Canadian Coast Guard / La Garde côtière canadienne

PUBLICATION DATA FORM

1. Publication No.	2. Project No.	3. Recipient's Catalogue No.
0-662-66881-2		

4. Title and Subtitle	5. Publication Date
Research and Development Annual Report, 2001-2002	2002
	6. Performing Organization Document No. DFO/CCG
7. Author(s)	8. DFO File No. AWAM 2204-9172-Y2K2
9. Performing Organization Name and Address Fisheries and Oceans, Canadian Coast Guard Research and Development 200 Kent Street, 5th Floor Ottawa, Ontario K1A -0E6	10. PWGSC File No. T34-20/2002E
	11. PWGSC or DFO Contract No.
12. Sponsoring Agency Name and Address Same	13. Type of Publication and Period Covered Annual Report 2001-2002
	14. Sponsoring Agency Code
15. Supplementary Notes	16. Project Officer

17. Abstract

The Canadian Coast Guard (CCG) annual report on its R&D activities, describing the research projects undertaken by the various branches and regions of the CCG during the fiscal year 2001-2002.

18. Key Words	19. Distribution Statement
Canadian Coast Guard, Research and Development Annual Report, R&D	Marine community, universities, colleges, and government agencies

20. Security Classification (of this publication)	21. Security Classification (of this page)	22. Declassification (date)	23. No. of pages	24. Price
unclassified			68	N/A

Table of Contents

INTRODUCTION

The Program

The Canadian Coast Guard's (CCG) Research and Development (R&D) program is oriented to meeting the challenges of increased expectations regarding marine safety, protection of the marine and freshwater environment, and support to ocean development. The priority of the R&D program is to support the CCG's operational, regulatory and procurement objectives. Its mission is to develop knowledge essential to the achievement of those objectives.

The R&D program is co-ordinated at Headquarters and delivered at the branch and regional levels. Senior management determines the overall direction and funding level of the program in accordance with the CCG's Strategic Plan and individual business plans. Each CCG business line delivers the program in the form of individual R&D projects. The business lines provide project management as well as securing external funding and creating partnerships. The R&D Office provides policy advice, strategic direction and co-ordination.

CCG branches involved in R&D often draw upon the resources and expertise of other federal agencies such as the Transportation Development Centre (TDC) and the National Research Council (NRC) as well as seeking co-operative funding from the New Search and Rescue Initiatives Fund (NIF), and the Program for Energy, Research and Development (PERD) and other special funds.

CCG is also involved in Joint Research Project Agreements (JRPAs) with other countries. Canada has a long history of successful JRPAs with the United States, Japan and Finland, confirming its reputation as a leader in marine technologies.

The Future

For the future, the CCG has as its highest overall priority the development of a new orientation to the electronic navigation systems; the enhanced use of critical information will enable improved navigation services at a lower cost. A second major theme is the promotion of sustainable transportation, involving a focus on minimizing the marine footprint of the world's oceans. Traditional priorities, which include safety of life, operational efficiency, and support to the domestic marine industry also, remain strong. Safety and security against terrorism will take on new importance in the years to come and will be integrally linked to enhanced electronic systems. The CCG will explore these and other opportunities by sponsoring R&D in these theme areas.

This Research and Development report reflects the delivery of the Canadian Coast Guard's (CCG) Research and Development (R&D) Program that support CCG's business lines: Navigation Services, Fleet, Integrated Technical Support, and Safety and Environmental Response Systems.

Navigation Services provides, operates and maintains a system of aids to navigation, provides waterways development and maintenance, and ensures protection of the public right to navigation and protection of the environment. Also a part of Navigation

Services is Icebreaking operations are those activities such as icebreaking escort, channel maintenance, flood control, harbour breakouts, ice routing and information services for marine traffic navigating through or around ice-covered waters, and for the general public. It also co-ordinates the movement of cargo for the annual re-supply of Northern settlements and military sites using contracted commercial carriers.

Integrated Technical Support provides project planning and management services to all Branches within Coast Guard.

Fleet consists of the acquisition, maintenance, and scheduling of the DFO vessel and air fleets in support of the following DFO program areas: Marine Navigation Services, Marine Communications and Traffic Services; Icebreaking Services; Rescue, Safety and Environmental Response; Fisheries Management; Fisheries and Oceans Science and Hydrography; as well as exploring environmental technologies.

Safety and Environmental Response Systems conducts R&D in the following major program areas: marine search and rescue, environmental, the promotion of boating marine public through prevention and regulation. Recently this branch has added a new responsibility to provide distress and safety communications and co-ordination, vessel screening to prevent entry of unsafe vessels into Canadian waters, regulation of vessel traffic movements, and management of an integrated system of marine information and public correspondence services.

R&D office has the responsibility to establish goals, objectives, priorities, and accountability measures for the program that support CCG's Business Plan. It is also the program's focal point for resource/business management services, special projects and planning and co-ordination of the program.

Risk Management is responsible for the development of a marine services Risk Management Program. Its R&D focus pertains to the development of a comprehensive marine activity and risk model to address CG planning issues as well as to serve as an important component of coastal mapping.

A description of each R&D project undertaken by CCG during the 2001-2002 fiscal year may be found under their appropriate section heading. More details on these initiatives can be obtained by contacting the responsible project officers. A contact name and telephone number is given at the end of each project report.

Additional information on the R&D program, and/or a copy of the R&D Strategic Plan is available from:

Manager, Research and Development
Marine Programs, Canadian Coast Guard
200 Kent Street
Ottawa, Ontario
K1A OE6
Tel: (613) 990-3087
Fax: (613) 996-8902

Navigation Systems

Located at headquarters in Ottawa, this directorate conducts R&D to support a safe, efficient and accessible waterway by improving operational performance of aids to navigation; reducing maintenance costs and ship-time usage in the servicing of short- and long-range aids to navigation; and improving water flow models and water level prediction capability. This directorate also supports Icebreaking activities through improved technologies and effectiveness in delivering icebreaking and ice-routing services, thereby enhancing the safety of ice navigation and providing support to marine transportation and to the economy in general.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
	Aids to Navigation			
FNBB1	Development of Laser Range Light	CCG	See ITS Section	
FKAE6	Evaluation of Large Electric Double-layer Capacitors for Powering Aids to Navigation	CCG	See ITS Section	
FKAF6	Determine Shipboard Multipath Levels & Their Impact on Marine Navigation	CCG	See ITS Section	
FKAC6	Long Life Lamp Development	CCG	See ITS Section	
FKAD6	Long Life Synthetic Mooring	CCG	See ITS Section	
FKAB6	Lighted Plastic Buoy Development	CCG	See ITS Section	
	Icebreaking			
FTPA6	Cross-Polarized Radar Trials	CCG	50	30
	Navigation Systems - **TOTAL**		**50**	30

Aids to Navigation

The R&D program funded six projects submitted by the Aids to Navigation directorate in 2001-2002. The projects were subsequently tasked to the Integrated Technical Support (ITS) branch. The project titles are listed in the preceding table while the project descriptions can be found in the ITS section of this report.

Contact: Reiner Silberhorn (613) 998-1441

Icebreaking

Cross-polarized Radar Trials

The availability of the X-Polarized radar technology will provide precise ice information regarding ice conditions. Better route planning and improved operational efficiency will result for CCG Icebreaking and commercial operators.

During the 2001/2002 fiscal year, extensive efforts were dedicated to completing the development and debugging of the slaving controller and the slaved radar. The complete drive mechanism was replaced and new gears were fabricated to eliminate backlash and ovalisation.

Lab tests were conducted where problems with the tracking algorithm and RF elements of the prototype system were detected. Reliability problems associated with the prototype nature of the system were also uncovered.

New control algorithms were developed and the system is now capable of maintaining angular tracking to within less than +/- 0.08 degrees of azimuth error. Software has been developed to activate various lineup functions to be used during lab tests. A complete electronic redesign of the system was undertaken and a new PC board based system is now ready to be lab tested.

New lab tests will be undertaken early July 2002 and an installation on board the M/V Arctic is targeted for early August.

Contact: Fiona Robertson (613) 998-1581 *Project Number: FTPA6*

FLEET

Located at Headquarters in Ottawa, this directorate conducts R&D to improve cost-effectiveness and performance of the Fisheries and Oceans fleet and the management of policies and standards for improved safety and development of seagoing personnel.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FQBK6	Hearing Standard for Seagoing Personnel	CCG	290	60
FQAG6	Vision Standards for Seagoing Personnel	CCG	125	
	Fleet - **TOTAL**		**415**	60

Hearing Standards for Seagoing Personnel

In continuing to determine appropriate clinical test(s) to be used to test employees against the recommended standard for hearing and to validate the pass/fail mark assigned for each test, phase II is being carried out in 3 interdependent but mutually exclusive stages.

During this fiscal year, all relevant background noise was collected during vessel/work environment visits across the regions accounting for all vessel/work environment types and all programs. The choice of 15 locations corresponding to representative noises of CCG and C&P environments was completed using SME's from CCG and C&P at the University of Ottawa.

Tests of auditory abilities will continue in audiometric rooms using different noise environments simulating sound environments from CCG vessels. Results obtained with a large number of normally hearing subjects (N=48) will be compared to those from functional tests identified in Stage 1. Statistical analyses will then be used to evaluate the predictive value of tests identified in Stage 1 for screening auditory skills necessary for the accomplishment of hearing-critical tasks in the simulated sound environments from CCG vessels. Furthermore, these statistical analyses will enable us to specify whether it would be necessary to opt for many tests that measure various auditory abilities (speech intelligibility in noise, localization, perception of sound signals), or if a single test would be sufficient to meet requirements of the CHRC. This is of great importance since it can entail lower costs related to the administration of tests.

