood and windshield, I questioned my sanity but made it OK. On the spit between Nuwuk and Eluitkak it was (and still is) necessary to dodge the ice rubble on the spit and let the old truck clamber over what it couldn't get around. Ann was along to help but there was nothing we could do for the gauge as slush ice was running in heavy seas. So, since it was at least recording we awaited another day.

It came - at 40 knots out of the Northeast. The temperature dropped, blinding snow and the waves smashed into the ice wall with a vengance. Today's ride out was something else, as blocks of ice sailed through the air and the surf ran like a beserk ocean of concrete. Spray froze on the windshield making visibility nil but you couldn't look out the window as the flying ice hurt like hell and could smash eyeglasses if you were unlucky. Sea level dropped - so low the sensor was out of water for several hours last night but the ice wall over it has remained solid. The new ice forming is building ramparts of 3-5' high along the beach as it is heaved up by the breakers and in places the consistency of the sea is of freshly mixed cement. As the now-rising sea level and waves forces this mix over the ice wall it spills onto the spit like pahoehoe and sets up immediately. Flying chunks of ice, from the waves smashing against the ice wall preclude even getting near the water, let alone trying to work in it. We did not return from Eluitkak, we retreated.

That's how things stand now. If it ceases blowing and will turn cold, the lagoon may freeze solid for the winter. Right now it is a jumble of piled ice and slush all on the move. The wind has stopped but the temperature is going up and that may be a prelude to more southerly winds. Nevertheless, if an opportunity presents itself we will get that sensor leveled, then reset in deeper water and leveled again.

Until the, c'est le vie

Don

Technical Results

The results of ARPA sponsorship are that a sea level record from Point Barrow, Alaska is now available for over a 3 year period, excluding several breaks. A simultaneous record is available for Oliktok Point for three separate periods of about 1000 hours each. Weather records synchronous with all sea level records have been taken. Two months' of data from Point Lay have been provided to us by Dr. William Wiseman of the Coastal Studies Institute at Louisiana State University. These latter data further fill out our knowledge of arctic sea level conditions. Further a new gauge, the Bass tide gauge was tested against the bubbler gauge.

TABLE 1. CONTINUOUS SEA-LEVEL RECORDS COLLECTED.

Year	Hr/Dy/Mo From	Hr/Dy/Mo To	Year Hr From	Year Hr To	# Hr OK	# Hrs Missing	Days OK	Days Missing
1969	14/13/Sep	9/23/Sep	6134	6369	235	153	9.8	6.3
	18/29/Sep	23/31/Dec	6522	8759	2237		93.2	
1970	00/1/Jan	20/2/Feb	0	788	788	4	32.8	.2
	1/3/Feb	12/5/Jul	793	4452	3659	132	152.4	5.5
	24/10/Jul	13/16/Jul	4584	4717	133	479	5.5	20.0
	12/5/Aug	7/31/Aug	5196	5815	619	126	25.8	5.3
	13/5/Sep	23/31/Dec	5941	8759	2818	741	117.4	
1971	00/1/Jan	20/16/Aug	0	5468	5468	122	227.8	5.1
	22/21/Aug	23/31/Dec	5590	8759	3169	122	132.0	
1972	00/1/Jan	14/17/Jan	0	398	398	26	16.6	1.1
	16/18/Jan	15/2/Feb	424	783	359	94	14.9	3.9
	13/6/Feb	23/11/Feb	877	1007	130	39	5.4	1.6
	14/13/Feb	20/15/Feb	1046	1100	54	7	2.2	.3
	3/16/Feb	6/17/Feb	1107	1134	27	9	1.1	.4
	15/17/Feb	8/28/Feb	1143	1400	257	41	10.7	1.7
	1/1/Mar	1/7/Mar	1441	1585	144	37	6.0	1.5
	14/8/Mar	3/9/Mar	1622	1635	13	35	0.5	1.5
	14/10/Mar	7/23/Mar	1670	1975	305	32	12.7	1.3
	15/24/Mar	00/25/Mar	2007	2016	9	70	.3	2.9
	22/27/Mar	14/29/Mar	2086	2126	40	10	1.7	.4
	24/29/Mar	21/18/Apr	2136	2613	477	39	19.8	1.6
	12/20/Apr	13/2/Jul	2652	4405	1753	169	73.0	7.0
	14/9/Jul	1/22/Jul	4574	4873	299	91	12.4	3.8
	20/25/Jul	19/13/Sep	4964	6163	1199	39	49.9	1.6
	10/15/Sep	24/30/Sep	6202	6576	374	13	15.6	0.5
	13/1/Oct	15/3/Nov	6589	7383	794	141	33.1	5.9
	12/9/Nov	4/19/Nov	7524	7756	232	15	9.7	0.6
	19/19/Nov	6/21/Nov	7771	7806	35	45	1.5	1.9
	3/23/Nov	9/25/Nov	7851	7905	54	7	2.2	0.3
	16/25/Nov	23/31/Dec	7912	8783	871	7	36.3	
OLIKTOK POINT								
1971	0/14/Nov	14/31/Dec	7608	8750	1142	9	45.6	0.4
1972	0/3/Aug	0/19/Sep	5160	6264	1104	1536	46.0	6.4
	0/21/Nov	23/31/Dec	7800	8783	983		41.0	
1973	0/1/Jan	18/5/Feb	0	858	858		35.8	

The main achievements of the program (and its objectives) are the acquisition of sea level data for arctic Alaska. Table 1 shows the data collected to date. This covers funding periods by the University of Alaska, by the Arctic Institute of North America under ONR Contract 429 and the present ARPA contract (from 1 June 1971). The table shows that the Barrow gauge operated from 1 June 1971 to 16 August 1971 when ice removed the sensor. From 21 August 1971 the gauge ran through the remainder of the year. For 1972 a full year's coverage was obtained with about 10% bad or missing data.

Data which is missing for a period of 5 hours or less has been filled in by manual interpolation. The average length of break is about 1-1/2 days and the longest a 7-day break in July 1972 (ARPA sponsored period only). The contract covers data acquisition only so that no analytical results such as tidal harmonic amplitudes and phases, mean sea levels or other results can be given. The results of analytical work will have to await further work and funding.

DOD Implications

The principal investigator for this project does not feel qualified to evaluate the DOD implication of this work. However it occurs to him that knowledge of sea level variations and surges and the associated ice movements and build-up on the shoreline could aid DOD operations in the arctic.

Implications for Future Research

Since this project is a data acquisition program the most immediate priority is for the analysis of these data.

The problems of operating standard tide gauges in the arctic only further underlines the need for a reliable bottom-mounted long term instrument. The principal investigator has already addressed this problem simultaneously with the present project. An instrument with no moving parts capable of operating under extreme conditions for long periods has been developed (see 'Ocean Tides' in EOS No. 1 1973). Such instruments need further development and exploitation in the arctic.

Conclusion

The project has more than fulfilled its original objectives within its original budget.

Reference

Matthews, J. B. 1970. Arctic tides and storm surges. Proceedings World Ocean Conference, Tokyo 1970. p. 332.