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Investigation of the Capability of Ship-of-Opportunity Sampling for British Columbia Coastal Waters

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1996

Canadian Contractor Report of Hydrography and Ocean Sciences 46

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Canadian Contractor Report of Hydrography and Ocean Sciences

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ABSTRACT

This contractor's report identifies a selection of potentially useful ships-of-opportunity together with the sailing routes and schedules of these ships in British Columbia coastal waters. It identifies a list of interested "clients" for oceanographic and meteorological data which might be obtained by using these ships. Potential clients include a number of Federal government departments, Provincial government departments, Municipal/Regional government bodies, University researchers and private sector companies from both Canada and the U.S.A. A brief catalogue of potentially useful sensors which might be used in support of such a program with an emphasis on sensors which can be implemented in an autonomous or nearly autonomous mode of operation is included. The report closes with a number of specific recommendations for the future direction of a ships-of-opportunity program including the implementation of a ships-of-opportunity workshop followed by a series of specific pilot projects in Saanich Inlet, and in other areas of strategic interest such as the Georgia Basin or the Straits of Juan de Fuca.

Key words: ships-of-opportunity, sampling, coastal monitoring, Saanich Inlet, Georgia Basin, Strait of Juan De Fuca

RÉSUMÉ

Ce rapport présente une sélection de navires commerciaux potentiellement utiles pour le rassemblement de données scientifques, ainsi que les routes maritimes et les horaires de ces navires dans les eaux côtieres de la Colombie Britannique. Il identifie aussi une liste de 'clients' intéressés aux données océanographiques et météorologiques que l'on pourrait obtenir en employant ces navires. Ces clients potentiaux incluent plusieurs départements des gouvernements fédéral et provincial, certains organismes des gouvernements municipaux and régionaux, des chercheurs universitaires et des compagnies privées tant au Canada qu'aux États-Unis. Ce rapport inclut un bref catalogue de détecteurs qui pourraient être employés au soutien de ce programme, mettant l'accent sur ceux détecteurs qui peuvent opérer d'une façon autonome ou presque autonome. Il se termine par plusieures recommandations spécifiques au sujet de l'orientation future d'un programme d'utilisation des navires commerciaux, entre autres l'établissement d'un atelier sur ce sujet suivi par une série de projets-pilote menés dans le bras de mer de Saanich et d'autres régions d'intérêt stratégique telles que le bassin Georgia ou le détroit de Juan de Fuca.

Mots clé: navires commerciaux, rassemblement de données, monitorage des côtes, bras de mer de Saanich, bassin Georgia, détroit de Juan de Fuca

Preface

This report describes work completed under Contract No. FP 95-5321-924-9020 (Financial Coding: 5247). It was completed by Jasco Research personnel over an approximate three month period in early 1996.

We would like to acknowledge Dr. D.L. Mackas as the scientific authority for the project and thank him for his participation. We would also like to express our thanks to those we have contacted in the course of this study, either as clients, as owner/managers of ships-of-opportunity or as suppliers of specialized scientific equipment for their always courteous support and informed suggestions.

1.0. Introduction

This report describes work completed under Contract No. FP 95 - 5321-924-9020 (Financial Coding: 5247). It was completed by Jasco Research personnel over an approximate three month period in early 1996.

1.1. Background and Project Rationale

The background and project rationale is clearly laid out in the contract Statement of Work (SOW), i.e.,

> *"Most of our present monitoring capability for coastal seas is shoreline and/or sea-surface. Areas such as the Strait of Georgia and Hecate Strait have many potential platforms and routes that have been sporadically fitted with flow-through surface water property sensors. But the scientific value of ships-of-opportunity could be greatly extended with wider coverage, and with the addition of modern acoustics and optical sensors to measure e.g. sub-surface currents, fish and plankton distributions. Although this ultimately would require a substantial capital and O&M commitment, payback in terms of coverage and in-house ship costs is likely to be even larger. The present project is a scoping effort to identify suitable platforms and contacts, types of sensors/sampling that could be used on what types of platforms, data/sample management implications, and overall costs.*
>
> *If implemented, we anticipate better space and time resolution for baseline monitoring of rapidly-varying coastal seas; plus freeing-up of DFO vessels for specialized intensive rather than on-going extensive sampling activities."*

1.2. Project Objectives

The objectives as identified in the SOW were listed as follows:

> *" The contractor will identify and evaluate platforms and sensors offering improved capability for ship-of-opportunity sampling of British Columbia coastal waters.*
>
> *For platforms, the study addresses topics such as the density and consistency of spatial and temporal coverage; the willingness of owners/operators to collaborate with government laboratories; incremental hardware and personnel costs (if any), sustainability for various types of internal, hull-mount, and towed sensors, and logistics of sensor installation, maintenance, operation and data recovery.*
>
> *For sensors, the study should cover topics such as: what variable(s) can be measured; application to ocean science and fisheries issues; depth coverage; sampling resolution; ease and stability of sensor calibration and operation; data-logging requirements; and personnel requirements for installation, operation, and data analysis."*

This report summarizes the findings of this initial scoping effort. It is organized into five principal sections, Part 1 (this section) introduces the reader to the background, rationale, scope and objectives of the study.

Part 2 identifies a selection of potentially useful ships or "platforms". A specific contact is provided for each of the identified organizations or companies operating these potential ships-of-opportunity and a brief description of the initial response to the proposed participation in a ship-of-opportunity program is given. An indication is provided as to the density and consistency of spatial and temporal coverage provided by these ships with detailed information on exact sailing schedules included in an Appendix. A brief narrative accompanies each contact person/organization summarizing any relevant comments, suggestions or concerns expressed during the conducted interview on the questions of suitability, costs and logistics of sensor installation.

Part 3 identifies a list of interested "clients" for oceanographic and meteorological data which might be obtained from a ship-of-opportunity program. These clients include a number of Federal government departments, Provincial government departments, Municipal/Regional government bodies, University researchers and private sector companies from both Canada and the U.S.A. The rationale for this approach is twofold, first it ensured that a broad spectrum of diverse clients were contacted during the study, thus allowing us to learn of their needs and interests and benefit from their support and expertise. Second, and more pragmatically, to help identify a collection of potentially interested clients external to DFO who may be interested in cost-sharing arrangements or outright purchase of information which might be obtained from a suite of instrumented ships-of-opportunity. In this age of diminishing fisheries budgets this approach is of critical importance and may help ensure the future success of this DFO initiative.

Part 4 provides a brief catalogue of potentially useful sensors which might be used in support of such a program with an emphasis on sensors which can be implemented in an autonomous or nearly autonomous mode of operation. This section includes a summary of what is currently being measured in other ship-of-opportunity programs and suggests some innovative and emerging applications of little used or non-conventional sensors.

Finally, Part 5 presents a summary of the report findings and suggests a few specific recommendations for the future direction of a ships-of-opportunity program. The summary provided attempts to classify the expressed client interest into specific coastal regions or zones. From an

analysis of these requirements and through discussion with the SA as to the priority weighting of these requirements it was possible to identify coastal regions or zones of highest priority and thus help to define which ships-of-opportunity are the most desirable in terms of meeting the needs of the end-users of the recorded data.

The recommendations call for the implementation of a ships-of-opportunity workshop followed by a series of specific pilot projects. It is suggested that these pilot projects be initiated in Saanich Inlet, an area of strategic importance to a number of clients and located close to the Institute of Ocean Sciences in Pat Bay, B.C. and later be extended to larger scale programs in other areas of strategic interest such as the Georgia Basin and/or the Straits of Juan de Fuca.

2.0. Platforms

2.1. Introduction.

This section describes the contacts made with a number of organizations responsible for operating ships which show potential for use as ships-of-opportunity in the context of this study. The companies, together with a description of the number, routing and sailing schedule of ships operated by that company are described separately in the following sub-sections.

Section 2 closes with a summary of all the identified routes by geographic region. This concluding section includes a brief discussion of what makes a "good" route in terms of the frequency, consistency of travel path and intersection with important ocean areas in terms of circulation, biological productivity, contaminant exposure etc. Using this approach, a few of the more highly ranked routes are flagged as higher priority routes which could potentially be exploited first under a 'ship-of-opportunity' initiative.

2.2. Ships operated by the B.C. Ferry Corporation.

In early 1996, contact was made with senior staff representatives of B.C.F.C. i.e.,

Contact(s): Mr. Rob Hamilton, Environmental coordinator
Ms. Alijcia Rudzki, Environmental officer
Address: B.C.F.C.
1112 Fort St.
Victoria, B.C. V8V 4V2

Ph: (604) 381-1401 ext 1134
Fax: (604) 381-5452
Web: **http://vvv.com/ferries/**

At this meeting discussions were held on the subject of using B.C. Ferries as ships-of-opportunity in support of ongoing oceanographic research. We were informed of the fact that a number of other studies had been done in the past using B.C. Ferries as ships-of-opportunity and that B.C. Ferry Corp. would indeed be willing to consider in a positive light any future initiatives of this type. It was clear that the final decision would of course have to be made in cooperation with the ships engineer who is responsible for the operation and safety of the vessel. In general, we received a very positive response from the B.C.F.C. representatives who seemed quite willing to participate in future research experiments of this type provided it did not interfere with their primary mission. The meeting ended with a request for copies of detailed sailing routes of B.C. Ferry vessels - this information was later provided and delivered to the SA under separate cover.

B.C.F.C. affords by far the widest selection of available vessels which could be exploited in a ships-of-opportunity program. The routes travelled by these ferries are shown in Figures 1-4 on the following pages.

Figure 1 shows the BC Ferry routes connecting the BC mainland with Vancouver Island together with those operating on the Sunshine coast. The sailing schedules for each of the routes of Figure 1 are given in Tables 1-9 of Appendix A.

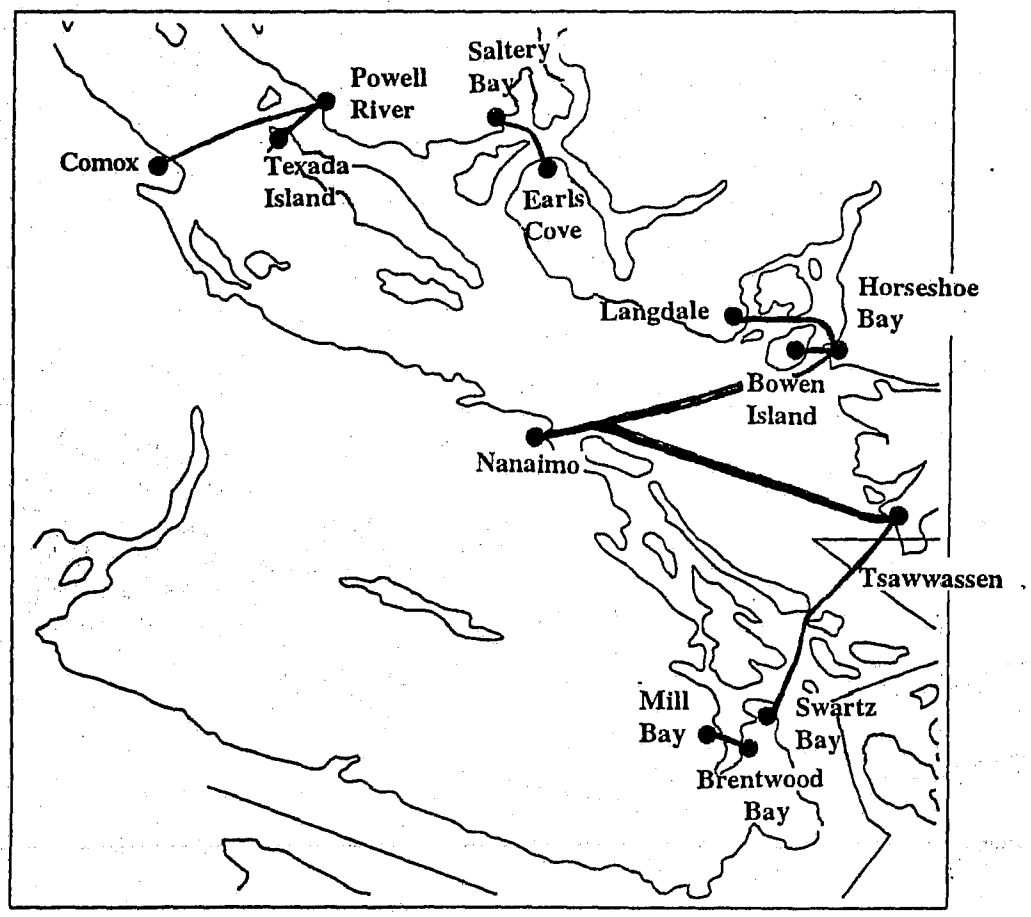

Figure 1. Nine separate BC Ferry routes for the BC Mainland, Vancouver Island, Sunshine Coast ferries.

