CENTRAL COAST TRAWL IMPACT AND RECOVERY STUDY

Study Design for External Science Review

NOVEMBER 25, 2008

The Nature Conservancy's (TNC) California Coastal and Marine Program is working with key partners to design and implement a five-year study to examine the impacts of groundfish trawling on soft-bottom habitats, and the amount of time it takes for seafloor habitats to recover from trawling. The purpose of the study is to inform best management practices for groundfish trawling in soft-bottom habitats along the Central Coast of California. Our goal is to provide better scientific information to better transform groundfish fishing practices and develop alternative resource management policies for central California that are economically and environmentally viable. This document provides an overview of the study design that has been reviewed by an external team of scientists.

TNC is in a unique position to conduct this study, given that we have a groundfish trawling vessel and permit in use under a private Conservation Fishing Agreement (CFA) based in Morro Bay and a remotely operated vehicle (ROV) that can be used to assess the impacts of trawl gear on the seafloor. With other key partners, who provide research expertise and other resources, we have an opportunity to conduct a controlled experiment using directed trawling effort in study plots to assess changes in seafloor communities over time.

Our current understanding of groundfish trawling impacts to soft sediment environments is limited both by the small number of studies in these habitats and by the lack of precise estimates of fishing effort applied to the areas being studied (Collie et al 1997; Schwinghamer et al 1998; Engel and Kvitek 1998; Collie et al 2000; Kaiser et al 2000; Lindholm et al. 2004). To-date there are only a few trawl impact and recovery studies from the West Coast (Engel and Kvitek 1998; Tissot and Hixon 2007; de Marignac et al., in review; Lindholm et al., in press). These studies, while instructive, have largely been snap-shots based on limited data collected post-trawling with little knowledge of the intensity of trawling effort. While bottom trawling has been identified as a dominant threat to seafloor habitats, it has been hypothesized — based on limited evidence — that soft-bottom habitats tend to recover more quickly than rocky habitats (Watling and Norse, 1998; National Research Council 2001). Currently, flatfish — which are an important component of the groundfish fishery in central California — can be caught in commercial quantities only by using trawl gear. Understanding the impacts of trawl gear on soft-bottom habitats through directed trawl studies (National Research Council 2001) will help us determine the appropriate intensity of groundfish trawling effort and identify the most appropriate locations for trawling to minimize adverse impacts to seafloor habitats, while allowing the catch of economically important fish.

The research questions that will be addressed by this study include:

- How do seafloor microhabitat, invertebrate abundance and fish abundance differ between intensely trawled plots and control plots over time in a depositional soft-sediment environment?
- What are the changes in seafloor communities after trawling effort has occurred and what is the pattern of recovery over time?
- What is the catch of flatfish and bycatch of associated species in this soft-bottom habitat?

Collaborative Research Partnership:

This project is being funded by the California Ocean Protection Council (OPC), through a State Coastal Conservancy grant, by a private foundation, and through the in-kind contributions of project partners. The research study design has been reviewed by an external review panel of scientists and gear experts who provided important input on project design. The project represents a broad collaborative partnership among non-profits, state and federal agencies, academia, and members of the fishing community. The research effort involves key staff and resources from:

- **The Nature Conservancy (TNC)**: Dr. Mary Gleason, lead marine scientist for The Nature Conservancy's California Coastal and Marine Program, is an expert on Central Coast marine habitats and the recovery of ecological communities following disturbance events. She will manage this project for The Nature Conservancy and serve as co-lead on scientific design and analysis.

