

# DFO Marine Fish Habitat Information Requirements for Finfish Aquaculture Projects

## Introduction

Fisheries and Oceans Canada - Habitat Management (DFO-HM) is responsible for the protection and management of fish habitat under the authority of the federal *Fisheries Act*. Like other types of industrial development taking place in and around water, aquaculture projects have the potential to affect fish and fish habitat. In order for DFO-HM to determine whether or not a site is an appropriate location for a finfish farm, management plans, specifications and habitat information will be required.

This document provides general guidance for proponents regarding basic information required to document the marine species and fish habitat characteristics present in a proposed finfish tenure area. This information will provide the basis for DFO-HM to conduct habitat reviews under Section 35 of the *Federal Fisheries Act*, the supporting "Policy for the Management of Fish Habitat" (DFO, 1986), and the "Interim Guide to the Application of Section 35 of the *Fisheries Act* to Salmonid Cage Aquaculture Developments" (DFO, 2002). DFO-HM will review the habitat information submitted to assess whether or not a proposed farm is likely to result in a Harmful Alteration, Disruption or Destruction (HADD) of fish habitat. After all mitigation measures have been explored with the company, DFO-HM will determine if a HADD is still likely to occur and if it's possible to issue an Authorization for the HADD. If the proposed mitigation measures can be shown to prevent or adequately mitigate the HADD, DFO-HM will respond with a Letter of Advice listing mitigation measures.

It is important to note that information collected for each survey is not evaluated in isolation from other submitted information. The proposed Management Plan, proposed mitigation measures along with the results detailing habitat and physical characteristics and DEPOMOD dispersion modelling are assessed in conjunction with each other in order to assess potential impacts to fish or fish habitat.

This guide applies to both New Aquaculture Lease Applications and to Replacement of Existing Aquaculture Lease Applications (i.e. Renewals).

**If significant deviations from the recommended sampling approaches described below are necessary, proponents should discuss their sampling plans with DFO prior to conducting the survey. Inappropriate or inadequate sampling may result in rejection of the report.**

### **Assessment Area**

The assessment area must include the entire proposed tenure area, with some focus on all proposed net pen locations. A large-scale **Site Location Map** (approximate scale 1: 50 000 - preferably an enlargement of the relevant hydrographic chart) must be submitted in the final report.

### **Tidal Height/Water Depth**

The lowest normal tide (0.0m), or chart datum, will be used as the reference point for the measurement of tidal height and water depth. Tidal height is recorded as positive relative to chart datum, while water depth below chart datum will be recorded as a negative value (i.e. if the assessment is made when the tide is at 2.0m, and a record is taken at a water depth of 8.0m, then the depth will be recorded as -6m). Tidal height should be corrected using the secondary port found in the Canadian Tide and Current Tables, with further correction made for daylight savings time as required.

### **Acceptable Sampling Season**

The Intertidal and Shallow Subtidal Habitat surveys (and Quantitative surveys as required) must be conducted during the productive spring/summer periods when macrophytes, bivalve shells, abalone and rockfish species are more readily identifiable (May through September). Intertidal and Shallow Subtidal sampling outside of the recommended timeframe may result in the rejection of the data.

If visibility is a problem, appropriate tidal levels and midday lighting conditions are recommended. See specific sections for further details regarding acceptable sampling times.

It is also recommended to conduct all other surveys within the productive spring/summer periods. However, it may be possible to conduct the Deep Water ROV survey if the site is deeper than 70m. It may also be feasible to conduct the Benthic Grab Sampling outside of the recommended sampling season. However, companies choosing to conduct Deep Water ROV (when the site is deeper than 70 m) and Benthic Grab Sampling outside the recommended timing window must be prepared to conduct additional sampling in the spring/summer if necessary.

### **Required Sampling**

In order for DFO Habitat Management Area staff to determine if the proposed application may adversely impact fish habitat, the following surveys and modelling suite will be required:

- 1) Above-Water Shoreline Video, 2) Nearshore Swim, 3) Foreshore Transects,
- 4) Important Species or Habitats Survey (as necessary), 5) Deep Water/ROV Survey
- 6) Benthic Grab Sampling (including Biological Sampling for Replacement of Existing Tenure Applications) and 7) DEPOMOD.

*Proponents must be aware that depending upon results obtained from this habitat assessment procedure, they may be required to provide more detailed information so that DFO can further evaluate specific habitat issues and/or species occurrences that are observed.*

## **1. Above-Water Shoreline Video**

Purpose of survey:

Shorelines and intertidal zones can provide highly productive fish habitats, and also support sensitive species that require particular attention from DFO in determining whether or not a project will likely result in a HADD of fish habitat. The primary purpose of the Above-Water Shoreline Video is to provide a continuous visual record of the shoreline habitat including the upland vegetation, intertidal zone and shallow subtidal zone within 1 km of the tenure boundaries, and including all shorelines within the tenure. The video will document any existing anthropogenic impacts, the slope of the shoreline, the substrate types present, and the biological attributes of the area (e.g. presence of eelgrass, saltmarsh, clam beaches, streams etc).