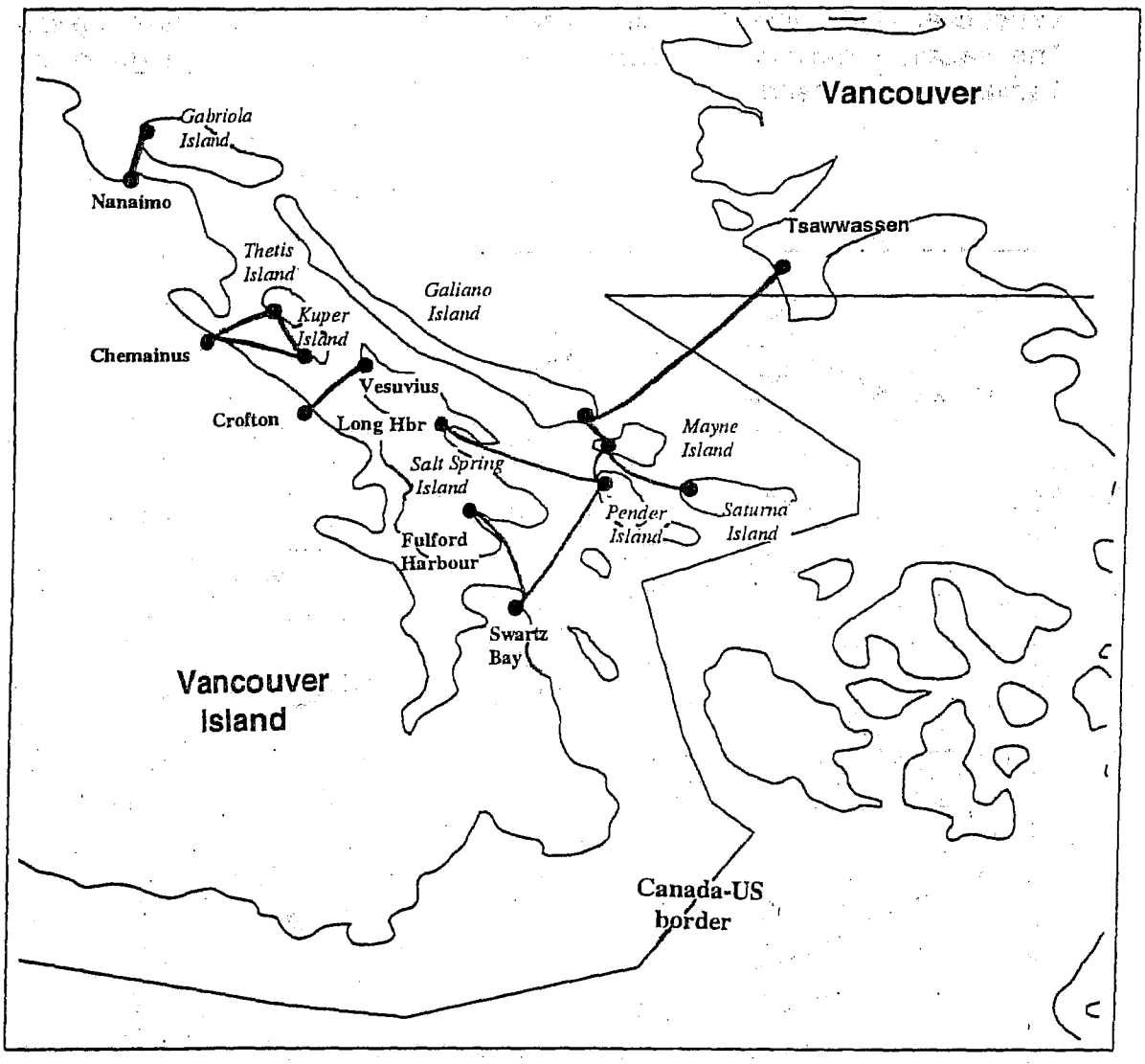

Figure 2. BC Ferry routes for the Southern Gulf Island ferries.

Figure 2 identifies the three ferry ports by name on Salt Spring Island, namely Vesuvius, Long Harbour and Fulford Harbour. The ferry ports for the other Gulf Islands are; Village Bay on Mayne Island, Otter Bay on Pender Island, and Sturdies Bay on Galiano Island. The sailing schedules for each of these routes are given in Tables 10 - 17 of Appendix A.

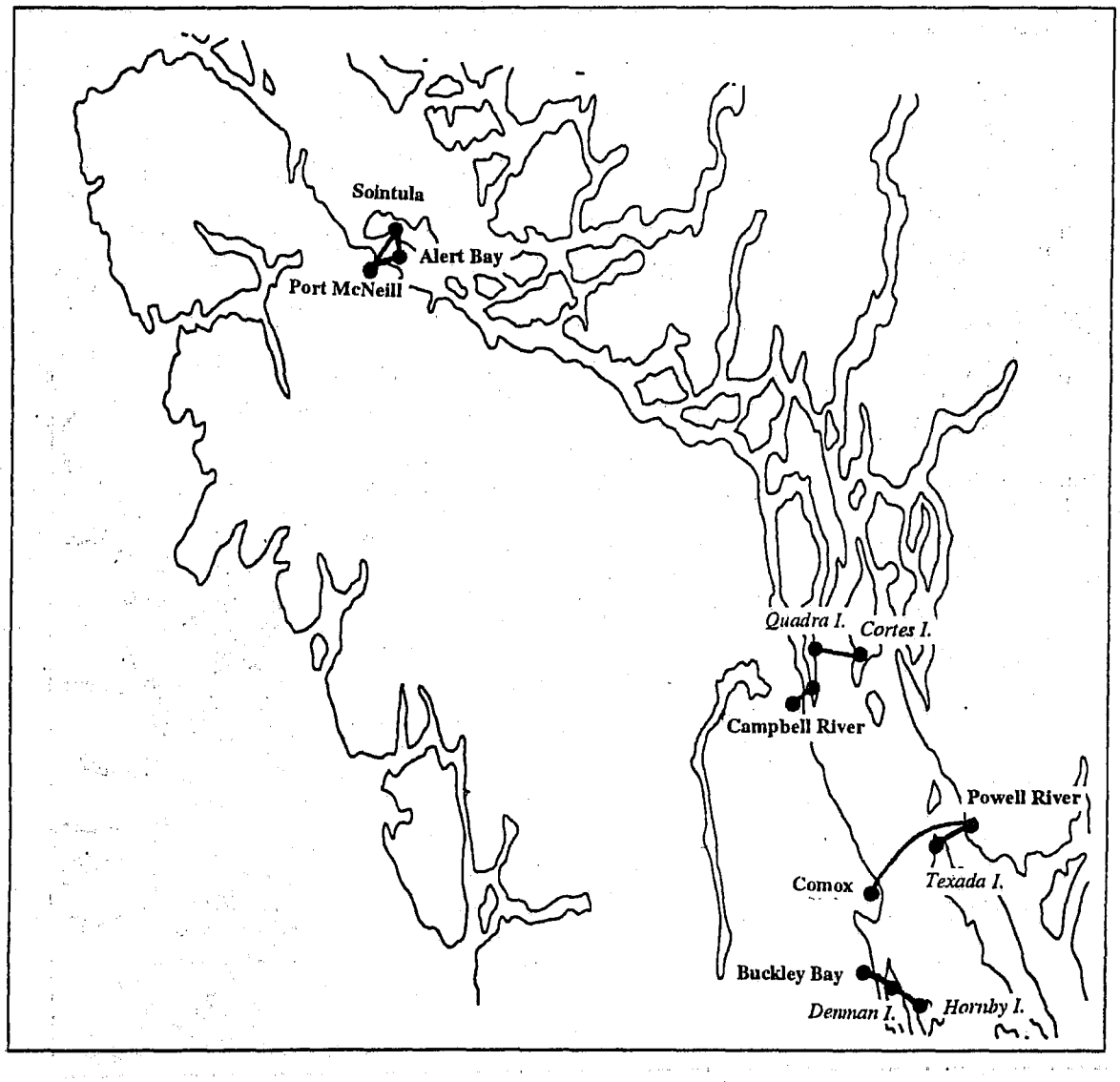

Figure 3. This figure shows the sailing routes for B.C. Ferries operating North of Nanaimo and connecting Vancouver Island with the Northern Gulf Islands and B.C. mainland. The sailing schedules for each of these routes are given in Tables 18 - 21 of Appendix A.

