

GRAND BANKS OTTER TRAWLING IMPACT EXPERIMENT: II. NAVIGATION PROCEDURES AND RESULTS

D.L. McKeown and D.C. Gordon, Jr.

Science Branch
Maritimes Region
Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia B2Y 4A2
Canada

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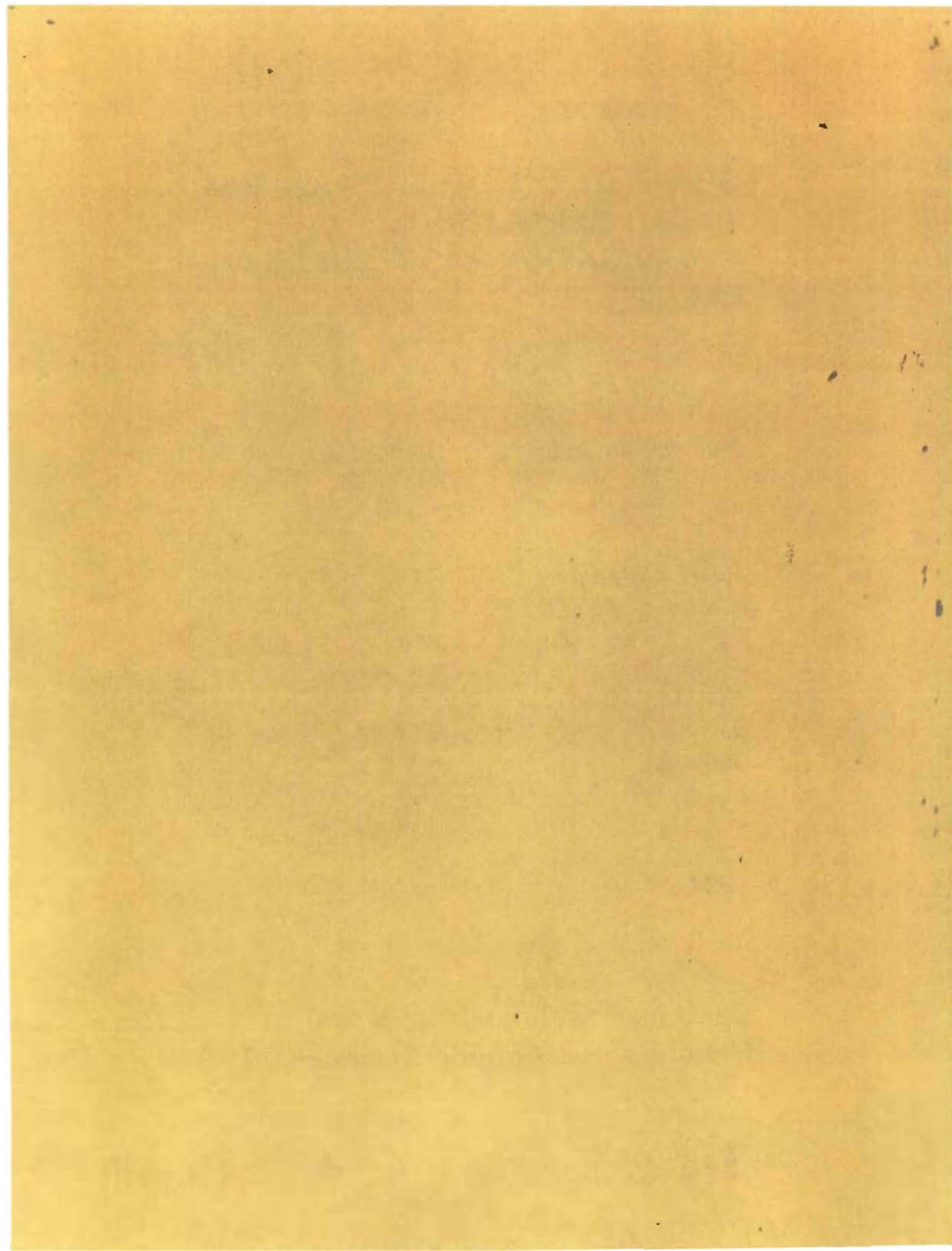
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by

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ABSTRACT

McKeown, D.L., and D.C. Gordon, Jr. 1997. Grand Banks otter trawling impact experiment: II. Navigation procedures and results. Can. Tech. Rep. Fish. Aquat. Sci. 2159: xi + 79 p.

In 1990 a collaborative research program between the Maritimes and Newfoundland Regions of Fisheries and Oceans Canada (DFO) was established to study the potential impacts of mobile fishing gear on benthic marine ecosystems in Atlantic Canada. It was decided early on that the best approach was to conduct carefully controlled field experiments in areas protected from fishing activity employing mobile gear in contact with the seafloor. These experiments would include initial seafloor surveys using different kinds of sensing and sampling equipment, intentional disturbance with a given type of mobile fishing gear, and follow-up seafloor surveys to assess the extent and duration of disturbance on both physical habitat and biological communities. In order to meet the operational requirement of this approach, it is absolutely essential to have precise navigation information on both the location of the seafloor disturbance and the relative position of all sensing and sampling equipment. The first offshore experiment in this program was conducted on the Grand Banks from 1993 to 1995 using an otter trawl. This report describes the navigational equipment (dGPS, Trackpoint II, AGCNav) and procedures that were used, summarizes data processing procedures, presents selected results, and explores the quality of the position fixes and methodologies employed. It is concluded that the accuracy of ship position using dGPS is on the order of 3 to 4 m at the Grand Banks experimental site. The position of the otter trawl as well as sensing and sampling equipment (sidescan sonar, BRUTIV, epibenthic sled, and video grab) relative to the ship was determined using Trackpoint II, and it is concluded that the accuracy of positions is on the order of 4 m near the ship and less than 20 m at a distance of 600 m. Therefore, it is possible to plot with a high degree of accuracy both the zone of disturbance and the location of samples. Analysis of the results confirms that all samples collected during the 3-yr experiment were obtained from disturbed or control areas as intended.

RÉSUMÉ

McKeown, D.L., and D.C. Gordon, Jr. 1997. Grand Banks otter trawling impact experiment: II. Navigation procedures and results. Can. Tech. Rep. Fish. Aquat. Sci. 2159: xi + 79 p.

En 1990, un programme de recherches concertées entre les Régions des Maritimes et de Terre-Neuve du ministère des Pêches et des Océans (MPO) a été mis sur pied en vue d'étudier les effets possibles des engins de pêche mobiles sur les écosystèmes benthiques du Canada atlantique. On a, dès le départ, décidé que la meilleure méthode consistait à effectuer des expériences contrôlées dans des endroits protégés contre les activités de pêche mettant en contact des engins mobiles avec le fond océanique. Il allait s'agir notamment de réaliser des levés préalables du fond marin au moyen de divers matériels de détection et d'échantillonnage, de créer des perturbations délibérées avec un type donné d'engin de pêche mobile et d'effectuer ensuite d'autres levés du fond marin pour évaluer la portée et la durée des perturbations sur l'habitat physique et sur la biote. En raison des exigences opérationnelles d'une telle méthodologie, il est absolument essentiel de disposer de données de navigation précises concernant tant l'emplacement des

biote. En raison des exigences opérationnelles d'une telle méthodologie, il est absolument essentiel de disposer de données de navigation précises concernant tant l'emplacement des perturbations sur le fond marin que la position relative de tout le matériel de détection et d'échantillonnage. La première expérience réalisée en haute mer dans le cadre du programme l'a été sur les Grands Bancs de Terre-Neuve de 1993 à 1995, au moyen d'un chalut à panneaux. Le présent rapport décrit le matériel de navigation utilisé (dGPS, Trackpoint II AGCNav) et la marche suivie, résume les méthodes de traitement des données, présente certains résultats et étudie la qualité des points de relevé et de la méthodologie utilisée. Il conclut que la précision de la position du navire fournie par le dGPS sur le site d'expérience des Grands Bancs est de l'ordre de 3 à 4 mètres. La position du chalut à panneaux ainsi que du matériel de détection et d'échantillonnage (sonars à balayage latéral, BRUTIV, traîne épibenthique et benne preneuse à vidéocaméra) par rapport au navire a été établie au moyen du système Trackpoint II. Le rapport détermine que sa précision est de l'ordre de 4 m près du navire et de moins de 20 m à une distance de 600 m de celui-ci. Par conséquent, il est possible de délimiter avec une grande précision la zone de perturbation et les sites d'échantillonnage. L'analyse des résultats confirme que tous les échantillons recueillis durant les trois années de l'expérience ont été obtenus dans des zones contrôlées ou perturbées, comme prévu.

INTRODUCTION

In 1990 a collaborative research project between the Maritimes and Newfoundland Regions of the Fisheries and Oceans Canada (DFO) was established to study the potential impacts of mobile fishing gear on benthic marine ecosystems in Atlantic Canada. The long-term objectives of this project are to develop new instrumentation for viewing and sampling marine benthic habitat in order to quantify its productive capacity, to obtain quantitative information on the impacts of mobile fishing gear on benthic habitat (both physical structure and biological communities) and to obtain quantitative information on the recovery rate of benthic habitat after disturbance by mobile fishing gear. Because of its multidisciplinary nature, the project has involved strong collaboration among numerous participants including the Habitat Ecology Section (Bedford Institute of Oceanography [BIO]), Ecology Section of the Groundfish Division (Northwest Atlantic Fisheries Centre [NAFC]), Ocean Science Division (BIO), Engineering and Technical Services Division (BIO), Geological Survey of Canada Atlantic (GSCA) (BIO), and numerous contractors in both Nova Scotia and Newfoundland.

The experiment was conducted with an otter trawl which is the most widely used mobile fishing gear in Atlantic Canada (Rowell et al. 1994a). An experimental site was chosen on the Grand Banks of Newfoundland centred at 47°10'N, 48°17'W (about 60 km north east of Hibernia) with an average water depth of 137 m. This site was selected because it had not been subjected to heavy trawling in the past decade, could be closed to all mobile gear for an indefinite period, has a medium-fine sand that is easy to process, and, most importantly, has an abundant and diverse community of benthic organisms, including a well developed assemblage of epibenthic forms (e.g. sea urchins, sand dollars, brittle stars, crabs, etc.) (Prena et al. 1996).

Three 13-km long experimental corridors, each with a different bearing, were laid out in a triangular pattern (Fig. 1). On three successive years (1993 to 1995), each corridor was trawled 12 times by the C.S.S. *Wilfred Templeman* using a rockhopper-equipped Engel 145 otter trawl. Biological samples were collected by the C.S.S. *Parizeau* from two of the corridors before and after each trawling episode, as well as from parallel control corridors established 300 m away from the experimental corridors (Fig. 1). Sampling locations for each group of samples were pre-selected on a random basis to ensure that the same area of the seafloor was not sampled twice during the 3-yr experiment.

The principal sampling equipment used was an epibenthic sled, extensively modified from an earlier design, and a video grab designed and built specifically for this project. More detailed descriptions of the sampling equipment and experimental design are provided by Rowell et al. (1994b; 1997). The biological results of this experiment will be presented in future publications. Sidescan sonar and BRUTIV video surveys were also run.

Accurate navigation information on both the trawling and sampling vessels was absolutely essential to meet the operational requirements of this experiment. First, it was necessary to determine as accurately as possible the exact path followed by the otter trawl as it was towed along on the seafloor during each pass so that the resultant zone of disturbance can be mapped. Secondly, it was essential to position the ship and sampling equipment so that biological samples can be collected from

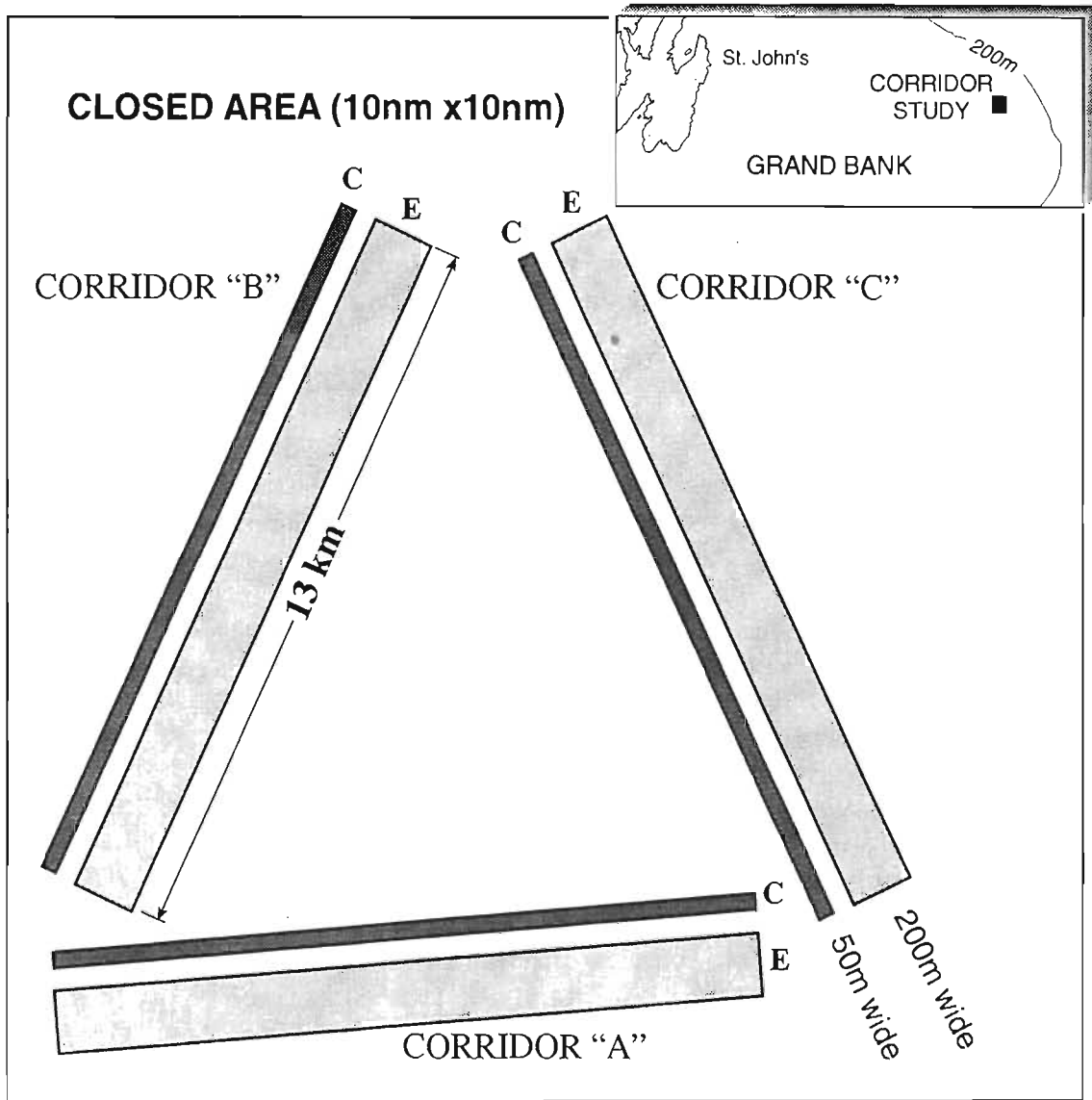


Figure 1. Map of the experimental site on the Grand Banks centred at $47^{\circ}10'N$, $48^{\circ}17'W$, and the layout of corridors. E is the experimental corridor, and C is the control corridor.

within very specific areas on the seafloor. Thirdly, it is important to confirm that sled and grab samples collected along experimental corridors did in fact come from the disturbed zones and, conversely, that samples along the parallel control corridors are collected from areas not influenced by trawling.

This report describes the navigational equipment and procedures that were used, summarizes data-processing procedures, presents selected results, and explores the quality of the position fixes and methodologies employed. Its purpose is to document the navigational component of this major project for our own benefit, as well as provide a moderate level of detail of what we did for others who may wish to conduct similar experiments in the future. Many of the procedures used in processing navigation data evolved during the 3-yr course of this experiment, and only the most recent are presented.

SAMPLING STATION SELECTION PROCEDURES

Each corridor was divided into 260 50-m segments (i.e. boxes) for sampling purposes. As the video grab samples only one-half a square meter and was deployed while the ship was holding station, only one box was designated for each grab sample. However, five contiguous boxes (i.e. a length of 250 m) were designated for each sled sample because the sled was deployed while the ship was moving at several knots, which reduced the accuracy of contact with the seafloor, and was towed along the bottom on the order of 50 m. Sled samples were identified by the number of the central box, even if they were collected in part from any of the five contiguous boxes.

Grab and sled samples were described by an identification code in the form “**mlnnnts**” where:

m	Corridor (A, B, or C)
l	Line (E=Experimental [trawled], C=Control)
nnn	Sequential box number along the line (000-260)
t	Type of sample (G=grab, S=sled)
s	Sampling event (1=before trawling on first mission, 2=after trawling on first mission, 7 = after trawling on last mission, etc.)

The sampling locations for each mission were randomly selected in advance using a program called SMPLSITE (see Appendix A). From 5 to 10 grab and from 2 to 10 sled samples were selected from each corridor for each sampling event. After three consecutive years of sampling, there were just a few sets of five contiguous unsampled boxes left in each corridor. Control samples were collected from parallel boxes on the control corridor immediately opposite the similarly numbered ones on the experimental corridor. SMPLSITE produces waypoint files which are compatible with AGCNav, the navigation display system used, and can be edited as necessary. Because the program utilises a random-number generator to select sample sites, it should only be run once at the beginning of the field program to produce a random sequence of grab and sled sites for sampling during all planned missions.

Also included in Appendix A are three additional programs which create waypoint files for use with AGCNav. SURVLINE generates a waypoint file for parallel sidescan survey lines on either side

of a baseline. BRUTLINE generates a waypoint file for survey lines displaced a specified distance to one side of the sidescan survey lines. TRNSCTWP generates a waypoint file for sample sites along a baseline, for example at set distances along a gradient in any direction away from a fixed point. While not available until after completion of the Grand Banks experiment, these additional programs have been included in this report because of their direct utility in future experiments planned for this project.

SHIP NAVIGATION

The C.S.S. *Parizeau* was equipped with a differential Global Positioning System (dGPS) on all missions. The dGPS receiver was a Magnavox 4200. During all missions, differential corrections were obtained via the StarFix system operated by John E. Chance & Associates and supplied by Seaforth Engineering Group Inc. (Dartmouth, N.S.). This provides real-time corrections from land-based monitoring stations by way of geostationary telecommunications satellites which, when incorporated with the GPS information, will produce ship positions to an accuracy of 5-10 m (D. Lombardi, private communication, March 16, 1994). Once a clear line-of-sight location for the shipboard satellite tracking antenna was found, the system worked very reliably. Ship position and related navigational information are available from the receiver in a number of different NMEA formats. Normally, the NMEA ship position data string **\$GPGGA** would be used. However, the version of this data string produced by the Magnavox 4200 is not updated if differential corrections are lost. Therefore, the Magnavox proprietary data string with the identifier **\$PMVXG,023** was selected because: in addition to latitude and longitude, this sentence contains a time tag; it automatically adjusts to the highest quality of position fixing (3-D differential, 2-D differential, etc.) that the receiver can achieve with the available inputs; and it contains information identifying the quality of the fix. It was normally logged at a 2-sec. rate.

In 1994 and 1995, experimental transmission of dGPS corrections from the Canadian Coast Guard's Cape Race, Newfoundland, medium-frequency beacon station was available almost continuously at the experimental site. As this represented a no-cost alternative to StarFix in the future, its availability, reliability, and quality was evaluated using a CSI model MBX-1 receiver. At the experimental site, there appeared to be an offset of about 10 m in an east/west direction between the dGPS positions as computed from corrections derived from each of these systems. The medium-frequency Cape Race transmissions were disrupted by electrical interference generated during storms, whereas the StarFix was unaffected. Otherwise, the former appeared to be as reliable as the latter. The former produced course-over-ground (COG) and speed-over-ground (SOG) information that was about twice as good as that derived from StarFix corrections. High quality COG and SOG information is especially helpful when conducting epibenthic sled tows.

A BayTech eight-channel serial multiplexer was used to merge the navigational data and distribute it about the ship as serial ASCII at 9600 baud. Examples of the most useful data strings are:

dGPS ship position data from the Magnavox 4200 receiver:

\$PMVXG,023,125247,4444.667,N,06134.168,W,00021.1,257.6,013.6,04,125246,04,1*76

(Note: When more modern dGPS receivers are used, the NMEA data string \$GPGGA should be recorded instead.)

Ship's heading from the autopilot;

\$AGHDT,259.,T

Ship's speed from a BEN Galatee Mk3 Doppler log;

\$VMN04,13.23,*58

Water depth from an Atlas LAZ4400 sounder;

\$SDDBS,0429.0,f,0131.0,M,071.0,F

ORE Trackpoint acoustic positioning system data.

3 08:06:58 160.9 3.2 1.0 -2.8 1.0 0.0 52

(Note: This is the data string produced by the Trackpoint II receiver and available as an input to the Baytech Multiplexer. AGCNav reformats it into the NMEA format with the identifier \$POREB before logging it.)

During the first year of the experiment, the C.S.S. *Wilfred Templeman* used Loran-C and non-differential GPS to navigate while trawling the corridors. During some of the tows, the C.S.S. *Parizeau* tracked the position of the trawl using the Trackpoint system (described below). It was observed that the trawl track occasionally wandered beyond the intended bounds of the experimental corridors (100 m either side of the centre line). During the 1994 operation, a dGPS system was installed on the C.S.S. *Wilfred Templeman*. This time, trawl tracking with the Trackpoint system by the C.S.S. *Parizeau* showed that the trawl track was very tightly constrained to near the centre line, and there was now some concern that the disturbance was not adequately distributed over the full width of the intended experimental corridors (200 m). Therefore, in 1995 the dGPS system was again used on the C.S.S. *Wilfred Templeman* and the ship purposely wandered back and forth across centre line to spread the trawling disturbance more widely in the experimental corridors.