- **California State University Monterey Bay (CSUMB)**: Dr. James Lindholm, Rote Professor of Marine Science and Policy, is an expert on trawling impacts and has conducted similar studies on soft-bottom habitats. He will co-lead on scientific design and analysis, lead the analysis of impacts on sea-bottom micro-habitats and epifaunal invertebrates, and oversee analysis of infaunal invertebrates. Donna Kline will assist with oversight of field operations and data collection and will conduct analyses on all videographic and still photographic data .
- **National Marine Fisheries Service (NMFS)**: Dr. Elizabeth Clarke, is a fishery oceanographer and an expert on groundfish management and assessment, essential fish habitat for Pacific coast groundfish, and impacts of fishing activities. She will provide design and analytical advice to the project and will lead analysis of fish abundance and fishery catch data.
- **Monterey Bay National Marine Sanctuary (MBNMS)**: Dr. Andrew DeVogelaere, Dr. Lisa Wooninck, and Jean deMarignac will provide input on study design, data collection support, and coordinate use of NOAA resources (ship time, equipment, and crew) to support the research effort.
- **Marine Applied Research and Exploration (MARE):** Dirk Rosen, President, is an expert on ROV technology and operations. He will lead cruise planning and operations of the ROV system and associated technology.
- **Central Coast commercial fishermen**: Ed Ewing is a Morro Bay-based commercial fisherman who will use TNC's trawl permit under private agreement to conduct the directed trawling effort. He will adjust his trawling activity as required to implement the experimental design and provide monitoring data from his directed trawling activities. We will seek other opportunities to collaborate with fishermen who can provide vessel time for ROV and/or grab sample operations.

Research Objectives:

The general research objectives of this project are to compare the distributions of seafloor microhabitats[1] and associated fauna across a gradient of mobile bottom-contact fishing effort. This objective can be stated as two null hypotheses:

> $H_O(1)$: There are no differences in the relative abundance of seafloor microhabitats between intensively trawled treatments and control plots over time, and:
>
> $H_O(2)$: There are no differences in faunal abundance, density and microhabitat associations between intensively trawled treatments and control plots over time.

The specific objectives of the project are to quantify the relative abundance of a) seafloor microhabitats, b) epifaunal macro-invertebrates, c) infaunal macro-invertebrates and d) fish species in intensively trawled plots versus control (untrawled) plots over time in a primarily soft-sediment depositional environment.

Directed Trawling Treatments:

The study will be designed with paired controls and treatments in a stratified random design:

- Control: untrawled (at least since before 2000). Three (or four, if possible) control plots would be paired with treatment plots and provide replication for the untrawled condition over time.

[1] Microhabitat refers to both the physical substratum (e.g., sand waves), any associated structure-forming taxa (e.g., anemones, sponges, amphipod tubes), and any biogenically built structure (e.g., mounds and depressions). . In addition to the organisms that form them, microhabitats are critical for a variety of fish species at different life history stages.

- Intensely Trawled Treatment: Plots will be trawled annually and intensively (multiple passes, annually for at least 2-3 years). This treatment would represent intensive and repeated trawling, with annual recovery monitored before the next round of trawling began and trawling impacts assessed after each trawling event. The number of trawl passes implemented will be determined after an assessment of trawl intensity in this region based on historic trawl data.

Treatment blocks will be approximately <1 kilometer by ~200m in size (final size to be determined after some baseline data has been analyzed). The directed trawling effort will be conducted by a trawl fisherman using a TNC permit and vessel and a modified trawl (small footrope) gear that is currently being employed on the TNC vessel (Attachment 1). This gear was selected as it is lighter and smaller gear than conventional trawl gear; final gear design to be employed will be informed by consultation with a trawl net design expert. The trawling effort will be carefully monitored by project staff and/or NOAA Groundfish Observers to ensure accurate trawling in treatment plots.

Site Selection:

A site has been identified on the continental shelf in Estero Bay, just offshore from the town of Morro Bay. This site has been selected based on site-prospecting and baseline surveys conducted on the MBNMS vessel (R/V *Fulmar*) using the ROV in September 2008 and in consultation with some members of the commercial fishing community in Morro Bay. The site is a depositional soft-bottom habitat at a depth zone of 160-170 meters. This is a relatively productive area just shoreward of the Rockfish Conservation Area and the shelf-slope break. It is an area that was historically trawled for flatfish (petrale, dover sole) but has not been trawled (based on VMS data) since before 2000. The plots will be situated to avoid an area where undersea cables were installed. The site and potential study design are shown in Figure 1.