The project is on schedule and within budget. Project completion is expected in December 2002.

Contact: Sharon Robertson (613) 990-2573 *Project Number: FQBK6*

Vision Standards for Seagoing Personnel

BCResearch Inc. (BCRI) submitted a draft report for Phase 1 Summary on risk assessment and task analysis for review and comment. The report presents the researchers findings which:

- Identify those tasks having a substantial visual component, as well as provide completely documented task descriptions of those tasks;
- Identify the high-risk, critical, and frequently performed tasks;
- Quantify risk, determine acceptable levels of risk, and identify previously set acceptable job performance levels;
- Categorize those tasks according to the feasibility of testing task performance on board, in simulation, or not at all;
- Recommend standardized visual function tests potentially capable of significantly predicting performance on those tasks.

BCRI is finalizing the report based on CCG comments. A presentation to senior management is expected shortly. Preparation for Phase 2 is underway for an 8 month trial period next year.

INTEGRATED TECHNICAL SUPPORT

Located at Headquarters in Ottawa, this directorate conducts research and development on behalf of other Coast Guard Branches. The goal is to improve the efficiency and effectiveness of those central services provided in support to DFO Programs by: testing and evaluating communication and electronic technologies; exploring new environmental technologies; developing and implementing vessel maintenance programs and services; and human factors research to improve the safety and effectiveness of our sea-going personnel.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS		CLIENT GROUP
			CCG	PARTNER	
FRBQ6	U.S. Ship Structures Committee	CCG	0		
FQAB6	VNET Line Replacement for DGPS	CCG	9		MCTS
FQAE6	ANIK-Based Ship-to-Shore Data	CCG	125		Fleet
FNBB6	Development of Laser Range Light	CCG	115		Aids to Navigation
FQAL6	Development of Ionospheric Monitoring and Prediction Tools for the CCG	CCG	25		Aids to Navigation
FQAM6	Evaluation of Large Electric Double-layer Capacitors for Powering Aids to Navigation	CCG	80		Aids to Navigation
FQAN6	Determine Shipboard Multipath Levels & Their Impact on Marine Navigation	CCG	75		Aids to Navigation
FQAO6	Long Life Lamp Development	CCG	50		Aids to Navigation
FQAP6	Long Life Synthetic Mooring	CCG	200		Aids to Navigation
FQAS6	Lighted Plastic Buoy Development	CCG	60		Aids to Navigation
	INTEGRATED TECHNICAL SUPPORT **- TOTAL**		**739**		

International Ship Structure Committee

The Ship Structure Committee (SSC) based in the Unites States is an international agency with the mandate to further research and development in the area of ship structures. CCG is a member. Over the past several years, the SSC has completed several research projects supporting inspection and repair of vessels. There are always economic considerations encouraging the extension of the service life of vessels. There are also now demands for increased safety of life at sea and reduced environmental risk. These demands call for a proper service life program for maintaining the structural integrity of ships. New methods of collecting inspection data are needed, and new ideas for integrating these systems being developed, more uniform methodologies for damage assessment and repair documentation are needed both for structural components and for coatings. The operational performance of marine structures manifests the integration of materials, loading and response, design methods, and production of marine structures. The linkage of these focus areas will be incomplete if attention is not directed to the ability of the operational system to perform their tasks. Superior design, construction, inspection, maintenance, and repair methodology are essential for safe operation. It was necessary to delay the start of a project by CCG due to fund allocation restrictions in 2001/2002. The project will commence next fiscal year.

Contact: Daniel Gauvin, (613) 998-1666 *Project Number: FRBQ6*

VNET Line Replacement for DGPS

The project is completed. The project investigated viable alternatives and the associated costs to the existing VNET communication system used by the DGPS system. The results of the project concluded that the VNET system is currently the most economic solution in monitoring and controlling remote sites from a centralized location. VNET was compared against other technologies such as satellite, frame relay and business line systems. These other systems are further disadvantaged in that they require a start up capital investment. The private network nature of VNET provides a measure of DGPS security needs. A hardware solution is recommended if security enhancement is desired in the light of recent events. Also, monitoring of VNET lines not meeting the desired level of service is recommended.

Contact: Sun Wee, (613) 998-1514 *Project Number: FQAB6*

ANIK Based Ship/Shore Communications

This three-year project started in 2001/02 to investigate the use of Anik Satellites to improve ship-to-shore communications in CCG. Due to an independent study on the "Feasibility into Expanding Ship/Shore Email, Internet, and Intranet Capabilities" in the summer of 2000, some of the steps in the original project plan became redundant. The feasibility study concluded that the Anik E and F satellites were too expensive to serve CCG in their attempt to improve ship/shore communications. The study, however, recommended that the CCG investigate the Direct Broadcast Satellites (DBS) and in particular the Nimik ExpressVu satellite as the downlink for high-speed data and the

existing MSat as the uplink. CCG revised the original project milestones and schedule based on these findings.

In 2001/02, two of the above-recommended systems were procured for test trials . One system was installed on CCGS Hudson and has been under trial for the last year. The system has worked extremely well and has provided an excellent platform for usage data as well as coverage of the satellites. The second system was to be installed on CCGS Larsen later last year, but due to scheduling problems in the Region, has not yet been installed.

In December, another system was procured and installed on CCGS Samuel Risley. It is now operational and will provide more useful information in the following months. All the systems above use Sat-Tel of Red Deer, Alberta as the Internet Service Provider (ISP). Each system uses a different antenna or different antenna configuration to test the reliability of the various antennae as well as the coverage of the various sizes of antennae. Also, equipment was procured to evaluate the capability and performance of a system not using Sat-Tel as the ISP, but connecting directly to Bell ExpressVu. This system still used MSat as the uplink. This system was installed on CCGS Griffon and is presently in the early testing stage. Due to late delivery of some equipment, not all installations could be completed before the end of March.

Next year, in addition to collecting more data on the operation of the above system, it is planned to test the Sat-Tel ISP software at HQ in Ottawa. If this trial is successful, it could allow the department to act as it's own ISP and run and maintain the system completely in-house. It is also planned to procure and test several improved MSat antennae, which have just been introduced on the market. These antennae are stabilized and promise an improvement in the operation of the MSat.

Contact: Rick O'Laney, (613) 998-1561 *Project Number: FQAE6*

Development of Laser Range Light

The laser range light project was initiated as a result of developments in laser technology and the need for the CCG to reduce its operating costs. It was suggested that replacing the two sites required for a conventional light range with a single site could decrease costs. It was proposed to replace the conventional lights with a more powerful and accurate light source capable of providing adequate and fast information to mariners.

A project was therefore set up to develop a light source that would:

1. require one site instead of two;
2. be as visible as a standard range light;
3. be eye-safe; and
4. consume less energy than a standard range light

Initial research indicated that laser technology could provide greater light range effectiveness than conventional lights for less power. The INO (Institut National d'Optique), located in Quebec City, was selected to develop this new type of aid to navigation based on its reputation as a recognized expert in the area of optics and lasers.

The development and testing of a single colour laser range at St-Michel de Bellechasse began in 1995. A laser light was installed on the St-Michel de Bellechasse range tower in

the St. Lawrence River near Quebec City. This portion of the St. Lawrence is prone to fog, greatly reducing visibility and effectiveness of conventional range lights.

During the evaluation phase of the St-Michel de Bellechasse laser range light, mariners reported favourably on the light strength and high visibility in fog and precipitation. However, they reported that it was sometimes difficult to accurately distinguish between the light coding used for the centre of the channel, the port and starboard coding. Mariners indicated that the starboard coding was easier to interpret than the port coding, which was due to the longer pulse length for the starboard coding. Often, it was reported that under certain angular positions, the port coding did not clearly show 4 pulses, but only 2 or 3.

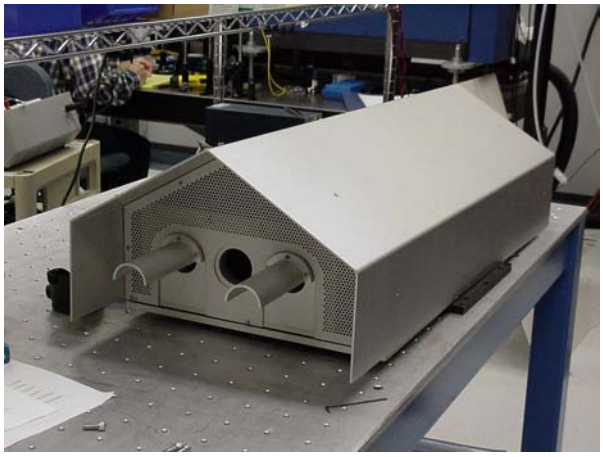
St-Michel de Bellechase Laser Range

As a result of the mariner's evaluation of the St-Michel Bellechasse laser trial, it was agreed that in order to provide a more effective and reliable laser range, the position coding shortcomings would have to be addressed. Specifically, the effectiveness of the off-centre code would need to be improved by increasing the duty cycle of the port and starboard angle codes. However, the off-centre-coding problem experienced in the single light laser could be addressed by developing a two-colour laser range.