AGCNav NAVIGATION DISPLAY AND LOGGING SYSTEM

AGCNav is an IBM compatible (PC) computer-based navigation display and logging program specifically developed for marine scientific surveying and sampling. It accepts input from a range of navigation devices providing they present data in a NMEA format. It also accepts data from the Trackpoint II acoustic tow fish positioning system and several other sensors. It produces a versatile display of the positions of the ship and up to six different acoustic targets simultaneously in real time in either a classic chart-like mode for sampling and conventional ship's navigation or in a line-following mode which is useful when running survey lines. Important data such as day, time (GMT), ship position, heading, and speed are displayed as text alongside the graphical information. Operations such as logging a fix or changing the display format or scale are accomplished with simple key strokes. Multiple independent displays can be set up throughout the ship by connecting additional PC's to the navigation data network.

AGCNav maintains and utilises a data base of waypoints and survey lines. Each waypoint entry consists of an identifier or label and a position. The user can construct or modify waypoint files containing sample locations, survey line endpoints or destinations using either the waypoint editor contained within AGCNav or an external text editor. Fixes (i.e. current ship position) can be added to this data base at the press of a single key. Once created, the waypoint data base can be used to set up a pattern of sequential survey lines.

Initializing and operating the software by pull-down menus is intuitive but does require some training and experience. When the program is first used, a set-up procedure must be carried out to define serial port communication parameters, antenna position, parsing of NMEA navigational data, sentences to be logged, etc. This information is saved in a computer file (AGCNAV.INI) which is updated whenever any changes are made to the set-up. At any future time when AGCNav is restarted, the program initially defaults to these settings. (Refer to Appendix C for more specific set-up and operating instructions.)

AGCNav has the capability of logging incoming navigational data. The operator can define which incoming data sentences are to be logged and at what frequency. The program automatically creates a logging file named "**ssssdddA.yyE**" where:

ssss	Ship identifier (e.g. PARI for the C.S.S. <i>Parizeau</i>)
ddd	Julian day (e.g. 175)
yy	Year (e.g. 95 for 1995)
E	Indicates file contains "E-type" or NMEA formatted data

Each new line of data is appended to this file throughout the day, and then the file is closed to preserve the integrity of the data. If the program is shut down and then re-started on the same day, new data will be appended to the original file. It automatically starts a new data file when the day changes (i.e. 0000 GMT).

AGCNav was developed at the Atlantic Geoscience Centre (now the Geological Survey of Canada Atlantic [GSCA]) in 1992 by D. Heffler and R. Currie. The code was written under contract by Coldwell Consulting. Four field seasons of extensive testing, modification, and operational experience have led to a very reliable and robust program. XON Digital (Dartmouth, N.S.) now own, maintain, and market the program. It is used by GSCA and has been installed on several Fisheries and Oceans Canada ships. More details of its functionality and operation are described in the AGCNav manual (Anon. 1994).

AGCNav proved to be a key ingredient in the successful conduct of the Grand Bands otter trawling impact experiment. The video display was used by the quartermasters to manoeuvre the ship onto the specified video grab and epibenthic sled stations and to follow sidescan sonar and BRUTTV survey lines. It was used by the scientific staff to direct sampling operations, log all the navigational information, and monitor the position of the trawl being towed by the C.S.S. *Wilfred Templeman*.

The following practices were adopted during the 3-yr experiment to ensure data integrity and reduce navigational errors:

1. All waypoint files were prepared by the scientific staff and then transferred to the bridge computer by floppy disk. This procedure ensured that both scientific and ship's personnel were working from the same data base.
2. The waypoint data base was saved to disc several times each day to ensure that editorial changes and additional fixes were permanently recorded.
3. Logged navigation data files were backed up on floppy disk on a daily basis. The size of the data files depended upon the number of strings and logging intervals selected. Those files exceeding floppy disk capacity (1.4 MB) were condensed before copying using PKZIP, a commercially available file compression utility. Occasionally the size of the compressed file exceeded the capacity of a floppy disc or it was necessary to save an uncompressed version of a large file to a floppy disc. In these circumstances, the program SPLTFILE (Appendix A) was used to subdivide the original data file into manageable segments.

TRACKPOINT II

The position of towed gear was determined using an ORE International Inc. Model 4410C Trackpoint II integrated, ultra-short baseline acoustic tracking system. It presents the user with a graphic display of the position of the target relative to the ship. The system is microprocessor-based and consists of a hydrophone boom assembly, an interconnecting deck cable, and a command/display module located in the ship's laboratory. The beacon (acoustic target) is a self-contained transponder module mounted on the gear being deployed. The rechargeable batteries originally supplied with the beacons were replaced by manganese-alkaline ones which extended the operating life to well beyond an entire mission.

The hydrophone was installed on the bottom of a very substantial faired, aluminum boom secured on the ship's side. The boom can be rotated out of the water to a horizontal position when not required and can be lifted in board while at sea in anticipation of heavy weather. Because of the structure of the hydrophone, ship's speed was limited to 6 knots when it was deployed. During the 1993 operations, the boom was mounted on the starboard side of the foredeck rail where it interfered with sampling gear cables. For Mission 93-029, a protective cage was fitted around the hydrophone. After the mission, ORE engineers warned that this cage would seriously affect the bearing measurements, so it was removed. The boom was then permanently moved to the port side of the ship at the location indicated in Figure 2 where it was well clear of all over the side operations. Details of installation and operation of the hydrophone boom are contained in Appendix D.

In order to establish the maximum workable range at normal survey speeds, the ship conducted ranging trials on a sea floor transponder. Table 1 summarizes the results of two pairs of runs at about 3 knots with the transponder both ahead and astern of the ship. At all distances up to the maximum useful range, most interrogations were successful and resultant range and bearing data were acceptable. The maximum useful range in all cases exceeded the manufacturer's specification of 1000 m.

Prior to Mission 93-029, the hydrophone was enclosed in a cage to protect it

TABLE 1. Maximum working range of Trackpoint II.

Source direction	Speed (knots)	Max. useful range (m)
Astern	3.6	1045
Astern	3.1	1400
Ahead	3.5	1500
Ahead	2.7	1300

The Trackpoint II system measures the direction of the acoustic beacon with respect to its internal reference axis. This is converted to a geographical reference frame by adding to it the ship's heading. Therefore, each time the transducer assembly is installed, its reference direction must either be set parallel to the ship's fore/aft axis or a correction established and applied. The former is preferred as being less prone to error or omission. To facilitate this adjustment, an ability to rotate the boom through a small angle has been incorporated into the top of the boom assembly. The adjustment is best done while the ship is alongside in spite of the problems caused by reflections of the acoustic signals from the nearby seafloor and pier structure. The boom is first deployed in the vertical position. An acoustic beacon is then lowered to a convenient depth on a weighted line from the bow, stern, and at two points along the ship's side about 15 m forward and aft of the boom. At each location, about five minutes of relative bearing measurements are recorded to a disc file using a communications program such as MIRROR. Each of these data sets is edited to remove outliers usually caused by reflections

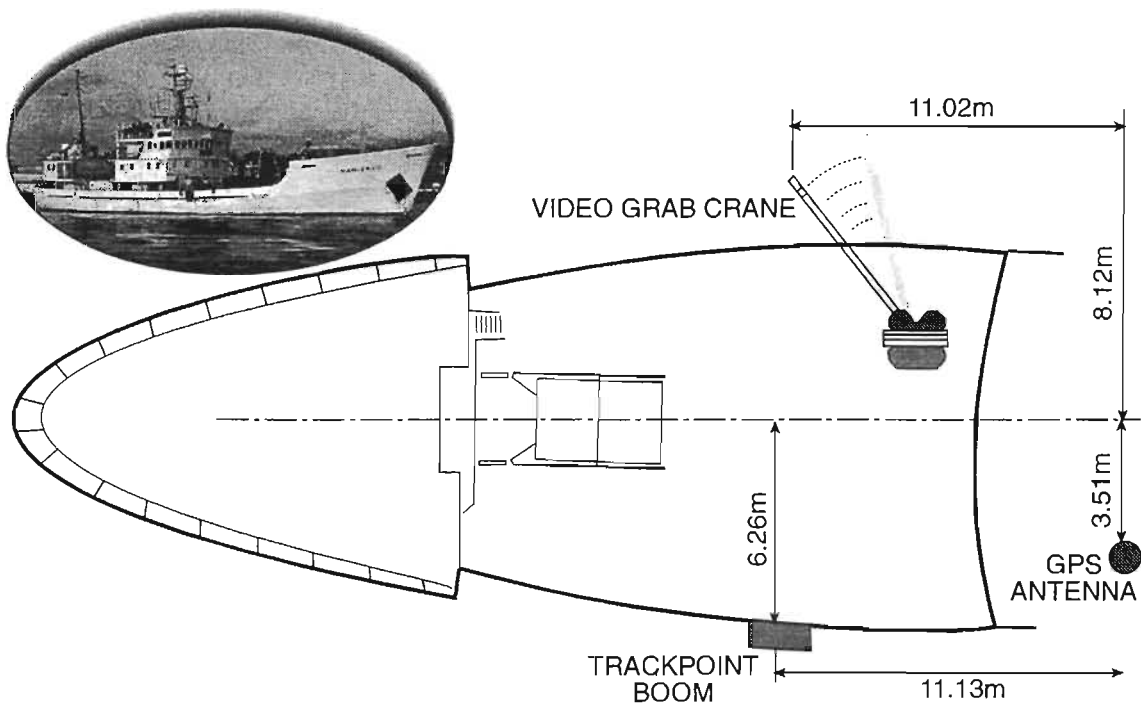


Figure 2. Plan of the C.S.S. *Parizeau* showing the relative positions of the Trackpoint boom, the GPS antenna, and the crane used to handle the video grab. Prior to 1994, the Trackpoint boom was located on the starboard side.

from nearby structures. The mean of each edited relative bearing data set is computed and compared to the actual relative bearing that should have been observed according to the physical geometry. If the differences are not zero, the reference direction of the boom is adjusted accordingly and the process repeated until agreement is achieved.

During positioning operations at sea, the following settings were usually employed on the Trackpoint receiver. (Refer to Appendix C for more specific set-up and operating instructions.)

1. All geometrical offsets were set to 0.0
2. The transponders were interrogated at a 2-sec. interval
3. Smoothing: OFF; Filter Level: LOW; Threshold: LOW
4. Format-3 position data (error-corrected beacon number, bearing relative to the ship, slant range, etc.) was selected for merging into the ship's navigation data network. Each AGCNav station on the network converts this to a pseudo-NMEA string with the identifier \$POREB. The position of the transponder is then calculated by AGCNav and saved in the navigation file as a text string with the identifier \$POREP. This text string is not time tagged but always follows immediately after the corresponding \$POREB string.

During the first trawling event (1993), a transponder was put on the headline of the otter trawl towed by the C.S.S. *Wilfred Templeman* and tracked by the C.S.S. *Parizeau* on all 12 passes along Corridor A and for six passes along Corridor B. Acoustic interference of unknown origin, but suspected to have originated onboard the C.S.S. *Wilfred Templeman*, prevented tracking the final six passes along Corridor B. For the second trawling event (1994), a Trackpoint system was mounted on the C.S.S. *Wilfred Templeman*, along with dGPS, with the intention of tracking all trawl passes; but unfortunately it did not perform. On this occasion, the source of the problem was clearly identified as acoustic noise radiating from the ship. However, the C.S.S. *Parizeau* was able to track six of the 12 passes along Corridor B during the evening hours; and this data base was used to see how closely the headline of the otter trawl followed the path of the C.S.S. *Wilfred Templeman* (see below). No attempt was made to install Trackpoint on the C.S.S. *Wilfred Templeman* for the third trawling event (1995), but again the otter trawl was tracked by the C.S.S. *Parizeau* for four passes along Corridor A and three passes along Corridor B. While there were specific incidents of ambient noise interference, for the most part the Trackpoint system on C.S.S. *Parizeau* seemed to have no problem communicating with the transponder on the trawl headline at ranges out to nearly 1000 m. The Scanmar net mensuration system was in operation on the C.S.S. *Wilfred Templeman* but did not cause any interference.

The difficulty of operating the Trackpoint system on board the C.S.S. *Wilfred Templeman* was of some concern because future plans in this project could include carrying out a similar experiment using its sister ship, the C.S.S. *Alfred Needler*. Both ships were known to be very acoustically noisy when first delivered. Recently, the C.S.S. *Alfred Needler* had a new propulsion system installed. Science users subsequently reported that the noise problem appeared to be substantially reduced,

although no quantitative information existed. Therefore, an investigation of acoustic noise on the C.S.S. *Alfred Needler* was carried out in January 1995 (McKeown 1995) (Appendix E). In summary, it appears as though the Trackpoint system should function satisfactorily on the C.S.S. *Alfred Needler*.

There were periods during operations when acoustic noise apparently generated by the C.S.S. *Parizeau* caused problems. In all cases, this was restricted to only one or two of the 18 channels available on the Trackpoint system. To address this problem, an operational procedure was established which would identify the best channels to use. The Trackpoint receiver was turned on and set up as follows:

1. Interrogation off
2. Min Range set to 10 m
3. Depth set to 1 m
4. Filter/Smoothing/Threshold set to Off/Low/Low
5. Select beacon frequency (such as 22 kHz)
6. Turn its Tracking ON

By observing the red light at the upper left corner of the Trackpoint display screen and listening to the audio signal, one can quickly learn whether or not the selected channel is useable. The process is then repeated for each channel or frequency of interest. A more quantitative approach is to log 5 min. of raw Trackpoint data output from each channel to a computer file using a communication program such as MIRROR. A text editor can then be used to determine the number of false replies during this period for each channel. This exercise was done on two occasions, 24-h apart, during the 1994 mission with very similar results. The results of one set of such observations are shown in Table 2. They indicate that the 25 and 28 kHz channels were noisy, a conclusion very consistent with operational experience at the time.

TABLE 2. Example of Trackpoint channel noise measurement when deployed from the C.S.S. *Parizeau*.

Frequency (KHZ)	Number of random fixes recorded
22	5
23	1
24	0
25	159
26	0
27	0
28	153
29	0
30	0

Because the epibenthic sled is several hundred metres behind the ship while sampling, the Trackpoint system was used to position all tows to verify that the samples were collected within the designated sampling boxes and disturbed area. It was also used to position the video grab for the initial part of the first mission, but this practice was discontinued when the grab cable fouled on the hydrophone boom (mounted at that time on the starboard side) and suffered damage. Trackpoint was also used to position the sidescan sonar towfish and BRUTIV on several occasions.

The Trackpoint receiver video monitor displays the beacon positions relative to the ship (i.e. hydrophone position). AGCNav can be used to display these in a geographic frame of reference. However, it is important to bear in mind that the beacon position displayed on AGCNav will default to the ship position if the measured slant range (i.e. ship/beacon distance) is less than the beacon depth entered manually within the Trackpoint receiver. Operationally, this is a common occurrence when using the epibenthic sled as the beacon depth was normally set to the water depth. When the sled was lowered to the seafloor, its displayed position would remain alongside the ship but then suddenly jump out to its correct location when the slant range exceeded the set depth.

The Trackpoint system produced excellent relative bearing and slant range data throughout all operations so long as reasonable attention was paid to minimizing the effects of ambient acoustic noise. An example of slant range and bearing time series data during a typical sled operation is shown in Figure 3. Acoustic noise generated by the ship's bow thruster and screws can cause spikes, especially in relative bearing; and in the worst case signals from the beacon could be obliterated. If noise does become a problem, resetting the Minimum Range value for the beacon in question to a more appropriate value is often a simple cure.

Much of the foregoing discussion of Trackpoint II system noise problems may suggest that its use during the trawl impact experiment might be a questionable decision. However, on the contrary, actual field experience over a 3-yr period has engendered much confidence in the system. For example, on one occasion two beacons were placed adjacent to each other on the head rope of the trawl. The Trackpoint system alternately interrogates each transponder at 2-sec. intervals, so it was not possible to simultaneously obtain fixes on both beacons. However, because the ship tracking the trawl was maintaining a position approximately abeam of the beacons at a range of about 300 m and the relative speed was nearly zero, small differences in interrogation times can be ignored. Thus, for the purpose of this analysis, fix pairs within 6 sec. were utilized, and only those for which the relative bearing difference was less than 3.0° and the slant range difference was less than 20 m were selected. This produced a data set of 2,000 fix pairs. The relative bearing and slant range correlation indices (R^2) were 0.98913 and 0.9976 respectively. When the geographic positions of the two beacons were computed from this data set and compared, the mean difference in position was 1.058 m. The accuracy of the positioning system is addressed more fully in the Data Quality section later in this report.

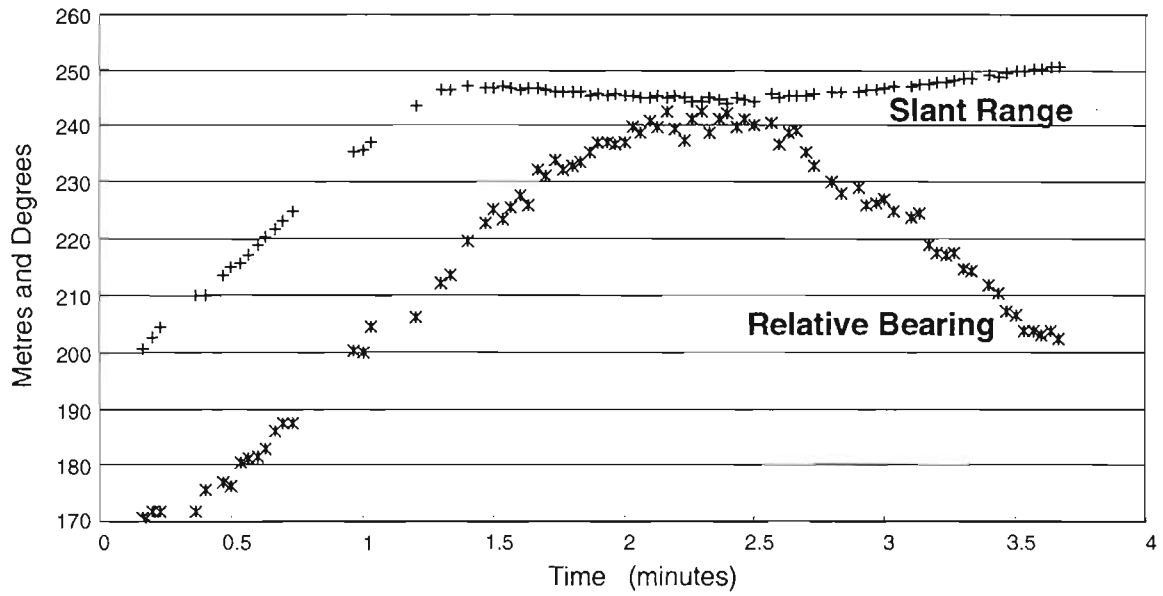


Figure 3. “As logged” relative bearing and slant range time series Trackpoint data for Epibenthic Sled Tow AE187S5, Mission 94-015.

DATA PROCESSING AND RESULTS

DATA FILE-NAMING CONVENTIONS

GSCA has developed a file-naming convention which has been followed during this experiment. The format of the navigation data file name (e.g. PARI192A.95E) has already been described above. As noted, the original logged navigation data file is considered to be an "E-type" file because it is in the standard comma-delimited NMEA format where each data line commences with a six-character identifier beginning with the symbol "\$." File names in this format always terminate with the letter "E." "A-type" formatted files were the other type of data file used during these experiments. They are produced using a program called ETOA (Appendix B). These are chronological listings of day/time, decimal latitude (S negative), and decimal longitude (W negative). Their filenames always end with the letter "A." Examples of each follow:

E-type Data File:

```
$AGHDT,259.,T
$PMVXG,000,ALT,0,0,0000,0*0D
$GPGLL,4444.6675,N,06134.1684,W,*5C
$SDDBS,0429.0,f,0131.0,M,071.0,F
$GPGGA,125246,4444.6675,N,06134.1684,W,1,6,01,021,M,-21,M*6B
$GPVTG,257.6,T,,013.6,N,,*4A
```

A-type Data File:

```
168220311 43.289257 -65.120567
168220314 43.289272 -65.120548
168220316 43.289283 -65.120535
168220318 43.289290 -65.120518
168220320 43.289295 -65.120507
```

EXTRACTING, EDITING, AND PLOTTING NAVIGATION DATA

The first step in data processing is to extract the desired subset of data from the AGCNav E-type navigation file for the day in question (e.g. PARI175A.95E). In the case of compressed files, the appropriate decompression utility must first be used (e.g. PKUNZIP). Data extraction is done using one of two different procedures depending on what end result is required.

If dGPS ship positions or a complete subset of all data for a portion of the day in question is required, a program called EXTRACT is used (see Appendix A). This program will copy to a new file all data sentences logged between the user-specified start and end times. If the ultimate objective is to plot the ship track, the extracted E-type data is next converted to an A-type file via the program ETOA

and then plotted using APLOT (see Appendix B). dGPS ship positions rarely require any editing, as spurious values are rare.