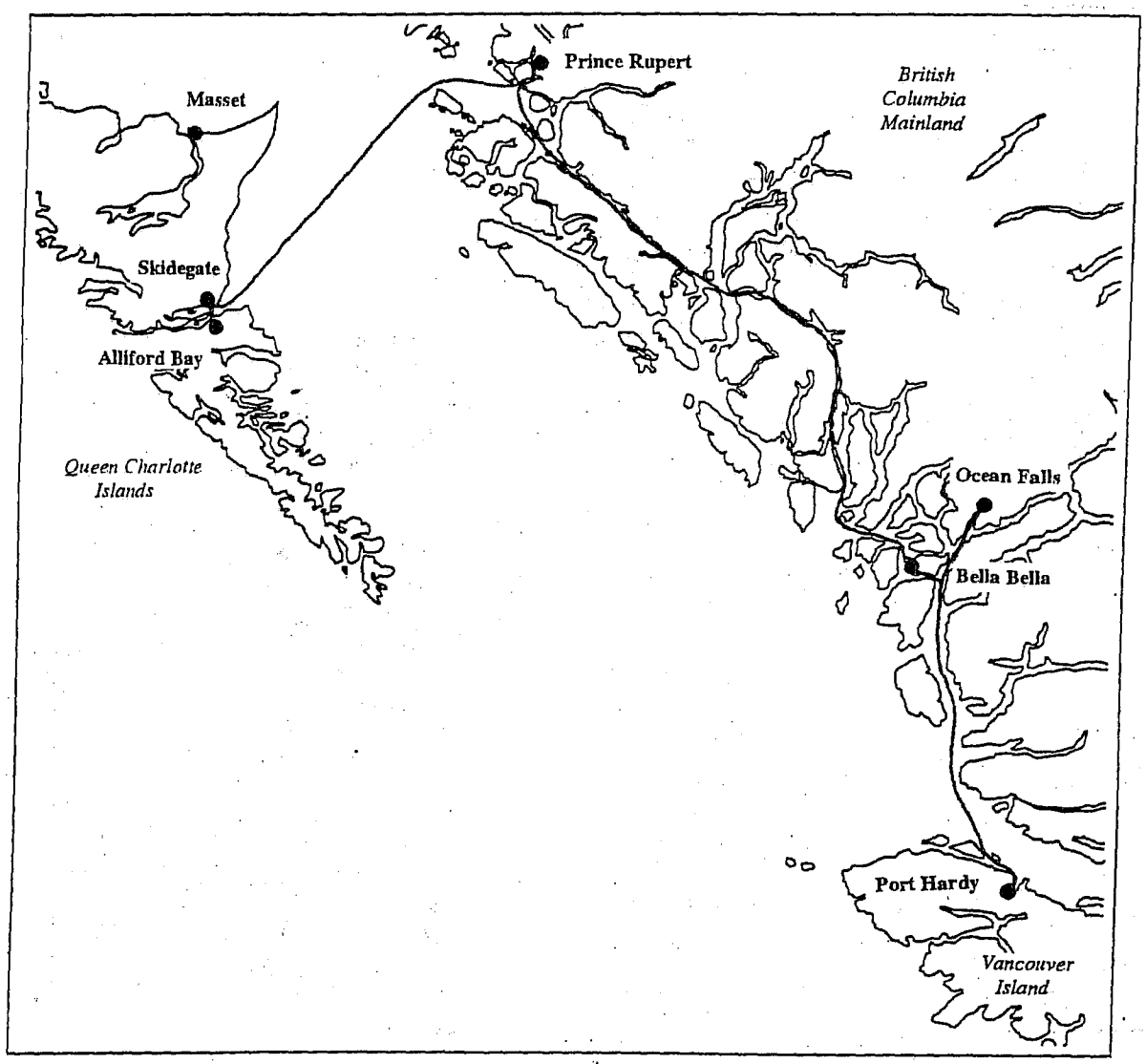

Figure 4. Routes for the BC Inside Passage and Queen Charlotte Island ferries. The sailing schedules for each of the above routes are provided in Tables 22 - 24 of Appendix A.

2.3. The Washington State Department of Transportation Ferries.

The second major ferry operator in the BC coastal waters is the Washington State Department of Transportation. The contact numbers for WSF are:

In Washington State:	In Sidney, B.C.:
(206) 464-6400	(604) 381-1551 or (604) 656-1531

WSF also has a useful internet address at:

http://www.wsdot.wa.gov/ferries/current/

WSF operates a number of ferry connections in Washington State as indicated in Figure 5 below. Of these routes, only the Sidney - Anacortes ferry and the Port Townsend - Keystone schedules are listed in the Appendix as Tables 25-26. Other schedules have been provided under separate cover and can be readily found on the internet at the above address.

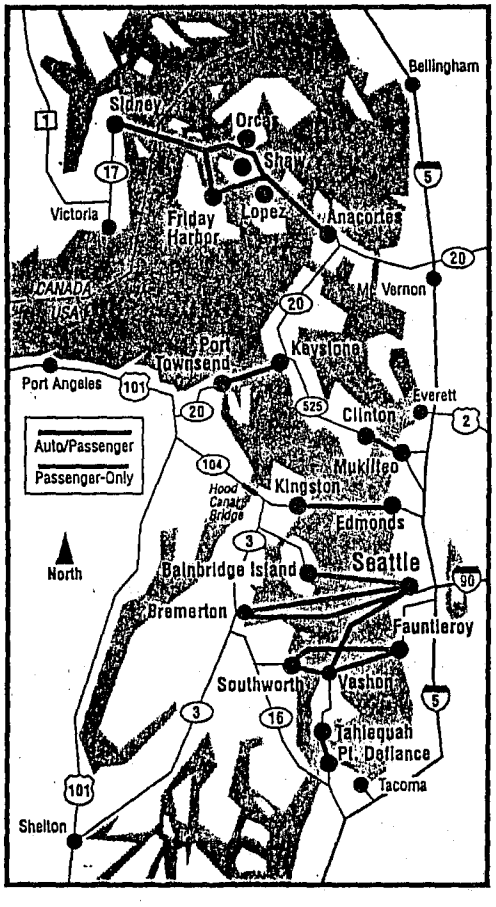

Figure 5. Routes for the Washington State Department of Transportation ferries.

2.4. Black Ball Transport, Inc - the M.V. Coho.

Black Ball Transport Inc operates the M.V. Coho year round on a route connecting Port Angeles, Wa to Victoria, B.C. Important contact addresses and phone numbers for Black Ball are:

In Bellevue, Wa.	In Port Angeles, Wa.	In Victoria, BC
1077 Main St., Ste 106 Bellevue, WA 98004 Ph: (206) 622-2222 Fax:(206) 622-2225	101 E. Railroad Ave. Port Angeles, WA 98362 Ph: (360) 457-4491 Fax:(360) 457-4493	430 Belleville St. Victoria, BC V8V 1W9 Ph: (604) 386-2202 Fax:(604) 386-2207

The appropriate contact person for all potential ship-of-opportunity applications should be made to Mr. Pat Furmento in Victoria, BC.

Table 27 shows the year round ferry sailing schedule for this route and Figure 6 shows the approximate location of the route in Juan de Fuca Strait.

FERRY SCHEDULE
VICTORIA-PORT ANGELES
M.V. COHO

1996

(Daylight Time When In Effect)	Leave Port Angeles, WA	Leave Victoria, B.C.
March 7 - May 15	8:20 A.M.	10:30 A.M.
	2:00 P.M.	4:00 P.M.
May 16 - October 15	8:20 A.M.	**6:20 A.M.
	12:45 P.M.	10:30 A.M.
	5:15 P.M.	3:00 P.M.
	*9:30 P.M.	7:30 P.M.
October 16 - December 31	8:20 A.M.	10:30 A.M.
	2:00 P.M.	4:00 P.M.

*This trip operates June 6 through September 17 only.
**This trip operates June 7 through September 18 only.

Crossing time: 1 hour, 35 minutes — Vertical Clearance: 14 feet
Subject to change without notice — Advance reservations not accepted
Printed in U.S.A. SCHEDULE 65 cancels SCHEDULE 64

FERRY SCHEDULE
PORT ANGELES-VICTORIA
BLACK BALL TRANSPORT, INC.

Table 27. Sailing Schedule for the Victoria - Port Angeles ferry (MV Coho).

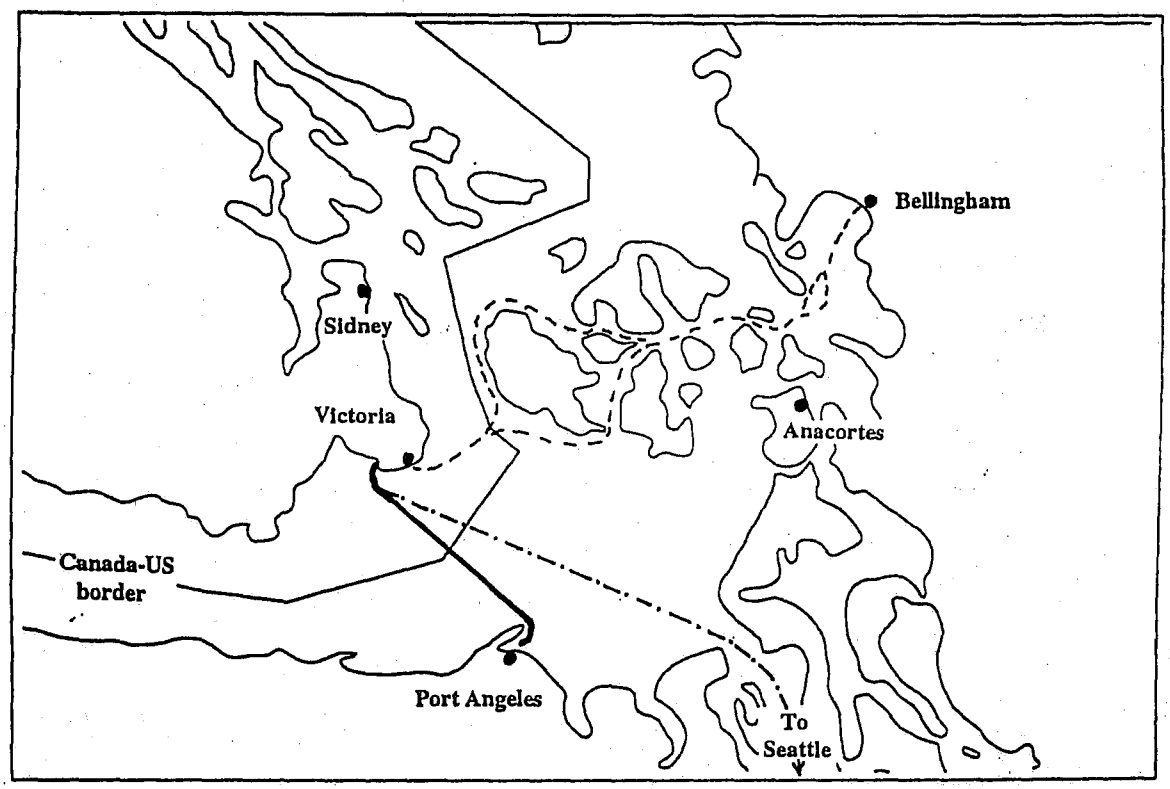

Figure 6. Routes for ferries operating between Victoria, B.C. and Washington State. The solid line shows the Victoria Express and the Black Ball ferry route, the dash-dot line shows the Victoria Line and the short dashed line, the Victoria-San Juan Cruises route.

2.5. Victoria Line - the Royal Victorian.

Victoria line Ltd. is a Crown corporation of the Province of British Columbia. It operates the Royal Victorian on a route connecting Victoria, B.C. to Seattle WA for part of the year from mid-May to mid-October. Important contact addresses and phone numbers for the Victoria Line are:

In Victoria, BC

185 Dallas Road,
Victoria, BC V8V 1A1
Ph: (604) 480-5544
Fax:(604) 480-5222
Web: http://victoria-line.bc.ca

The appropriate contact person for all potential ship-of-opportunity applications is Mr. Cal Smith, Operations Manager in Victoria, BC.

The sailing schedule is 1 trip per day, leaving Victoria at 7:30 a.m. and returning from Seattle at 1:00 p.m. - a sailing time of 4½ hrs.

2.6. Victoria Rapid Transit Inc - the Victoria Express

Victoria Rapid Transit Inc. is a privately owned and operated high speed (~20 kts) passenger ferry service connecting Victoria, B.C. to Port Angeles WA. It operates seasonally, from mid-May to mid-October and provides two-three round trip services per day. The schedule is:

May 25 - June 14th

Depart Port Angeles	Depart Victoria
8:10 a.m.	9:45 a.m.
12:15 p.m.	6:15 p.m.

June 15th - Sept. 2nd

Depart Port Angeles	Depart Victoria
8:10 a.m.	9:45 a.m.
12:15 p.m.	2:00 p.m.
4:15 p.m.	6:15 p.m.

Sept 3 - Oct. 13th

Depart Port Angeles	Depart Victoria
8:10 a.m.	9:45 a.m.
12:15 p.m.	6:15 p.m.