Parameters Measured and Sample Sizes:

Multiple transects will be identified in each control or treatment plot and randomly selected from for each monitoring effort (Figure 2). The number of transects will be determined after the baseline survey data from 2008 is analyzed to assess variability in parameters to be measured. The pre- and post-trawling monitoring efforts will utilize three primary sources of data:

ROV video and still photo surveys – A total of ~10 ROV transects will be conducted per plot (each transect will be ~100-200 m in length, pending analysis of preliminary data collected in September 2008). Species and habitat accumulation curves will be plotted to determine the optimal length of a transect necessary to capture the variability in soft sediment communities. The ROV is configured with two video cameras (forward-oblique and down-looking), a down-looking digital still camera, and two down-looking lasers for image calibration and estimating height off the bottom. The ROV will be "flown" at an altitude of approximately 0.75 m above the seafloor. Each transect will consist of continuous video and digital-still photographs recorded on DVD. Still photographs will be taken at approximately 1-minute intervals throughout each transect. Each photograph will cover an area of approximately 0.42 m^2.

1) Video and Still Photographs: these data will be used to measure:
    - relative abundance of seafloor microhabitats
    - relative abundance of epifaunal macro-invertebrates
    - relative abundance of fish

    Digital-still photographs will be used to assess the relative abundance of 'common' microhabitat types. Down-looking video will be used for computing the relative abundance of 'rare' habitat types. Note that the term rare is used in the numerical sense based on under-representation in the photographs rather than in a population context. Paired parallel lasers (20-cm spacing) will be used to indicate a consistent height for taking still photographs (to maintain constancy in area of coverage for each image) and for maintaining altitude for video transects. Still photographs will be taken from a camera height of approximately 0.75 m off the seafloor and covered an area of approximately 0.42

m^2. Each video transect will be treated as a series of non-overlapping video frames (or quadrats). The size of a down-looking video frame at a height of 0.75 m from the seafloor will be approximately 1.32 m^2.

2) **Grab samples** – A total of ~ 10 grab samples, co-located with the randomized ROV transects, will be collected in each plot to measure:
   - relative abundance of infaunal macro-invertebrates
   - Total organic carbon, median particle size (Phi), sorting coefficient, and % moisture

   Bottom grab samples for the analysis of infaunal macro-invertebrates will be collected using either a Van Veen or a Smith-MacIntyre bottom grab (0.1 m^2). Samples will be live-sieved in the field and preserved. All organisms will be identified to the lowest taxonomic level possible.

3) **Fish Catch** – the directed trawling effort will result in catch of both targeted flatfish and non-target species. The entire catch will be retained and quantified to the taxonomic level possible to measure:
   - relative abundance of target and non-target species per unit of trawling effort and/or area.

Analytical Methods:

The study is designed to compare paired control and treatment plots in a random stratified design over time.

Seafloor Microhabitats

Digital-still photographs will be used to assess the relative abundance of 'common' microhabitat types. Down-looking video was quantified for computing the relative abundance of 'rare' habitat types. Data on the percent relative abundance of common microhabitats will be derived from images using a classification system based on abiotic and biotic seafloor features that fishes have been shown to use for cover (Auster 1998, Lindholm et al. 2004). Data will be produced from the still photographs using a series of 50 randomly distributed dots overlaid on each photograph. The microhabitat feature under each dot will be counted and apportioned to a particular microhabitat type. Unique random patterns will be used for each photograph from each transect. The percent relative abundance of a given microhabitat will be calculated as the number of each habitat type divided by the total number of occurrences for all microhabitats for that transect. Imagery from the down-looking video camera will be used to characterize the relative abundance of rare microhabitats (i.e. biogenic depressions and biogenic mounds). Each video transect will be treated as a series of non-overlapping video frames (Auster et al. 1991, Lindholm et al. 2004). The size of a down-looking video frame at a height of 0.75 m from the seafloor is approximately 0.48 m^2.