Trackpoint navigation data are extracted from E-type files using a program called 2POREM (see Appendix A). As originally logged, the Trackpoint fix string (\$POREB) is tagged with a time derived from the receiver's internal clock. This usually bears little resemblance to the correct time. Therefore, it is adjusted to dGPS time in the string \$POREM using adjacent ship fixes to establish a correction. Two output formats are available. All the information relevant to a Trackpoint fix contained in different NMEA strings (e.g. ship position, ship heading, Trackpoint receiver output, etc.) can be condensed into a single comma-delimited NMEA data string which begins with the identifier \$POREM. Alternatively, a data file of geographic positions of the acoustic beacon can be generated in the A-type format of day/time, decimal latitude, and decimal longitude which can then be plotted directly by APLOT. However, this is rarely advisable as Trackpoint data tend to have numerous spikes and sequences of successive bad fixes that must first be removed.

The Trackpoint data time series may be edited by using either one of two programs. The first program, TRKPTEDT, automatically deletes all slant ranges and relative bearings that fall outside operator-controlled limits. Once the data have been edited, a smoothed version of each slant range and relative bearing is saved to the output file. The Trackpoint fix must then be recalculated from this smoothed data either by using the program CALC_FIX or AGCNav. TRKPTEDT requires only minimal user time and effort but, under some circumstances, may delete good as well as bad fixes. A special version of this program, SMTH_DIF, was created to deal specifically with the trawl position data.

The second program, EDITDATA, sequentially displays segments of the slant range or relative bearing time series data and allows the operator to delete or flag individual outliers using a mouse. The edited data including the geographic beacon position as originally computed by AGCNav are written to a new file in the same format as the input file. Edited E-type files of Trackpoint \$POREM data sets can be converted to A-type files using a program called M_TO_A. Additional information on all these programs can be found in Appendix A. Once the Trackpoint fixes have been edited, recomputed (if necessary), and converted to an A-type format file, they can be plotted using APLOT (Appendix B).

POSITION OF OTTER TRAWL RELATIVE TO THE C.S.S. *WILFRED TEMPLEMAN*

Unfortunately, as described above, Trackpoint data giving the exact path of the otter trawl on the seafloor are not available for all trawling events. Therefore, in order to estimate the width of the disturbance zone when these data were not available, it was necessary to determine how closely the trawl followed the course of the C.S.S. *Wilfred Templeman*. If close, then ship position could be used as a proxy for trawl position.

This was done using the data sets collected in 1994 and 1995 when the C.S.S. *Wilfred Templeman* was equipped with dGPS (and navigation were logged) and the C.S.S. *Parizeau* tracked the trawl using Trackpoint for six tows along Corridor B in 1994 and four tows along Corridor A plus

three tows along Corridor B in 1995. These 13 data sets were analysed by a program called TRWL_FIX (see Appendix A). In brief, it first edits out bad Trackpoint fixes of trawl position by comparing the measured position to that estimated from the position of the C.S.S. *Wilfred Templeman* and an estimated layback (the distance the transponder on the trawl is behind the ship) and then deleting those fixes where the difference exceeds a pre-set distance (e.g. 100 m). It then creates a data file of edited Trackpoint fixes or a file of ship and trawl cross-track positions and trawl layback as a function of distance along the corridor from the Start-Of-Line (SOL). This latter format is suitable for further analysis and plotting via the aforementioned program SMTH_DIF.

In 1994, the C.S.S. *Wilfred Templeman*, equipped with dGPS, stayed very close to the centre line of experimental corridors, most of the time well within 20 m, while the trawl was consistently set to port on the order of 20-35 m relative to the ship (Fig. 4). The direction of towing along the corridor made no difference to the offset, indicating that it was due to how the trawl was deployed and not current and/or waves. It was later confirmed that one warp of the otter trawl was slightly longer than the other. Layback was somewhat variable but was usually in the range of 410-460 m (Fig. 5). The reasons for this variability were examined in detail to determine whether it might reflect errors in the navigation data. The variability was found to be real and presumably caused by automatic tension adjustments to the trawl warp made on the C.S.S. *Wilfred Templeman*.

Very similar results were obtained in 1995, even though new warps had been installed and the automatic tension adjustment equipment removed from the C.S.S. *Wilfred Templeman*. The ship wandered further away from the centre line as it deliberately steered a sinusoidal course in order to distribute the trawling disturbance more widely (Fig. 6). Again, the trawl was consistently displaced to the port on the order of 15-30 m relative to the ship regardless of the direction towed. Layback was on the order of 490 m and relatively constant (Fig. 7).

Therefore, it appears that one warp was slightly longer or that there was some slight imbalance in the trawl itself. While easily measured because of the technology available, this consistent displacement to port of 15-30 m is actually quite minor and only amounts to 25-50% of the distance between the trawl doors. It is concluded that dGPS ship positions can be used if necessary to estimate the position of the trawl headline during the 1994 and 1995 trawling events as long as it recognized that the trawl is actually positioned slightly to port. As corridors were trawled in both directions, the actual width of the disturbance zone will be on the order of 30-60 m greater than estimated from ship position.

DETERMINING THE POSITION OF DOOR TRACKS

In order to plot the width of the area on the seafloor potentially disturbed by trawling along the experimental corridors, it is necessary to estimate the path of the trawl doors which mark the outer limits of trawl influence. This was done using a program called TRWLLMTS which generates an A-type navigation file of estimated trawl door positions based on the assumption that the door is offset a specified distance to one side of the transponder position on the trawl headline in a direction perpendicular to the mean azimuth of the corridor (see Appendix A). If Trackpoint fixes of the mid-point of the trawl are unavailable, the program will assume this position is represented by the

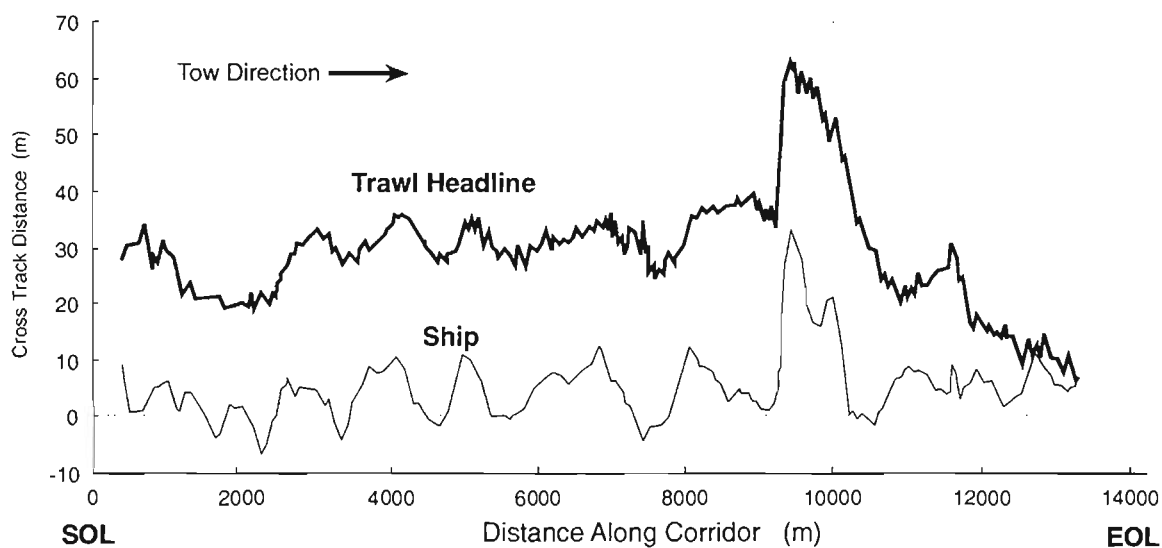


Figure 4. Cross-track deviation of the C.S.S. *Wilfred Templeman* and the otter trawl headline from the experimental corridor axis during Tow 1 along Corridor B in 1994. The ship was steaming from Start-Of-Line (SOL) to End-Of-Line (EOL).

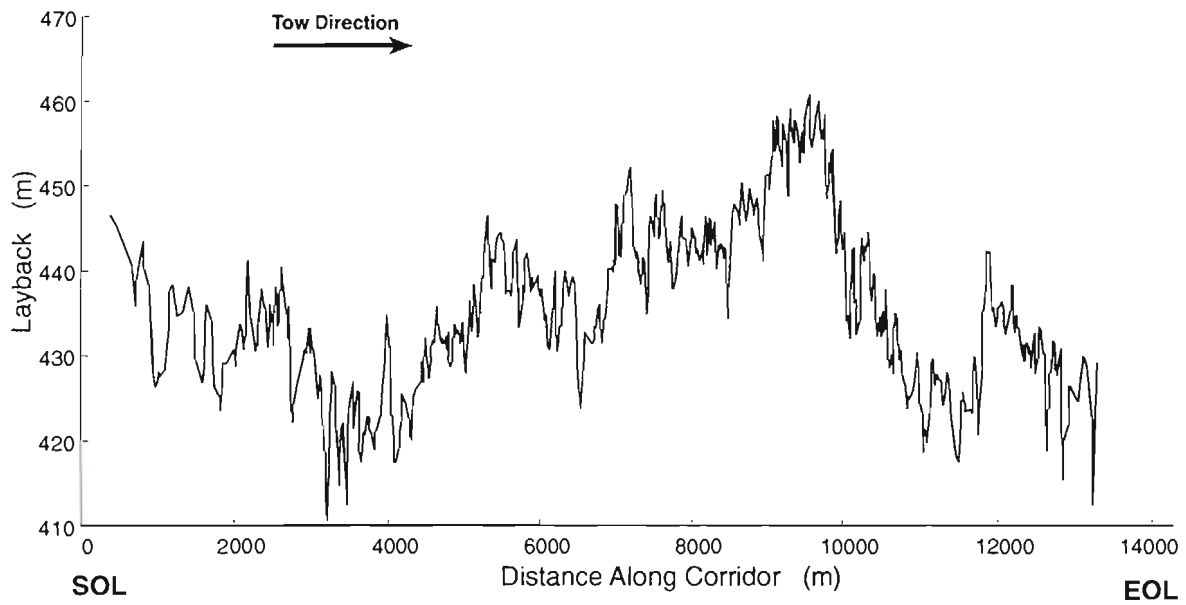


Figure 5. Layback of the otter trawl headline from the C.S.S. *Wilfred Templeman* during Tow 1 along Corridor B in 1994. The ship was steaming from SOL to EOL.



Figure 6. Cross-track deviation of the C.S.S. *Wilfred Templeman* and the otter trawl headline from the experimental corridor axis during Tow 4 along Corridor A in 1995. The ship was steaming from EOL to SOL.

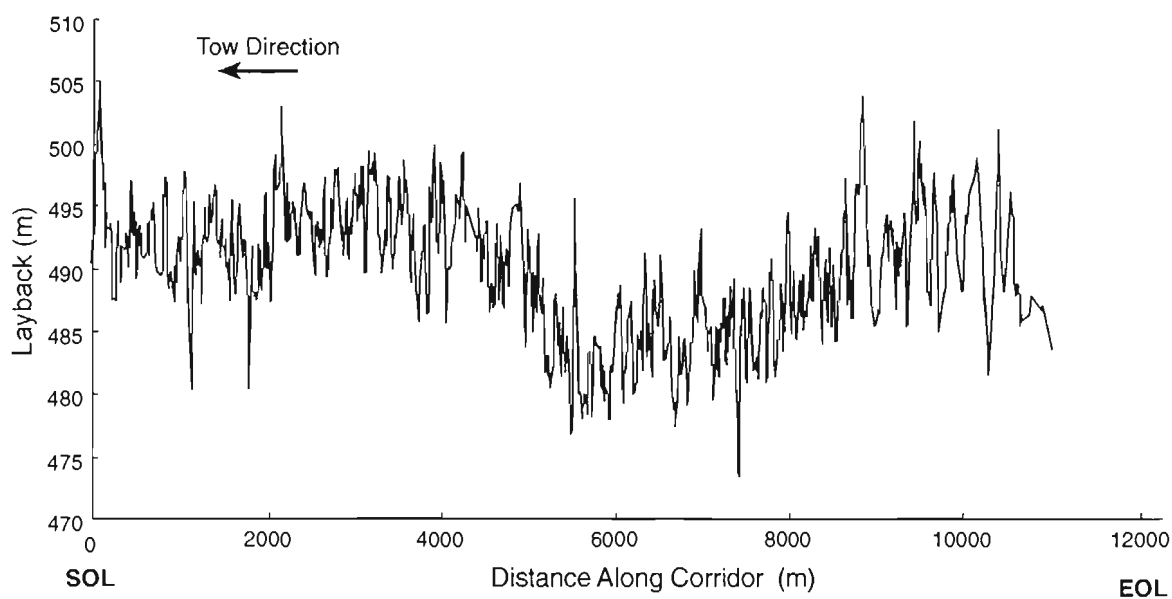


Figure 7. Layback of the otter trawl headline from the C.S.S. *Wilfred Templeman* during Tow 4 along Corridor A in 1995. The ship was steaming from EOL to SOL.

corresponding ship position. As the spread of the doors for the Engel 145 otter trawl used in these experiments averaged 60 m, an offset of 30 m was applied. Only one door track can be calculated at a time, but the two output files can be concatenated to give both port and starboard door tracks for plotting with APLOT.

Trawl door tracks were plotted for each trawling disturbance using the navigation data sets shown in Table 3.

TABLE 3. Navigation data sets used to estimate the path of trawl doors on the seafloor.

Year	Corridor	Data set
1993	A	Trackpoint data, all 12 tows
	B	Trackpoint data, 6 tows
	C	No data
1994	A	Ship data, all 12 tows
	B	Trackpoint data, 6 tows
	C	Ship data, all 12 tows
1995	A	Ship data, all 12 tows
	B	Ship data, all 12 tows
	C	Ship data, all 12 tows

The most accurate data set is for Corridor A in 1993, which has Trackpoint fixes for all tows. Trackpoint data for Corridor B in 1993 and 1994 probably underestimate the width of the disturbance zone because they include only half the tows and the other tows may have wandered further afield. Data for Corridor A in 1994 and both corridors in 1995 definitely underestimate the width of the disturbance zone, as they are based on ship position and it is known that the trawl was consistently set to port (Fig. 4 and 6).

The actual width of the disturbance zone created each year by the otter trawl was estimated by reading the distance between the outer most door tracks off a hard copy plot of each grab and sled sample generated by TRK_PLT (see Fig. 8 to 12 for examples). More details on using TRK_PLT are provided below. These data are summarized in Table 4.

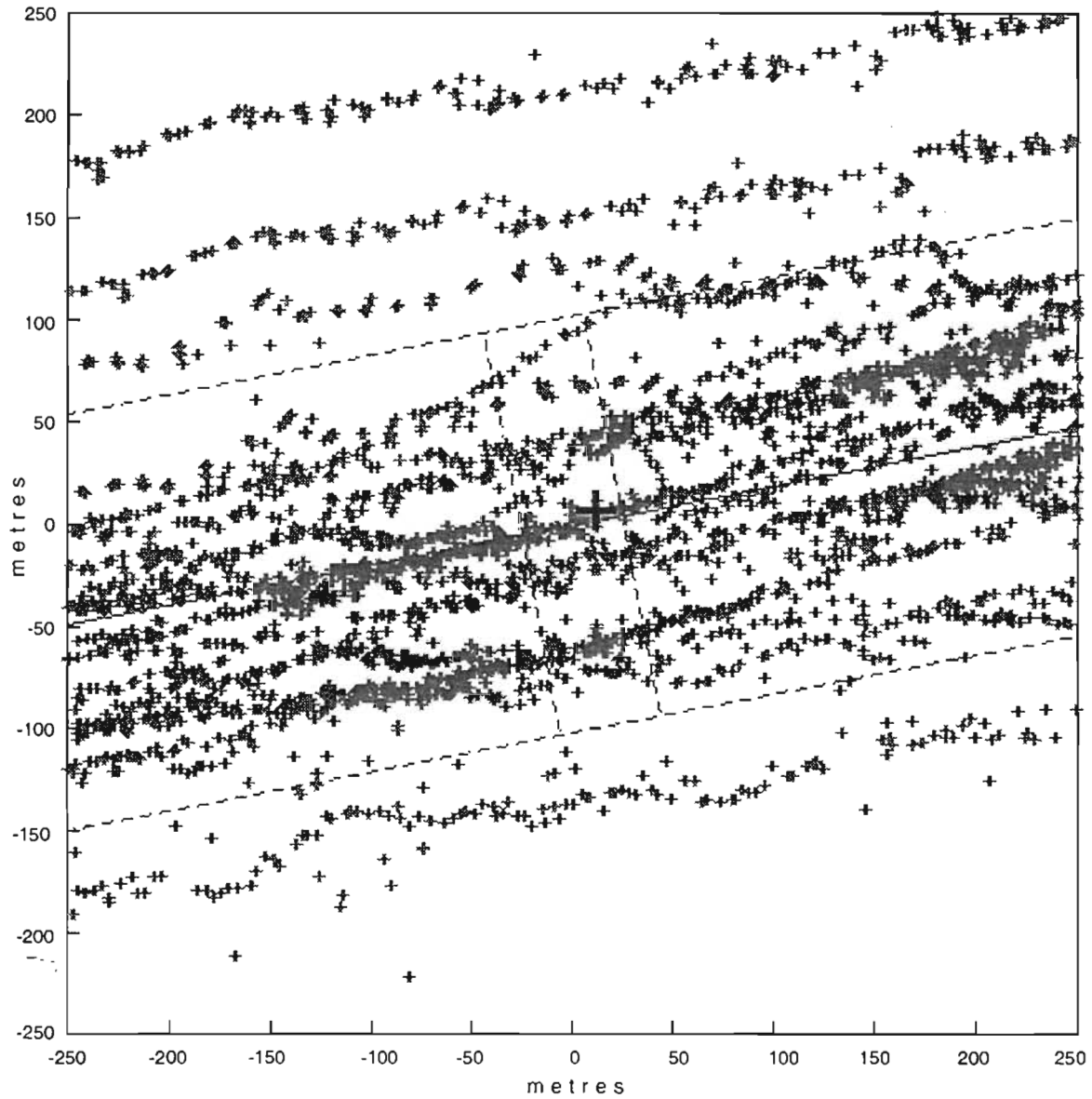


Figure 8. Estimated path of trawl doors from the 1993 trawling event at a representative site along Corridor A based on Trackpoint navigation data. The cross marks the location of Grab Sample AE022G2. The three parallel lines denote the axis (solid) and outer bounds (dashed) of the corridor. The orthogonal pair of dashed lines denote the along-track box boundaries.

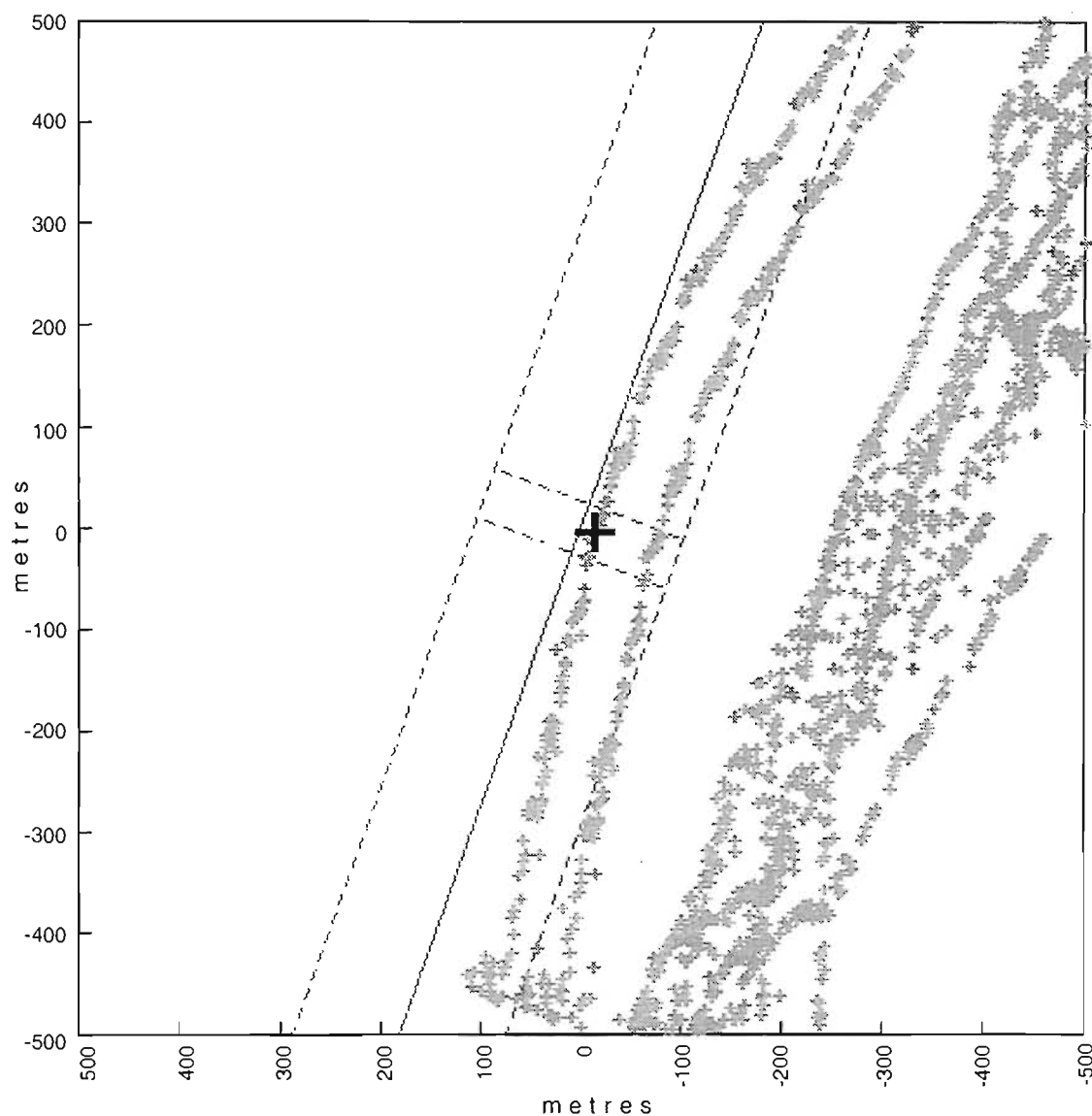


Figure 9. Path of errant otter trawl tow that wandered over into the control corridor at the start of Corridor B in 1993. The cross marks the location of Grab Sample BC017G4 (collected in July 1994) which may have landed in the door track. The three parallel lines denote the axis (solid) and outer bounds (dashed) of the corridor. The orthogonal pair of dashed lines denote the along-track box boundaries.