The appropriate contact person for all potential ship-of-opportunity applications is Mr. Jack Harmon, Operations Manager his contact number in Victoria, BC is:

Ph: (604) 361-9144
Web: **http://www.cityofpa.net/ferry**

2.7. Victoria - San Juan Cruises Ltd - the Victoria Star

Victoria - San Juan Cruises is a privately owned tour company which operates a seasonal daily service connecting Bellingham WA with Victoria, BC via the San Juan Islands. This company specializes in narrated "whale watching" tours which offer tourists the opportunity to observe marine mammals and seabirds in their native habitat. The daily season schedule is:

May 25 - October 6th

Dep. Bellingham	Arr. Victoria	Dep. Victoria	Arr. Bellingham
9:00 a.m.	1:00 p.m.	4:30 p.m.	8:00 p.m.

Contact: Mr. Drew Schmidt, manager
Ph: 1-800-443-4552
Web: **http://www.whales.com**

2.8. Inter Island Launch - the Prince of Whales

Inter Island Launch is a privately owned passenger/mail ferry (enclosed launch) and tour company which operates all year round out of Sidney BC. The "whale watching" side of the business is seasonal however the inter island launch service operates a daily regularly scheduled passenger ferry and mail service throughout the Gulf Islands. The daily season schedule is:

May 25 - October 6th

Dep. Bellingham	Arr. Victoria	Dep. Victoria	Arr. Bellingham
9:00 a.m.	1:00 p.m.	4:30 p.m.	8:00 p.m.

Contact: Mr. Allen McGillivray, owner/operator
Ph: (604) 656-8788

2.9. Sea Quest DSV Adventures Ltd.

This company operates a "whale watching" eco-tourism and diving business out of Sidney, BC. The "whale watching" and diving services can be done year round but are regularly scheduled during the season from about April 1st to mid-Oct. During the season, the tours run daily from 9:00 a.m. till 5:00 p.m. every two hours. The routes will vary depending on whale sightings but typically range from Active Pass, to Haro Strait and the Straits of Juan de Fuca as far as Race Rocks.

Contact: Ms. Liz Madro, owner/operator
Ph: (604) 656-7599
Fax:(604) 655-3771
Web:**http://www.fifth.ca/~ewhare/sfnews.htm**

2.10. Star Marine Services - Sidney Harbour Shuttle

Star Marine Services operates a regularly scheduled shuttle service between Canoe Cove, Tsehum Harbour, Swartz Bay and Piers Island. The service operates year round in close proximity to the Sidney-Victoria coastline. It has been included in this report as a potentially useful platform for local near-shore coastal monitoring of environmental contaminants.

Contact: Barbara Watson, owner/operator
Ph: (604) 655-5211
pager: (604) 480-6930

2.11. The Alaska Marine Highway ferryliners

The Alaska Marine Highway Department of Transportation and Public Facilities, operates a fleet of "ferryliners" which travel from Prince Rupert, BC and Bellingham, WA to Alaska via the Inside Passage. The vessels range from the M/V Columbia at 418 ft to the M/V Le Conte and Aurora at 250 ft. For the purposes of this study, we will restrict the vessels of interest to those which operate in BC coastal waters and simply note that there are a number of other routes and Alaskan coastal areas which are serviced by these "ferryliners".

The primary routes of interest in the context of this study are those sailed by the M/V Columbia (Bellingham, WA to Prince Rupert,BC, Ketchican,AK and then to the southeast Alaska ports) and by the M/V Malaspina, the M/V Matanuska and the Taku (between Prince Rupert, BC and a number of southeast Alaska ports).

The M/V Columbia sails throughout the year, about once per week during the summer season (May-Sept) and twice a week during the winter. The exact sailing schedules are complex, including stops in Prince Rupert, Ketchican, Wrangell, Petersburg, Sitka, Juneau, Haines and Skagway. A brochure detailing the exact sailing schedule is readily available and a copy has been provided under separate cover.

The routes and schedules of the other three vessels can be found in a detailed description on the Alaska Marine Highway internet home page,

http://www.dot.state.ak.us/external/amhs/general

a portion of which is reproduced in italics below:

> *"**Vessels:** The 500 passenger M/V Malaspina and M/V Matanuska and Taku, connect Southeast Alaska ports with Prince Rupert, B.C. in a 450 mile route ending in Skagway. Service is scheduled four to six days per week in each direction during the summer, except Sitka which is covered on two trips northbound and one trip southbound. Winter service is regular but less frequent."*

Discussions held with representatives of AMHS confirm that the company provides support to US Federal government agencies (in the form of free passage and sometimes meals) who are providing naturalist programs to the travelling public as part of their government mandate. In particular, the Forest Service, U.S. Deptartment of Agriculture, welcomes travellers aboard selected Alaska State ferries and provides a visitor services and

naturalist program to them as they cruise the forested waterways along the Chugach and Tongass National Forests.

To quote from the description provided on the internet Home Page,

> *"Programs vary according to each ship's schedule and facilities, and include: narrative talks, films, slide programs, children's activities and brochures about the natural and cultural resources of Alaska and the National Forests. Naturalists staff the ferries from about June 1 through Labor Day each year as part of a cooperative agreement between the State of Alaska and the Forest Service. Ferries that are staffed include the Columbia, Malaspina, Matanuska, and Taku through Alaskan waters bordering the Tongass National Forest in Southeast Alaska and portions of trips by the Bartlett and Tustumena in Prince William Sound near the Chugach National Forest in Southcentral Alaska."*

Other programs are also supported, again to quote from the AMHS internet page:

> *"Alaska Department of Fish and Game Department biologists and technicians provide interpretive programs on selected "Inside Passage" sailings."*

A number of researchers were contacted who are presently working in Alaskan waters and these individuals and their comments are described later in Section 2.

Further information can be obtained from:

Contact(s): Mr. George Refenstein, operations manager
Ms. Linda Mickle, marketing and public relations

Ph: (907) 465-8815
(907) 465-8809

Alaska Marine Highway Department of Transportation and Public Facilities,
Alaska Marine Highway System,
Box 25535, Dept.9316,
Juneau, AK 99802-5535
Ph: 1 - 800 - 642-0066
Fax: (907) 277-4829
or: (604) 627-1744
Web: http://www.dot.state.ak.us/external/amhs/general

The appropriate contact person for all potential ship-of-opportunity applications is Mr. George Refenstein, Operations Manager.

2.12. The Cruise Lines

During the investigation of potential ships-of-opportunity, a number of "cruise" lines were identified which operated in the waters off the BC and Alaskan coasts.

These cruise lines included:

- Holland America Lines
- Princess Cruise Lines
- Norwegian Cruise Lines
- Carnival Cruise Lines

Unfortunately, time constraints did not permit us to make personal contact with representatives from these shipping lines.

It is important to note that, the information we were able to obtain and review in the course of this study typically showed that the individual ships operating in these waters were seasonal and were rotated frequently to other areas. For example, the Sun Princess, a Princess Cruises ship, operates in BC/Alaska waters from early May to mid-September but then moves to the Caribbean for the winter months of December-April. This pattern is typical of a large number of these ships.

Moreover, the routes travelled by these cruise lines are similar if not identical to those travelled by the Alaska Marine Highway "ferryliners" and so no new coverage is likely to be gained from this fleet of ships.

2.13. Other Ship-of-Opportunity Programs

During the course of this study, a number of other ship-of-opportunity programs were identified. These programs focus principally on coastal and international freighters although there have been cases where oil tankers have been instrumented. The programs identified in this study are:

Canadian Dept. of Environment - Atmospheric Environment Service -The Canadian Federal Department of Environment ship-of-opportunity program. The program has been operational for many years with the objective of supporting meteorological observations. A meeting was arranged with the port meteorological officer, Mr. Bob McArter in the context of this study. Mr. McArter was very helpful and expressed a willingness to provide whatever information he could to the S.A. on request. This information included a list of currently in-use ships-of-opportunity which he is responsible for.

Contact: Mr. Bob McArter, port meteorological officer

Ph: (604) 664-9136
Fax: (604) 664-9195

Environment Canada
Pacific Region
Atmospheric Environment Service
Suite 700
1200 West 73rd Ave.
Vancouver, B.C. V6P 6H9

National Oceanic and Atmospheric Administration (NOAA) -The Observing Networks Branch/Ocean Observations Division is responsible for collecting, archiving and distributing global ocean data including XBT and TESAC profiles. This data is collected using the SEAS or Shipboard Environmental [data] Acquisition System. Two associated publications are available by contacting the Observing Networks Branch of NOAA. These are:

[1] Annual Summary SEAS Program Data 1995
[2] 1994 Global Summary Real-Time XBT Data

Contact: Dr. Bill Woodward
Ms. Martie Campbell

Ph: (301) 713-2790
Fax: (301) 713-4499

N/OES Room 6308, SSMC IV
1305 East-West Highway,
Silver Spring, MD 20910
USA

Scripps Institute of Oceanography - the Volunteer ship program. Dr. Dean Roemmich is currently managing a volunteer ship program from Scripps Institute of Oceanography. This program has been in operation for about ten years. The thrust of the program is to provide input data for physical oceanographers in support of the World Ocean Circulation Experiment (W.O.C.E.) The data is typically obtained by booking passage on board a trans-Pacific freighter for a research scientist who then performs a number of XBT and XCTD "drops" along the freighters route. The geographic region of interest has been from as far north as the Strait of Juan de Fuca down to Antarctica. Some of the ships used in the program have been tankers operating out of Valdez Alaska. There appears to be a strong interest in any possible Canadian ship-of-opportunity program which might be initiated and the idea of collaborative research was well received.

Contact: Dr. Dean Roemmich
Dr. Dave Cutchins
Ms. Andrea Quigley

Ph: (619) 534-2307
(619) 534-1139
Fax: (619) 713-4499

Scripps Institute of Oceanography
La Jolla, California

2.14. Summary and Ranking of Routes.

This section provides a summary of a number of key routes in three main geographic regions, namely Saanich Inlet, the Strait of Georgia and the Straits of Juan De Fuca. The routes identified here are all considered to be "good" routes i.e., they are travelled frequently - between 3 and 10 times per day, they travel a consistent and well specified path and all intersect with important ocean areas in terms of circulation, biological productivity, contaminant exposure etc.

It is important to note that the suggested route ranking is admittedly largely subjective and based principally on the comments and suggestions of individuals contacted in the course of the study, nevertheless, it is included here as a suggested starting point for discussion and consideration in a possible ship-of-opportunity program.

Rank 1. Brentwood Bay - Mill Bay.

In the context of this study, we suggest that the most important initial route is the Brentwood Bay - Mill Bay ferry run operated by the B.C. ferry corp.

The reasons for this are as follows, first it is ideally located, being a 10-15 min car-ride from an active DFO fisheries research laboratory, the Institute of Ocean Sciences at Pat Bay. This fact greatly facilitates the implementation and testing of new sensor packages being considered for installation aboard B.C. ferries. It was clear from our discussions with representatives of the Ferry Corp. that any equipment or sensor packages which were to be installed aboard a selected ferry would need to be approved by B.C. Ferry representatives, including the ships chief engineer. We suggest that the chances of having a sensor package installed in a more-or-less permanent mode of operation aboard a ferry are undoubtedly better on a smaller, slower and less populated ferry operating in relatively sheltered waters than on a fast, heavily populated ferry operating in crowded and exposed open ocean waters.