The Proponent should make use of this information to assist in verifying that siting criteria are met and to guide the appropriate placement of Foreshore Transects (2b below) so they are representative of the habitat types present in the proposed tenure area.

How DFO uses this information:

1. Survey results will serve to verify the appropriate placement of Foreshore Transects (2b below), to determine if the proposed project will meet specific siting criteria (e.g. one km from the mouth of an anadromous stream with spawning habitat), and to identify the presence of any sensitive intertidal habitats (i.e. eelgrass beds, kelp beds, and bivalve beds) that may require specific mitigation measures.
2. In some cases the video footage may result in a request for more detailed information so DFO can assess the biological importance of a particular habitat present.

## **Recommended Methods**

An Above-Water Shoreline video must be taken of the foreshore, following a path parallel to the shoreline (where bottom topography allows). If an *Important Species or Habitat* (i.e. abalone, intertidal/subtidal bivalve beds, kelp beds and eelgrass/surfgrass

beds) is identified on the shoreline video, a more detailed field assessment will be required to determine the exact location, size, depth, etc. of the habitat (Section 2 c).

Note that TRIM and other resource maps should be reviewed prior to conducting the shoreline video to assist in determining where streams may exist (at low tide some streams may go underground before they reach the lower intertidal area), as footage of all stream mouths within 1 km of the proposed tenure is required. A Stream Survey must be conducted on all streams within 1 km of the netpen array. Stream Surveys methods as described in the Resources Inventory Committee (RIC) standards are appropriate.

The video footage must be collected of all shorelines within 1 km of the tenure boundaries. This video should be obtained at the lowest tide possible and the footage must focus on the intertidal zone. Tenure boundary markers on the upland should be clearly recorded on the video and **Basemap**. The traveling speed (e.g. from a boat) must be sufficiently slow to allow features to be seen clearly and easily. Similarly the zoom should be at an appropriate level so that footage is not blurry. If there is an item of importance, such as a stream, it is recommended that the boat slow down and a few minutes of footage, including close-up views, be recorded of the habitat feature. A fully labeled, unedited video must be submitted for review. The video should include a narrative that enables viewers to keep track (spatially) of what they are observing. The date and start/end times of the video must be recorded. The habitat information generated during this survey must be recorded on the **Basemap** (e.g. Stream mouths, beaches etc.). See reporting section for further information regarding video requirements and mapping. See Appendix A for map examples.

## **2. Intertidal and Shallow Subtidal Habitat Surveys**

### **2 a) Nearshore Swim – SCUBA**

**Purpose of survey:** The purpose of this survey is to obtain a qualitative assessment (i.e. overview or general assessment) of the species richness/productivity of fish and fish habitat within the nearshore portion of the tenure. The Nearshore swim complements the Above Water Shoreline Survey by providing detailed continuous information on both subtidal and lower intertidal habitats. The video footage produced as a result of this survey, along with the accompanying information will guide the proponent to determine the number of, and appropriate location for, transects required in the Foreshore Transect Survey (Section 2 b) as well as to identify if additional surveys for any *Important Habitats/Species* will be required (Section 2c).

#### **How DFO uses this information:**

1. The habitat and physical characteristics identified as a result of this survey will allow the reviewer to get an overview of any existing anthropogenic impacts and

provide an overall qualitative indication of the productivity of the nearshore environment.

2. The information provided by this survey will also act as a check system for DFO with respect to foreshore transect placement, number of foreshore transects required, and presence of important habitat/species in the nearshore areas.

## Recommended Methods

The entire shoreline within the proposed tenure must be surveyed. It is important to collect information such as habitat types, organisms, macrophytes and *Important Habitats/Species* (i.e. abalone, kelp beds, eelgrass/surfgrass beds and intertidal/subtidal bivalve beds excluding mussel beds). Emphasis should be placed on depths between 3 and 13 meters. A “zigzag” swim pattern is recommended to ensure adequate coverage of both the kelp and no kelp zones. Habitat observations should be recorded wherever significant changes in habitat type occur. A qualitative visual assessment should be made as to the presence and relative abundance of fauna, macrophytes and predominant substrate type. The following substrate size classification system should be used:

- Bedrock
- Boulder > 256 mm
- Cobble 64- 256 mm
- Pebble/Gravel 2-64 mm
- Sand 0.0625 - 2 mm
- Silt/Mud/Clay < .0625 mm
- Shell Hash (shell fragments/fines) >2 mm
- Organic Debris (specify: wood debris, etc.)

Observations must be summarized in a tabular **Species List** (Appendix A) which would include common names, scientific names and comments regarding habitat characteristics. The Species List is not meant to be a comprehensive inventory of every plant and animal inhabiting the survey area. However, every effort must be made to identify all easily observable macrophytes and animals to species level (or at least family level). When unidentifiable species are observed it is acceptable to report them as “unidentified sponge #1” for example, and a description should be provided.

Video footage should be recorded continuously and video recordings of the divers’ depth gauges should be taken periodically to record depth. Notes should also be made if existing impacts are observed (i.e. accumulations of wood debris). The video must be clear and focused, the videographer should ensure that footage is taken in such a manner that species encountered are clear and identifiable and that some overall wider view shots are taken of adjacent deeper and shallower areas.