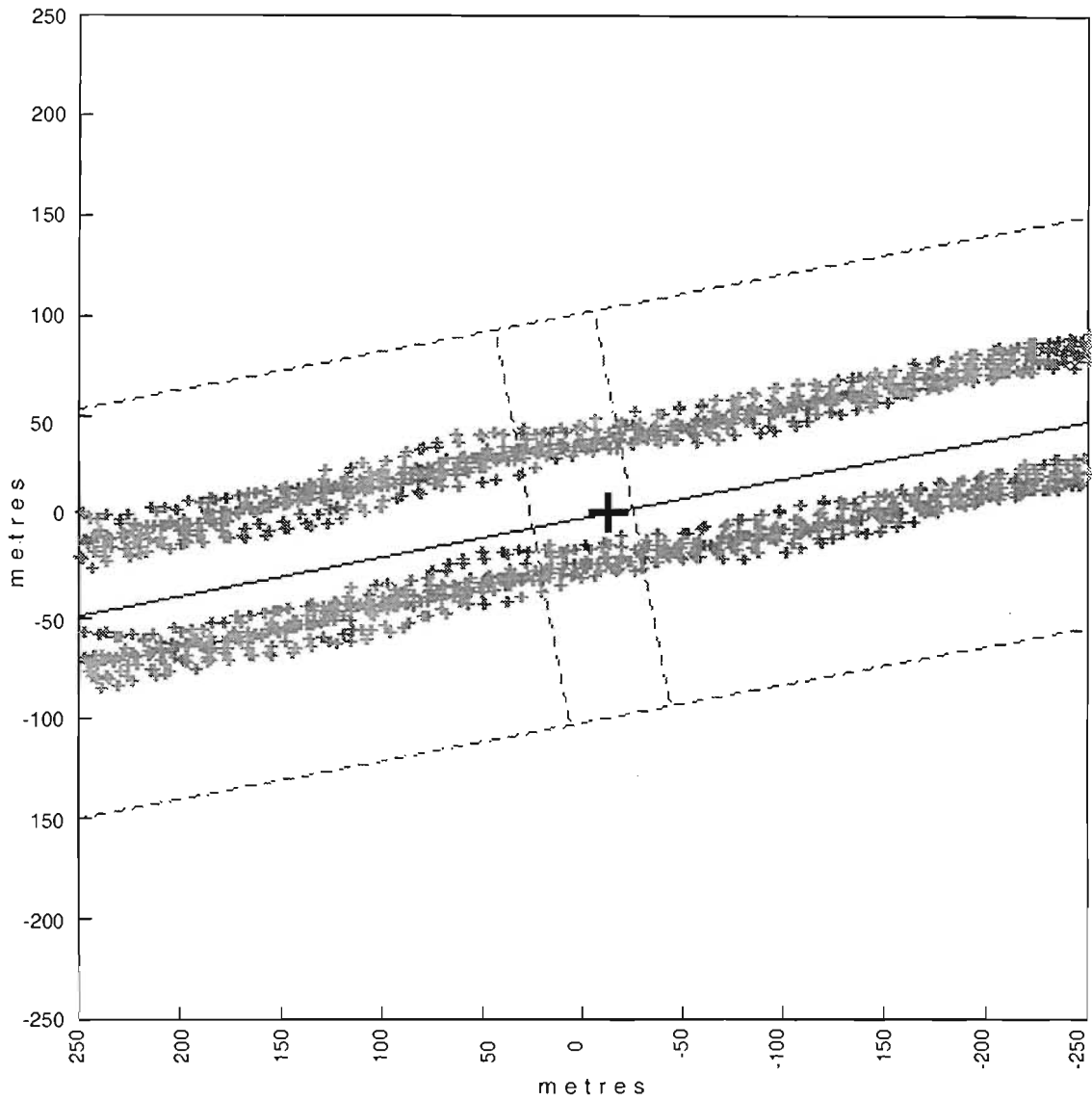


Figure 10. Estimated path of trawl doors from the 1994 trawling event at a representative site along Corridor A based on ship navigation data. The cross marks the location of Grab Sample AE101G5. The three parallel lines denote the axis (solid) and outer bounds (dashed) of the corridor. The orthogonal pair of dashed lines denote the along-track box boundaries.

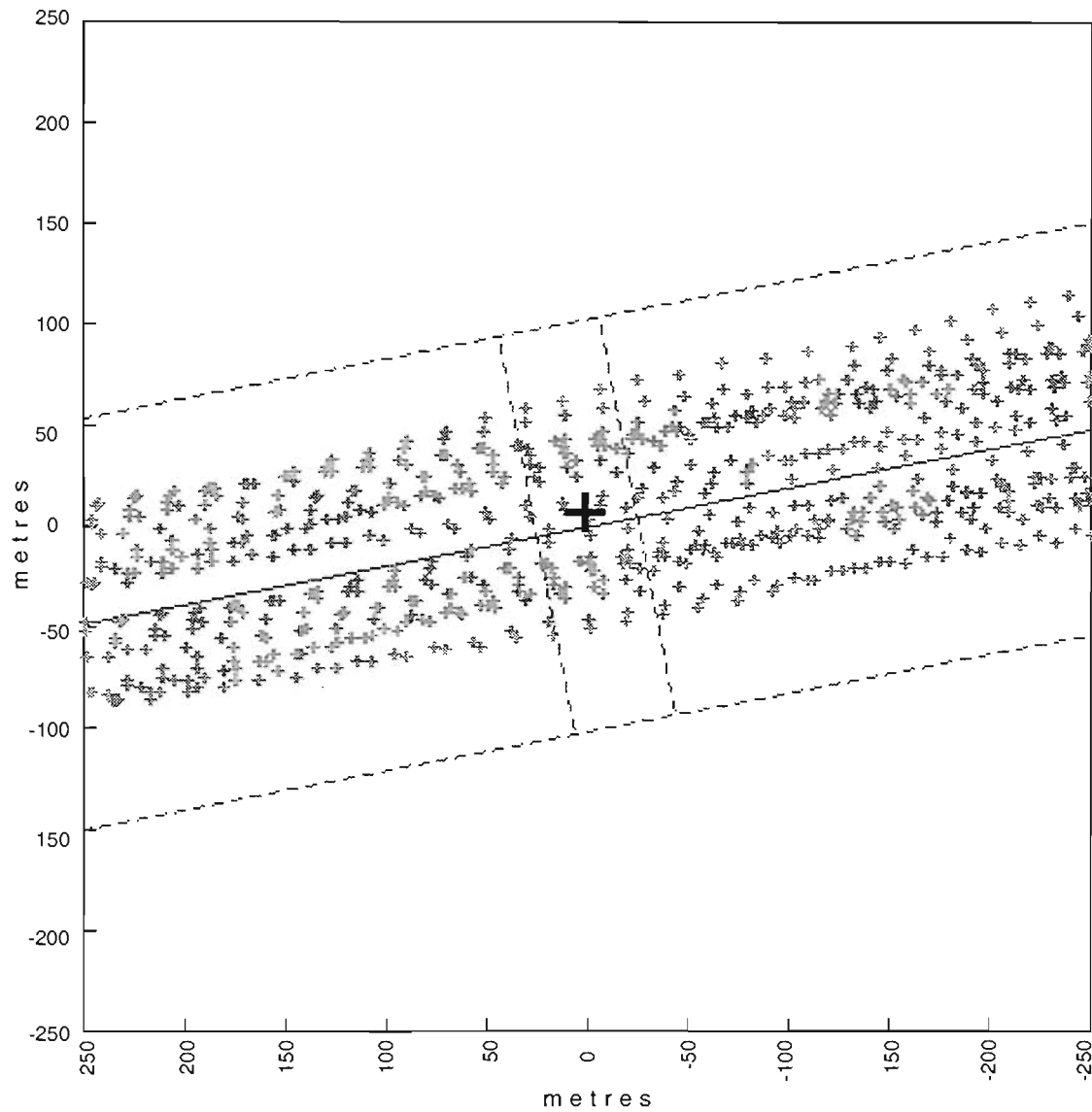


Figure 11. Estimated path of trawl doors from the 1995 trawling event at a representative site along Corridor A based on ship navigation data. The cross marks the location of Grab Sample AE216G7. The three parallel lines denote the axis (solid) and outer bounds (dashed) of the corridor. The orthogonal pair of dashed lines denote the along-track box boundaries.

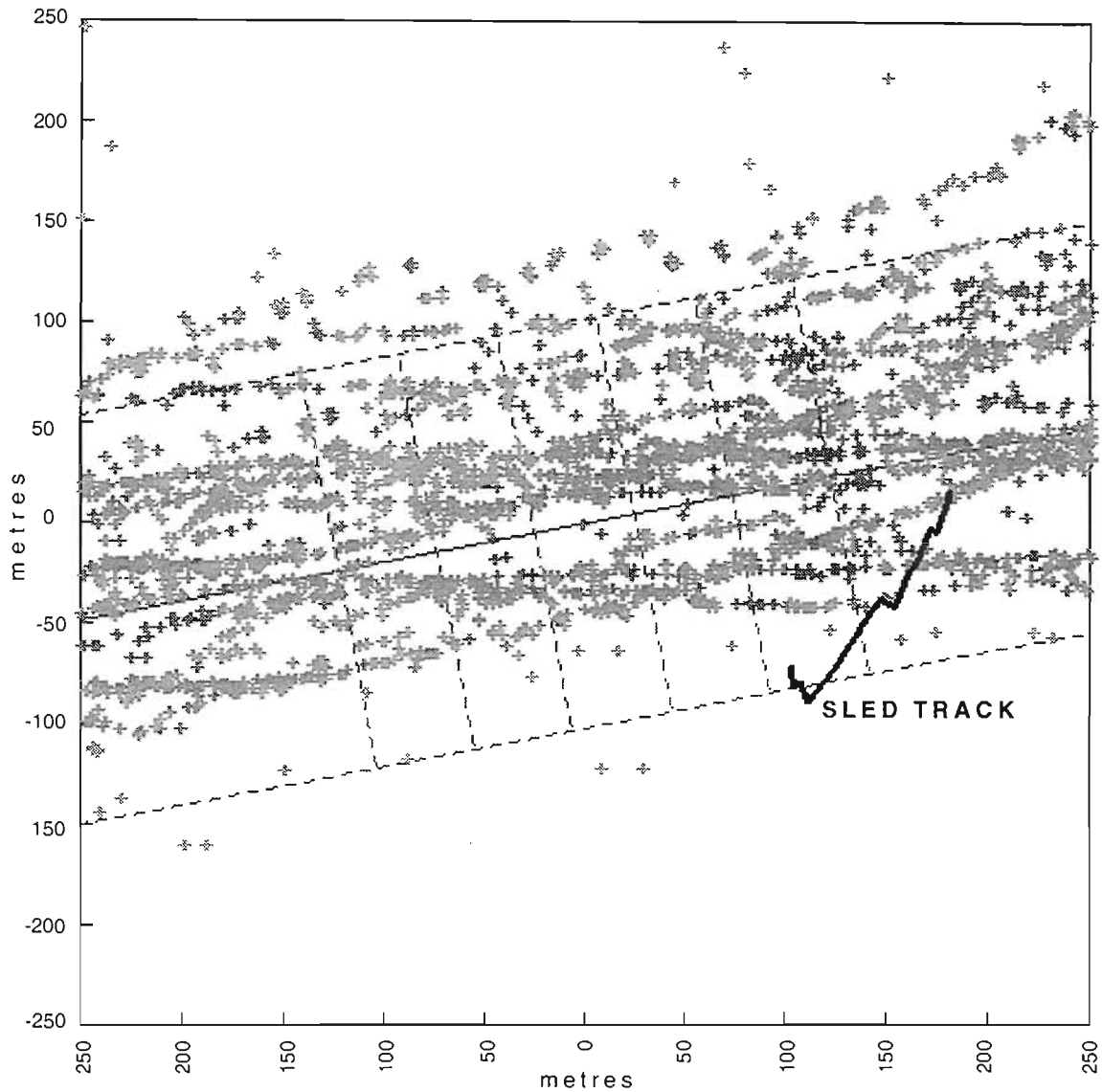


Figure 12. Path of Sled Tow AE210S2 relative to trawling disturbance along Corridor A in 1993. Both data sets are based on Trackpoint navigation data. The three parallel lines denote the axis (solid) and outer bounds (dashed) of the corridor. The orthogonal pair of dashed lines denote the along-track box boundaries.

TABLE 4. Estimated width of disturbance zones on the seafloor created by otter trawling.

Year	Corridor	Mean (m)	Std. Dev. (m)	Min. (m)	Max. (m)	n	Data source (see note)
1993	A	264	55	160	360	34	Trawl(12)
	B	204	102	80	420	33	Trawl(6)
1994	A	81	10	75	125	30	Ship(12)
	B	119	15	90	150	30	Trawl(6)
1995	A	121	9	110	140	19	Ship(12)
	B	112	16	90	160	20	Ship(12)

Note: Ship: Disturbance zone of trawl estimated from ship position and estimated layback.
 Trawl: Disturbance zone of trawl estimated from measured head rope position.

The widest zone was created in 1993 when the C.S.S. *Wilfred Templeman* was not equipped with dGPS. The mean width in Corridor A was 264 m. Trawling clearly extended outside the intended 200-m wide disturbance zone (e.g. Fig. 8) and this was confirmed by sidescan sonar. Near the southwestern end of Corridor B, one errant trawl came close to the control line (300 m parallel to the experimental line) for a short distance (Fig. 9).

The width of the disturbed zone was substantially less in 1994 because the C.S.S. *Wilfred Templeman* was equipped with dGPS and therefore able to stay closer to the intended line. For example, the mean width in Corridor B dropped from 204 m in 1993 to 119 m in 1994 (both means based on Trackpoint data from six tows) (Table 4). Trawling was clearly restricted to well within the intended 200-m wide disturbance zone, and it appears that the doors rarely crossed over the centre line, even taking into account the 15-30 m displacement to port of the trawl relative to the ship. The difference in measured width between Corridor A (ship navigation data) and Corridor B (Trackpoint navigation data) is on the order of 40 m, which agrees with the observed trawl displacement (i.e. add 30-60 m to ship position data to estimate actual disturbance zone width).

The width of the disturbance zone increased somewhat in 1995 because of the deliberate sinusoidal courses steered by the C.S.S. *Wilfred Templeman*. The mean width for Corridor A in 1995 was 121 m compared to 81 m in 1994 (both means based on ship navigation data) (Table 4). Even accounting for the trawl displacement to port, this is still within the intended 200-m wide disturbance zone.

In summary, after adding an average correction of 45 m to ship data means where appropriate, it is estimated that the actual width of disturbance zones averaged on the order of 264, 126 and 166 m for 1993, 1994 and 1995, respectively.

The trawling disturbance is clearly not evenly distributed within this zone. Some areas of the seafloor may have been influenced by just one trawl set while others may have been influenced by all twelve in a given year. Some areas may be undisturbed. The degree of disturbance will also be influenced by the part of the otter trawl which comes into contact with the seafloor (e.g. door, warp, roller, net, etc.).

PLOTTING POSITIONS OF GRABS AND SLEDS ON DISTURBANCE ZONES

As described above, the Trackpoint II system was used to position the initial video grab samples on the first mission in 1993. However, the video grab cable tended to foul on the Trackpoint boom which was at that time located on the starboard side of the ship. For transit between stations one had to either lift and then redeploy the boom or restrict ship speed to less than 6 knots. Either choice reduced the efficiency of the sampling operation considerably. Therefore, after using Trackpoint on 26 stations and gaining some experience with the navigation system, it was decided that the GPS ship antenna position, the instant the grab landed on the seafloor, would serve as an adequate proxy for the sample location. This seemed reasonable, as the ship was stopped on station and wire angle was very small. An experiment to test the validity of this assumption was conducted in 1995, and the results are presented and discussed in the Data Quality section.

Trackpoint was used for all sled deployments throughout the 3-yr experiment. However, some data were lost by human error (e.g. forgetting to turn on the Trackpoint receiver, failing to log data in AGCNav, etc.). Data were extracted from navigation files (using start and door closure times for each tow), edited to remove spurious values, and plotted using the procedures described above. Tow length, estimated directly off a plot displayed on a computer monitor, agreed quite well with odometer readings recorded directly by the sled (Table 5). For longer tows, the Trackpoint estimates of distance may actually be more accurate because the odometer wheels frequently jam. In general, it appeared as though the starboard odometer jammed less often and better represented the distance towed across the bottom. Therefore, the operational procedure was to tow until the starboard wheel count reached 50 m and then close the sled door. Consequently, the standard deviation of the starboard wheel distances in Table 5 is lower than that of the port odometer wheel. The Data Quality section contains an additional discussion of the distances sampled as determined by the odometer wheels and Trackpoint/dGPS fixes.

TABLE 5. Comparison of sled tow length (m) as estimated by Trackpoint/dGPS and odometer readings, Mission 94-015.

	Trackpoint	Port odometer	Starboard odometer
Number	40	40	40
Mean	55.7 m	49.0 m	51.6 m
Std. Dev.	8.3	5.8	2.1
Minimum	32	21.5	47.7
Maximum	70	58.6	60.5

The positions of all grab and sled samples relative to the estimated door tracks were plotted using a program called TRK_PLT (see Appendix A), and hard copies of the output printed. TRK_PLT creates a graphic image on the computer screen of:

- corridor centre line and lateral boundaries (100 m to either side),
- along-track boundaries of a single grab sample box (50 m) or five contiguous sled boxes (250 m),
- estimated tracks of trawl doors through the area (using what ever trawling event is desired), and
- grab position or sled track.

All samples collected in 1993 and before trawling in 1994 were plotted over the trawling disturbance applied in 1993. All samples collected after trawling in 1994 and before trawling in 1995 were plotted over the trawling disturbance applied in 1994. All samples collected after trawling in 1995 were plotted over the trawling disturbance applied in 1995. Representative plots are shown in Figures 8 to 12.

Review of the hard copy plots of all samples confirmed that, with just one possible exception, all experimental samples were collected from the area disturbed by the trawl. The single exception was Sled Tow AE210S2 that started in the disturbed zone but ended outside (Fig. 12). In addition, it appears that three control grab samples in Corridor B (BC010G4, BC017G4 AND BC020G3) may have been affected by a door track from the initial trawling in 1993 when the C.S.S. *Wilfred Templeman* wandered briefly over into the control area during one tow (Fig. 9).

REPEAT SAMPLING IN THE SAME BOX

The original intention while designing the experiment was to sample each box just once in order to prevent any chance of later samples being influenced by earlier sampling activities. However, this goal was not fulfilled all the time for various reasons, both intentional and unintentional.

In 1994 and 1995, grabs along the experimental corridors before and after trawling were deliberately collected from the same box in order to reduce spatial variability. Grab positions (actually ship GPS antenna positions) were compared and most were well separated. Only a few appeared to be within 10 m of each other. As only a few days elapsed between the two sampling events, it is assumed that disturbance would have been readily visible on the video monitor in the unlikely chance that the grab landed on the exact site of the previous sample.

Some confusion was generated when the procedures for naming boxes were changed after the first mission when it was decided that the box width could be reduced from 100 to 50 m, thus doubling the number of sample boxes. This in turn caused some problems when the site-selection program (SMPLSITE) was re-run to establish new sample box sets for subsequent missions (ideally this program should be run just once prior to the start of the field program to generate sampling sites for all future missions). As a result, some boxes were selected for sampling twice. In most cases, this involved a grab sample in the guard box of a sled sample (the end boxes of the contiguous group of five).

Sea state, wind, and the experience of crew controlling the vessel position and gear deployment were important factors affecting the accuracy of sampling. Review of the hard-copy plots of all sled and grab samples indicated that only 21 samples out of a total of 305 were not collected from within the intended box(es) (Table 6).

TABLE 6. Accuracy of sampling (see note).

Mission	Grab in	Grab out	Sled in	Sled out
93-021	19	1	3	2
93-029	33	7	4	3
94-015	56	4	40	0
95-013	56	4	40	0

Note: Grab target was a box 50 x 200 m. Sled target was a box 250 x 200 m. Sled tracks that extended beyond target bounds were classified as "Out."

When these two sources of error are added together, there were 31 instances (out of a total of 305 samples) where the same box was sampled twice. This usually involved a sled and a grab; and, in most cases, the sled sample was collected first. In one instance, two sleds sampled the same box and in another instance two grabs were taken (unintentionally) in the same box.

It is highly unlikely that two samples collected from the same box (10,000 m² in area) actually sampled the same area of the seafloor. Even if the sled did cross over an area previously sampled by the grab (0.5 m²) along its path of approximately 50 m, any effect would not be discernible above other sources of variation. The greatest potential effect would occur if a grab sample was collected within a sled track along an undisturbed control corridor. However, it is highly probable that disturbance would have been readily visible on the video monitor in the unlikely chance that the grab landed exactly on a sled track.

In conclusion, there seems to be no compelling reason to discard samples collected from boxes that had been sampled previously.