The development of a two-colour laser range light in Hay River began in 1998. Hay River is one of the major ports on the Mackenzie-Athabaska Waterway, in Canada's North West Territories, just below the Arctic Circle. The Mackenzie-Athabaska Waterway stretches 2,216 kilometres from Lake Athabaska to the Arctic Ocean. The principle means of moving cargo along the Waterway is by tugs pushing long arrays of barges. The Hay River Range Light marks the entrance to the port of Hay River.

The laser was installed on the front tower of the Hay River Range on June 8, 2000. The Hay River system used 20 mW red and green lasers. It was powered by solar equipment and was installed with a gun sight for easy alignment. It was designed for a range of 3 kilometres and a channel width of 115 meters with a planned service life of 10,000 hours.

The use of the two colours, red and green, addressed the shortcomings of the single colour system, which was dependent on light coding to indicate channel alignment. In the two-colour system, the red and green automatically showed the port and starboard deviation from the centre channel. For example, on the starboard side, the mariner would see light characteristic red flash of 0.5 second every 2 seconds. In the centre of the channel, the mariner would see an alternating red and green flashing light of 0.5 seconds every 2 seconds. On the port side, the mariner would see the light characteristic green flash of 0.5 seconds every 2 seconds.



Hay River Laser in Lab

Laser Range Light at Hay River

In November 2000, the end of the navigation season, the laser was shut down. The main users of this system were the CCGS Eckaloo and the Northern Transportation Company, which operates a large number of tugs and barges on the Mackenzie River stated that the laser was not bright enough for the arctic navigation season. The mariners also complained that it was very difficult to determine how far they were off the centreline of the channel. However, this prototype indicated that with some modifications, the technology could work. In June 2001, the laser was removed and was shipped to the CCG base in Prescott for storage.

For the development of a two-colour laser range light in St-Basile, the Hay River system provided the initial groundwork for the development of a more sophisticated two-colour system with greater angular discrimination and greater range.

Whereas the Hay River system utilized 3 cones and a range of 3 kilometres, the system for St-Basile was designed with 13 cones and a range of 13 kilometres. The system was installed in July 2001 and preliminary reports from mariners indicate that they find the light too bright. They also find it difficult to determine "exactly" where they are in the channel because they are having difficulties interpreting the code. However, it is hoped that the evaluations by mariners will help CCG measure the effectiveness of the two colour laser and make the final modifications to make this a workable system.

St-Basile Laser in Lab

St-Basile Laser on Site

In summary, the preliminary findings have shown that laser light ranges are expensive because of site-specific adjustments and configuration requirements. Each laser must be designed and manufactured for a specific site. The findings also indicate that lasers are difficult to install, maintain and service. The use of laser technology to replace conventional range light sites will require more work before proving positive, both in terms of potential cost savings to CCG and increased accuracy for mariners.

In 2002/03 a committee will review the work done to date to decide on the future direction of this project.

Contact: Ernie Koteles, (613) 990-3044 *Project Number: FNBB6*

The Development of Ionospheric Monitoring and Predictions for the Canadian Coast Guard

Last year Dr. Skone delivered a final report titled "An Ionospheric Warning and Alert System for Canadian Coast Guard DGPS Users". Dr. Skone investigated methods of monitoring and predicting the impact of ionospheric effects on navigation users. Correlations were derived between archived NOAA SEC K indices and degradations in horizontal DGPS positioning accuracies for a three-year data set. However, no analysis was conducted to establish the accuracy and reliability of individual prediction intervals. In order to continue with operational implementation of such a system, an analysis of accuracies - in terms of false alarm rates and missed events - must be conducted. Additionally, the NOAA SEC K indices are derived from magnetometer data at a mid-latitude station in Boulder, Colorado. It would be preferable to base ionospheric predictions on magnetic field indices derived for the local latitudes and sectors where the CCG marine DGPS service is offered. Such local indices and predictions could be based on data from the Geological Survey of Canada magnetometer sites.

Therefore, the primary objective for this year of research investigated the reliability of the proposed ionospheric predictions service. The three tasks were:

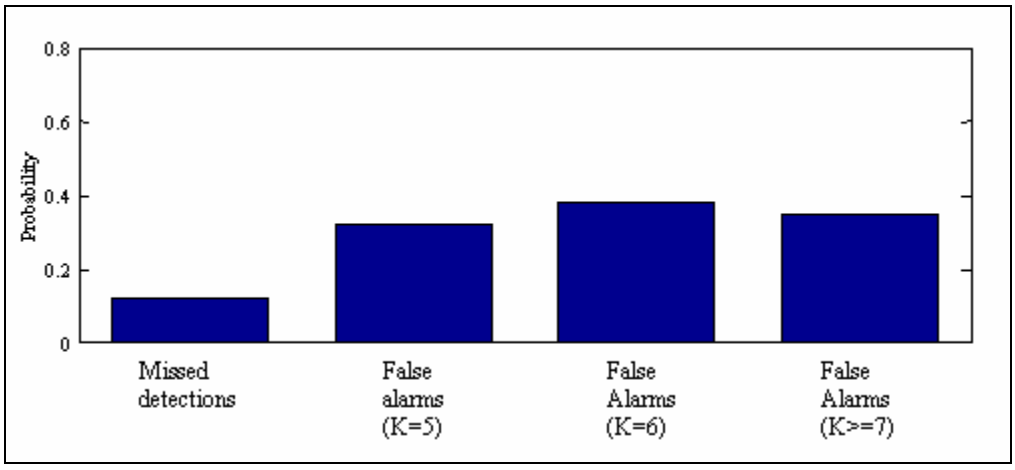
1. Quantify the accuracy of the previous ionospheric warnings, in terms of false alarms and missed detections.
2. Compare the accuracy of the predicted ionospheric warnings with the actual measured values. Qualify the accuracy of the predicted warnings in terms of false alarm and missed detections.
3. Qualify the accuracy of the Geological Survey of Canada's ionospheric warnings.

In task 1, *Analyze the missed detections and false alarms from the previous analysis*, three years of data from four western Canadian baselines of varying lengths were used to determine the number of missed detections and the number of false alarms, based on archived three-hourly K indices from mid-latitude station Boulder. The minimum percentage of missed detections was 3 percent, for the shorter E-W baseline. The maximum percentage of missed detections was 10 percent, for a N-S baseline. Typically, 90 percent of these missed detections were horizontal position errors with magnitudes less than 5-6 metres. Of the 232 events for which warnings would be issued, greater than 60 percent these were false alarms for the E-W baselines, while approximately 35 percent of these were false alarms for the N-S baselines. No position errors exceeded 12 metres for the correct predictions.

In task 2, *Analyze the missed detections and false alarms for the predicted ionospheric warnings*, archived warnings issued by NOAA SEC were used to evaluate the number of missed detections and false alarms for a one-year data period. Data from the four western Canadian baselines were used in this study. DGPS horizontal position errors were tested for the 199 space weather alerts issued during the one-year period. The minimum percentage of missed detections was 4 percent, for the shorter E-W baseline. The maximum percentage of missed detections was 16 percent, for the longer N-S baseline. Typically, 90 percent of these missed detections were horizontal position errors less than 7 metres. Of the 199 alerts evaluated, 50-65 percent of these were false alarms for the E-W baselines, while approximately 30 percent of these were false alarms for the N-S baselines. No position errors exceeded 10 metres for the correct predictions. Overall, results of this task were similar to those for Task 1.

In task 3, *Analyze the missed detections and false alarms using the Geological Survey of Canada's Data*, extensive four-year data sets were evaluated to test the feasibility of regional predictions based on local indices. Data from the four western Canadian baselines were evaluated using three-hourly archived K indices from Victoria; data from a central Canadian baseline were evaluated using three-hourly archived K indices from Ottawa. The central Canadian baseline was oriented in the N-S direction, and was of comparable length to the longer western Canadian baseline – such that it could be used for comparison purposes. For the four-year western Canadian data set, the minimum percentage of missed detections was 3.5 percent, for the shorter E-W baseline. The maximum percentage of missed detections was 13 percent, for a N-S baseline. Typically, 90 percent of these missed detections corresponded to horizontal position errors less than 6 metres. False alarm percentages were generally in the range 40-60 percent for the E-W baselines, while false alarm percentages were in the range 30-35 percent for the N-S baselines. No position errors exceeded 13 metres for the correct predictions. Results for the central Canadian baseline were similar to those derived for the ALBH-WILL baseline in western Canada.

Although the results show that the number/percentage of false alarms and missed detections are too high to deploy the current ionospheric warning system, the research is very encouraging. During the next fiscal year the research will centre on improving the false alarm and missed detections.



Probabilities of missed detections and false alarms for the 489 km baselines in central Canada using the Geological Survey of Canada's Data

Contact: Sam Ryan, (613) 998-1528 *Project Number: FQAL6*

Evaluation of Large Electric Double Layer Capacitors for Powering Aids to Navigation

This project is investigating the possibility of using large electric double-layer capacitors for powering minor aids to navigation and reduce its overall reliance on batteries.

Due to late delivery of the capacitors and electronic equipment, testing is rescheduled for early 2002/2003.

NEC Electronics will provide, free of charge, two prototype double-layer capacitors built to the design concepts of the Coast Guard. The equipment will be subject to an inspection at the plant in May 2002.

The testing of four systems is underway at: St. John's (Newfoundland), Dartmouth (NS), Quebec City (Quebec) and Parry Sound. Two more systems are scheduled for testing in Victoria and Prince Rupert. The test trials will continue in 2002-2003.