Second, the proximity of this route to I.O.S. makes it more feasible to install remote radio monitoring of the on-board sensor packages. The close proximity will allow for "proof-of-concept" testing of selected transmitter/receiver combinations at various broadcast frequencies which could then be migrated to more distant ship-of-opportunity applications far removed from the receiving site. The close proximity will be invaluable during the 'de-bugging' phase of any innovative real-time monitoring application.

Third, the area traversed by this route is in an area of immediate concern to a wide range of clients. This fact can provide motivation for the installation and testing of a wide variety of sensor packages ranging from water quality monitoring packages which can be used to provide ongoing baseline monitoring of the nutrients in the Inlet, to specialized acoustic instruments used to track the movements of fish in the Inlet. Thus, in addition to providing immediately useful data for the clients, the experience gained in developing and installing instrumentation packages for this route will provide a paradigm for installation and monitoring of similar or identical sensor packages on other routes and on other ships-of-opportunity.

Rank 2. Nanaimo-Tsawwassen, Swartz Bay-Tsawwassen & Horseshoe Bay-Nanaimo

We suggest that the second most important routes suggested to us by the contacted clients are those which traverse the Strait of Georgia. These routes include the Nanaimo-Tsawwassen, Horseshoe Bay-Nanaimo and

the Swartz Bay - Tsawwassen ferry runs operated by the B.C. ferry corp. It is clear that the Strait of Georgia has been and continues to be an area of great interest to a wide variety of clients, principally due to its proximity to a large urban population centre - the city of Vancouver. All three of these routes traverse this very important geographical area.

Rank 3. Canada-U.S. ferry routes

The third most important routes suggested to us by people contacted during the study are those crossing the Canada-U.S. border. These routes include the Sidney-Anacortes ferries operated by the Washington State Ferry Corp. and the Black Ball ferry operating between Victoria and Port Angeles.

In addition to the obvious interest in ongoing baseline monitoring applications, it was clear that there is a real motivation on the part of both Canadian and U.S. clients to support programs which are seen to be cooperative in nature. Overwhelmingly, the feedback provided to us was that it is vitally important to encourage a climate of international cooperative research between Canada and the U.S. Thus the routes recommended here have been selected as much for the purpose of maintaining and encouraging international scientific cooperation as they are for their importance to existing environmental monitoring programs.

Rank 4. Other Georgia Strait routes.

It is suggested that the fourth most important routes are those which can provide additional coverage to both ends of the Strait of Georgia. For example, B.C. Ferry routes connecting Campbell River - Quadra Island-Cortez Island cover the northern end of the Strait of Georgia as do ferries on the Comox-Powell River-Texada Island routes. At the southern end of Georgia Strait, routes through the San Juan Islands such as the Victoria-Bellingham route traversed by Victoria-San Juan Cruises Ltd. can provide additional data which can help to build a more complete 2D (or possibly 3D) picture of this important ocean area.

Finally, it may be useful to instrument ships which travel on north-south routes through the Strait of Georgia to provide "tie-lines" for data gathered on cross Strait routes. Ships suitable for this purpose may be for example Alaska ferryliners or coastal freighters already in the Dept. of Environments meteorological ship-of-opportunity database.

Part 3: Clients

3.0. Introduction and Rationale.

This section identifies a list of interested "clients" for oceanographic and meteorological data which might be obtained from a ship-of-opportunity program. Potential clients range from Federal government departments, to Provincial Municipal and Regional government bodies, University researchers and private sector companies from both Canada and the U.S.A. are also identified as organizations with a strong interest in data which might be obtained under a ships-of-opportunity program.

As indicated in the introduction, the rationale for this approach is twofold, first it ensures that a broad spectrum of diverse clients are made aware of this initiative and asked to provide input to the study, thus allowing us to learn of their needs and interests and to benefit from their support and expertise. Second, and more pragmatically, to help identify a collection of potentially interested clients external to DFO who may be interested in cost-sharing arrangements or outright purchase of information which might be obtained from a suite of instrumented ships-of-opportunity. In this age of diminishing fisheries budgets this approach is of critical importance and may help ensure the future success of this DFO initiative.

3.1. Industrial & Private Sector Clients.

Throughout the duration of this study, contact was made with a number of different organizations and individuals having an interest in ship-of-opportunity capability for supplying information of interest to their work. In the category of industrial or private sector clients a number of people were contacted. These included:

Mr. Eric Wickham - President of the B.C. Blackcod Fishermens Association

Ph: (604) 734-0632
Fax: (604) 734-0623

4210 Blenheim Street
Vancouver, B.C.
V6L 2Z4

Mr. Wickham expressed an interest in a number of ocean parameters including sea-surface temperature and upwelling phenomena, both of which are important to fishermen.

Mr. Tony Boydell - Mr. Boydell is currently representing South Island Development Corporation (S.I.D.C.), a private sector development corporation currently applying for a development permit to build a new townsite in the vicinity of Bamberton, B.C.

Ph: (604) 652-5032
Fax: (604) 652-8695

Mr. Boydell is potentially interested in a specific ship-of-opportunity monitoring application proposed by the author (see Section 5) as applied to Saanich Inlet. Mr. Boydell's client, S.I.D.C. may be required to provide an assessment of the impact of the proposed development on Saanich Inlet. This will likely require extensive baseline monitoring prior to any development taking place, a detailed modelling program and possibly continuous monitoring of the Inlet if permission is given to proceed with the development plan.

3.2. Federal Government Clients.

A number of Canadian Federal government agencies expressed an interest in the sort of oceanographic data which might be gathered by a ship-of-opportunity program. They included:

Canadian Dept. of Fisheries and Oceans - contract sponsor

The Canadian Department of Fisheries and Oceans has a strong motivational interest in developing a ships-of-opportunity program to enhance their data acquisition in the British Columbia coastal waters. It is clear in the present economic times that it will be increasingly difficult to obtain costly ship time for the sole purpose of ongoing baseline monitoring of ocean data such as sea-surface temperature, salinity, conductivity, turbidity etc. and yet at the same time the need for such baseline monitoring has never been greater. With increasing population the strains on BC coastal waters will continue to increase. In order to assess the degree to which the coastal waters have been and are being effected it is essential to have available good baseline oceanographic data on an ongoing basis.

Overwhelmingly, the response to the concept of a ship-of-opportunity program has been very positive and all of the individuals contacted have expressed a willingness to participate in future discussions of such a program.

Contact: Mr. Dave Mackas, Fisheries Biologist

Ph: (604) 363-6442
Fax: (604) 363-6479

Institute of Ocean Sciences
PO Box 6000
Sidney, BC V8L 4B2

Other scientists were contacted in the course of this study, all of whom generally expressed support for the concept. The requirements of most of

these individual scientists were varied and quite specific, for example Dr. Farmer's interests were primarily in the field of acoustical physical oceanography and would typically not be suited for a ship of opportunity program per se however should a program be initiated it is conceivable that the selected ships could be used to provide "ground truth" information which could help to interpret data obtained during his global ocean tomography experiments.

Dr. Freeland expressed interest and pointed out that I.O.S. is already active in a broader program supported by the World Meteorolgical Office (W.M.O.) to obtain meteorological and sea surface temperature information which is generally reported and distributed monthly via a bulletin board service and a published newsletter. It was clear from the discussions held with Dr. Freeland that the BC fishing community made use of the available information provided by Dr. Freeland's program however they felt that their interests would be better served by concentrating more on the areas in which they fish, namely BC coastal waters. It may be possible to build upon this solid foundation and expand the existing capability with more applicable and useful data deriver from a targetted ship-of-opportunity program.

Canadian Dept. of Environment - Atmospheric Environment Service

The areas of primary concern for D.O.E. are in meteorological observations but there is a close correlation between the parameters of interest to meteorologists and those of interest to physical oceanographers.

Contact: Mr. Bob McArter, port meteorological officer

Ph: (604) 664-9136
Fax: (604) 664-9195

Environment Canada
Pacific Region
Atmospheric Environment Service
Suite 700
1200 West 73rd Ave.
Vancouver, B.C. V6P 6H9

Canadian Dept. of National Defence - Acoustic Data Analysis Centre (P)

Discussions were held with Commander Larry Weir, director of the Acoustic Data Analysis Centre (Pacific) together with Mr. Doug Bancroft, a senior staff officer in the Meteorology and Oceanography Centre, MARPAC HQ. The interests of both ADAC and MARPAC are in supporting the Canadian Pacific Fleet in their operational activities. It was clear from our discussions that the future requirements for the Pacific fleet

are undergoing considerable change. These changes include the delivery of a new fleet of Maritime Coastal Defence Vessels (MCDV's) and the staffing and operation of the newly constructed ADAC facility in CFB Esquimalt. To date, most of the Canadian Forces requirements have been satisfied by MARPAC however there was a strong interest expressed in collaborating with other government agencies in a ship-of-opportunity program.

It is important to note that at the time of the meeting, there appeared to be a willingness to consider using the new MCDV fleet in support of other ocean going scientific programs. These ships could potentially provide a bridge between ships-of-opportunity which typically travel on pre-determined routes on pre-determined schedules and chartered or facility operated vessels which are at the full disposal of the on-board scientist. The MCDV's have been designed as multi-purpose vessels and it is conceivable that scientific experiments, particularly acoustic experiments performed by scientists from other government departments and universities could be undertaken from this fleet of coastal vessels. They will likely have a considerable degree of flexibility in both sailing location and sailing schedule and may prove to be a valuable Canadian asset to many different Canadian and international organizations.

Contact: Maj. Larry Weir, Commander Acoustic Data Analysis Centre (P)

Ph: (604) 363-2952
Fax: (604) 363-5443

Maritime Forces Pacific
FMO Victoria, B.C.
V0S 1B0

Contact: Mr. Doug Bancroft, senior staff officer

Ph: (604) 363 - 2958

Meteorology and Oceanography Centre,
MARPAC HQ
FMO Victoria, B.C.
V0S 1B0

Canadian Dept. of Environment - Marine Environmental Data Service

The following Canadian researchers were identified as those who assisted in the preparation of data sets for a recently released NOAA report entitled: "*1994 Global Summary real-time XBT data*" - a copy of which was provided to the SA as part of this contract.

Contact(s): Dr. Ron Wilson
Dr. Bob Keely

Unfortunately due to time constraints, these researchers and this research organization have not been contacted, however either or both of these individuals might have an interest in data obtained from a Canadian based ship-of-opportunity program.

NOAA's National Oceanographic Data Center -

As above, researchers from NOAA's Oceanographic Data Centre provided assistance in the preparation of the above referenced report. The identified contact is:

Contact: Dr. Melanie Hamilton

3.3. Provincial Government Clients.

Land Use Coordination Office

One of the most fruitful discussions held with potential clients for oceanographic data was with Mr. Don Howes, program manager and land inventory & information analyst with the BC Land Use Coordination Office in Victoria. Mr. Howes has been active for many years in developing a comprehensive oil spill response information system which can be used in the field by oil spill response teams to optimize the response and help minimize the damage to BC coastlines. Mr. Howes originally suggested the idea of a workshop on this topic and indicated he would be very interested in participating if one should be put together. Mr. Howes has worked with a number of local environmental consulting companies in developing the oil spill response system and is strong proponent of collaborative research initiatives.