Epifaunal Macro-Invertebrates

Digital-still photographs will also used to assess the relative abundance, diversity, and species richness of epifaunal, macro-invertebrate species. Counts of all individuals distinguishable to major taxa, and identified to lowest possible taxonomic level, will be made by overlaying each image with a 10-cm grid.
Multiple measures will be used to compare trawled and control plots to test for differences between epifaunal communities. Species richness (S) will be calculated as the total number of species per transect for each site. The Shannon-Weaver index (H') will used to calculate diversity (Pielou 1966, Krebs 1999). This index incorporates both numbers of species and their proportional abundance as an estimate of diversity. Community comparison of species composition and relative abundance between trawled and recovering sites will be measured using the Percent Similarity Index (PSI; Wolda 1981, Krebs 1999).

Benthic Grabs

Sediment samples will be live-sieved in the field through a 1.0-mm mesh screen and preserved in 10%-buffered formalin with rose bengal. All infaunal samples will be transferred to 70% ethanol after returning to the laboratory, where animals will be sorted from sample debris under a microscope and identified to the lowest practical taxon (usually to species). The upper 3-5 cm of sediment from an additional 1-2 grabs also will also be taken at each station, combined into a single station composite, and then sub-sampled for analysis of total organic carbon (TOC) content and grain-size distribution. The surface layer of sediment will be removed from the grab with a scoop, placed in a bowl, and mixed. A TOC sub-sample will then removed from the homogenized sample and placed in a 125-mL plastic jar with lid and stored frozen. An additional sub-sample for grain-size analysis will be removed from the homogenate and placed in a 500-mL plastic jar with lid and stored frozen. TOC and grain-size samples will be processed using protocols modified from Plumb (1981).

Five-Year Study:

This is designed as a five year study, with immediate impacts of trawling being measured annually and recovery over time assessed annual treatments relative to control plots. Ideally, pre-trawling and post-trawling surveys would be done close in time and allow for post-trawling surveys to focus only on treatment plots that have been recently trawled. The annual trawling effort will be discontinued after year 2 or 3 to monitor recovery in all plots for 2-3 years. The study timeline is as follows:

Year 1 (2009):
Mid-August to Early September: Collect additional baseline ROV and infauna samples in all plots before trawling
September: Trawl treatment plots
Late-September to mid-October: Collect post-trawling ROV and infauna samples in all plots

Year 2 (2010):
Early September: Collect pre-treatment ROV and infauna samples in all plots
Mid-September: Trawl treatments plots
Late-September: Collect post-treatment ROV and infauna samples in treatement plots only

Year 3(2011):
same

Year 4 (2012):

Discontinue all trawling in treatments plots to monitor recovery
September: Collect ROV and infauna samples in all plots.

Year 5 (2013):
Discontinue all trawling in treatments plots to monitor recovery
September: Collect ROV and infauna samples in all plots.

Summary:

This overview of the study design has been reviewed by partners and an external science review team. Final details on some elements of the study design are still being resolved pending analysis of preliminary data and additional evaluations. In particular, pending analysis will inform the exact number of ROV transects and infauna samples that will be collected in each plot, the size of the trawl treatment plots in which trawling will be conducted, and the exact specifications of the trawl gear to be used. Pending an analysis of the trawl track intensity in prior years by staff from National Marine Fisheries Service, we will determine the exact number of trawl passes to be implemented in the trawl treatments.

Figure 1: Estero Bay site map and potential study design (note controls and treatments would be assigned randomly in a paired design). Map shows 8 treatment plots (4 trawled plots paired with 4 control plots). Replicate number in final design may be adjusted to only include 6 plots, depending on logistical constraints.