Contact: Sunny Leung, (613) 998-1390 *Project Number: FQAM6*

Determine Shipboard Multipath Levels and their Impact on Marine Navigation

CCG is concerned with the location of shipboard GPS antennas in terms of multipath induced errors. Multipath is one of the larger error sources in both single point and differential GPS. Multipath is the error caused by reflected signals entering the RF front end of the GPS receiver and mixing with the direct signal. It affects both pseudorange and carrier phase measurements, although the latter is small, with a theoretical maximum of 5 cm at L1. These effects tend to be more pronounced in static receivers close to large reflectors such as metal objects, water bodies, etc. Multipath is specific to a receiver-antenna system and depends on the surrounding environment. The amount of multipath observed is also dependent on the placement of the antenna on a ship and is thus a concern to CCG.

In the first part of this project the University of Calgary was contracted to analyze the multipath environment of a Canadian Coast Guard vessel, namely the CCGS Martha L. Black. This was accomplished by developing appropriate analysis tools, test measures and test statistics, and then collecting data from the ship.

The equipment was successfully set up on the CCGS Martha L. Black, on February 18, 2002. Data was collected over an approximately two-week long period using two specific antenna positions and wide-correlator receivers onboard the ship. Much effort was spent developing appropriate analysis tools. As a consequence, only two day of test results were assessed in the report. However, the results from these two days are sufficiently representative to draw conclusions.

Multipath in excess of 10 m was detected in about 2 - 5% of the measurements for satellites with elevations of 20° or less. The corresponding percentage for measurements with satellite elevations between 50° and 90° is about 0.7 to 1.4%. Even in the latter case, however, multipath between 25-50 m is detected in a limited number of observations. The maximum multipath range detected is the 50-80 m range where numerous cases occur in the 10° - 20° elevation range. Multipath correlates well with satellite elevation. Since multipath errors in excess of a few tens of metres are still present at relatively high elevations however, selecting a higher mask angle will not solve the problem. The level of multipath at both antenna locations is very similar and thus the choice of antenna location based on the level of observed multipath is difficult to make.

The second part of the study analyzed the static and kinematic position errors in four different navigation solutions, namely:

1) residual checking and rejection (standard 3 sigma rejection) enabled with no height constraint,

2) no residual checking and rejection (standard 3 sigma rejection) enabled with no height constraint,
3) residual checking and rejection (standard 3 sigma rejection) enabled with height constraint, and
4) no residual checking and rejection (standard 3 sigma rejection) enabled with height constraint.

The position errors in both static and kinematic mode often exceeded 30 m. The major conclusions from this analysis are as follows:

1) The differences between the height constrained and un-constrained results are not significantly different.
2) Implementing residual checking and rejection does not improve the results much. This is likely due to the fact that satellite redundancy and critical geometry become weaker while the remaining measurements still contain a high level of noise. A full MDB analysis would be required to confirm this.
3) The two antennas/receivers produced similar results, including in the case of the kinematic data test, which is somewhat surprising.
4) There are instances (e.g., static data) where the coordinate errors are greater when the residual checking and rejection scheme is implemented. This is likely caused by significant satellite geometry degradation, thus showing that straight residual rejection without taking into account geometry degradation and MDB changes can be dangerous.
5) The large coordinate errors occur over relatively short time intervals. The use of a trajectory constraint, together with MDB analysis implementation, residual rejection, and carrier phase smoothing, should help substantially in improving the overall trajectory.
6) The carrier-to-noise density ratio values of the receivers were not analysed in detail in this study. Yet, a recent study at the University of Calgary (still internal at this time) shows the advantages of using of weighing the measurements with the C/No values. This should be considered in the next phase.

Several questions arise for the above findings, namely the impact of wide versus Narrow Correlator™ spacing, the effect of different antenna gain pattern, and antenna multipath reduction technologies. Finally, the possibility of detecting and rejecting multipath to decrease the likelihood of erroneous ship positions needs to be addressed.

The current study was limited to the effect of code multipath in the observation domain. A second question which arises is whether the receiver firmware that estimates positions from code measurements is affected by multipath and whether it can effectively mitigate its effect on position. This question, which is receiver dependent, is dealt with in another series of reports prepared by the University of Calgary for CCG, in which several receivers are tested with a hardware simulator with induced multipath.

The project will continue next year and address multipath mitigation techniques applicable to the CCG DGPS fleet.

Contact: Sam Ryan, (613) 998-1528 *Project Number: FQAN6*

Long Life Lamp Development

This project is studying the LED technology for potential lighting applications in marine aids. Draft LED performance specifications have been completed and were distributed to the known LED manufacturers for review and comment. The next steps are to seek approval of the performance specifications, complete LED lantern testing to confirm compliance with the specifications and issue a qualified products list. The implementation of LED lanterns will financially benefit the CCG in terms of reducing maintenance costs, ship time and fuel consumption. The LED lanterns have shown that they can last up to five years in service without maintenance.

Contact: Douglas MacLeod, (613) 993-6412 *Project Number: FQAO6*

Long Life Synthetic Mooring

In 1992, CCG began the 5-year buoy project to reduce the costs and increase the efficiency of the Aids to Navigation Program by developing 5-year maintenance free floating navigational aids. This goal was demonstrated to be theoretically achievable for most mooring sites, however, in practice six years of buoy service with mooring replacement every three years has been adopted in most regions.

One avenue followed by CCG in 1995, to achieve a reliable 5-year mooring for difficult sites, was east coast field testing of a new mooring system that goes under the trade name of the Hurricane Mooring System (HMS), developed by Strait Moorings International Inc. of Shediac, N.B. This mooring system employs a Spectron rope as the main load-carrying element with a Seaflex segment used to reduce peak load events. These mooring systems were deployed with dead weight or helical screw anchors.

The HMS Evaluation project has reviewed the development of the hurricane mooring system and its use. In addition, the long-term strength of the deployed hurricane mooring system was investigated and some limited design calculations were completed to develop an understanding of the system's performance.

Mooring reliability and cost comparisons indicated that the deployed HMS mooring system through life (capital and maintenance) costs were approximately twice that of the conventional mooring systems and conventional mooring systems demonstrated two to five times the reliability (buoy operational days between failures) of HMS's. When the analysis is restricted to smaller size buoys, the comparison shows similar reliability and life cycle costs. It was also noted that the cost differential is due primarily to the higher HMS mooring system material costs and service frequency. In completing this work, the limitations of the SIPA database and its data were noted and recommendations made that could make SIPA a more effective navigational aid management tool.

Break load testing and examination of HMS mooring ropes retrieved from the field were used to understand the modes and rates of synthetic rope degradation. Preliminary mooring line load analyses for conventional and HMS moorings at three mooring sites were completed to demonstrate the relative performance of these systems over time.

The results demonstrated that the conventional mooring systems were less likely to be off position than the installed HMS mooring systems with deadweight anchors. The estimated peak mooring loads were generally higher in the installed HMS system than in a conventional chain mooring system, due primarily to the low scope used in the

deployed HMS systems. Based upon these results, additional work to clarify the long-term fate of HMS components was recommended.

Concurrent with the HMS evaluation, Brooke Ocean Technology Ltd. (BOT) was contracted to measure forces at two moorings in Chedabucto Bay, correlate the tension measurements with environmental conditions. This information will be used to assist in the modeling of Hurricane and chain buoy systems.

BOT developed a load measuring system and installed one at each of the proposed sites. The data collected has demonstrated that currents have little affect in increasing static loads in the mooring. Average tensions under calm and the most extreme conditions are essentially the same for both moorings. However, similar dynamic tension measurements in more extreme environmental conditions and higher sea states are needed to fully evaluate and inter-compare different mooring designs.

As an un-funded extra, BOT deployed a developmental real time telemetry system that held the potential to reduce the number of visits to the buoys. This deployment proved to be very successful and provided valuable information aiding in the management of the project.

Also, G.P. Rigging was contracted to evaluate the tension measurements of the OceanSurge mooring system – a prototype elastic mooring system. The initial results suggest that the system is a promising option for morring capability.

Three final reports have been published entitled, *Hurricane Mooring Evaluation*, Final Report, March 2002, Prepared By Fleet Technology Limited, Aaron Dinovitzer, P.Eng.; *Long Life Synthetic Mooring, Measurement Of Mooring Forces In-Situ With Load Cells,* Final Report, March 28, 2001, Prepared By Brooke Ocean Technology Limited, Arnold Furlong, P.Eng.; and, *Evaluation Of The Oceansurge Elastic Mooring System*, Jim Hamilton, Bedford Institute of Oceanography and Gilles Pellerin, GP Rigging; 20 March 2002, Final Report.

The project continues next year with the development of a Long Life Synthetic Mooring Selection Guide, based on the existing Chain Mooring Selection Guide (MSG) as well as a separate contract to measure mooring forces in-situ with load cells.

Contact: Doug Jones, (613) 998-1387 *Project Number: FQAP6*

Lighted Plastic Buoy Development

This project is part of CCG's investigation in the use of plastics as a potential replacement material for the steel predominantly used in buoy construction. There are many structural and strategic problems to overcome before these buoys can become a reality. In 2001-2002, CCG reviewed the performance of the buoys in service including a lighted plastic spar buoy to determine specifications for operational requirements. Further research is required into the design and manufacture of both steel and plastic buoys as well as an in-depth study contrasting the methods of handling steel and plastic buoys.