Contact: Mr. Don Howes, P.Geo., P.Ag., program manager

Ph: (604) 356-7721
Fax: (604) 953-3481
e-mail: DHOWES@GALAXY.GOV.BC.CA@GEMS

Land Use Coordination Centre
1-836 Yates Centre,
Victoria, B.C. V8V 1X4

B.C. Ministry of Environment, Lands and Parks - Water Quality Branch

Discussions were held with representatives from the Water Quality Branch, of the Ministry of Environment, Lands and Parks, principally with Mr. Ben Kangasniemi. Initially, Mr. Kangasniemi was unsure of how a ship-of-opportunity program might be applicable to his departments

mandate. As discussions proceeded, however, and it was pointed out that one "ship-of-opportunity" which might be used was the BC ferry operating on the Brentwood Bay-Mill Bay route. This ferry traverses on a year round regular schedule, Saanich Inlet, an area of enormous interest at the present time due to a pending residential development application. The benefits of a regular baseline ocean monitoring program were of considerable interest and it is anticipated that Mr. Kangasniemi would be a key participant in the suggested Saanich Inlet pilot project identified in Part 5 of this report.

Mr. Kangasniemi also provided a copy of a recently published (August 1994) report by the British Columbia/Washington Environmental Cooperation Council entitled: *"The Shared Marine Waters of British Columbia and Washington"*. This report provided *"a scientific assessment of the current status and future trends in resource abundance and environmental quality in the Strait of Juan De Fuca, Strait of Georgia, and Puget Sound"* . This report provides a number of recommendations for more effective environmental management of these shared waters and is an excellent reference point for identifying other "clients" with a strong potential interest in a ship-of-opportunity program.

Contact(s): Mr. Ben Kangasniemi
Mr. Alan Calder

Ph: (604) 387-9500
Fax: (604) 356-8298
web: http://www.env.gov.bc.ca/epd/wqb

Ministry of Environment Lands and Parks
Water Quality Branch
Third Floor, 765 Broughton Street
Victoria, B.C. V8V 1X4

3.4. Regional Government Clients.

CRD - Health Protection & Environment Programs.

Contact was made with representatives from CRD Environmental Health in Victoria, B.C. who expressed an interest in oceanographic data from populated areas - such as Saanich Inlet where there may be problems effecting the health of people. Specific areas of interest mentioned were in beach closures for bathing and malfunctioning sewage disposal systems leading to health problems and/or health warnings.

Contact: Mr. Bob Bradbury - Manager

Ph: (604) 475-5101

Capital Regional District
Health Protection & Environment Programs

CRD - Engineering.

Contact was made with Ms. Laura Taylor, a representative from CRD Engineering in Victoria, B.C. who expressed an interest in oceanographic data obtained in the Strait of Juan De Fuca. Her area of interest is in monitoring the effects of effluent in this region and she is a member of the Strait of Juan De Fuca Monitoring Task Force. Ms. Taylor expressed strong support for the concept of a ship-of-opportunity sampling program and indicated a strong desire to be informed of any future developments in this area - particularly the workshop, if it is implemented pursuant to the completion of this study.

Contact: Ms. Laura Taylor

Ph: (604) 360-3090

Capital Regional District
Engineering Dept.
524 Yates St.,
Victoria, B.C.

3.5. University based Clients.

Contact has been made with a number of university based scientists during the course of this study. These potential clients include fisheries biologists from the UBC Fisheries Centre, the University of Victoria, Scripps Institute and the University of Alaska.

University of British Columbia Fisheries Centre.

Contact was made with Dr. Tony Pitcher, Dr. Carl Walters and Dr. Keith Thompson of the UBC Fisheries Centre to solicit their input to this study. Dr. Thompson expressed a strong interest in the proposed ship-of-opportunity program and indeed, provided information on a number of projects currently underway at UBC which are either already using ships-of-opportunity or which would benefit significantly from data obtained from instrumented ships recruited into the proposed program.

Dr. Walters was very supportive of the concept of a ship-of-opportunity initiative and provided valuable and informed comment during the initial stages of the study, He observed that due to the reduced nature of the west-coast fishery, that it would be wise to focus primarily on coastal freighters and passenger ferries as potential ships-of-opportunity since they run on a mor-or-less continuous basis and the routes travelled - particularly the Alaska ferries - transected areas of considerable interest to researchers involved in the modelling of fish stock migration patterns.

Contact(s): Dr. Keith Thompson
Dr. Carl Walters
Dr. Tony Pitcher

Ph: (604) 822-2731 (Office)
Fax: (604) 822-8934

Fisheries Centre,
2204 Main Mall,
U.B.C., Vancouver,
British Columbia, V6T 1Z4

University of Victoria Department of Environmental Studies.

Contact was made with Dr. Peggy Faulds of the University of Victoria department of Environmental Studies. She indicated that her program, the *Restoration of Natural Systems Program,* would be interested in the ship-of-opportunity program. She expressed support for the concept of the proposed workshop and indicated that she would like to be included in any future developments in this area.

Contact(s): Dr. Paul West - Director UVIC Environmental Studies
Dr. Peggy Faulds - program coordinator, restoration of natural systems program

Ph: (604) 721-7353
(604) 721-8463

University of Victoria Biology Department.

Contact was made with Dr. Craig Hawryshyn of the University of Victoria Biology department who has been working in the field of fish vision acuity and migratory patterns. His work includes topics requiring the use of open ocean acoustic fish tagging and tracking systems. It is conceivable that a ship-of-opportunity fitted with a custom developed acoustic tracking array (such as the one designed by Jasco Research) could be used to track individual salmon feeding and migration patterns over an extended period. This system and other systems under active development are discussed in Section 4.

It is important to note in this context, that a ship-of-opportunity used in support of a project of this type will likely be one which is free to vary widely from a prescribed route and sailing schedule. It is conceivable that the Maritime Coastal Defence Vessels (MCDV's) identified earlier could be used as ships-of-opportunity in this application.

Contact(s): Dr. Craig Hawryshyn

Ph: (604) 721-7142

University of Alaska.

Contact was made with a number of different researchers at the University of Alaska. These researchers included:

Contact(s): Dr. Ted Cooney Ph: (907) 474-7407
Physical Oceanographer,

Dr. Tom Royer Ph: (907) 474-7835
Physical Oceanographer,

and from the National Marine Fisheries Service N.M.F.S. office:

Mr. Bruce Wing Ph: (907) 789-6043
Physical Oceanographer,
Auke Bay Fisheries Lab,
Juneau, Alaska

The comments received from the Alaska based researchers were positive and a number of cross-references to other researchers were obtained, in particular, one innovative example of a "ship-of-opportunity" was mentioned and that was using US Naval submarines to obtain deep ocean samples while the sub was on standard patrols in Alaskan waters. The contact for this project is:

Contact(s): Dr.Peter McRoy Ph: (907) 474-7783
Physical Oceanographer,

Finally, a contact was suggested for new automated instumentation packages which might be used aboard ships-of-opportunity i.e.,

Contact(s): Dr.Shari Vaughan Ph: (907) 424-5800
Physical Oceanographer,

Dr. Vaughn has apparantly been developing systems for use on vessels operating in Prince William Sound.

All of the contacts made expressed a strong interest in being kept abreast of the evolution of any ship-of-opportunity program, especially one which transected Alaskan waters and indicated that they would be interested in attending a workshop on this subject pursuant to the recommendations of this study.

3.6. The Puget Sound Water Quality Authority.

Contact has been made with a representative from the Puget Sound Water Quality Authority, Dr. John Dohrmann. Dr. Dohrmann expressed an

interest in the proposed ship-of-opportunity program and the possible accompanying workshop. The specific area of interest is in the Strait of Juan De Fuca (see also Sec. 5.5).

Part 4: Sensors

4.1. Water Quality Monitoring Sensors.

During the period that this contract was completed, the proposal author had the opportunity to attend an automatic water quality monitoring workshop held in Richmond, B.C., Feb. 12-13 1996. This workshop brought together equipment manufacturers/vendors, scientists and program managers in a forum focussed on automatic water quality monitoring techniques. The workshop lasted two days, (with a third day devoted to Federal-Provincial discussions of management and coordination of overlapping and complementary areas of water quality management). The workshop was presented by the Canada-B.C. Water Quality Monitoring Agreement Coordinating Committee. the listed contacts for the workshop were:

Contact(s): Dr. Norman Wade — Ph: (604) 666-8079
Environment Canada,
and
Dr. Larry Pommen — Ph: (604) 387-9516
BC Environment,

This workshop was very well organized and would serve as an excellent model for a similar one on the topic of "Automatic ocean monitoring using ships-of-opportunity" - (See Section 5). It also provide an opportunity to see and become familiar with a host of new automated water quality instrumentation which could be used in both fresh water - the focus of the workshop - and in salt water applications.

Much of the information distributed by the various manufacturers and sales representatives was forwarded to the SA separately however a few were sufficiently innovative and applicable that they are mentioned separately in this section.

4.1.1 Geo Structure Instruments Inc. - Data Acquisition and Telemetry Network

It was clear at the outset that this workshop would focus on *automatic* monitoring systems. The approach adopted throughout this proposal was to seek out and identify new or emerging technology which could be used aboard a ship-of-opportunity in an automatic or quasi-automatic mode of operation. One aspect of this approach is to consider the applicability of remote data acquisition systems coupled with an integrated telemetry network. A system of this nature is well suited in many cases to operation in BC coastal waters, particularly in areas of high priority such as Saanich Inlet, Georgia Basin and the Strait of Juan de Fuca.

The Geo Structure Instruments INC., System 2300 has been used in a variety of applications, most notably in an application to monitor

dangerous methane gas emmissions in the vicinity of a landfill in Montreal, Quebec. The system design appears to be very compact, robust and easily networked via simple radio communication. It has available support software which can run on a low-cost PC using a Windows user interface. A copy of the System 2300 brochure is attached as Appendix B. It is suggested that this system, and other similar systems, be investigated as representative of possible data acquisition and remote data monitoring components of any instrumented ship-of-opportunity.

4.1.2 Global FIA Inc. - Flow Injected Analysis (FIA) systems & automated environmental monitoring applications

One of the most directly applicable new chemical analysis systems demonstrated at the workshop was presented by Global FIA Inc. The company representative, Dr. Graham Marshall, presented a paper describing the application of one of the company FIA systems in two different marine environmental monitoring applications, the first involved the monitoring of nitrate in the final effluent stream of a waste water treatment facility and the second involved monitoring the nitrate level in a run-off stream feeding into Gig Harbor at Arabellas Landing.

Discussions with Dr. Marshall indicated that the FIA system was designed to operate in a real-time application mode, to reduce or eliminate the need for ongoing laboratory analysis of discrete samples for the purposes of environmental monitoring. Furthermore, he indicated that the FIA system was readily adaptable to use aboard a ship-of-opportunity as it could run unattended for periods of up to one week before requiring attention from a support technician who would be responsible for refreshing the various chemical reagents and collecting the data. A copy of the Global FIA company profile is included in Appendix II.

Although the concept of automated chemical analysis has been around for nearly 30 years (See methods of Seawater Analysis, Grasshoff, 1976) work has been done recently by this company to build versatility and low-cost into their automated instrumentation. A paper presented at the automated water quality workshop showed two examples of how this automated system was used in environmental monitoring applications, although these were applications of high nitrate concentrations relative to typical sea water. It is my impression that this system can be recalibrated to provide similar automated analysis in salt water samples with relatively low nitrate concentrations, however this has not been confirmed and should be discussed with the company representative directly if this application is of interest to a potential client.

4.2. Traditional Oceanographic Sensors.

4.2.1 Temperature.

1. Sea Surface Temperature.

Temperature measured throughout the ocean volume is one of the most widely studied and recorded variables in furthering the understanding of the oceanic processes. The most accessible of oceanic temperatures is the sea surface temperature.