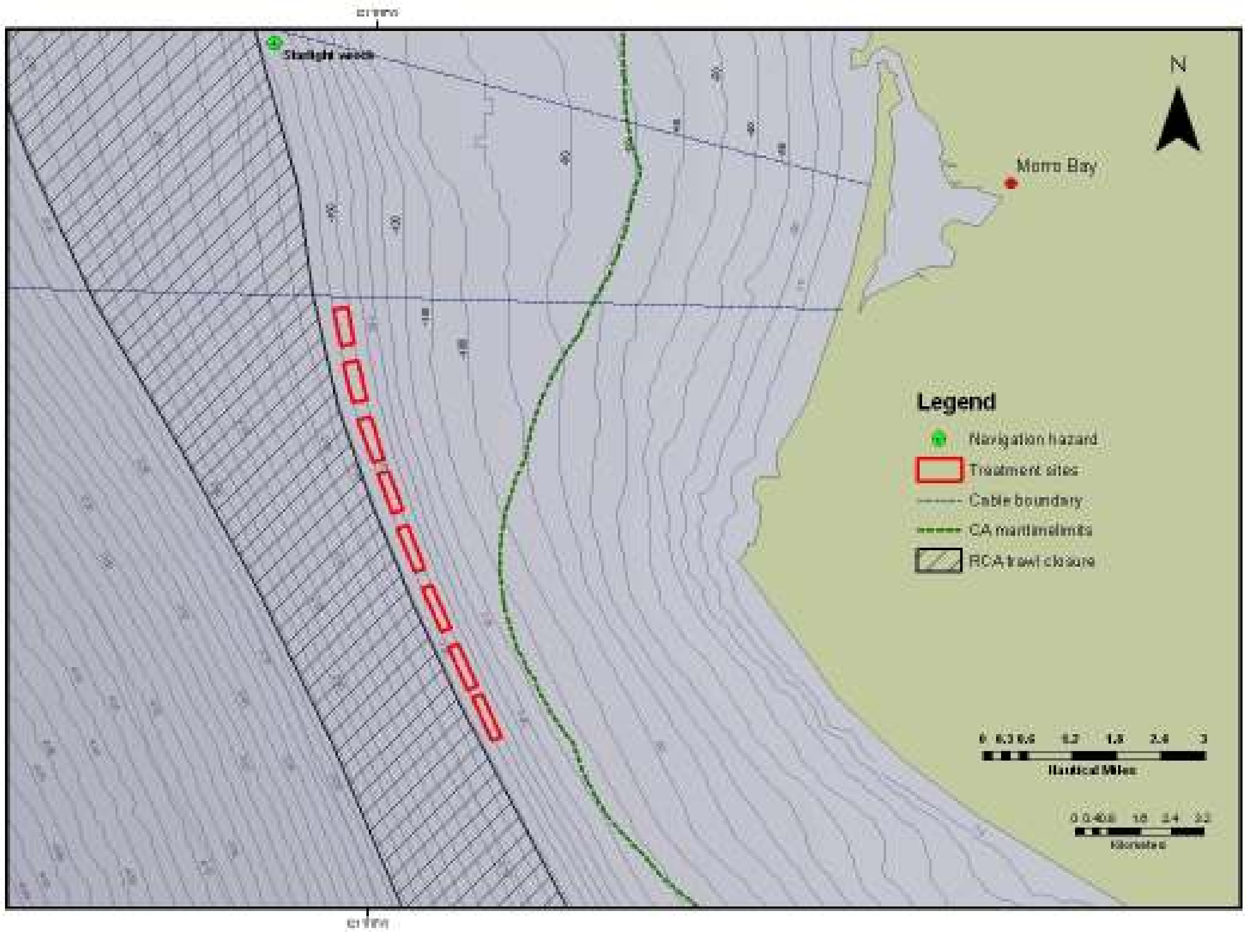