The development of performance specifications for lighted plastic buoys will begin next year. A project team consisting of CCG headquarters and regional personnel will be

established to review all government, industry and IALA recommendations relevant to steel and plastic buoy design specifications and operational reports.

Contact: Douglas MacLeod, (613) 993-6142 *Project Number: FQAS6*

SAFETY AND ENVIRONMENTAL RESPONSE SYSTEMS

Located at HQ in Ottawa, this directorate conducts R&D projects for search and rescue, environmental response, boating safety activities and marine communications and traffic services. For Search and Rescue, projects provide the technological support and innovative techniques necessary for the saving of lives and the protection of the marine environment.

The Environmental Response projects test and evaluate technologies for waste disposal, response strategies for marine oil and chemical spills; and new countermeasure equipment.

The Boating Safety initiatives address the safety aspects of recreational boating and environmental concerns such as noise from recreational watercraft, attitudes to safety and training.

The Marine Communications and Traffic Services projects are aimed to improve cost-effectiveness and performance in communication and information processing systems for the marine community and for the benefit of the public at large, in support of a safe and environmentally sound marine transportation system. Technological solutions in support of the overall effectiveness of the MCTS program can be made in areas relating to communications and transmission network technologies, automatic identification system (AIS), and integrated information management.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
	Search & Rescue			
	No projects in 2001-2002.			
	Environmental Response			
FKCA6	Development of Response Strategies for Orimulsion	CCG	245	21.6
	Office of Boating Safety			
FKCT6	Research Project for Increased Wearing of Personal Flotation Devices (PFD)	CCG	See Newfoundland Section	
	Marine Communications & Traffic Services			
	No projects in 2001-2002.			
	Safety & Environmental Response - **TOTAL**		**245**	21.6

Development of Response Strategies for Orimulsion and Heavy Oils

CCG in partnership with Environment Canada's Emergencies Engineering Technologies Office (EETO) are undertaking a multi-year research plan to evaluate new and existing oil spill recovery and containment equipment to assist in the advancement of recovering Orimulsion in the event of a spill. Three research studies were undertaken this year and the results are described below.

The in-situ burning tests concluded that orimulsion once separated into bitumen and water can be ignited on small scale and will burn with useful efficiency. Ignition of the Orimulsion is best accomplished with addition of a primer such as diesel fuel. The application of a flame alone does not appear to have potential for ignition. The efficiency of burning Orimulsion is comparable to any other fuel. The burning process herded residual oil to one or more areas so that as an average, very little product was left on the surface. These small scale results show that there is potential for Orimulsion in-situ burning. Larger scale tests should be conducted to confirm this potential and to measure the same parameters measured in the small scale tests.

The second study modified a CCG GT-185 skimmer pump with a direct steam and hot water injection system and manufactured for testing. The main goal of the testing included determining the performance characteristics of a GT-185 pump with flow enhancing adapters in the presence of/and absence of, steam injection at the inlet and outlet flanges when pumping heavy oils. The system was successful at improving flowrates and can be used as a means of transferring extremely viscous product. Additional research was recommended to further investigate the use of steam and hot water injection to improve the pumpability of viscous oils.

The third study examined the dynamics of Orimulsion in water with varying salinity and temperature. Previous studies have shown that Orimulsion apparently is driven by buoyancy to rise in salt water and sink in fresh water; but behaviour in brackish water was difficult to predict. Temperature has also been indicated as having an influence on Orimulsion behaviour. This year, the study extended experimentation down to lower temperatures, and a large number of salinity values in the range from fresh to salt water. This study showed that there is a complex interaction among salinity, time and temperature. The interaction between these was measured in 19 experiments and the data was used to develop simple equations to describe and predict the concentration of bitumen in the water column as a function of time. Similarly nomograms showing the amount of oil on the bottom and on the water surface was presented.

The project team will continue with their studies in 2002-2003.

Contact: Ron MacKay (902) 368-0204 Project Number: FKCA6

RESEARCH AND DEVELOPMENT OFFICE

Located at HQ in Ottawa, this office is the focal point for planning, co-ordinating and reporting of CCG R&D activities. Projects are initiated when required to improve CCG management practices or to promote multi-disciplinary issues with other government departments, the marine community and international agencies.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FKAA6	Federal Partners in Technology Transfer	CCG	10	
	R&D Office - **TOTAL**		**10**	

Federal Partners in Technology Transfer

Funds were provided as a CCG contribution to a federal group charged with the promotion of technology transfer. The original commitment was for a three-year support agreement (FY 1999/2000 to 2001/02). The departmental evaluation indicated that the process was not especially useful in supporting departmental goals and that funding should be curtailed at the end of the three-year trial period.

Contact: Wayne Ellwood, (613) 990-3093 *Project Number: FKAA6*

RISK MANAGEMENT

Located at HQ in Ottawa, this office is the focal point for developing a comprehensive marine activity and risk model to address CG planning issues.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FKDE6	Maritime Activity Geomatics and Risk Analysis in the Coastal Zone	CCG	275	60
	Risk Management- **TOTAL**		**275**	

Maritime Activity Geomatics and Risk Analysis in the Coastal Zone

Significant progress has been made in several segments of this research effort to develop methodologies and computer tools to analyse and display marine traffic, incidents and incident rates.

The methodology involves several steps:

- Collect/generate movement data on all maritime vessel activity;
- Organize incident data in a form suitable for GIS and risk analysis;
- Analyze risk factors based on attributes of vessels and environment; and
- Create GIS software (MARIS) and tools to analyze maritime traffic pattersn and trends, as well as incident rate and risk distribution. Software tools include those targeted to end-users (Coast Guard) as well as those geared towards the researchers' needs. Additional software (MRV-recon) is being developed to process satellite images for small vessel detection.

Data collection and processing has proceeded well. Many algorithms for data acquisition, analysis and simulation have been initiated and are at various stages of evaluation and refinement.

Several computer programs are also under development to advance the ability to acquire and analyze maritime traffic information, and other factors associated with maritime risks.

Research results to date have lead to the preparation of several draft reports and theses. Please consult with the contact below to determine availability.

The project will wrap up next year with the delivery of a Geographic Information System (GIS) based risk model of maritime activities. CCG will employ the marine risk model for Search and Rescue planning requirements, accident prevention activities, congestion evaluations, and oil spill response.

Contact: Brian LeBlanc, (613) 990-5882 *Project Number: FKDE6*

NEWFOUNDLAND REGION

With regional headquarters located in St. John's, Newfoundland, this Region selects R&D projects to assist in their challenge to adapt to trends in operational demands, strategic changes in levels of service, and evolving expectations from clients. The priority technological opportunities in support of their overall effectiveness of service delivery operations relate to: boating safety, communications and transmission network technologies, and aids to navigation.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FKCT1	Research Project for Increased Wearing of Personal Flotation Devices (PFD)	CCG	228.5	
	Coast Guard Public Information System		Cancelled	
	Fishing Vessel Safety Study		Cancelled	
	Newfoundland Region- **TOTAL**		**228.5**	

Research Project for Increased Wearing of Personal Flotation Devices (PFD)

The 2001-2002 R&D project consisted of conducting a national Personal Flotation Device (PFD) Attitudinal Survey. Approximately, 4,000 telephone interviews were completed with Canadian recreation boaters (16 years of age or older) to determine boater's attitudes towards PFDs.

The major objectives of the study were to measure current attitudes towards PFD wear and to provide recommendations to assist in the development of a major communications campaign to increase wear through motivational factors. In addition, the results will serve as a benchmark from which changes in attitudes, resulting from the campaign will be measured.

Based on attitude differences, the research identified 6 distinct market segments. Each segment requires distinct messaging to encourage increased PFD wear rates. Some of the segments, based on positive attitudes, will be relatively easy to influence. However, the Adrenaline Seekers will be very difficult to influence.

The report identifies many positive attitudes towards the use of PFDs:

- The majority or recreational boaters report a positive attitude towards wearing a PFD. However, the study indicates that as a boater's rate of participation in a boating activity increases, the PFD wear rate decreases. Although at least 2/3 rd of the sample say that their boating activity will be much safer if PFDs were worn, they are not necessarily going to wear a PFD if they think that they can manage the risk.

- Recreational boaters see wearing a PFD as a normal part of boating and they feel safer wearing one. Strong personal skills and being cautious are not valid reasons for not wearing a PFD. The importance of wearing a PFD outweighs any reason for not wearing one. Respondents do not see rational proof that PFDs save lives as a persuasive argument for wearing.

- Most boaters would put on a PFD if asked to by someone else, especially the boat operator. Being a role model for children is also a reason for wearing a life jacket.

- About 3/4 of the respondents indicated that more comfortable PFDs would lead to increased wear.

In terms of confidence in organizations providing Canadians with PFD information the Canadian Coast Guard was seen as being the most credible.

The study indicated there is considerable work remaining to educate recreational boaters about the improvements to PFDs, the differences between PFDs and life jackets and the new Competency of Operators of Pleasure Craft Regulations.

Overall, this major study identified a number of possible approaches that may move recreational boaters to increase wear rates for PFDs. The next phase would be, based on the detailed analysis of the results of this report, would be to identify a number of communication strategies for each segment, test and refine them prior to the launch of the communications campaign.