In recent years, it has become common in ship-of-opportunity measurement programs to monitor the temperature inboard at the ship's engine cooling sea-water intake pipe. This approach has some inherent difficulties associated with it, not the least of which is that the point at which the sea-water is sampled is in fact not the sea surface but rather a point located at a depth of several metres and often several tens of metres below the sea surface. This bias is well known in most ship-of-opportunity programs and some pains have been taken to 'correct' existing archived sea-surface temperatures for this effect. In the context of this study, it is important to recognize that if sea-surface temperature is to be measured as part of an ongoing ship-of-opportunity sampling program that the depth at which the salt water is sampled is an important factor and should be recorded with the measured data.

Sampling salt water from the ship's cooling system is typically done in one of two ways, either via a u-tube arrangement, wherein the intake pipe is diverted through an added u-tube equipped with a set of measurement sensors or secondly via a 'sea-chest' arrangement which is more akin to a holding tank for the incoming salt-water. The latter approach has been used by researchers from the University of Alaska who used this approach in conjunction with a set of continuous running fluorometers. The u-tube approach has been adopted by numerous other researchers.

One final comment made during the course of the study was that other researchers faced with the problem of obtaining sea-surface temperature from a ship-of-opportunity adopted a somewhat innovative approach of measuring the sea-surface temperature indirectly by attaching a string of thermisters to the inside of the ship's hull from just above the water-line down to the ship's keel. It was not known to what extent this approach had proven successful but seems to be worthy of consideration when used in conjunction with more traditional measurement methods.

2. Sub Surface Temperature.

Sub surface temperatures at depths to as much as 1500m below the sea surface are obtained by using expendable bathythermographs (XBT's). These are thermometers carried in a streamlined housing which is designed to sink at a known rate. The thermometer housing also carries a very fine insulated wire which relays temperature information to the XBT recorder located aboard the ship. The wire is wrapped inside the case such that it unspools in two opposing directions - along track and vertically downwards - so that half of the wire pays out vertically downwards with and towards the thermometer, the other half pays out towards the ship. XBT's thus record temperature-vs-depth profiles at a known point in the ocean without the ship having to stop at the station.

Traditional ship-of-opportunity programs have made and are currently making extensive use of XBT measurements and these data are archived elsewhere (see Se. 2.13).

4.2.2 Salinity.

Salinity is another traditional ocean parameter of interest to the scientific community. There are a number of readily available sensors which can be used to measure conductivity and hence infer the salinity for both salt and fresh water applications, one example is the OS200 CTD system sold and serviced by the Gabel Corporation (a brochure is attached in Appendix II). This small, lightweight low-power instrument is capable of measuring conductivity, temperature and depth in a range of environments and is also available as an autonomous data logger, a feature which is important for ship-of-opportunity applications.

Most sensors of this type require a stationary platform and so they are best suited to ships-of-opportunity which can easily amend their normal operations, temporarily stop the ship, take a measurement and continue their normal operations. A good example of this type of ship-of-opportunty is the inter-island launch "Prince of Whales" which is described ealier (See Section 2.8).

4.3. Hydroacoustic Sensors.

4.3.1 National Hydroacoustics Program.

It is clear, both from the statement of work prepared for this contract and from other recently published reports, that it is becoming increasingly important to extend traditional methods of ocean monitoring to longer ranges and to deeper depths. This fact is echoed by a new initiative struck earlier this year and funded by the Assistant Deputy Minister,

Science, of the DFO establishing the National Hydroacoustics Program (NHP). The stated goal of this program is:

> *"to improve the capability to obtain reliable fish stock measurements of biomass, size, species, and migration patterns in support of fisheries management by means of hydroacoustic survey systems".*

The contact for this new program is:

Contact(s): Dr. John Jorgenson

Ph: (204) 983-5072
Fax: (204) 984-2403
email: jorgenson@wpgdfo.wpg.dfo.ca

Freshwater Institute,
501 University Crescent,
Winnipeg, Manitoba,
R3T 2N6

Dr. Jorgenson was contacted as part of this study and he outlined to us the mandate of the National Hydroacoustics Program which was to be a client driven program. Like this study, it was seeking input from both users and manufacturers of hydroacoustic systems with an eye to financially supporting initiatives which would lead to innovative uses, applications and new product development in this rapidly evolving field. Dr. Jorgenson was provided with a copy of the SOW for this work and efforts were made to ensure that work on both of these projects proceeded in a complementary fashion. To this end, Dr. Jorgenson is aware of the interest of both this company and the SA in any developments in this area. Unfortunately, no results had been compiled by Dr. Jorgenson at the time of writing of this report and so no new information was available for inclusion in this report. It was suggested that should his conclusions be similar to those in this report, i.e., that it would be useful to initiate the NHP by holding a National workshop, that it may make sense to hold them simultaneously in the Victoria area.

4.3.2 The WASP system.

The Water Acoustic Structure Profiler or WASP system manufactured by Sigma Technologies and sold and serviced by the Gabel Corporation is relatively new technology designed to provide non-intrusive medium-to-long term monitoring tasks. Demonstrated applications include a nine month deployment to monitor the behaviour of plankton layers under the mobile pack ice of the southern Beaufort Sea, returning Salmon in the Skeena River, vertical migration of shrimp in fresh water lakes and detection of schooling herring off the coast of British Columbia. These applications have made use of the WASP system in a fixed deployment

mode of operation, potentially, this system could be used aboard a ship-of-opportunity, together with a GPS receiving system to acoustically monitor similar biological ocean phenomena from ships-of-opportunity. A copy of the WASP brochure is included in Appendix II.

4.3.3 Bio-telemetry products.

Several companies are currently producing products which make use of acoustic, radio and GPS technologies to tracking and monitoring the ocean environment.

As an example of this kind of sensor, we have included information (in Appendix II) provided to us by LOTEK Marine Technologies Inc based in Newfoundland, Canada.

Discussions held with fisheries biologists and LOTEK representatives indicate that most applications making use of these bio-telemetry sensors are supported either from land or from a dedicated tending support vessel (typically a small boat or launch). Indications from a number of researchers indicated that there is wide potential application of these sensors in an open ocean environment provided that:

i) the sizes of the transmitting sensors can be reduced.
ii) the cost of the sensors can be kept reasonable.
iii) the life of the sensor is sufficiently long so as to provide meaningful data.
iv) the range of the sensor is sufficiently great that the operator has a reasonable chance of detecting and tracking the tagged fish.
v) the fish can be uniquely identified by using a coded tag.

Discussions on open ocean application of sensors of this type identified a need for more sophisticated signal processing methods and better acoustic receivers than are presently available in order to accurately track tagged fish in an open ocean environment.

4.3.4 New Bio-telemetry products - the FRITTATA array.

New initiatives which are under development or newly released include a proposed acoustic array to be developed by Jasco Research together with Dr. Craig Hawryshyn of the University of Victoria Biology dept. This array, with the acronym **FRITTATA**, (for **F**ish **R**eturn **I**tinerary **T**racking **T**owed **A**rray for **T**agged **A**nimals) is designed to track selected test fish and obtain telemetered information about their swimming depth, orientation, bearing and other useful parameters. The proposed hydrophone array was designed to track the target fish automatically and thereby replace the traditional method which required intensive manual aiming of a directional hydrophone, usually deployed from a smaller launch or fish boat.

It is unclear at the time of writing whether it is practical to monitor tagged fish and/or marine mammals using a combination of an acoustic receiver attached to or towed from a ship-of-opportunity and existing or emerging acoustic fish tags. Recent discussions with animal/fish tagging company representatives from LOTEK, indicate that this field is under active development. In general, the trend is towards smaller, lighter tranducers which can be inserted into fish or attached to marine mammals. The ability to detect acoustic signals transmitted from these tagged animals depends on a number of factors, including the source strength of the underwater tag (this can be larger for marine mammals but will clearly be limited for smaller fish), the flow noise at the receiver (either at a single hydrophone or at a multi-element hydrophone array), the local acoustic noise produced by the ship-of-opportunity itself and the degree of sophistication of the signal processing. Recent experiments (the Heard Island Feasibility Test - Monk et al.) have shown that 'coded' signals are capable of being detected in highly noisy environments and there is a high expectation that fish tags which exploit this new signal processing technology will permit longer range monitoring of tagged fish.

4.4. Hardy Plankton Recorders.

A recently published article in Sea Technology (Mar. 1996) by Quarterly and Reid describes a set of long-term oceanographic data sets collected by the Sir Alister Hardy Foundation for Ocean Science in the UK. The article documents a 60 year time series of plankton data recorded using the continuous plankton recorder (CPR) by the British marine biologist Alister Hardy. This ocean monitoring program is still active in the north Atlantic with more than 40 plankton recorders used in a monthly ship-of-opportunity survey on 21 routes. To quote from the article:

> *"Currently, about 70,000 miles are sampled each year, yielding nearly 4,000 plankton samples for analysis. Since the survey started in 1931, about 4 million miles have been covered and 200,000 samples analyzed; from this data more than 400 publications have been written"*

The instruments used in this ship-of-opportunity application are manufactured by Valeport Ltd., of Dartmouth, UK and are designed to be towed behind the ship. The normal operation has the plankton recorder towed at a fixed depth of about 7 metres from commercial ships that operate regular routes. The recorders are "unaccompanied" in that they are operated by the ships crew rather than by assigned scientists or technicians. Typical transit speed is 15 knots but some vessels can operate in excess of 20 knots.

Recent developments at Valemont include the development of a "U-tow" system to further enhance the measurement program, to quote from the article:

> *"A second objective is to build on the experience of running routine ship-of-opportunity surveys by expansion of the CPR approach to other parts of the world and by deployment of new sensors that can take a suite of oceanographic measurements in addition to the plankton sampling system. This second objective is compatible with new initiatives such as the Global Ocean Observing System (GOOS), Global Ecosystem Dynamics (GLOBEC) and the Large Marine Ecosystem (LME) proposals."*

to this end, Valemont Inc. has been funded to develop a towed body - the "U-tow" system capable of carrying additional instrumentation payloads as well as or instead of the plankton recorder. Other instrumentation suggested include CTD and fluorometer sensors. The U-Tow system is capable of operating either in level flight or in an undulating mode (between the surface and 50m depth).

Information on the Sir Alister Hardy Foundation for Ocean Science and the Valemont U-Tow system can be found on their Web page at:

http://www.npm.ac.uk/sahfos/annual_report_1994.html

An alternative to a towed system may be a flow through system permanently installed aboard a ship-of-opportunity. Recent work (1994) at Valeport Ltd. has shown that it is important to monitor the variability in through-flow for CPR's since the silk used in the CPR is likely to become clogged by dense plankton concentrations and therefore reduce the actual volume of water sampled. To address this shortfall, engineers at Valeport, in collaboration with SAHFOS have designed a logging electro-magnetic flow-meter for mounting on the CPR which will not impede water flow through the recorder and which can provide a more accurate measure of the actual volume of sea water sampled.