DATA QUALITY

POSITIONING ERROR SOURCES

The Trackpoint II system determines the position of a remote beacon by measuring its distance and bearing relative to the hydrophone array on the ship. A previous evaluation has shown that the receiver measures slant ranges with an accuracy of ± 0.39 m and relative bearing with an accuracy of $\pm 0.87^\circ$ (McKeown et al. 1991). Incorrect choice of the sound velocity or beacon depth will lead to further horizontal range errors. An offset between the reference direction of the hydrophone array and the ship's fore/aft axis will contribute an additional relative bearing bias error. The ship's position as determined by dGPS may also be in error. Finally, there exists the possibility that AGCNav and/or CALC_FIX may incorrectly compute the beacon position from this information. The influence of each of these error sources on the final geographic position of the beacon attached to the video grab, epibenthic sled, trawl, sidescan sonar fish, or BRUTIV was examined in order to arrive at a practical estimate of fix error.

For one mission only (Mission 93-029), a protective cage was fitted around the Trackpoint II hydrophone. It was removed at the urging of ORE engineers who said it would probably cause serious relative bearing measurement errors. All video grab and epibenthic sled samples were collected well within the bounds of the targeted sample boxes. Therefore, it is concluded that, while the use of the cage may have contaminated the position data during Mission 93-029, this did not adversely affect the trawl impact experiment data set.

dGPS ACCURACY

Suppliers of dGPS position corrections (e.g. Government of Canada's Ministry of Transport) guarantee 10-m positioning accuracy at sea. Expert users of the dGPS system on the east coast of Canada estimate the actual position error to be about 3-4 m at the Grand Banks using corrections obtained either from StarFix or Canadian government low-frequency transmissions (Grant 1996). In support of this estimate, S. Grant of the Canadian Hydrographic Service reported that C.N. Marine are using dGPS to turn their ferries in the very confined area of Port aux Basques Harbour, Newfoundland, and then dock them in zero visibility. This estimate of dGPS accuracy is consistent with results of an experiment described in the next section which was designed to establish the overall accuracy of the combined dGPS/Trackpoint positions.

ABSOLUTE ACCURACY OF TRACKPOINT/dGPS FIXES

As the Trackpoint II system measures polar position, the bearing portion introduces a position error that is directly proportional to the distance between the sampling or survey device and the ship. At beacon locations beyond about 100 m from the ship (i.e. all gear used in the experiment except the video grab), the position error tends to be dominated by the relative bearing error of the Trackpoint II system. Therefore, to place error bars about the epibenthic sled, trawl, sidescan sonar, and BRUTIV positions, an estimate of the overall range dependent system error is required. In order to quantify this, an experiment was devised to simulate the positioning geometry at various ranges during the trawling experiment. An acoustic beacon was attached at a depth of 151 m below the surface near the bottom of a mooring. The position of the mooring was then established by a least squares fitting process for a set of 29 randomly distributed dGPS ship positions and corresponding slant ranges (McKeown 1975). It is estimated that this process defines the beacon position to an absolute accuracy of 3.4 m.

The ship then steamed back and forth past the mooring and around it in circles, as illustrated in Figure 13, to produce a data set containing almost 4,200 beacon fixes. In normal operation, random acoustic noise events cause the Trackpoint II system to produce a significant number of fixes that are totally false. Before proceeding with any analysis of positioning accuracy, these outliers must be eliminated. First, any fix for which the computed beacon position differed by more than 100 m from the mooring position, as determined by the least squares fit described above, was deleted. Then, the time series editing program EDITDATA was used to manually delete additional outliers. The combination of these two processes eliminated 17% of the fixes. This level of false fixes appears to be typical of all the navigation data sets collected during this field experiment. Finally, the beacon positions were recomputed to adjust for the actual sound velocity encountered during the experiment and to correct for a mechanical offset in the hydrophone array reference direction.

While there are several ways to quantify positioning system accuracy, the one that best describes a polar positioning system such as the Trackpoint II is the Circular Error Probable radius, CEP66 (Harre 1990). In essence, it defines the radius of a circle within which lie 66% of all fixes. In the context of this discussion, the CEP66 is computed from the ensemble of fixes after the original 17% outliers have been eliminated from the data set. As the fix error is known to be range dependent, the

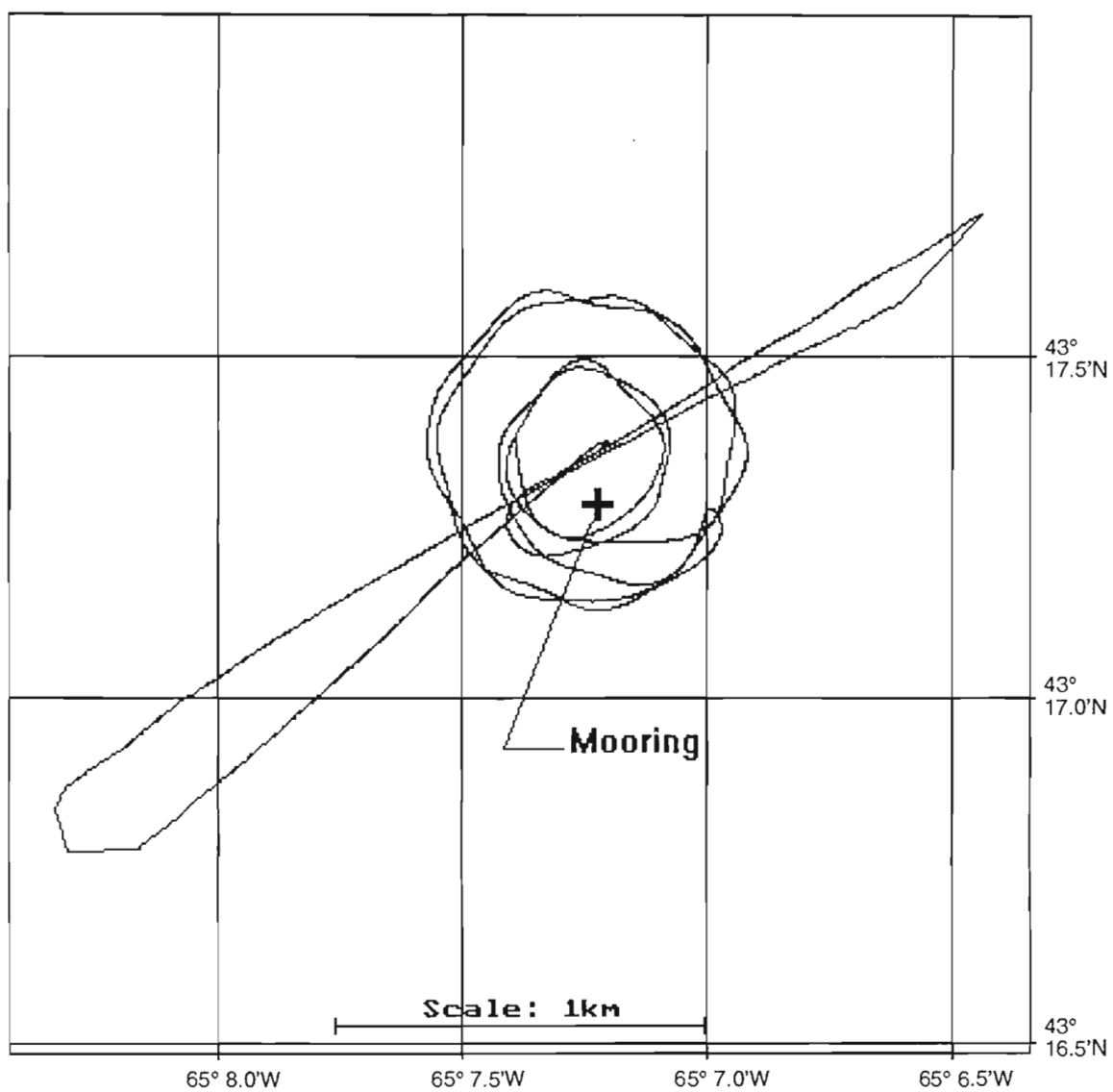


Figure 13. Track of the C.S.S. *Parizeau* relative to the acoustic beacon attached to a seafloor mooring at location marked +.

data set was sorted by range into bins 50 m wide and the CEP66 was computed for each bin. These computations are summarized in Figure 14. As the actual positioning geometry during the trawling experiment rarely exceeded a slant range of 600 m, it is safe to conclude that beacon positions were determined with an accuracy of better than ± 20 m.

POSITION ERROR SENSITIVITY ANALYSIS

From the data set for the Trackpoint/dGPS fixes on the moored beacon as described above, the sensitivity of position error (CEP66) to either a 10 m/s error in sound velocity, a 5-m beacon depth error, or a hydrophone azimuth error of 2° was evaluated. The results are summarized in Figure 15. It is apparent that azimuth errors have the greatest impact on position accuracy. This points out the importance of carefully aligning the reference direction of the hydrophone array to the fore/aft axis of the ship during installation.

The navigation data for the four Grand Banks missions conducted during this experiment were then reviewed in light of these observations. All Trackpoint fixes were obtained at an assumed sound velocity of 1500 m/s. Historical CTD data for a nearby site suggest that a more appropriate mean sound velocity should have been 1453.4 m/s. At times, fixes were logged with an incorrect beacon depth. Prior to Day 192 on Mission 94-015, the Trackpoint boom reference direction was set 2.6° clockwise from the ship's fore/aft axis. These errors have little effect on video grab sample positions which are within 50 m of the ship. However, they could have a significant impact on the recorded epibenthic sled tow positions. It was decided that sled tows collected in 1993 and 1994 within 25 m of the outer bounds of the disturbances zone should be recomputed. For the 1995 data set, this threshold was reduced to 15 m.

Four sled tows from Mission 94-015 were identified as being within 25 m of the outer edge of the zone of disturbance. In each case, the corrected track moved about 10 m in a southerly direction. This caused the track of two tows to move further into the zone of disturbance (AE041S5 and AE073S5) and two to move closer to the edge (AE062S5 and AE128S5). Of the 1993 sled tows, only one, AE210S2, was identified as being questionable. Unfortunately, it was not possible to recompute the positions as the raw Trackpoint fix data had not been logged. However, based on the results of the recomputations of the 1994 tows, one can infer that the sled track would have moved about 10 m closer to the edge of the disturbed area. There were no tows in 1995 that were identified as questionable. In none of these cases did the adjustments in position suggest that any of the data sets should be discarded.

COMPUTATIONAL ACCURACY OF AGCNAV AND CALC_FIX PROGRAMS

The computational accuracy of AGCNav and CALC_FIX was verified by selecting a few representative fixes on the above-mentioned beacon at a depth of about 151 m. The logged dGPS, gyro, and Trackpoint NMEA data strings were entered into the two programs, and the positions they computed were compared to that computed manually from the same fix data. The two programs

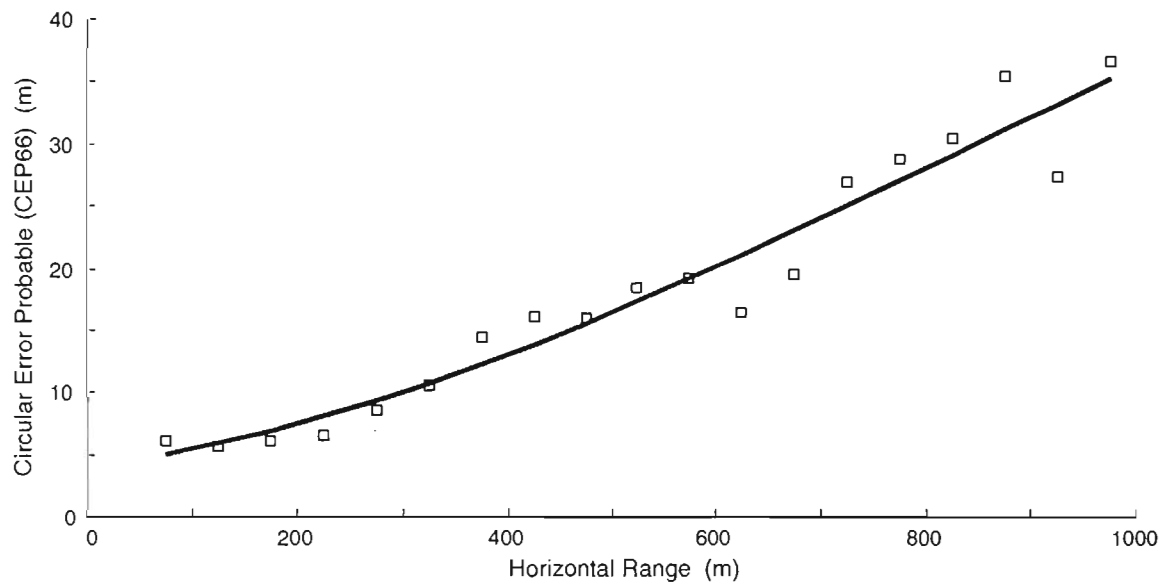


Figure 14. Trackpoint/dGPS fix accuracy (CEP66 radius) as a function of beacon/ship horizontal separation.

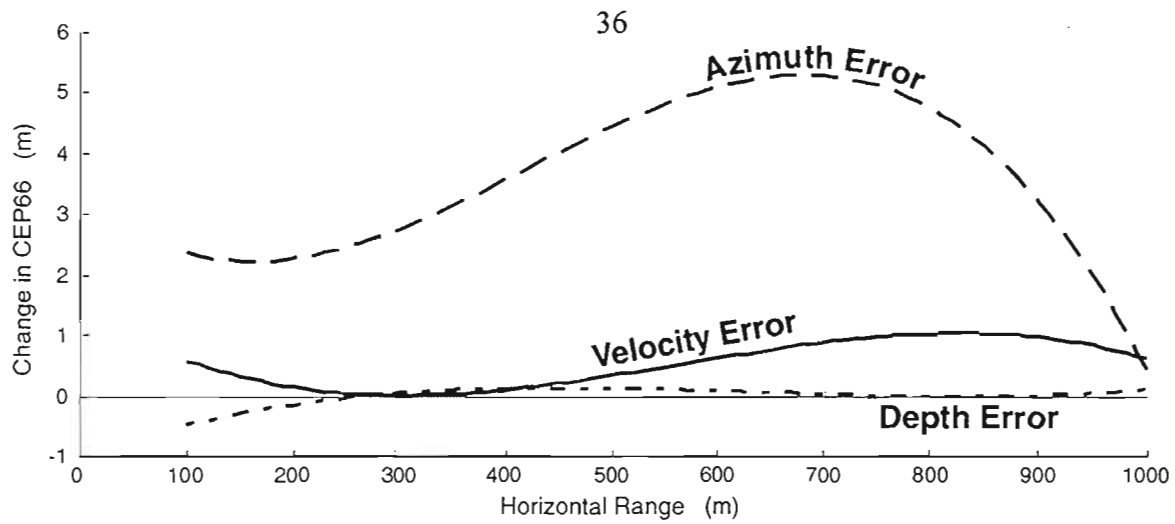


Figure 15. Sensitivity of the Trackpoint/dGPS fix accuracy (CEP66 radius) to a 10 m/s sound velocity error, a 5-m beacon depth error, or a 2° hydrophone array azimuth error.

produced identical positions which differed from the manually computed fix by less than 1 m. It is believed that this difference is the result of rounding errors rather than any inherent inaccuracy in the computations. However, caution must be exercised when using AGCNav to compute Trackpoint II positions. It uses a constant value for the number of metres in a minute of latitude and converts longitude to easting by using the cosine of the latitude of the first ship position received after the program is started, rather than computing correct geodetic conversion factors. CALC_FIX, on the other hand, does use correct geodetic conversion factors computed specifically for each ship position. As the trawl impact experiment was restricted to a very small geographic area, the approximations used in AGCNav are of little consequence to the navigation results.

EPIBENTHIC SLED TRACK LENGTHS - ODOMETERS VS. TRACKPOINT

Throughout the field program there was continuing concern as to whether or not the odometer wheels on the epibenthic sled correctly measured the length of seafloor sampled. The video camera on the sled was oriented such that the wheels could be observed during the tows. Frequently it was noted that either one or other of the wheels would jam for a short period and then resume rotating. For example, in Figure 16 it can be seen that the port odometer stopped rotating from about 30 to 70 sec. Furthermore, throughout the experiment, there was a systematic difference between the distance towed as determined by the port and starboard wheels.

In an effort to address these concerns, the possibility of using the Trackpoint II sled track positions as an alternative measure of distance sampled was examined. During sampling the sled is typically 200-300 m behind the ship. Thus, Trackpoint positions can be expected to have an uncertainty in the order of 10 m or less (Fig. 14). While this accuracy is sufficient to identify where the tows took place relative to the zone of disturbance, there was some doubt as to what extent the Trackpoint/dGPS fixes could be used as an alternative to the odometers for measuring the length of the sample path.

First the question of the systematic difference in distance towed as measured by the port and starboard odometer wheels was examined. Twelve sled tows from Mission 94-015 were selected after verifying that both odometer wheels had apparently not jammed or otherwise generated anomalous counts during the tow. The ratio of the port-to-starboard count was 0.967 with a standard deviation of 0.008824. The odometers generate three counts per revolution. The starboard wheel is smooth and has a circumference of 0.9616 m. The port wheel has a number of spikes protruding from it such that its circumference at the base of the spikes is 0.9496 m and 1.0298 m at the tips.

The distance the port wheel rolls along the bottom during each revolution depends on how deeply the spikes penetrate into the seafloor. The sediment at the experimental site is a well sorted sand which appears to be mechanically uniform so one would expect that the odometers would behave similarly during all tows. The port/starboard distance ratio noted above is consistent with the spikes penetrating to approximately one-half their depth. If one accepts that

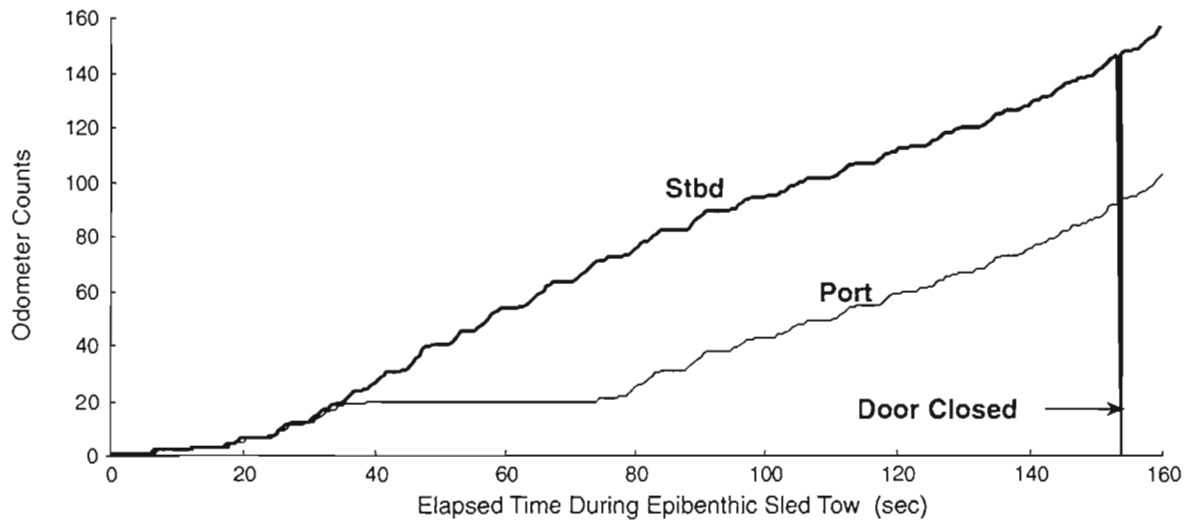


Figure 16. Port and starboard odometer wheel counts during Sled Tow AC041S5, Mission 94-015. From approximately 32 to 72 sec., the port odometer wheel appears to be jammed.

this is a reasonable operating condition for the port (spiked) odometer, then one can conclude that the sampling distances as measured by the two odometer wheels are actually the same.

Next, the issue of whether or not one could use the Trackpoint/dGPS fixes to reliably quantify the sampled distance was explored. The sled was towed in approximately a straight line along the seafloor for a distance of several hundred metres on two occasions during Mission 95-013. The data sets were then examined and four periods of 6, 6, 11, and 21 min. duration were selected according to the following criteria:

- no apparent jamming of either odometer during the period as observed on the video;
- no apparent unusual behaviour of either odometer counts time series; and
- close agreement between the port and starboard odometer time series.

The sled tracks as determined by Trackpoint/dGPS for each of the four periods selected are illustrated in Figure 17. The corresponding comparisons between the distance towed as determined by the positioning system versus that determined by the starboard odometer are shown in Figure 18. In three of the four examples, which are longer than the standard 50-m tows for sampling, the distances determined by odometer were less than those determined by Trackpoint/dGPS and the longer the tow the greater the difference. Even for "good" odometer data, there is clearly some cause for concern about how well the wheels quantify the true length of the seafloor sampled on longer tows.

As described earlier in this report, the length of sled tows was also estimated by plotting the edited fixes and manually scaling the distance between the start and end points. This method was also applied to these four longer data sets. The distances as determined by each of these three methods for the four segments selected are compared in Table 7.

TABLE 7. Comparison of methods for measuring the distance sampled by the sled.