Contact: Sharon Sellars, (709) 772-2079 *Project Number: FKCT1*

MARITIMES REGION

With regional headquarters located in Dartmouth, Nova Scotia, this region selects R&D projects to assist in their challenge to adapt to trends in operational demands, strategic changes in levels of service, and evolving expectations from clients. The priority technological opportunities in support of their overall effectiveness of service delivery operations relate to: spill response technologies, and ice data collection and information management.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FMDG2	Enhanced Sweeping Methods	CCG	100	864
FMDF2	Magnetic Ship Joint for Sweeping Systems	CCG	40	
	Maritimes Region- **TOTAL**		**140**	864

Enhanced Sweeping Methods

This project is testing the operational capabilities/limitations and feasibility of a Norwegian boom system for use in Canadian waters. The boom is expected to perform at encounter rates in excess of 4 knots, winds 25 knots and 2m seas.

CCG joined partnership with SERVS Alyeska Pipeline, NOFI/AllMaritim and NOFO of Norway in December 2001 in the development of the "OCEAN BUSTER", high speed sweep technology. Production of the prototype boom began in March 2002 with field tests scheduled for August 2002. Delivery of the first system to SERVS Alyeska Pipeline is expected in September 2002.

Canadian field testing is expected to take place from November to March 2003 in conjunction with the R&D project entitled "Magnetic Ship Joint for Sweeping Systems" field trails testing. While the trials are dependent upon ship availability, SERVS Alyeska has offered their platform for Canadian testing should there be a requirement. The final field test for the Ocean Buster will be held during a NOFO exercise planned for June 2003 in the northern waters of Norway where the Ocean Buster will be tested in real oil under real sea conditions.

Contact: Ron Mackay, (902) 368-0204 Project Number: FMDG2

Magnetic Ship Joint for Sweeping Systems

The Magnetic Ship Joint for Sweeping Systems project is composed of two phases. In the first phase, the Magnetic Connector was fitted to accept the NOFI 600 Sweep system. The success of the connector necessitated the ability for it to be utilized by various sweep systems presently held in CCG inventory, namely the RO-Sweep. An adapter was designed and fabricated, and made ready for field testing with the RO-Sweep System.

During phase two, the Magnetic Connector underwent several changes and improvements that included reducing the size of the connector without affecting its performance.

Unfortunately, attacks on the World Trade Centre, NY, postponed the field test of the Magnetic Ship Joint for Sweeping Systems, the Ocean buster and RO-Sweep systems. They are rescheduled for 2002/03.

Upon completion of the field test for the magnetic connector, a final report will be prepared outlining the effect on on-water off-shore and near-shore recovery enhancement and provide recommendations. An operations manual, video, and pictures will also be provided.

Contact: Ron Mackay, (902) 368-0204 Project Number: FMDF2

QUÉBEC REGION

With regional headquarters located in Quebec City, Québec, this region selects R&D projects to assist in their challenge to adapt to trends in operational demands, strategic changes in levels of service, and evolving expectations from clients. The priority technological opportunities in support of their overall effectiveness of service delivery operations relate to: ice information management, marine traffic management, aids to navigation, erosion/sedimentation mechanisms, and SAR and environmental response.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
FJNF3	Lighted Spar Buoy	CCG	50	
FMCC3	Erosion-Sedimentation Model of the St. Lawrence River	CCG	150	in-kind
FMJQ3	Feasibility of Immersing Ice Booms in Place	CCG	20	
FJMP3	Dispersion of Oil Spills in Ice and its Environmental Fate	CCG PERD	60	20 20
GMJE3	St. Lawrence River Ice Manager – Integrated Ice System	CCG	150	
GMJF3	Squat Study for the Purpose of Re-evaluating Underkeel Clearance Specifications	CCG	60	
GMJG3	Computer-Assisted Ice Observation System in Helicopters	CCG	65	
GMJH3	Wireless Communication Protocol Application for Geo-referenced Marine Data Internet Access	CCG	75	
GMJJ3	User-friendly Software Forecasting the Trajectory of Oil Spills in Case of Environmental Intervention	CCG	125	80
	Québec Region- **TOTAL**		**755**	120

Lighted Spar Buoy

The first stage of the project (done internally) consisted in consolidating the history of the experiments, tests and research undertaken over the last decades by the CCG. Following that, two consultants were hired to review the literature and undertake an environmental study related to the research field. Both studies considered two aspects:

- **Civil Engineering** – The objectives of the review of the literature can be summarized as follows:

✓ Classification of Coast Guard documents dealing with buoys and their related elements

✓ Review of the literature on the various types of buoys used in the world, along with their anchoring, visual identification and radar reflector systems.

✓ Development of a performance criteria grid for buoys and their various systems.

✓ Preliminary research on existing materials and those being developed which could among other things resist the various hydrodynamic and ice stresses identified in the hydraulic engineering study and which would require less maintenance over a 15-year time horizon.

✓ Identification of external partners with the expertise required to work with us in order to meet the project's various challenges.

A preliminary report was delivered on March 31, 2002. It met roughly 70% of the mandate. The final report should be tabled by June 30, 2002.

A review of prior experiments undertaken by the Coast Guard under the Aids to Navigation Program helped identify Light Wave Options as a key partner. This is a firm representing Sabik, the Finnish company which is the world leader in the manufacturing of LED lanterns. The review also revealed that the Finnish maritime administration had developed a lighted spar buoy for winter which could potentially resist stresses in the St. Lawrence River in the sector upstream from Trois-Rivières.

- **Hydraulic Engineering** – The study had two objectives:

✓ Identify the stresses on buoys caused by currents, waves and ice in order to characterize the St. Lawrence River according to the severity of these stresses.

✓ Review navigational aids used in other northern countries and assess their applicability in the harsh environment of the St. Lawrence River.

The hydraulic study helped establish the hydrodynamic stresses and the scale of the impact force of the ice on the buoys marking the waterway between Montreal and the mouth of the Saguenay River. The impact force could reach as high as 80 KN for a spar buoy with a 1m diameter. Furthermore, the force exerted by the ice shows that spar buoys are the best shaped to reduce the impact force, break thin ice and submerge under the thickest ice.

In light of the review of navigation aids in northern countries, the hydraulic study recommends testing a lantern (module MPV/LED) developed for ice conditions as harsh as those in the St. Lawrence River.

Studies done in 2001-2002 provided a clear update on the development situation of lighted spar buoys for winter at the international level.

In 2002-2003, we expect:

- **Civil Engineering:**

✓ Finish the document review begun in 2001-2002. The financing will pay the consultant's overtime.

✓ Acquire and test a spar buoy manufactured in Finland and 4 LED lanterns. Partnership agreements will be signed with the various companies. The financing will pay the acquisition and observation costs through the winter of 2002-2003. This will be followed by a report with recommendations.

✓ Complete a pre-feasibility study on the coating equipment of the buoy with the help of the Defence Research Establishment Valcartier (DREV).

The budget obtained will help structure the approach and identify realistic clues to determine what the various discoveries achieved; to this end, a financial analysis of the operational costs of present buoys will also be developed for comparative purposes.

- **Hydraulic Engineering:**

✓ Validate the hydrodynamic and ice stresses indicated in the study report undertaken in 2001-2002 and gather data on the performance of spar buoys presently in use in our region.

The 2002-2003 budget will be used to instrument between two to four buoys during the winter of 2002-2003, collect and analyze experimental data and produce a study report.

Contact Sylvie Pelletier, (418) 648-7450 Project Number: FJNF3

Erosion-Sedimentation Model of the St. Lawrence River

The development of an erosion-sedimentation model for the St. Lawrence River encompassed two objectives:

- to gain a better understanding of the erosion, transport and sedimentation processes in the St. Lawrence River based on various hydrological and hydraulic conditions;
- to evaluate the potential impact of navigation and maintenance of the waterway on the environment (bank erosion and sedimentation).

The project involves integrating several digital models in a graphic interface (SedSim): sediment transport model, wind- and boat-generated wave generation and transformation models and a bank erosion model. These models must be validated by

field measurements. The graphic interface must make it possible to execute and visualize simulations corresponding to various hydrological and hydraulic conditions.

The project began in 1999-2000 and will end in 2005. The sediment transport model (Psed) was delivered in 2001/2002. The boat-generated wave models and the bank erosion models were developed in 2001-2002. The validation of these models and their integration in the graphic interface began, but they will not be completed before March 2003. Field data will eventually be required to complete the validation of the wave and soil erosion models.

The boat-generated wave model was incorporated into the SedSim interface in 2001-2002, and the erosion model will be in 2002-2003. During that year, it is anticipated that the developed models will be refined to take into account wind-generated waves and to improve interaction between the models.

The last two years (2004-2005) will be devoted to analyzing the erosion and sediment transport processes in the St. Lawrence based on various hydrological and hydraulic scenarios; and to the evaluation of potential impacts of navigation and maintenance of the waterway on the environment in terms of erosion and sedimentation.

Contact: Pierre Rouleau, P. Eng. (418) 648-7493 *Project Number: FMCC3*

Feasibility Study to Immerse Ice Booms in Place

The purpose of this project is to evaluate the feasibility of immersing/raising booms as an alternative to current management, which calls for the removal and installation of booms each year. This may reduce annual maintenance costs over the long term. Preliminary tests were conducted in Prescott in 1999 by Fleet Technology. The findings resulted in the launch of a more in-depth study in 2000-2001 along a complete section of booms in lac St-Pierre. The current R&D project is the subject of this study.

This method is seen as having several advantages, as it will:

- Reduce the costs of removing and deploying the booms;
- Minimize the exposure of boom components to the force exerted on them by ice during the break-up (if they are submerged during the winter);
- Reduce the exposure of the booms to handling-related impact.