4.5. Turbidity Meters.

Turbidity measurements are a useful measure of suspended solids in both salt and fresh water environments. Contact was made with the President of the company during the Automatic Water Quality Monitoring Workshop held in Vancouver earlier this year and discussions were held as to the practicality of using his designed instrumentation in a ship-of-opportunity program. A brochure of the OBS-3 and OBS-3B suspended solids and turbidity monitor are included in Appendix II and the contact name and address is:

Contact: Dr. John Downing, President/owner D&A Instrument Company
Ph: (360) 385-0272 Fax:(360) 385-0460
e-mail: dainst@olympus.net

4.6. Fluorometers.

The fluorescence of a selected water sample can be measured using instruments manufactured by a number of companies including:

Turner Designs,
845 W. Maude Ave.,
Sunnyvale, CA 94086

Contact: Ms. Barbara Kyser
Ph: (408) 749-0994
Fax:(408) 749-0998
e-mail: tdesigns@ix.netcom.com
Web:**http://www.turnerdesigns.com/dye.htm**

and

Optical Technology Devices Inc,
175 Clearbrook Road,
Elmsford, NY 10523
USA

Contact: Mr Felix A. Brogna, President
Ph: (914) 592-1900
Fax:(914) 592-5284
Web:**http://www.techexpo.com/firms/opttech.html**

Contact was made with both manufacturers and both expressed an interest in the proposed ship-of-opportunity/instrumentation workshop. Mr. Brogna provided a reference to a Dr. Jadamic of the Coastal Research Lab at the University of Connecticut who had used their instrument on board US coast guard vessels. The provided contact number for Dr. Jadamic is (860) 445-3501.

Part 5: Conclusions and Recommendations

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5.1. Conclusions and Recommendations.

It is clear from discussions held with numerous organizations and individuals throughout this contract that there is strong motivational interest in developing a ships-of-opportunity program to enhance data acquisition capabilities in a wide range of British Columbia coastal waters. The Canadian Department of Fisheries and Oceans has taken the lead in initiating this study for the purpose of identifying a suite of suitable ships, clients and sensors which could be used to develop a more extensive ships-of-opportunity program.

In the present economic times there is little doubt that it will be increasingly difficult to obtain costly ship time for the sole purpose of ongoing baseline monitoring of ocean data such as sea-surface temperature, salinity, conductivity, turbidity etc. and yet at the same time the need for such baseline monitoring has never been greater. The increase in human population puts an ever increasing strain on the assimilative capacity of BC's coastal oceans and inlets and the demands on the natural resources living in these waters such as salmon stocks, shellfish and groundfish are higher than ever before.

To address these twin concerns of less money for routine baseline monitoring of ocean conditions and a high demand for scientific data on which to base informed resource management decisions we are proposing a number of simple, low-cost initiatives and pilot projects which can be implemented immediately. In addition, we point the way to a number of larger and more ambitious projects which can be initiated once the pilot projects have been successfully implemented.

5.2. Organization of a Ships-of-Opportunity Workshop.

It is clear from discussions held with numerous organizations instrument manufacturers and individuals that there is a strong interest in the proposed ships-of-opportunity program. In the course of this study, the suggestion of holding a workshop on this subject was made to a number of individuals and all unanimously endorsed this as a first logical step. If this suggestion is adopted and the workshop is held, it promises to bring together a broad international spectrum of working scientists, resource managers, equipment manufacturers, ship owner/operators and private contractors with a clear objective of developing a very cost-effective and complementary program which can be used to provide enhanced coastal environmental and resource management to the DFO.

5.3. Pilot project #1 - Saanich Inlet.

In the course of this study, discussions were held with a number of individuals and information was obtained from other sources which highlighted the need for routine long-term baseline monitoring programs in a number of coastal areas. One area of immediate concern is Saanich Inlet, a glacially-formed fjord in close proximity to the city of Victoria, B.C. and the Institute of Ocean Sciences. Recently, (April 1996) a BC Provincial government report; *"Saanich Inlet Study - Synthesis Report Summary"* summarized the findings of a broad based study which had been designed to,

> *"provide baseline information required to make a wide range of future decisions regarding zoning, land use, habitat management and pollution prevention"*

In this context, the implementation of a pilot project to monitor baseline ocean parameters in Saanich Inlet on an ongoing basis is much needed and very timely, furthermore, the proximity of the Inlet to the Institute of Ocean Sciences affords an excellent opportunity to test a number of different shipboard (and possibly ship towed) instrument packages prior to their more widespread implementation in the more ambitious ship-of-opportunity projects suggested for the Strait of Georgia or Strait of Juan de Fuca.

Saanich inlet is traversed by a small car ferry operated by the B.C. Ferry Corporation which operates year round between Brentwood Bay and Mill Bay. It is our suggestion that this small ferry be exploited as the first "ship-of-opportunity" in a possible ship-of-opportunity program. By using one small ferry to continuously monitor a number of ocean parameters in an area of great environmental sensitivity it is possible to develop, install and test a wide variety of automatic monitoring equipment which could be used extensively in a more ambitious program.

The benefits of using a local ferry in this way are numerous, first it can act as a floating laboratory to develop and test instrumentation which can later be incorporated into self-contained instrumentation 'packages' which can then be commercialized and sold for use in similar environmental monitoring applications around the world. The development and installation of new and existing instrumentation manufactured and developed by local companies will provide badly needed work for these small R&D companies and more importantly, allow them the opportunity to showcase their system integration, analysis and development capabilities in this field to a larger world market, a market which is ready for this kind of environmental monitoring technology. Second, it will provide valuable baseline ocean measurements in an area which is of tremendous

strategic interest for the future development plans for southern Vancouver Island, in fact it is at the time of writing the focal point of a possible $2billion development application under review by various BC ministries. It is crucial to responsible government managers that accurate and long-term data be available for use in making decisions of this importance.

Finally, it is important to recognize that in addition to being an important water body in its own right, that it is part of a larger ocean ecosystem and will influence and be influenced by nearby ocean conditions. The Saanich Inlet Synthesis report commented on the relationship between Saanich Inlet and the Straits of Georgia as follows:

> *"The study focused on the waters of Saanich Inlet and, to some extent, the freshwater tributaries. However, there are a number of factors outside the Inlet which influence its physical, chemical and biological nature. For example, water from the Straits of Georgia and Cowichan Bay enters Saanich Inlet carrying nutrients, sediments and phytoplankton. Outside influences also affect the abundance of salmon, herring and marine birds in Saanich Inlet."*

and furthermore, that

> *"Saanich Inlet should be viewed as an important part of a larger system, encompassing the Georgia Basin, particularly with respect to fisheries issues".*

Thus, we would suggest that the Saanich Inlet pilot project identified here should be viewed as simply the first small step in a larger and more ambitious ship-of-opportunity program that could be extended into the Strait of Georgia and/or the Strait of Juan de Fuca.

5.4. Pilot Project #2 - Georgia Basin.

The second proposed pilot is in the area of the Georgia Basin. This area has been and continues to be the focus of keen ocean research interest. The recent Canadian Ocean Frontiers Research Initiative (COFRI) proposal, identified coastal zone management - Georgia Basin as one of four core ocean research programs of the initiative. To quote from the program overview,

> *"Coastal waters worldwide are under pressure from expanding populations and the effects of past, planned or anticipated exploitation and development. All coastal nations face difficult decisions related to development plans, conflicts over uses of land and water in the coastal zone, waste management issues, and costly programs to monitor the effects of practices and regulations. Most nations and development organizations recognize the importance of including the best possible scientific information in these decisions, but even the most advanced, Canada included, lack practical tools for accomplishing this task."*

Other prominent scientists have looked at the importance of the ocean environment in the Georgia Basin on fish stocks (eg. Beamish in *Proceedings, first annual Pacific ecozone workshop, Sidney,B.C.,Feb 1-3, 1994)* i.e.,

> *"In the Strait of Georgia, the major effects of the environment on stock dynamics may be predictable or at least understandable in terms of abundance changes."*

and

> *"We now know that there are two types of carrying capacity changes in the Strait of Georgia. The short-term or interannual effects are associated with the annual fluctuations in the amount of Fraser River discharge, and the long-term shifts are related to the chemistry of the bottom water that enters the Strait of Georgia from offshore. Both of these short-term and long-term changes appear to be closely related to the survival trends of chinook and coho salmon in the Strait."*

In an effort to provide a low-cost, yet effective data gathering component to ocean research in this strategically important area, we are recommending that a second pilot ship-of-opportunity program be initiated in the Strait of Georgia. Our recommendation is that following the Saanich Inlet pilot and the design, purchase, integration and testing of appropriate shipboard instrumentation packages, that a phased program be started on one or two key ferry routes traversing Georgia Strait and connecting Vancouver Island and the B.C. mainland.

Two possible routes of interest might be the Swartz Bay - Tsawwassen run and the Horseshoe Bay - Nanaimo run since these routes traverse the Georgia Basin on a regular basis year round. If this program proves successful, and provides data of value to a broad base of interested clients, then it could be expanded as time and funding permit to other routes and other ships - for example, by working in collaboration with the D.O.E. meteorological ship-of-opportunity program it may be possible to instrument selected coastal freighters already registered in the D.O.E. program with oceanographic as well as meteorological sensor packages. These coastal freighters could provide useful "tie-lines" running the length of Georgia Strait and serve as useful complementary data to that provided by the instrumented ferries running across the strait.

5.5. Pilot Project #3 - Strait of Juan de Fuca.

The third and final proposed pilot project is in the area of the Straits of Juan De Fuca. This area and the potential ferry routes transecting this area are shown in Fig. 6 of Section 2.4.

The rationale for initiating an ongoing monitoring program in this area may be motivated by different priorities than those discussed in Section 5.5. Firstly, this body of water geographically straddles an

international border between the US and Canada. This fact provides an opportunity for Canada to initiate a ship-of-opportunity program with an international focus and continue to foster cooperative ocean research programs that are currently underway. An excellent example of the sort of international program possible with intergovernmental cooperation is detailed in

"The Shared Marine Waters of British Columbia and Washington - A Scientific Assessment of Current Status and Future Trends in Resource Abundance and Environmental Quality in the Strait of Juan DE Fuca, Strait of Georgia, and Puget Sound"

This report was released in August, 1994 by the British Columbia/Washington Marine Science Panel.

An accompanying technical report,

"Review of the Marine Environment and Biota of Strait of Georgia, Puget Sound and Juan DE Fuca Strait - Proceedings of the BC/Washington Symposium on the Marine Environment Jan. 13 & 14, 1994, edited by R.C.H. Wilson, R.J. Beamish, Fran Aitkens and J. Bell

In addition to being an excellent summary of the current status of the shared marine waters of both countries, these reports contain a detailed list of contributors to the symposium from both countries and many different government agencies with an interest in these waters.

In particular, interest in the concept of using ships-of-opportunity to monitor some environmental parameters has been expressed by Dr. John Dohrmann, a scientist with the Puget Sound Water Quality Authority,

Contact: Dr. John Dohrmann,
Puget Sound Water Quality Authority,
P.O. Box 40900
Olympia, Wa
98504 - 0900
USA

Ph: (360) 407-7305
Fax: (360) 407-7333
e-mail: jddpswqa@wln.com

Dr. Dohrmann has indicated that an earlier review of the requirements of PSWQA researchers concluded that data which could be obtained from a ship-of-opportunity program was limited and not of direct interest to many of their concerns. He did express a strong interest in the proposed workshop on the subject, however, particularly in light of their ongoing program review and the advances in available sensor technology.

On the Canadian side, contact was made with a representative from B.C. Ministry of Environment, Lands and Parks, Mr. Ben Kangasniemi. Mr. Kangasniemi has been and continues to be an active participant in joint BC/Washington scientific initiatives and expressed strong interest in the concept of using ships-of-opportunity to provide ongoing baseline monitoring information in areas of interest to his department.