Data Set	Starboard odometer	Trackpoint/dGPS	
		Along track (m)	Between end points (m)
A	111.2	113.0	109.4
B	92.0	112.8	103.0
C	148.4	188.0	161.5
D	224.0	349.5	350.0

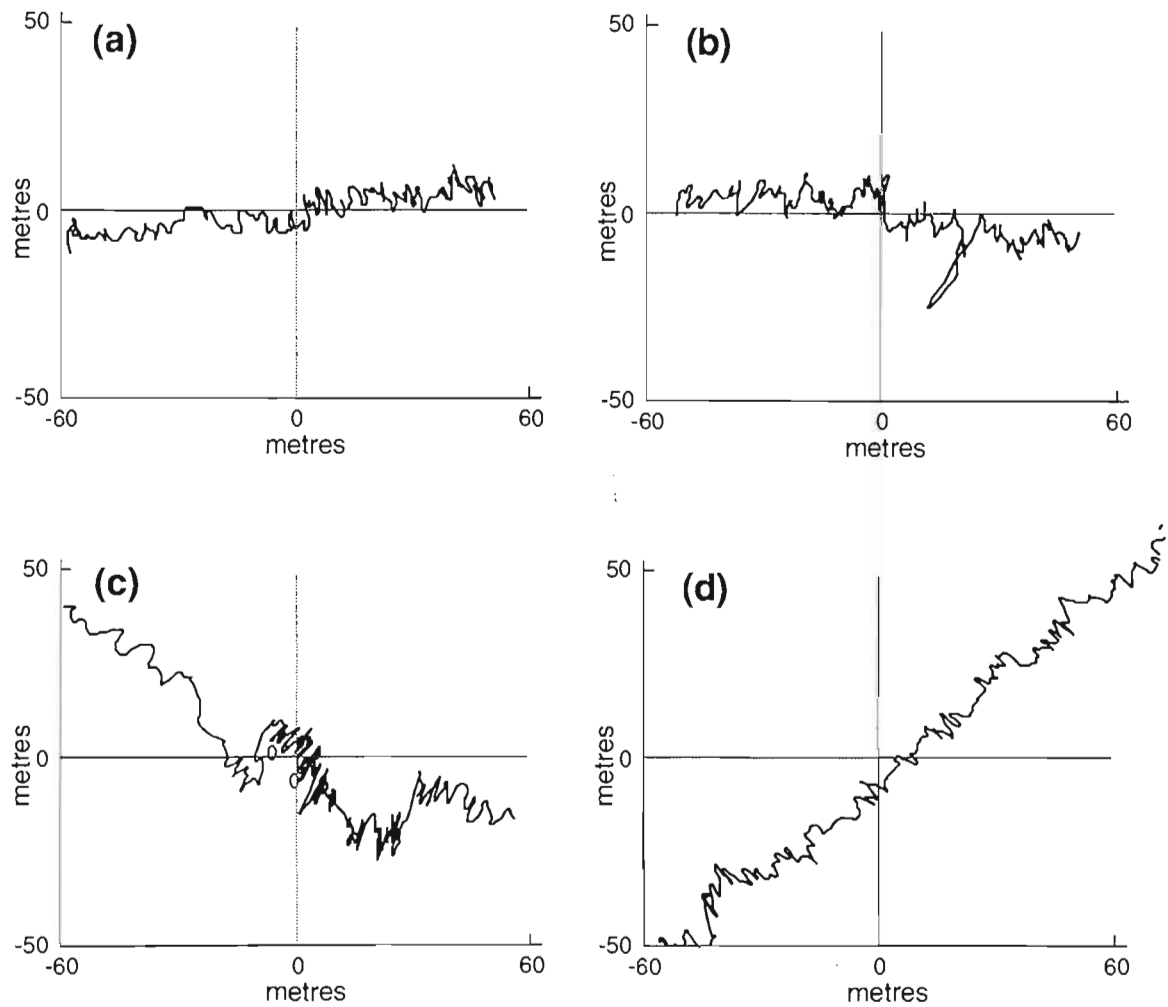


Figure 17. Tracks of four sled tows, determined from Trackpoint/dGPS fixes, used for a comparison of distance towed as determined by the odometer wheels, Mission 94-015.

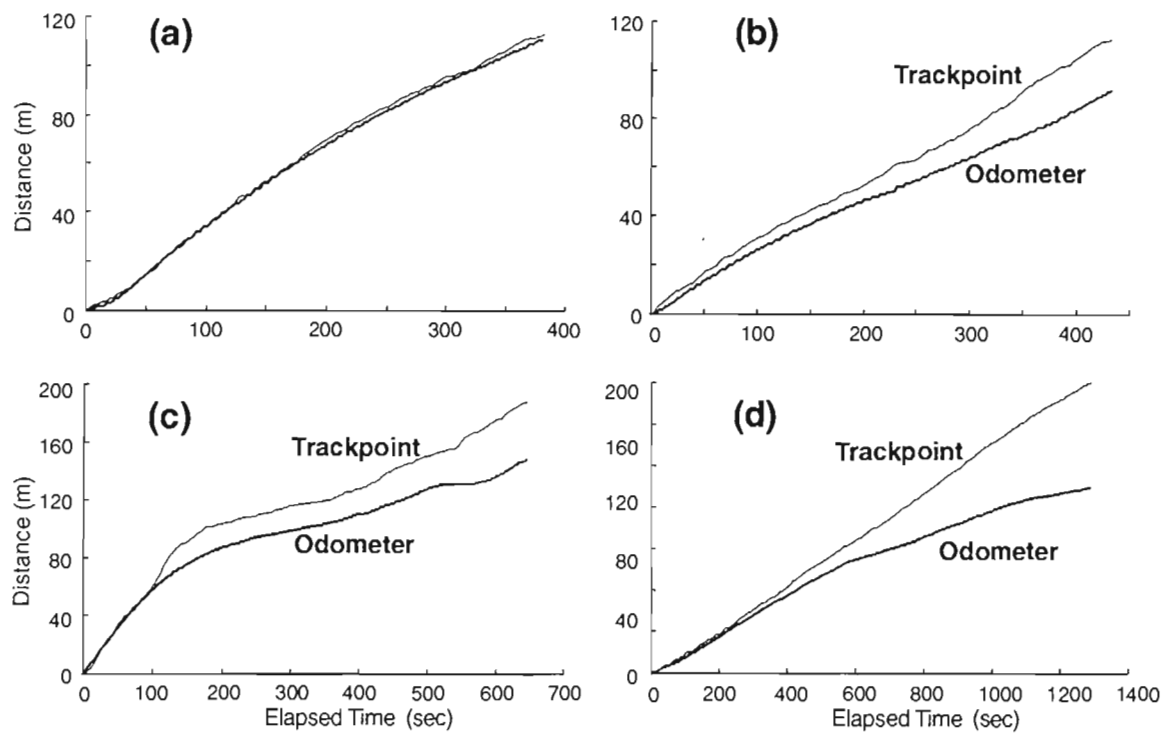


Figure 18. A comparison of distances towed as determined by the starboard odometer wheel and Trackpoint/dGPS fixes for the four sled tracks illustrated in Figure 17.

VIDEO GRAB POSITIONS

With the Trackpoint boom lowered, the ship was restricted to speeds below 6 knots when travelling between sample sites. Raising the boom for transit was equally costly in terms of non-productive ship time. On the first mission in 1993, a comparison between the ship's GPS antenna position and the actual video grab sample position within the 50-m wide sample box as determined by the Trackpoint system suggested that the former was an adequate proxy for the latter. Therefore, it was decided that, for all subsequent missions, video grab samples would be positioned without Trackpoint assistance. During the final mission in 1995, the validity of this procedure was explored more thoroughly. Also, the potential of using the position of the end of the crane supporting the video grab cable as a more appropriate substitute was examined.

During 19 sample stations on Mission 95-013, the video grab was positioned within the sample boxes by the ship's personnel using the GPS antenna position as a surrogate for grab position. At the same time, the actual video grab sample position was recorded using the Trackpoint II system. This information was then used to address three questions:

1. Given typical weather conditions and experienced ship operators, how close to the centre of the sample boxes were the samples actually taken when using the GPS antenna position as a proxy for the video grab position?
2. How well do the Trackpoint/dGPS fixes define the actual sample location?
3. Would the position of the end of the crane supporting the video grab be a more appropriate surrogate for sample location than the ship's GPS antenna location?

The ship's GPS antenna positions relative to the target sample box boundaries at the time the grab touched bottom are illustrated in Figure 19a. As the grab sat on the seafloor during each of the 18 sample operations for several minutes, multiple Trackpoint fixes were obtained. The mean location of each of these 19 sample positions relative to the boundaries of the target sample box are illustrated in Figure 19b. Relative to the centre of the sample box, the mean along-track (50-m box dimension) offset of the samples, as determined by Trackpoint, was 3.01 m with a standard deviation of 10.84 m; and the mean cross-track (200-m box dimension) was 7 m with a standard deviation of 11.85 m. In all but one case out of the 19, the samples were obtained from within the 50-m wide box and within the zone of the disturbance when the ship's personnel used the ship's GPS antenna position as a proxy for the grab position. The exception was just outside the 50-m box but within about 6 m of the GPS ship antenna position (Fig. 19b).

The CEP66 (the Circular Error Probable radius as described earlier in this section) was computed for each of the 19 ensembles of multiple fixes. The mean CEP66 was found to be 5.01 m with a standard deviation of 2.14 m. This agrees well with that determined above and summarized in Figure 14.

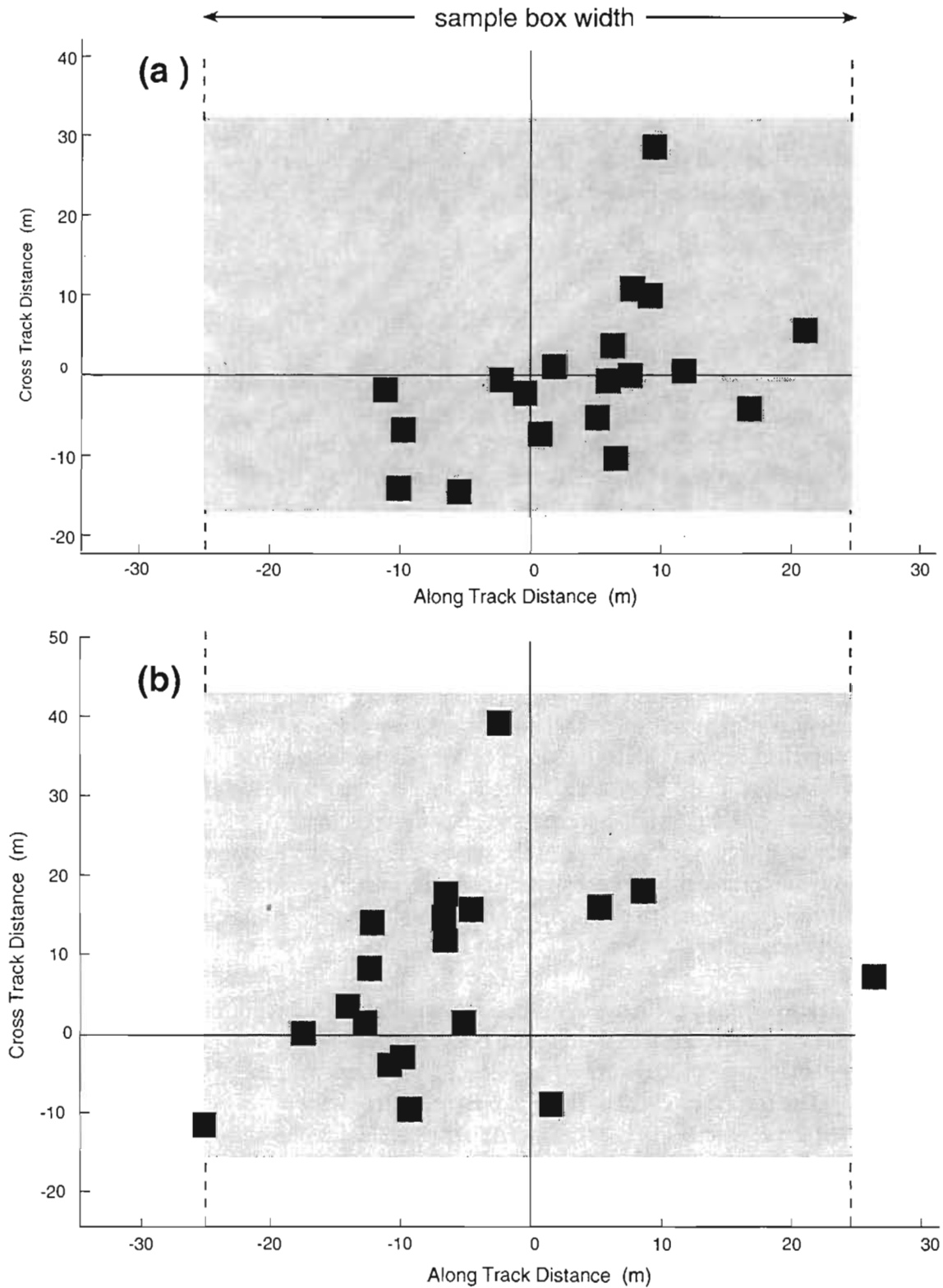


Figure 19. The location of nineteen grab samples collected on Mission 95-013 relative to their respective sample box boundaries as determined by: a) ship's GPS antenna position, and b) Trackpoint/dGPS fixes from a transponder mounted on the grab.

The outer end of the crane supporting the video grab cable is much closer to the actual location of the grab during its brief encounter with the seafloor. It was determined that, had this been used as a proxy for grab sample position instead of ship's antenna location, there would have been a 24% improvement in positioning the sample at the centre of the sample box. More importantly, it is probable that the one sample which fell just outside the box would have in fact been within the box bounds had the crane position been used. As AGCNav allows the user to select any point on the ship as the reference for graphically presenting the ship's position, it is a simple matter to implement this alternative proxy operationally.

SUMMARY

An integrated system of hardware, software, and methodology has been developed to provide information about the location of towed survey systems (sidescan sonar and BRUTIV), bottom-sampling devices (video grab and epibenthic sled) and fishing gear (otter trawl). This technology was developed as part of a program to quantify the productive capacity of marine benthic habitat, to obtain quantitative information on the impacts of mobile fishing gear on benthic habitat (both physical structure and biological communities) and to obtain quantitative information on the recovery rate of benthic habitat after disturbance by mobile fishing gear. This ensemble of equipment and positioning methodology has been used to conduct an impact experiment on the Grand Banks of Newfoundland.

Navigation equipment included a dGPS, a StarFix system to provide the appropriate differential corrections, the ship's autopilot for heading information, and a Trackpoint II ultra-short baseline acoustic positioning system with an over-the-side transducer boom to position towed survey systems and seafloor sampling devices. Ship and survey or sampling equipment positions were displayed both on the ship's bridge and in the laboratory, and the navigation data were logged using a software system known as AGCNav running on IBM-compatible personal computers. On board the C.S.S. *Parizeau*, this system unfailingly provided positions of the survey and sampling equipment throughout the entire program. However, problems were encountered when a similar Trackpoint II system was installed on the C.S.S. *Wilfred Templeman* to position the otter trawl. It is thought that the problem was caused by acoustic noise generated by that ship.

As the Trackpoint II system measures polar position, the bearing portion introduces a position error that is directly proportional to the distance between the sampling or survey device and the ship. The dGPS system introduces a position error of about 3-4 m independent of the fix location within the working area. The combined effect of these two error sources leads to an estimate that positions obtained during the course of this experimental program are defined to an accuracy ranging from about 4 m at the ship to about 20 m at a maximum realistic working range of 600 m from the ship. Position accuracy is very sensitive to proper alignment of the hydrophone array reference direction parallel to the ship's fore/aft axis. Errors in correctly defining the sound velocity or sample depth have a less dramatic effect, although the latter does become important at short ranges.

A significant number of the otter trawl tows made by the C.S.S. *Wilfred Templeman* were monitored with the Trackpoint and dGPS positioning system on board the C.S.S. *Parizeau* during each

of the 3 yr that trawling was carried out. These data were used to establish the width of the zone of disturbance along each corridor. It was confirmed that the trawl track could be adequately estimated from the path of the C.S.S. *Wilfred Templeman*, as determined by their on-board dGPS system, for the purpose of this experiment as long as it was recognized that the actual path of the trawl was on the order of the 15-30 m to port of ship position.

All epibenthic sled tows were positioned using the Trackpoint II and dGPS equipment. The positions obtained were deemed to be accurate to about 10 m. As the tows were only 50-m long, this accuracy is sufficient to locate the sample relative to the zone of disturbance but is of limited value in verifying whether or not the odometer readings were correct. However, the positioning data serve as a useful check on the odometer information. Once tows exceed a few hundred metres in length, the positioning information becomes more dependable than odometer readings.

When video grab sample sites were targeted using grab positions derived from the dGPS ship position and a Trackpoint fix on a beacon attached to the grab, the along-track error was 3.01 m (± 10.84 m) and the cross-track error was 7 m (± 11.85 m) relative to the centre of the sample box. Once confidence and experience had been gained with the navigation system on the first mission, the use of the Trackpoint portion of the system to position the video grab was dropped to simplify shipboard operations. Instead, the ship was manoeuvred onto station using the ship's GPS antenna position as a proxy for the grab position. Analysis showed that there was no significant loss in accuracy by using this procedure. Of 19 video grab samples collected in an experiment conducted in 1995, only one was outside the target sample box (by only a few metres); and all samples were obtained on or near the axis of the zone of disturbance. In future programs of this type, use of the outer end of the crane supporting the video grab cable as a proxy for grab position would result in a 24% improvement in positioning accuracy compared to the ship's GPS antenna position and would improve the likelihood that all samples are collected within the target zone.

During the four missions to the experimental site, a total of 305 video grab and epibenthic sled samples were collected. With the aid of the positioning system, all but 21 were collected within the intended sample boxes. In most cases, the errant samples were grabs which were collected from an adjacent sled site and usually involved the unsampled guard box rather than the actual boxes sampled by the sled.

In conclusion, the navigation procedures followed allow the zone of disturbance created by the otter trawl on the seafloor to be plotted with a high degree of certainty and provide confidence that the biological samples, both experimental and control, were collected from the desired locations.

ACKNOWLEDGEMENTS

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maintained, and upgraded the dGPS and AGCNav installations on the C.S.S. *Parizeau* and assisted staff of Seaforth Engineering Group Inc. with the installation of the StarFix system prior to each mission. D. Heffler and R. Currie of the Geological Survey of Canada (Atlantic) devised the AGCNav software and provided much helpful advice concerning its use during this project. We are most grateful for the helpful assistance and advice provided by both our scientific colleagues, especially T.W. Rowell, J. Prena, and P. Schwinghamer and the ship's watch-keeping officers and quartermasters during the experimental program. Funding was provided by DFO A-Base, the Northern Cod Science Program, the Atlantic Fisheries Adjustment Program, and the Green Plan Sustainable Fisheries Program.

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APPENDIX A. TRAWL IMPACT PROJECT COMPUTER PROGRAMS

The following programs were developed by one of the authors (D.L. McKeown) for use in the Grand Banks otter trawling impact experiment. They are designed to operate on an IBM-compatible personal computer with 640 K of conventional memory operating in a DOS environment. The language used was Borland's Turbo Pascal. The documentation supplied herein is meant only to provide a guide as to the function of the program. All programs are available on request as executable (.EXE) files accompanied by a documentation file (.DOC) in Word 6.0.

AGCNav-compatible waypoint files for surveying and sampling operations are created by the following programs:

- BRUTLINE: Create a waypoint file for BRUTIV survey lines offset from sidescan survey lines.
- SAMPLSITE: Create sets of waypoint files for randomly distributed grab and sled sampling stations along an experimental and a parallel control corridor.
- SURVLINE: Create a waypoint file of start and end points for a number of parallel survey lines.
- TRNSCTWP: Create a waypoint file for waypoints at specified distances along a specified transect.

The usual sequence of using the remainder of the programs is summarized in Figure A1.

2POREM

- Function:
The program scans through an E-type navigation file searching for Trackpoint fixes. Each time a fix is encountered, it extracts the relevant parts of the Trackpoint, dGPS, and ship's heading information and writes them to an output file. Each output data line is time tagged with the correct time of the event as derived from the dGPS clock. The data can be written to the output file in one of two formats: as a NMEA type comma-delimited sentence with the proprietary identifier \$POREM containing all the information related to the Trackpoint fix, or as an A-type position sentence.
- User Input:
 - a) names of the input and output data files;
 - b) which NMEA identifier denotes a dGPS ship position fix;
 - c) type of output format required;
 - d) whether or not to include the computed Trackpoint position in the \$POREM string;
 - e) start and end times for the output data set if the user wishes to extract a sub-set of the input file.
- Input File Format:
An E-type navigation file.