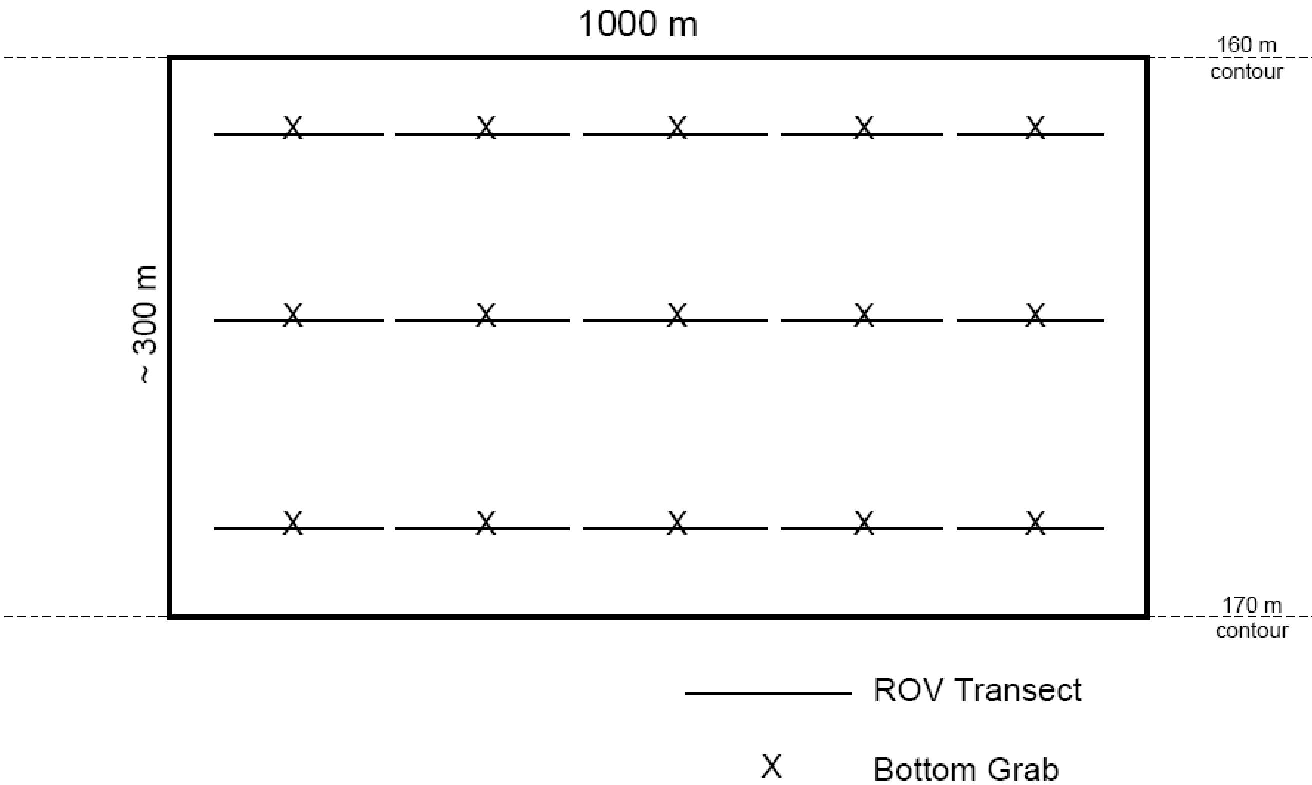