The anticipated disadvantages are as follows:

- Boom components would be exposed to corrosion for 12 months of the year;
- Complications could arise while immersing/raising the booms and during the time when the booms are submerged;
- They may be an obstacle to pleasure boating;
- The inner portion of the pontoons are exposed to corrosion and to the formation of algae;
- Instrumented buoys could prove difficult to install;
- Some difficulty may be encountered in inspecting parts and making repairs.

A complete section of the boom in lac St-Pierre and all its components were transported to Ottawa to be adapted for testing which took place in Prescott in the fall of 2000. The

CG performed one test in conditions at depths similar to those encountered in lac St-Pierre. A test was planned before the spring break-up of 2001 on the lake itself to validate one of the other objectives of this concept, i.e., immersion before the spring break-up to reduce damage to the booms. This test was not performed. The temperatures and ice conditions normally observed prior to tbe break-up did not seem conducive to this type of operation, at least as far as the method proposed by the consultant was concerned. The test was then postponed until after the break-up, but could not be performed before March 31, 2001 because of unfavourable climatic conditions and because the CG hovercraft was not available.

The CG agreed with the consultant to hold a series of successive tests in the spring and summer of 2001 to finish up the evaluation of the method.

The results were as follows:

- The section could not be sunk before the spring break-up, as mentioned earlier.
- The section was therefore sunk and left at the bottom of the lake in June 2001 and raised to the surface in October 2001, in keeping with the technique proposed by the consultant.
- Each of the two operations required two days of work.
- The section was then transported to Sorel for inspection.

The consultant updated its feasibility study with additional data gathered and delivered its final report in February 2002. The following are the main findings:

- The main advantage (immersion prior to ice removal/spring break-up) of the method was inaccessible.
- The method precludes inspecting the parts and making the required repairs.
- The method cannot be used when instrumented buoys are involved (there are five on the booms in the Quebec region).
- The operations were very long and arduous because of mud, waves and currents.
- This method cannot be used when debris is present (debris was removed prior to testing);
- Pleasure boating is riskier, because there is no guarantee the boom will stay on the bottom once it has been submerged.
- The method used did bring to the fore some risks to the safety of personnel assigned to these operations.
- The experiment was worthwhile, because the approach did hold some promise, in principle.
- The method, however, does not meet CCG requirements (immersion prior to ice removal and safety), given the prevailing conditions on the St. Lawrence and personnel safety problems.
- The method is perhaps holds more promise on smaller waterways.
- Removing the booms every three years could cause contractors to lose interest. The potential increased costs could nullify the anticipated benefits.

The feasibility of the method could therefore not be established. Barring an exceptional innovation which would eradicate the major drawbacks of this method, it is not recommended that further investment be made in this project over the short term, which ended on March 31, 2002.

Dispersion of Oil Spills Stranded in Ice and its Environmental Fate

This project has been very successful in its goal to quantify the feasibility of using oil-mineral aggregate (OMA) formation as an oil spill countermeasure strategy in ice infested waters and to identify the environmental impact of oil dispersed into the environment in this manner. Both field and laboratory studies were conducted to define the environmental factors controlling OMA formation. Methods to quantify OMA production and characterization were developed for operational use (i.e. production of a "field test" guideline document).

Water turbulence is the necessary conditions to form OMA from oil spilled in the environment, because it provides the shear energy necessary to disperse the oil into the water and keep minerals in suspension, thus promoting their interaction. This explains why surf-washing is successful in removing oil stranded on shorelines of loose sediments. Also, since viscosity of the oil seems to influence how well it is dispersed by shear energy, OMA formation is inversely related to oil viscosity, which is in turn affected by temperature and degree of weathering. It is therefore important to treat an oil spill as soon as possible if the method used aims at accelerating OMA formation.

OMA formation enhances the rates of oil degradation by indigenous bacterial species. Studies under this program have confirmed that OMA formation may occur readily in the presence of natural mineral fines, at low temperatures, such as those found in ice-infested waters.

In terms of ice-infested water applications, laboratory results indicate that:

- Even in cold water, OMA formation can bind significant amounts of oil provided the oil has a low to moderate viscosity (below approximately 1000 cPa.s, although this also depends on the oil composition).
- Organo-clays bind oil very efficiently but the resulting cakes are very buoyant. These minerals would be appropriate as an oil spill treatment if the resulting cakes could be skimmed from the water/ice surface. These minerals are the most expensive.
- Montmorillonite binds oil efficiently and the resulting OMA disperse and sink. They would be of use in a case where recovery of the oil is not possible.
- Natural fine sediments can be effective in forming OMA (especially if they contain smectites); they would be the least expensive material and may be available in proximity of the oil spill.

This research program has attracted the interest of other organizations with programs on the development of oil spill response strategies (e.g. collaborations with Cedre – France and AEA Technology – United Kingdom). As a result, an international workshop on Oil-Particle Interactions was hosted at the Bedford Institute of Oceanography in April 2000. Recognition of the significance of OMA formation on natural recovery and its potential for use in the development of spill response technologies (e.g. surf-washing) has resulted in the publication of a special volume of the peer-reviewed journal "Spill Science and Technology" that highlights the work from this program.

CCG is considering future research on operational tools based on the application of OMA driven oil spill clean-up technologies.

Contact: M. Blouin, (418) 648-4557 *Project Number: FJMP3*

St. Lawrence River Ice Manager – Integrated Ice System

The Integrated Ice System (IIS) began in 1997-1998 as a result of PERD financing (project no. 32214). The IIS consists of a set of data gathering instruments, a telecommunications network which transmits this data in real or quasi-real time to IIS servers, specialized software which processes and analyzes this data, and an Intranet site which makes information on ice conditions available to users.

During the winter of 2000-2001, the IIS was the subject of an operational mode evaluation, without financing from the PERD or R&D programs. Based on information gathered during that season, it was decided that R&D efforts during 2001-2002 would focus on improving the remote surveillance site of curve no. 1 at lac St-Pierre. The other two components presented in the project justification in the fall of 2000 were not retained (improvement of the IIPI (ice image processing interface) application and improvement of production and ice evacuation models).

The project conducted in 2001-2002 is the end result of an experimental project launched in September 1999 by the Canadian Coast Guard in cooperation with Université Laval. It involved testing two new instruments on curve no. 1 on lac St-Pierre – an ADCP (Acoustic Doppler Current Profiler) and an IPS (Ice Profiling Sonar). When installed at the bottom of the channel, these instruments essentially make it possible to measure the thickness and speed of the ice, and the speed of currents. The work done during the course of the 2001-2002 R&D project involved:

- Changing the IPS to allow for data acquisition in real time;
- Deploying both instruments at the site of curve no. 1 and recording this data in real time throughout the winter;
- Developing two software packages – one for the acquisition of IPS (IpsSaveReal) data in real time and the other to process in real time the data from both instruments (IADDS : IPS-ADCP Data Display System);
- Analyzing data gathered during the winters of 2000-2001 and 2001-2002 to evaluate the capacity of the ADCP and the IPS to measure the current and ice characteristics (study performed by Université Laval).

The project also included a survey to take manual measurements to validate the ice thicknesses measured by instruments and to characterize the ice flowing in the channel (mainly brash ice). This survey had to be canceled due to the mild weather conditions which did not allow for the formation of a sufficient ice cover to take the measurements.

Université Laval analyzed the data and it was discovered that:

1. IPS and ADCP data matches up quite well.
2. Both instruments are required to quantify ice characteristics (thickness, speed, concentration, unit flow).
3. These instruments can help detect and quantify ice jams.
4. The data provided by the IPS and ADCP can also be used to develop a digital method based on neural level networks to predict ice quantities based on meteorological conditions.

The findings show how useful the ADCP and the IPS are in quantifying ice and detecting ice jams. Consequently, the CCG will permanently install both instruments on curve no. 1 in lac St-Pierre. A portion of the R&D finds were used to purchase an IPS, since the one in use since 1999 was on loan from Université Laval, as was the ADCP (the CCG acquired its own ADCP in 2000-2001 with regional secondary investment funds).

The project will continue in 2002-2003, with two components receiving attention.

(a) The remote detection site of curve no. 1 will be finalized by improving the IADDS and establishing processing of ADCP and IPS data in quasi-real time, posting IADDS findings on the IIS Intranet site and continuing to analyze data in cooperation with Université Laval to improve detection and forecasts of ice blockages.
(b) The IIPI (ice images processing interface) will be evaluated to determine whether its development should continue in future years.

Contact: Réginald Corriveau, (418) 648-5620 Project Number: GMJE3

Squat Study for the Purpose of Re-evaluating the Underkeel Clearance Specifications for the St. Lawrence River

The purpose of this project was to study the squat phenomenon of ships, using GPS-OTF technology. The findings will make it possible to re-evaluate the underkeel clearance in force on the St. Lawrence. If necessary, the proposed study could lead toward the development of new tools to achieve optimal management of underkeel clearance on the waterway of the St. Lawrence River.

The first stage of the project, which involved a feasibility study, was completed in 2001-2002. This study included, among other things, a detailed definition of CCG requirements, an in-depth review of squat studies performed around the world, an analysis of available technologies to accurately measure the relevant parameters, the development of a well-defined quality control process during the data gathering phase for all of the parameters measured, the identification of resources required to collect and process the data (equipment and personnel), and the definition of a detailed work plan. Following the feasibility study, preliminary tests will be conducted to confirm the methodology chosen and the instruments retained.