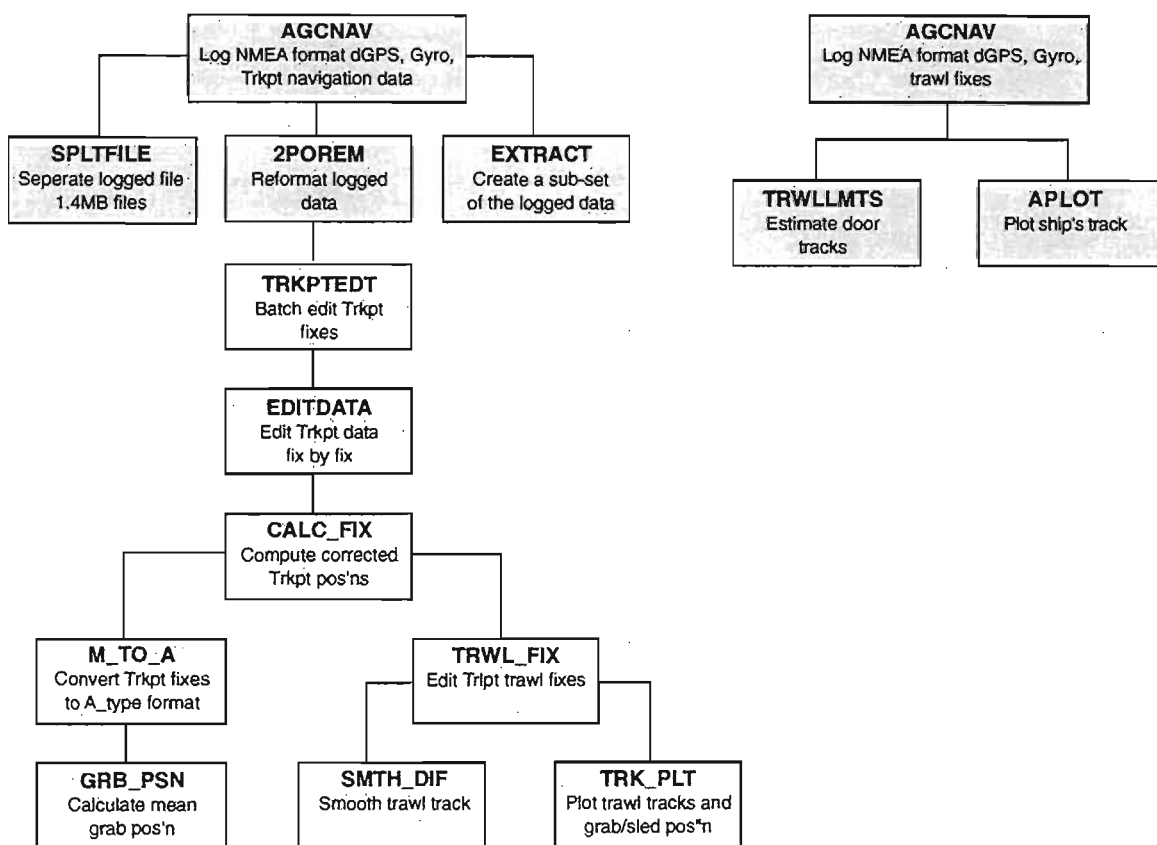


Figure A1. Flow chart of navigation data processing.

- Output File Format:

Either an E-type navigation data format:

- \$POREM - NMEA type identifier
- Time - corrected time of fix
- Lat, Lng - GPS ship position at time of Trackpoint fix from \$PMVXG,023 string
- Flag - type of GPS fix
- Hdg - ship's heading from \$AGHDT string
- Beacon - ID number of Trackpoint beacon
- RB - relative bearing of beacon with respect to the ship
- Slant - slant range of beacon with respect to the ship
- Depth - depth of beacon
- Trkpt Lat,
- Trkpt Lng - beacon position as computed by AGCNav from \$POREP string

Or an A-type navigation data format:

- Day number plus corrected Trackpoint time
- Trackpoint latitude in decimal degrees
- Trackpoint longitude in decimal degrees

BRUTLINE

- Function:

This program creates an AGCNav-compatible waypoint file containing the start and end points of one or more survey lines parallel to and offset from a specified survey line. It was created to generate waypoint files for BRUTIV tracks to be run parallel to but offset by a specified distance from the axis of a sidescan survey line.

- User Input:

- a) the name of the output data file;
- b) whether distance units are to be in nautical miles or metres;
- c) length and bearing of the reference survey line;
- d) the labels of the start and end point of each survey line being created, the offset from the reference line and to which side it is to be offset.

- Input File Format:

Not applicable.

- Output File Format:

A standard AGCNav-formatted waypoint file.

CALC_FIX

- **Function:**
This program re-computes Trackpoint fixes from the logged data and incorporates them into the calculation information supplied by the user.
- **User Input:**
 - a) input and output data file names;
 - b) number of the acoustic beacon to be selected;
 - c) hydrophone array position relative to the GPS antenna;
 - d) beacon depth;
 - e) sound velocity.
- **Input File Format:**
E-type navigation file.
- **Output File Format:**
E-type navigation file.

EDITDATA

- **Function:**
This program allows the user to display and edit time series data graphically. The data are presented in short, sequential segments until the entire file has been processed or the user chooses to terminate the activity. To assist the user to visualize the impact of deleting or including a particular data point, a smoothed version of the time series is presented along with the actual data points. Outliers are automatically flagged when the data are first displayed according to criteria under the control of the user. The user may then unflag these points or flag others by using a mouse. Only one variable can be displayed at a time, but the operator can switch back and forth between two different variables of the same time series data set and edit both simultaneously. The edited data are saved to a new file in the same format as the input data.
- **User Input:**
 - a) input and output data file names;
 - b) various parameters which identify the data string to be edited, how to parse it to extract the data point(s) of interest, and how the editing process is to be controlled;
 - c) whether the flagged data points are to be deleted or included in the output file with an appropriate marker appended.

The parameters describing the data and how the editing process is to be controlled can be entered manually, standard set-ups already contained in the software can be selected, or the processing information can be accessed from a control file created by the user.

- **Input File Format:**
ASCII data in either fixed or comma-delimited format.
- **Output File Format:**
Same format as input file.

EXTRACT

- **Function:**
This program searches through an E-type AGCNav data file and extracts to an output file a subset of the data between a start and end time specified by the user.
- **User Input:**
 - a) NMEA code identifying which string contains time;
 - b) start and end times of data set to be extracted;
 - c) input and output data file names.
- **Input File Format:**
E-type navigation data.
- **Output File Format:**
E-type navigation data.

GRB_PSN

- **Function:**
This program provides an interactive graphical means of editing a set of noisy Trackpoint video grab fixes.
- **User Input:**
 - a) names of the input and output data files;
 - b) ship position at the instant the grab is set on the seafloor.
- **Input File Format:**
A-type navigation file.
- **Output File Format:**
A-type navigation file.

M_TO_A

- **Function:**
This program extracts from E-type navigation files containing \$POREM data strings either the ship or Trackpoint fixes and creates an A-type navigation file.
- **User Input:**
 - a) names of input and output data files;
 - b) whether ship or Trackpoint fixes are to be selected.
- **Input File Format:**
E-type navigation file.
- **Output File Format:**
A-type navigation file.

SMPLSITE

- **Function:**
This program creates a series of AGCNav-compatible waypoint files each containing specified numbers of proposed epibenthic sled and video grab sites. These sites are randomly selected along both the experimental corridors and adjacent control lines. The program creates as many unique sets of sample sites it can for the specified line length and sample box width.
- **User Input:**
 - a) start point, length and azimuth of Experimental line;
 - b) offset of Control line with respect to Experimental line;
 - c) width of the sample blocks along the line;
 - d) number of sled and grab samples each data set is to contain;
 - e) name of a file containing a list of EXPERIMENTAL sample sites previously used.
- **Input File Format:**
ASCII text file containing list of sample sites to be excluded from selection process.
- **Output File Format:**
AGCNav waypoint files.

SMTH_DIF

- **Function:**
This program, through the medium of an interactive graphical interface, allows the user to edit out unacceptable computed trawl positions and creates an output file of trawler and smoothed trawl along and across track positions.
- **User Input:**
 - a) names of input and output data files;
 - b) window and despiking limits on trawl cross track and layback;
 - c) amount of smoothing to be applied to input values of trawl cross track and layback.
- **Input File Format:**
Data file produced by program TRWL_FIX.
- **Output File Format:**
ASCII data file of elapsed time, ship along and cross track positions, and smoothed trawl along and cross track positions.

SPLTFILE

- **Function:**
This program takes a large E-type data file logged by AGCNav and splits it into sequential 1.4-MB files so non-compressed data can be copied to floppy discs.
- **User Input:**
Name of input file.
- **Input File Format:**
E-type navigation file.
- **Output File Format:**
E-type navigation file.

SURVLINE

- **Function:**
This program creates an AGCNav-compatible waypoint file containing the start and end points of a set of survey lines parallel to a reference survey line.

- User Input:
 - a) name of output file;
 - b) position of start of the reference survey line;
 - c) Numerical label for this reference survey line;
 - d) distance units (nautical miles or metres);
 - e) bearing and length of the reference survey line;
 - f) distance between parallel survey lines;
 - g) number of survey lines west (or above) the reference survey line;
 - h) number of survey lines east (or below) the reference survey line.
- Input File Format:
Not applicable.
- Output File Format:
AGCNav waypoint file.

TRANSCTWP

- Function:
This program creates an AGCNav-compatible waypoint file containing the start point and a series of waypoints at user defined offsets from it along a specified azimuth.
- User Input:
 - a) name of output file;
 - b) position of start of survey line and its azimuth;
 - c) prefix for the waypoint labels;
 - d) distance units (nautical miles or metres);
 - e) distance from SOL to waypoints.
- Input File Format:
Not applicable.
- Output File Format:
AGCNav waypoint file.

TRK_PLT

- Function:
This program creates the following graphical image on the computer screen:
 - a) the corridor axis and its upper and lower bounds;

b) the along-track boundaries of a single sample box in the case of a grab sample, or the five sequential boxes in the case of an epibenthic sled sample;

c) the track of the trawl through the area;

d) the actual grab position or the actual sled track;

The operator can change the scale of the plot at will. The plot will always remain centred on the position of the middle of the target sampling area.

- User Input:
 - a) dimensions of the sample box;
 - b) sample box identifier label;
 - c) name of the file containing the position of the corridor start and end points;
 - d) grab position or name of file containing the sled track;
 - e) name of file containing the trawl track information.
- Input File Format:
 - a) corridor end points in AGCNav waypoint file format;
 - b) A-type sled track navigation file;
 - c) A-type trawl track navigation file.
- Output File Format:

Not applicable.

TRKPTEDT

- Function:

This program, through the medium of an interactive graphical interface, allows the user to edit out unacceptable Trackpoint fixes and create an output file of fixes containing smoothed slant range and relative bearing values.
- User Input:
 - a) names of input and output data files;
 - b) window and despiking limits on slant range and relative bearing;
 - c) amount of smoothing to be applied to input values of slant range and relative bearing.
- Input File Format:

E-type navigation file of \$POREM strings.
- Output File Format:

E-type navigation file of \$POREM strings.

TRWL_FIX

- **Function:**
This program synchronizes and merges a file of positions of the vessel towing a trawl with a file of Trackpoint fixes of the trawl obtained by a second vessel during the same tow. Once the two data sets have been merged, Trackpoint fixes that are clearly outliers are flagged or deleted. Finally, it outputs the merged and edited data set either as an E-type navigation file or as a time series of trawler and trawl along track and across track distances.
- **User Input:**
 - a) name of corridor waypoint file and which corridor is being trawled;
 - b) estimated layback of the trawl with respect to the trawler and the allowable difference between this layback and that calculated from the fix information;
 - c) whether questionable trawl positions are to be flagged or deleted;
 - d) number of the acoustic beacon to be selected;
 - e) the type of output file to be created;
 - f) names of the input and output navigation data files.
- **Input File Format:**
 - a) AGCNav-type waypoint file of corridor coordinates;
 - b) A-type navigation file of the trawler positions;
 - c) E-type navigation file of trawl positions.
- **Output File Format:**
Either an E-type file of trawler and trawl positions or a time series of trawler and trawl along track and cross track distances.

TRWLLMTS

- **Function:**
This program generates an A-type navigation file of estimated trawl door positions during a tow based on the assumption that the trawl door is offset a specified distance from the ship's position in a direction perpendicular to the azimuth of the corridor.
- **User Input:**
 - a) name of input file;
 - b) azimuth of the trawl corridor;
 - c) direction of offset north or south of the track;
 - d) distance the trawl door track is offset from the ship's track; i.e., it is possible to generate asymmetrical trawl door tracks about the ship's track by entering different offset distances for the north and south computations;

e) a comment line can be inserted in the output file for documentation purposes (APLOT will ignore it).

- **Input File Format:**
A-type navigation file of ship or trawl position.
- **Output File Format:**
A-type navigation file of trawl door positions. A separate file is created for each trawl door. To create a composite file, the computation must be repeated for an offset to the opposite side of the corridor then the two output files merged using the MS-DOS concatenate command.

APPENDIX B. GEOLOGICAL SURVEY OF CANADA (ATLANTIC) NAVIGATION PROGRAMS

The following programs were provided by D. Heffler of the Geological Survey of Canada (Atlantic). They are designed to operate on an IBM-compatible personal computer. The documentation supplied herein is that provided on-line with the programs. Should anyone wish a copy of either, they should contact D. Heffler.

APLOT

This program plots ship's tracks on an IBM-compatible personal computer monitor. It uses as input A-type navigation files. The following instructions can be obtained by typing APLOT and pressing the ENTER key. Further information is available via a HELP key within the program.

APlot Version 2.10 - written by Everett Coldwell and Dave Heffler

APLOT reads an AGC navigation data file, graphs positions and displays

One argument is required, the input file name.

Options: -i max_int specifies the maximum interval in seconds between data points, before a gap is shown in the chart's track.

-c coast file (use -C to scale on coast, -c to scale on nav).

-d to read depths from a file and plot in colour.

Example: APLOT HUDS365A.93A

ETOA

This program extracts time and corresponding ship positions from a file containing NMEA data strings and creates a corresponding A-type file of time-tagged ship positions. The following instructions can be obtained by typing ETOA and pressing the ENTER key.

ETOA Version 1.70 - written by Everett Coldwell and Dave Heffler

ETOA converts AGCNav NMEA sentences to AGC navigation format. It searches each line for \$ and a sensible time ,Lat and Long. It only decodes lines with valid (or no) checksums.

One argument is required, the input file name.

This file name must conform to the bbbbdddx.yyE format, where bbbb is the base of the filename, ddd is day of year, x is a sequence letter between A and Z, yy is the year, and the E specifies that the file is a AGCNav NMEA type navigation data file.

The output file name differs from the input file name in that the last letter is changed to A (signifying an AGC format navigation file). Subsequent files for successive days are opened.

-d IDENT n will copy depths (or another field) to the A file. where IDENT is a (case sensitive) string in the sentences to be searched and n is the field to copy. (\$IDENT is field 0).

-v will display the output on the screen.

Example: ETOA HUDS365A.93D -d PKEL 4

APPENDIX C. NAVIGATION SYSTEM OPERATING PROCEDURE

AGCNAV OPERATION

It is assumed that the AGCNav software is loaded on the C drive of an IBM-compatible personal computer in the AGCNAV sub-directory and that a working copy of the file AGCNAV.INI is stored in this sub-directory under the name BACKUP.INI.

Starting AGCNav:

- Change to AGCNAV sub-directory by entering DOS command: CD \AGCNav
- Start AGCNav by entering DOS command AGCNAV
- Press ENTER at opening screen
- Select menu item **NavSource/Serial Port Source** to initialize the serial ports

AGCNav retains the current user configuration such as active waypoints, screen mode, scales, etc., in the file AGCNAV.INI which resides in the same sub-directory as AGCNAV.EXE. Under some circumstances, this file may become corrupted. Should this happen, either the corrupted file must be deleted and AGCNav must be set up again from scratch or the corrupted file must be replaced. The latter approach is usually the most convenient. To do this, copy over the corrupted .INI file with a backup version as follows:

- Exit to DOS from AGCNAV
- Change to the AGCNAV sub-directory if not already there
- Enter the DOS command COPY BACKUP.INI AGCNAV.INI
 - **DO NOT** rename BACKUP.INI; **ALWAYS** create a copy of it -
- Re-start AGCNAV and change the setup as necessary.

C.S.S. *PARIZEAU* NAVIGATION DATA

All navigation data, including that from the Trackpoint receiver located in the laboratory, are merged into a single data stream on the bridge and transmitted to the "MULTIPLEXER OUTPUT" box in the laboratory. They then go from there to the AGCNav computer's serial port. All data strings are NMEA formatted. The first field is a six-character string consisting of a \$ sign followed by an additional five characters that uniquely identify the type of data. The data string produced by the Trackpoint receiver is not actually formatted as a NMEA string. The incoming string is reformatted into a pseudo-NMEA string by AGCNav. The following are the NMEA strings currently in use.

Ship Position

\$GPGGA,172423.4,4442.0067,N,06338.8211,W,2,5,01.5,0000.0,M,-023.6,M,007,0001*4C

GMT	Lat	Long	Flag (1=GPS, 2=dGPS)
-----	-----	------	----------------------

COG, SOG from GPS

\$GPVTG,039.3,T,060.1,M,00.7,N,01.4,K*42

COG SOG

Bridge Sounder

\$SDDBS,0213.0,f,0065.0,M,035.0,F

Depth in metres beneath transducer

Ship's Log

\$VMN04,-0.94,*4B

Ship's Heading

\$AGHDT,220.,T

Trackpoint Input Data

\$POREB,3,141420,,180.6,140.3,-0.7,-63.7,125.0,0.0,50,-0.6,2.5*68

Xpndr #	Trkpt Rx Time	RB	Slant Range	Depth
---------	---------------	----	-------------	-------

Trackpoint Transponder Position

\$POREP,3,4705.751422,N,4813.768568,E*41

DEPTH DISPLAY IN LABORATORY

The water depth beneath the ship's transducer can be displayed on the AGCNav screen by parsing the "Bridge Sounder" NMEA sentence into the "Flag" message location on the screen via the menu path **Setup/Ship Display Fields/Flag**.

REFERENCE POSITION FOR NAVIGATION DATA

The ship's GPS receiver computes and outputs the position of its antenna on the port side of the ship's mast. The Trackpoint Receiver generates range and bearing information relative to the transducer mounted on the vertical boom over the ship's port side. For operational convenience, AGCNav should be set up to display positions referenced to the outboard end of the Sea Crane used for handling the Video Grab and Campod. To accomplish this, the following offsets must be used in AGCNav:

Menu Path - **Setup/Antenna Setup**

- Antenna Starboard -11.6 m
- Antenna Forward -11.0 m

Menu Path - **Setup/ORE Setup**

- ORE Starboard -14.4 m
- ORE Forward +0.1 m
- ORE Depth +5.0 m

TRACKPOINT SYSTEM

Interconnection

The RS-232 serial output is first passed through a "dongle" with the following interconnections:

```

Pin 2 -----> Pin 2
Pin 3 -----> Pin 3
Pin 4 --
      |
Pin 5 --
Pin 7 -----> Pin 7

```

It is then transmitted to the Baytech Multiplexer on the bridge via the ships non-energized navigation system wiring. A null modem is required at this point.

Initial Setup

Via menu path **Display/Configuration/System**, review the system setup. If it does not conform to the following, then change as necessary.

- Via menu path **System/Xmit Control**, set
Xmit & Key On
Internal Key
- Via menu path **System/Hyd Offsets**, set
all offsets to "0.0"
VRU orientation to "Normal"
- Via menu path **System/Time/Date**, set the date. The Trackpoint receiver clock has a high drift rate, so it is not worth setting it until the system is about to be used to generate positions.
- Via menu path **System/Acoustic Data**, set
Temp Auto
Speed of sound 1500
Salinity 35 ppt
- Via menu path **System/More/Hardware/RS-232**, set RS-232 communication parameters to:
9600 baud, 8 bit, 1 stop
interval = 1
ON
- Via menu path **System/More/RS-232 Units**, set RS-232 units to metres.
- Via menu path **System/More/RS-232 Format**, set RS-232 output format to "Format-3."
- Via the menu path **Display/Configuration/All Targets**, review the setup for each transponder to verify that it conforms to the following table. If settings for any target differs from those shown in the table, change via menu path **Target/Choice**, then:
 Target/Reply Data to change - Type and Recv Freq
 Target/Tracking to turn tracking Off
 Target/Interrogate Data to change - Xmt Interval and Xmt Freq
 Filtering/Threshold to change Threshold

TABLE C.1. Trackpoint II receiver target menu setting.

				Xmit		Freq.	
Target	Type	Track	Threshold	Interval	Xmt	Recv	Telem
1	Xpndr	Off	Low	2.0	17.0	22.0	
2	Xpndr	Off	Low	2.0	17.0	25.0	
3	Xpndr	Off	Low	2.0	17.0	23.0	
4	Xpndr	Off	Low	2.0	19.0	27.0	26.0

Next, set the Smoothing and Filter Levels for all targets to Off via menu paths **Filtering/Smoothing** and **Filtering/Filter Level**.

Transponders

Battery Life

- If the transponders are fitted with non-rechargeable manganese alkaline batteries, they will operate for periods far in excess of a normal mission before needing replacements.

Use Which One Where

The following are the preferred usage, but in the end use what is available:

- Video Grab, Campod, Epibenthic Sled - small omni-directional or telemetering transponder
- Sidescan - high-power, directional transponder
- BRUTIV - high-power, directional transponder

Routine Operation

- When turning on, **ALWAYS** select "Previous Setup", i.e., press f1
- At least once per day, set Time via menu path **System/DateTime**
The Trackpoint Rx clock has a high drift rate. It does not have to be set exactly as the navigation processing software we use will determine the offset from GMT and correct the logged time. However, one should not allow it to drift too far from the correct time.
- Turn on the target to be tracked via menu path **Target/Choice** then **Target/Tracking**
When the target enters the water, one should see the green lights to the left of the screen flash and, if the volume is turned up on the receiver, hear the replies from the beacon.
- If fixes are very noisy, one can try raising the receiver threshold level for that particular target via menu path **Target/Choice** then **Filtering/Threshold**.

Quick Check of Boom Alignment

Hang a transponder over the starboard side of the ship directly abeam of the boom and record about 5 min. of Trackpoint data via a communication program such as MIRROR. Load data file into a spreadsheet program such as EXCEL. Edit out obvious bad data. Compute mean relative bearing. Should be 90° or 270°, depending on which side of the ship the boom is mounted.

ON-PASSAGE NAVIGATION DATA LOGGING PROCEDURE

Log the following strings at the stated intervals:

- \$GPGGA 30 sec.
- \$GPVTG 30 sec.