Figure 2: Idealized schematic depicting a set of transects and grab sample locations per control or treatment plot; for each monitoring effort, a subset of transects and grab samples will be randomly selected. Sample size will be determined after analysis of variability in baseline dataset.



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ATTACHMENT 1: Trawl Gear Design and Measurements

TRAWL GEAR SPECIFICATIONS: Modified Trawl Gear (2008)

TNC, through our fisherman partner Ed Ewing, is currently using a modified (small footrope) trawl gear described in these specifications on the F/V South Bay, based in Morro Bay, California. Final decision on trawl gear to be used in trawl impact study will be made in consultation with a trawl net design expert.

Overall

A basic trawl design consists of two panels of netting that are laced together to form an elongated funnel shaped bag (Figure 1). The funnel tapers down to the cod-end where the fish are collected while the net is hauled. The mouth, or opening, of the net is held open on the top by floats along the headline rope and weighted down on the bottom by groundgear that is attached to the footrope. The net is held open on the side by wires (bridles and mudgear, aka sweeps) running from the net to the trawl doors.

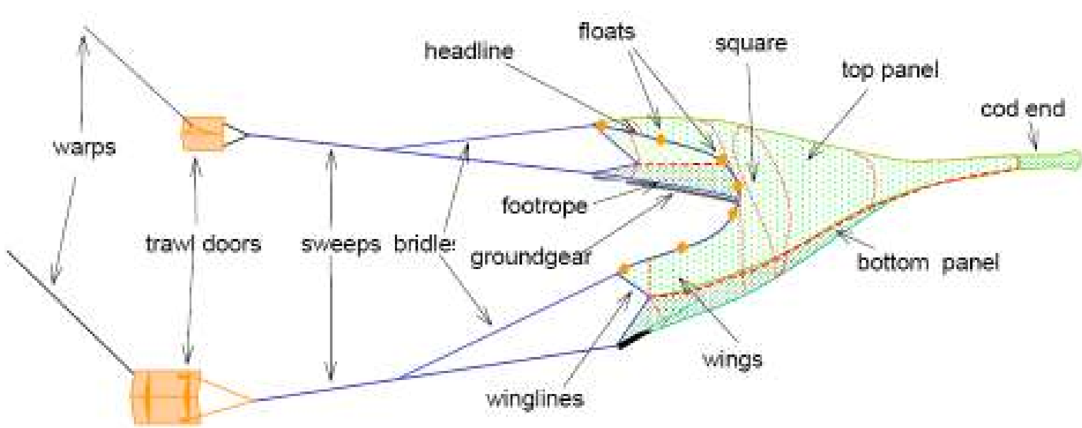

Figure 1. Diagram showing the basic design of bottom trawl gear.
(**Source: http://www.seafish.org/upload/b2b/file/r__d/BOTTOM%20TRAWL_5a.pdf**)

Ed Ewing's modified trawl design consists of a two bridle trawl and the opening has a fishing circle of 300 meshes with a mesh size of 4 9/16 in. The funnel tapers down to the codend at a 2:1 cutting ratio and the mesh size at the codend is 4 ½ in.

Headrope and Footrope Design

The length of the headrope for the trawl is 61 ft long while the footrope is 60 ft (Figure 2). Groundgear is attached below the footrope and runs along the entire length. The groundgear keeps the net from dragging directly along bottom substrate. The footrope is attached to the groundgear, which is constructed of both 8-inch and 4-inch discs that are evenly spaced along the groundgear (Figure 3).

Figure 2. Picture showing the footrope and groundgear (left) and the hearope with attached floats (right).

Figure 3. Picture showing the groundgear with both 8 in. and 4 in. discs.

Trawl Door Size

The door size of the trawl doors, or otter boards, is 3.5 ft by 4.5 ft and each individual door weighs approximately 700 lbs.

Opening and Dimensions

Trawling operations on the F/V South Bay are usually conducted at a speed of 2.1 knots. Speeds slower than 2.0 knots can cause the net to dig into the bottom and results in large amounts of mud, urchins, and sea stars to become caught in the net. When the otter boards are spread open the net width is 33ft (Figure 4) and the height is 8 ft (Figure 5). The distance between the headrope and the footrope bridles is 5 ft.

Figure 4: Picture showing the estimated spread of the net while trawling.

Figure 5: Diagram showing estimated net height while trawling.

Wire attachments

The wings along each side to the opening of the trawl net are attached to the trawl doors by a series of two types of wires called wires and mudgear (aka sweeps). A bridle runs from the headrope and footrope along each end of the net and connects to the mud gear which is then attached to the trawl doors or otter boards. The diameter of the wire for both the bridles and the mud gear is ½ in. The length of each of the bridles is 7 fathoms and the length of the mudgear is 70-75 fathoms long. The mudgear consists of tightly packed discs, similar to the footrope materials, which are 2.5 to 3 inches in diameter.