The feasibility study will trace out the subsequent two stages of the project:

- The second stage of the project (2002-2003) is devoted to planning and conducting the measuring survey and to validating and processing the data gathered.

- The third stage of the project (2003-2004) calls for the evaluation of the squat of ships and a comparison with the findings obtained with the underkeel clearance standard in force on the St. Lawrence.

Contact: Pierre Rouleau, P. Eng. / René Paré, (418) 648-7493 Project Number: GMJF3

Computer-Assisted Ice Observation System in Helicopters

As this project advanced from version 3.0 to version 3.1, several specific functions were developed so that they could be used on board Coast Guard helicopters during ice reconnaissance patrols for the purpose of conducting functional tests during the 2002-2003 winter season.

The ultimate goal is to implement use of the computerized ice observation system on board the Environment Canada Canice 3 aircraft, including the integration of radar observation data combined with visual observations. Finally, we anticipate using the data processed by that system to supply the digital ice forecasting model developed by the science group with the l'Institut Maurice Lamontagne (MPO).

A view of the Pen computer interface during an experimental ice reconnaissance flight on board Environment Canada's Canice-3 plane

Contact: ***Réginald Corriveau,*** *(418) 648-5620* *Project Number: GMJG3*

Wireless Communication Protocol Application for Georeferenced Marine Data Internet Access

The project, as described in the research and development project justification, has been completed. A functional prototype has been developed from a study of the various communication protocols. No communication methods correspond to CCG requirements in every respect. It is recommended that another solution be studied in greater detail. If this study is rejected, priority will have to be given to digital cellular technology. For more information, please refer to the project report.

Contact: Pierre Rouleau, (418) 648-7493 *Project Number: GMJH3*

User-friendly Software Forecasting the Trajectory of Oil Spills in Case of Environmental Intervention

According to the initial request, the project called for two separate stages:
2001-2002 : Development of a user-friendly software, including a user interface; and
2002-2003 : Training of CG users – Quebec Region, and additional changes to the interface to facilitate their work in actual situations.

This timetable was amended. Interface development and its integration into the work of CG officers are going on simultaneously.

The following work is to be done this year:

(a) Agreement for a joint project with UQAR. A contribution of $80,000 was made in 2001-2002, which is half of the forecasted contribution of $160,000. A specific description of the calculation interface was made along with the communication architecture to allow an Internet link;
(b) Development of the desired functionalities in the interface as a result of consultations with CG officers. An open development architecture was chosen to allow for the addition of functionalities as they will become necessary.
(c) Documentation on hydrocarbon retention potential for a sector along the coasts of the St. Lawrence River.
(d) Documentation comparing various interfaces to integrate the best performing parts.
(e) Test of the current interface in actual situations to identify where improvements are to be made.

The project is still under way and is scheduled to end in 2002-2003. The illustrations will be contained in the final report.

Contact: M. Blouin, (418) 648-4557 *Project Number: GMJJ3*

CENTRAL AND ARCTIC REGION

With regional headquarters located in Sarnia, Ontario, this region selects R&D projects to assist in their challenge to adapt to trends in operational demands and strategic changes in levels of service and evolving expectations from clients. The priority technological opportunities in support of their overall effectiveness of service delivery operations relate to: aids to navigation, vessel maintenance, SAR and environmental response, icebreaking and support to environmental standards for the protection of the fragile Arctic environment.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
HCAA6	Evaluation of Arctic Diesel Fuel and Marine Diesel Oil Blends with and without Lubricity Additives in a Vasa 32 Diesel Test Engine	CCG	205	80
FRCU6	Industrial Noise Interference with Marine Mammals	CCG	80	
FRCW6	Modular Shipboard Treatment Plan	CCG	197	
FGRS4	Small Footprint Sewage Treatment Plan	CCG	78	
	Central and Arctic Region- **TOTAL**		**560**	80

These projects have subsequently been transferred to Ottawa.

Evaluation of Arctic Diesel Fuel and Marine Diesel Oil Blends with and without Lubricity Additives in a Vasa 32 Diesel Test Engine

Tests in 2001/2002 were conducted in a full size medium speed diesel engine to assure the viability of the test procedures and standards for using lubricity additives over long term applications and that they would not jeopardize a CCG heavy icebreaker during a major mission.

The test program in Iqaluit was successful. A technical paper was presented at the Automotive Engineering seminar in February 2002.

Additives showed positive advantage in extending the life of fuel pump components. The work on the ball on three disk lubricity instrumentation for surface quality is on going; expecting positive results within the next few months.

It was ascertained during the test in Iqaluit that cavitation plays an important role in the life of the fuel injection equipment. Bosch confirmed that the pressure level on the fuel pump manifold can be raised to reduce this negative effect.

Tests will continue in next fiscal year in cooperation with a number of Canadian and US industries and major additive manufactures.

Contact:, Patrice St-Pierre (613) 991-2482 *Project Number: HCAA6*

Industrial Noise Interference with Marine Mammals

The project successfully delivered an environmental assessment tool that provides a self-contained software package that can be applied to various types of noise (low-frequency, high-frequency, broad-band) to various ocean environments (ice-covered Arctic versus open ocean; various bottom sediments), and to differing marine mammal species (dolphins, whales, seals and sea lions).

CCG now has available a fast, efficient, cost-effective tool to assess environmental impacts of their own and industrial activities with respect to noise effects on marine mammals. The tool will also lay the groundwork for potential mitigation methods and/or sensible regulation.

Contact:, Patrice St-Pierre (613) 991-2482 *Project Number: FRCU6*

Modular Shipboard Treatment Plan

This project investigated the possibility of improving vessel discharges below current detectable limits using a BIO-reactor treatment system developed by Advance Biological Solutions Inc. (ABS).

This year, the system was tested on the CCGS Eckaloo for bilge water treatment. It also included an evaluation of an oil content meter which is not affected by volatile

compounds at the parts per billion level. The system was successful in handling the bilge water requirements.

CCG is examining an implementation plan and assessing the life cycle management implications of installing this system.

Contact:, Patrice St-Pierre (613) 991-2482 *Project Number: FRCW6*

Small Footprint Sewage Treatment Plant

This project designed and tested a waste water treatment system that is self-contained and specifically designed for small marine vessel applications.

After a design change to correct the installation of venting components, the system produced discharge levels meeting regulatory requirements.

CCG is examining an implementation plan and assessing the life cycle management implications of installing this system.

Contact:, Patrice St-Pierre (613) 991-2482 *Project Number: FGRS4*

PACIFIC REGION

With regional headquarters located in Vancouver, B.C., this region selects R&D projects to assist in adapting to local trends in operational demands, strategic changes in levels of service and evolving expectations from clients. The priority technological opportunities in support of their overall effectiveness of service delivery operations relate to: communications and transmission network technologies, aids to navigation, Search and Rescue and environmental response, and marine traffic management.

Year End Budget Summary 2001-2002

PROJECT NO.	PROJECT TITLE	FUND SOURCE	2001-2002 FUNDS	
			CCG	PARTNER
	No projects in 2001-2002.	CCG		
		CCG		
		CCG		
		CCG		
	Pacific Region- **TOTAL**			

NEW SEARCH AND RESCUE INITIATIVES FUND (NIF)

The New Search and Rescue Initiatives Fund (NIF) is a unique undertaking by federal and participating provincial, municipal and private Search and Rescue (SAR) organizations. It's objective is the saving of lives by enhancing SAR prevention and the provision of SAR services. NIF is not specifically oriented to R&D projects but, rather, was established by the federal government to provide funding to new initiatives which enhance the effectiveness of SAR by all participants, especially those outside government.

NIF is managed by the National Search and Rescue Secretariat (NSS) reporting to the Lead Minister for Search and Rescue (the Minister of National Defence).

Within CCG, it is managed as a separate program within the Safety and Environmental Response Directorate (SERS). For the CCG R&D Program, NIF funded research projects are reported when a research project is sponsored by CCG.

In 2001/02, the Canadian Hydrographic Service (CHS), Pacific region initiated a program to develop numerical models that will provide simulations of tsunami-generated currents and heights in navigation channels.

Project List Summary

PROJECT NUMBER	PROJECT TITLE	2001/02 (NIF approved)	Other Sources
	SAR Response to a Tsunami in Pacific Region	71	33
	NIF - Total	**71**	33

SAR Response to a Tsunami in Pacific Region

CHS will develop numerical models of tsunami currents and heights to be expected as part of the next Cascadia Subduction Zone Earthquake. These models will use CHS high-resolution bathymetric data in harbours vulnerable to tsunamis to provide accurate simulations of currents in entrances to harbours, and estimates of heights in harbours. CHS will collaborate with Coast Guard Staff to provide guidelines for SAR staff to operate safely during such an event, and advice for mariners to avoid death.

The Cascadia Subduction Zone will generate a severe earthquake and tsunami within the next few hundred years. The earthquake will be magnitude 7 to 8 or more, and the tsunami height along the west coast of Vancouver Island will be about 5 metres, and higher in some embayments. The last such earthquake, in A.D. 1700, set up a major tsunami that may have wiped out a native village in Pachena Bay.

Once completed, DFO will have the information it needs to predict the impact of such an event and develop action plans for its fleet, SAR staff and volunteers during a tsunami. It is expected that a well informed SAR crew will be able to safely survive a tsunami and be available for marine rescues.

This three-year project will be completed in 2003/2004.

Contact: William R. Crawford, PH.D., (250) 363-6369 *Project Number: n/a*