- \$AGHDT 30 sec.
- \$VMN04 30 sec.
- \$SDDBS 30 sec.
- \$POREB none
- \$POREB none

VIDEO GRAB POSITIONING PROCEDURE

Trackpoint Receiver

- Turn on Target # x via menu path **Target/Choice** then **Target/Tracking**
- Enter seafloor depth via menu path **Target/Reply Data/Depth/Manual**
- Change to calculated depth mode via **Target/Reply Data/Depth/Mode**
- If data are noisy, try setting slant range gate to slightly less than water depth via **Target/Reply Data/Type/Min Xpndr Rng** or increase the interrogation interval via **Target/Interrogate Data/Xmit Interval**.

AGCNav

Log the following strings at the stated intervals:

- \$GPGGA 2 sec.
- \$GPVTG 30 sec.
- \$AGHDT 2 sec.
- \$VMN04 30 sec.
- \$SDDBS 30 sec.
- \$POREB 2 sec.
- \$POREP 2 sec.

Verify that AGCNav is logging data, i.e., message at lower right corner of screen is green.

CAMPOD POSITIONING PROCEDURE

Trackpoint Receiver

- Turn on Target # x via menu path **Target/Choice** then **Target/Tracking**
- Turn off all other targets via **Target/Choice** then **Target/Tracking**
- Enter seafloor depth via menu path **Target/Reply Data/Depth/Manual**
- Change to calculated depth mode via **Target/Reply Data/Depth/Mode**

If data are noisy, try setting slant range gate to slightly less than water depth via **Target/Reply Data/Type/Min Xpndr Rng** or increase the interrogation interval via **Target/Interrogate Data/Xmit Interval**.

AGCNav

Log the following strings at the stated intervals:

- \$GPGGA 2 sec.
- \$GPVTG 30 sec.
- \$AGHDT 2 sec.
- \$VMN04 30 sec.
- \$SDDBS 30 sec.
- \$POREB 2 sec.
- \$POREP 2 sec.

Verify that AGCNav is logging data, i.e., message at lower right corner of screen is green.

EPIBENTHIC SLED POSITIONING PROCEDURE

Trackpoint Receiver

- Turn on Target # x via menu path **Target/Choice** then **Target/Tracking**
- Turn off all other targets via **Target/Choice** then **Target/Tracking**
- Enter seafloor depth via menu path **Target/Reply Data/Depth/Manual**
- Change to input depth mode via **Target/Reply Data/Depth/Mode**

If data are noisy, try setting slant range gate to slightly less than water depth via **Target/Reply Data/Type/Min Xpndr Rng** or increase the interrogation interval via **Target/Interrogate Data/Xmit Interval**.

AGCNav

Log the following strings at the stated intervals:

- \$GPGGA 2 sec.
- \$GPVTG 30 sec.
- \$AGHDT 2 sec.
- \$VMN04 30 sec.
- \$SDDBS 30 sec.
- \$POREB 2 sec.
- \$POREP 2 sec.

Verify that AGCNav is logging data, i.e., message at lower right corner of screen is green.

BRUTIV POSITIONING PROCEDURE

Trackpoint Receiver

- Turn on Target 1 via menu path **Target/Choice** then **Target/Tracking**
- Turn off all other targets via **Target/Choice** then **Target/Tracking**
- Enter seafloor depth via menu path **Target/Reply Data/Depth/Manual**
- Change to input depth mode via **Target/Reply Data/Depth/Mode**
- Set minimum acceptable slant range to approx. length of cable out via **Target/Reply Data/Type/Min Xpndr Rng**

If slant range erratic or consistent but wrong by a substantial amount, increase interrogation repetition rate to 3 sec. via **Target/Interrogate Data/Xmit Interval**.

AGCNav

- Log the following strings at the stated intervals:
 - \$GPGGA 2 sec.
 - \$GPVTG 30 sec.
 - \$AGHDT 2 sec.
 - \$SDDBS 30 sec.
 - \$VMN04 30 sec.
 - \$POREB 2 sec.
 - \$POREP 2 sec.
- Verify that AGCNav is logging data, i.e., message at lower right corner of screen is green.

SIDESCAN POSITIONING PROCEDURE

Trackpoint Receiver

- Use high-power, directional transponder if available
- Turn on Target # x via menu path **Target/Choice** then **Target/Tracking**
- Turn off all other targets via **Target/Choice** then **Target/Tracking**
- Enter seafloor depth via menu path **Target/Reply Data/Depth/Manual**
- Change to input depth mode via **Target/Reply Data/Depth/Mode**
- Set minimum acceptable slant range to approx. length of cable out via **Target/Reply Data/Type/Min Xpndr Rng**

If slant range erratic or consistent but wrong by a substantial amount, increase interrogation repetition rate to 3 sec. via **Target/Interrogate Data/Xmit Interval**.

AGCNav

- Log the following strings at the stated intervals:
 - \$GPGGA 2 sec.
 - \$GPVTG 30 sec.
 - \$AGHDT 2 sec.
 - \$VMN04 30 sec.
 - \$SDDBS 30 sec.
 - \$POREB 2 sec.
 - \$POREP 2 sec.
- Verify that AGCNav is logging data, i.e., message at lower right corner of screen is green.

APPENDIX D. INSTALLING AND USING THE TRACKPOINT BOOM ON THE C.S.S. *PARIZEAU*

The Trackpoint transducer is mounted on the end of a vertical boom which is secured on the outboard port side of the C.S.S. *Parizeau* (Fig. 2). A large disc affixed to the top of the boom (Fig. D1) sits in a pocket attached to the outside of the port rail approximately mid-way along the foredeck. The pocket is secured by bolts that screw into threaded lugs welded to the face of the rail. A small crane mounted on the deck near the rail is used to lift the boom into and out of the pocket. The disc rotates freely within the pocket so that it can be stowed in a horizontal position out of the water when not in use. The face of the disc at the top of the boom must be well greased before it is mated with the pocket. Once this disc is installed in the pocket, two bolts with doubled spacers and a large-diameter washer under the bolt head are screwed into threaded holes near the top of the pocket to keep it from "jumping out."

The Trackpoint hydrophone array attached to the bottom of the boom is protected by an aluminium cover (Fig. D2) that can be slid up the boom out of the way once the boom is installed and ready for operation. Along the length of the boom are sections of rigid fairing (Fig. D3) which are free to rotate to align themselves with the flow as the ship moves forward or astern. Aluminium spacer rings are placed between each section of fairing. The boom itself can be safely operated at 8 knots. However, the maximum permissible speed for the Trackpoint transducer is 6 knots.

Two worm gear hand-cranked winches are installed on the top of the port rail near the fore and aft extremities of the deck to aid in rotating the boom to a vertical position when lowered and to tension the support stays. The forward winch is bolted to the rail just aft of the point where the rail starts to curve upwards. The after winch is secured to the rail just forward of the edge of the house. The forward winch has a snap hook with a locking sleeve on the end of its runner. A short length (approx. 3 m) of light line is left permanently secured from the eye at the end of the winch runner to the eye on the top end of the forward stay. This rope is just long enough to allow the forward stay to be slack when the boom is stowed in the horizontal position.

The aforementioned small crane is also used to raise and lower the boom. To accomplish this, the end of the lifting sling is detached from the top of the boom and secured to the runner on the crane. The other end of the lifting sling is left secured to the stay attachment point near the bottom of the boom. By hauling in or paying out on the runner, the boom can be raised and lowered.

To lower the boom:

1. Slack off the runner on the forward winch until the black tape mark is reached (approx. 3m).
2. Attach the crane runner to the end of the boom lifting sling and then take up the weight of the boom by hauling in on the crane runner.
3. Remove the bolts securing the plate to the pocket and retract the tapered pin.
4. Slack off the crane runner to lower the boom to a near vertical position.
5. Pull on the light line attached between the forward stay and the runner on the forward winch until the snap shackle on the end of the latter can be attached to the eye on the former.



Figure D1. Top end of Trackpoint boom. The large disc to the left fits into and then rotates within a pocket on the ship's port rail.

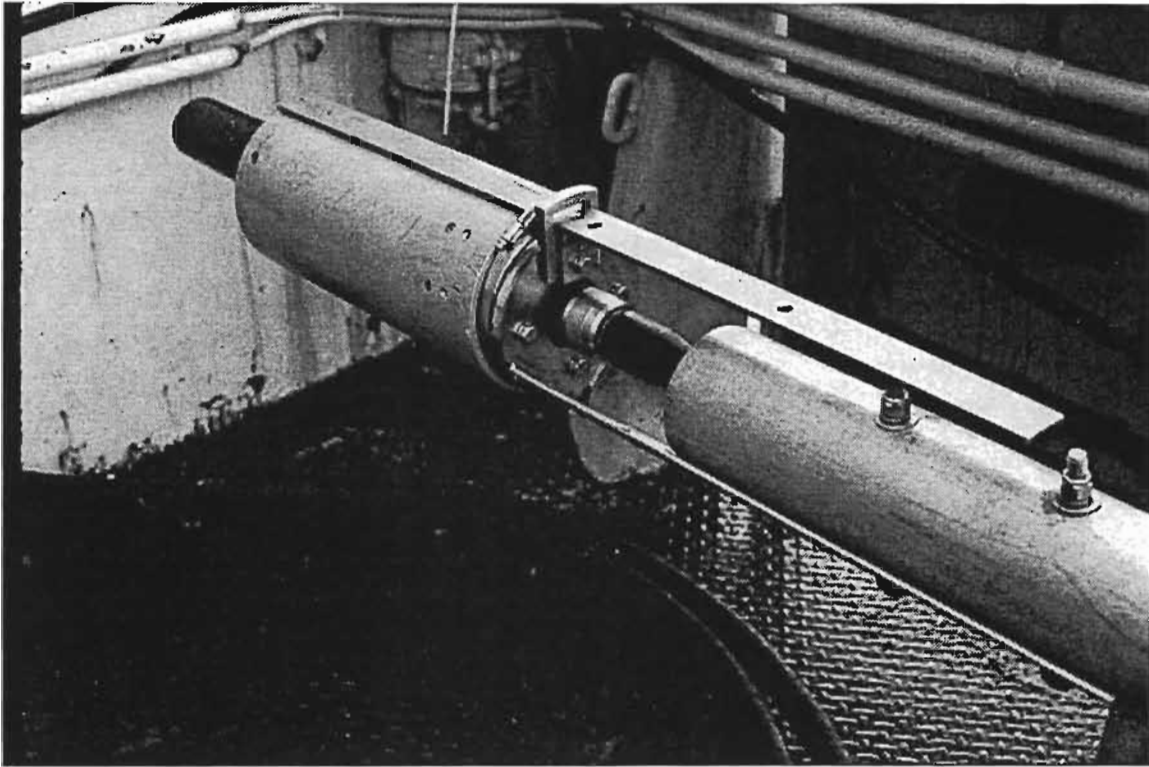


Figure D2. Detail of the Trackpoint hydrophone array on the bottom end of the boom. The sliding protective cover is shown in the retracted or operational position.



Figure D3. General arrangement of the fairing on the Trackpoint boom. The piece at the far right is made of aluminum. All the other sections are plastic. There is an aluminum spacer between each section of fairing. The strut at mid point serves as the attachment point for the after stay.

6. Tension the forward stay until the tapered pin in the disc can easily be screwed into its mating hole in the pocket and two bolts can be passed through the holes near the top of the disc and screwed into mating threaded holes on the pocket to secure the boom.
7. Detach the crane runner from the boom lifting sling and tie off the latter to a point on the rail with just enough tension to keep it from flapping about while steaming.
8. Tension the aft stay by a slight adjustment to its hand cranked winch.

To raise the boom:

1. Attach the crane runner to the end of the boom lifting sling and take up the load.
2. Remove the bolts securing the disc to the pocket.
3. Slack off the runner on the forward winch until the snap shackle can be released from the eye in the stay. The length of light line keeps this end of forward the forward stay from dropping out of reach.
4. Raise the boom to the horizontal position by hauling in on the crane runner.
5. Secure it by two bolts through the disc into threaded holes on the pocket using the tapered bolt an alignment aid.

While transiting to a work area or during a storm, the boom should be lashed securely to the rail or lifted in board.

APPENDIX E. C.S.S. *ALFRED NEEDLER* ACOUSTIC NOISE TRIALS

INTRODUCTION

Since 1993, an experiment to study the impact of otter trawls on the sea bed morphology and the resident benthic community has been underway on the Grand Banks. As part of this activity, the C.S.S. *Wilfred Templeman* towed an otter trawl back and forth along narrow, precisely defined corridors during field experiments in 1993, 1994, and 1995. To verify that the trawl remained within corridor boundaries, an acoustic source was attached to the head rope of the trawl. Its position relative to an accompanying ship was determined using an ORE Trackpoint ultra-short baseline acoustic positioning system. Because the ship's position was known from dGPS measurements, the geographical position of the trawl could thus be determined.

In 1993, this positioning was done using a Trackpoint transducer and receiver mounted on the C.S.S. *Parizeau* which maintained station a few hundred metres abeam of the trawl being towed by the C.S.S. *Wilfred Templeman*. After several days of satisfactory operation in this mode, the acoustic tracking system seemed to develop a noise problem which was only apparent when the C.S.S. *Parizeau* was in the vicinity of the C.S.S. *Wilfred Templeman*. At this point, trawl tracking operations were terminated and the two ships parted company. The Trackpoint system then worked correctly during extensive subsequent use aboard the C.S.S. *Parizeau*.

In 1994, a Trackpoint system was rented from Seaforth Engineering Group Inc. (Dartmouth, N.S.) for installation on the C.S.S. *Wilfred Templeman* so that the C.S.S. *Parizeau* would be free to carry out its post-trawl sampling activity independent of the trawling operation. The transducer was mounted on an over-the-side boom located amidships on the port side. This installation was very similar to that used on the C.S.S. *Parizeau*. The Trackpoint system on the C.S.S. *Wilfred Templeman* never functioned properly, apparently because of high ambient noise levels generated by the ship. The system was shut down and the trawl was successfully tracked using the Trackpoint system on the C.S.S. *Parizeau* as was done in 1993.

Within the next few years, it is likely that a trawling and sampling program similar to this one on the Grand Banks will be attempted on the Scotian Shelf using the C.S.S. *Alfred Needler*. While the C.S.S. *Alfred Needler* is a sister ship to the C.S.S. *Wilfred Templeman*, she has a different propulsion system which is said to be significantly quieter so it is possible that the ORE Trackpoint system might work when installed on her. In years past, Geological Survey of Canada (Atlantic) scientists have used the C.S.S. *Alfred Needler* for acoustic geophysical surveys. Should they do so again then, they will want to use the ORE Trackpoint system.

Therefore, two questions needed to be addressed:

1. What is the ambient noise characteristic of the C.S.S. *Alfred Needler*?
2. Will the ORE Trackpoint system work on the C.S.S. *Alfred Needler*?

ACOUSTIC NOISE LEVEL SPECTRA

Discussions with Marine Services at BIO led to the allocation of one day of ship time early in January of 1995 at the end of C.S.S. *Alfred Needler's* annual refit period to explore the extent of the problem (Mission 95-224). Department of National Defence (DND) engineering staff responsible for the Halifax Sound Range were contacted. They generously offered to do a dynamic sound range measurement of the ship on January 9 at no cost to DFO. This would allow quantitative determination of the ambient noise spectrum levels for the ship at various engine speeds.

The trawl could not be deployed during these measurements because of potential damage to the sound range hydrophone array. Therefore, ambient noise measurements were made with the engines operating in lightly loaded conditions. Reciprocal runs were conducted at three speeds: 175 RPM, 200 RPM, and 225 RPM which corresponded to ship speeds of about 4.0, 5.0, and 6.0 knots respectively. The range is set up to separately measure the acoustic noise radiated to starboard and port so two spectra were produced for each run through the range. These spectra pairs are similar but not identical. In all, 12 spectra were obtained.

The spectra were recorded in real-time on a paper chart recorder. No other form of permanent record, such as digitized signals on magnetic tape, was obtained because of lack of DND resources. The report containing these original chart recordings was supplied to the author. It has been classified CONFIDENTIAL by DND. Marine Services Division at BIO will store it with other engineering information relating to the C.S.S. *Alfred Needler*.

The problem of how to make the spectra publicly available was discussed with T. Langille, Range Officer, Halifax Sound Range. He explained that this could be accomplished if the recordings were reproduced in such a way that the fine detail of the spectra was obliterated. To achieve this, each chart recording was optically scanned to create a digitised image. The images were then edited to fill in parts that were missed by the digitisation process. Areas where the exact trace of the pen could not be determined have been outlined and shaded. The original 11" x 11" spectra were adjusted to fit on an 8.5" x 11" page at a constant scale. Figure E1 illustrates a representative spectra produced via this procedure.

ORE TRACKPOINT PERFORMANCE ON THE C.S.S. ALFRED NEEDLER

Later the same day, an attempt was made to determine the performance of the ORE Trackpoint system when operated on board the C.S.S. *Alfred Needler*. As a temporary expedient, the transducer was suspended just below keel level from the hydro winch amidships on the port side. A 0.75 m x 0.75 m vertical steel plate was secured behind the transducer housing to reduce noise generated by eddies around this cylindrical assembly. A 40-kg dead weight was attached beneath the transducer, and Kevlar stays were secured fore and aft in an attempt to maintain the transducer at a reasonable operating depth while the ship was under way.

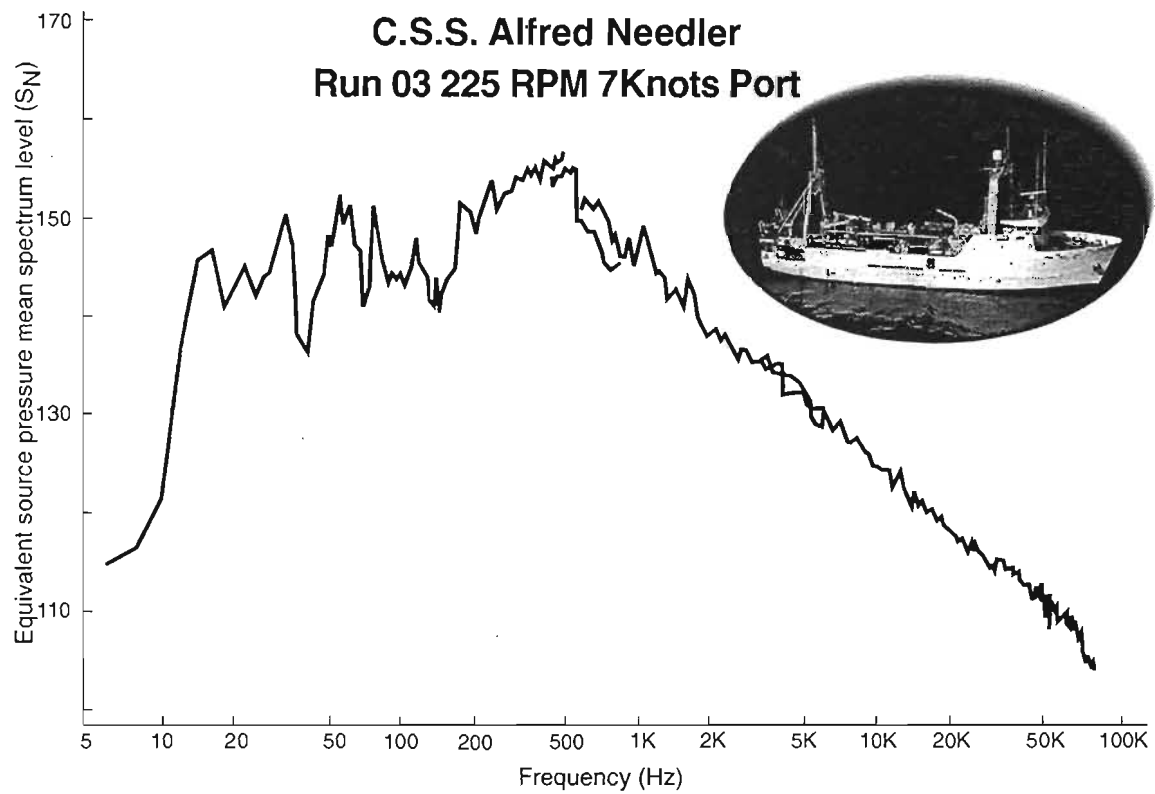


Figure E1. Spectrum of acoustic noise radiated to port by the C.S.S *Alfred Needler* at 225 RPM, 7 knots.

A 28-kHz ORE acoustic beacon was suspended about 2 m above the seafloor on a mooring placed in 110-m water depth off Chebucto Head, N.S. With no trawl in the water, the ship moved slowly away from the mooring while the slant range and relative bearing of the mooring were recorded along with the pitch angle of the transducer. The engine speed was initially set at 175 RPM then later increased to 200 RPM. As the ship speed increased, the drag on the transducer and its cable overcame the depressing force provided by the dead weight depressor causing the transducer to be forced to the surface. In spite of the poor transducer mechanical configuration, the system measured range and bearing with few failures out to about 600 m and with progressively poorer performance to about 900 m. The maximum working range specified for the system is 1000 m. Allowing for the poor circumstance of the transducer, it appears as though the system will work within specification on the C.S.S. *Alfred Needler* at 200 RPM on the engine and no trawl in the water.

The ship then shot its trawl and headed back toward the acoustic transponder mooring, eventually passing it to port at about the 200-m range. The intention had been to maintain a constant engine speed of 225 RPM for this tow. However, it had to be increased in several steps to 235 RPM in order to make reasonable headway. When the trawl was recovered, a very heavy steel wire under considerable strain was found hooked on the port trawl door. Apparently, it had been impeding the progress of the ship. Throughout the tow, the transducer was very near the surface and pitched over at an angle of about 35°-45°. The slant range measurements again appeared to be quite satisfactory, although the relative bearing measurements were very random. Performance of the ORE Trackpoint system under these adverse conditions was very encouraging, although it does not conclusively prove that it will position acoustic sources correctly on the C.S.S. *Alfred Needler* when the ship is actually trawling.