**Note:** If *Important Species or Habitats* (Section 2c) are observed during the Nearshore Swim survey, the depth and substrate must be recorded in the **Species List**. The location of the *Important Species or Habitats* must be accurately identified on the **Habitat Map**.

## 2 b) Foreshore Transects

### Purpose of survey:

The purpose of the Foreshore Transect survey is to obtain a qualitative assessment (i.e. overview or general assessment) of the species richness/productivity of fish and fish habitat within the intertidal and sub-tidal areas of the tenure. The results of this survey will expand upon the information gained from Nearshore Swim Survey. *Important Species or Habitats* (Section 2c), *species at risk* or unique habitats within the foreshore area will be identified.

### How DFO uses this information:

1. The foreshore transect survey will be used to assess the general productivity of the intertidal and shallow sub-tidal portions of the site by providing a qualitative indication of the diversity and abundance of the flora and fauna at that time.
2. Information obtained about the substrate types will be used to provide an indication on whether the proposed site has depositional tendencies and to identify if there are portions of the tenure where deposition is likely to occur.
3. Physical habitat characteristics (including past anthropogenic impacts), identified flora and fauna and proposed mitigation measures will be considered by DFO-HM to assess if there is a potential for a HADD.
4. Additionally, the results of the Foreshore Transect Survey will help identify and locate sensitive habitats or species for the purpose of planning and designing a quantitative assessment.

### Recommended Methods

Transects must begin at the highest high water mark (HHWM) and extend as deep as is safely and operationally possible. Transects should be established perpendicular to the shoreline. As general habitat types (i.e. predominant substrate types) will have been determined during the nearshore swim survey, transects must be spaced such that all habitat types present are proportionally represented. If less than ten transects is submitted, the number must be justified in the supporting documents. Transects should be individually numbered (and correspondingly labelled on the video), with the

commencement and termination points of all transects referenced by differential GPS (dGPS).

Habitat observations should be collected at approximately 5m intervals along the transect or when significant changes in habitat type occur. The presence of macrophytes, and the presence and estimated numbers of fauna, should be recorded in a tabular **Species List** for each transect (Appendix A). Information on predominant substrate and the presence of “other features” (i.e. debris, waste accumulations, rocky outcrops) must also be recorded. The location of the transects and the habitat information generated during this survey must be recorded on the **Habitat Map** and in the supporting document. A **Depth Profile** (Appendix A) must be submitted for each transect.

Each transect is to be recorded by scuba diver via a diver-held video camera. The depth should periodically be recorded on the video by holding the diver depth gauge up to the camera. The video must be clear and focused; the videographer should ensure that footage is taken in such a manner that species encountered are clear and identifiable and that some overall wider view shots are taken of adjacent areas.

## **2 c) Important Species or Habitats (as necessary)**

**If any of *Important Species or Habitats* are observed during the Above-Water Shoreline Video, Nearshore Swim, Foreshore Transect Survey or Deep-Water ROV Survey, a more detailed Survey will be required.**

### **Purpose of Survey:**

There are specific habitats and species that DFO considers sensitive, unique or important and therefore require additional consideration to ensure an appropriate level of management. In order to assess the extent (location and size) of the habitats and/or abundance of species, *Important Species or Habitat Surveys* will be required.

Examples of species or habitats of concern include: abalone, intertidal/subtidal bivalve beds (excluding mussel beds), kelp beds and eelgrass beds.

### **How DFO uses this information:**

1. The results of the assessment will describe the aerial extent of the habitat in question or give an abundance estimate so that DFO-HM can recommend additional mitigation measures, authorization or protection as warranted.
2. The results of the assessment may be referred to DFO –Science for advice on the potential for negative impacts. DFO-Science and DFO-HM will determine if the impacts can be mitigated and what monitoring methods may be applicable.

If Kelp Beds are identified during the above-water, nearshore swim or foreshore transect surveys, follow the survey protocol below.

### **Kelp beds – an *Important Habitat***

Kelp beds consisting of *Macrocystis* and *Nereocystis* species are considered to be *Important Habitats* and so further assessment is required. It is crucial that these surveys are conducted during the more productive spring/summer periods (i.e. late May- early September)

Having completed the initial foreshore survey, the approximate size of the macrophyte bed will be known. Now, the exact location of the bed and size must be mapped using dGPS. A scuba diver must swim the bed boundary recording the maximum and minimum depths of the bed (adjusted to chart datum). As the diver swims the perimeter of the bed, pelican floats or similar marking buoys should be placed at approximately 15-m intervals. dGPS readings can then be taken at the various buoys to delineate the bed and create a mapping polygon.

The perimeter of the kelp bed must be video taped and submitted for review. The kelp bed location and size must be digitized on the **Habitat Map** (or a separate map of the same scale) and the bed circumference **coordinates** submitted to DFO-HM along with reference information such as date, time, tidal height and weather conditions.

The diver must also record if other Important Species or Habitats are observed during this assessment. This should also be recorded on the **Habitat Map**.

Refer to Appendix B for the Survey Protocols for Abalone, Eelgrass/Surfgrass and Bivalves.

## **3. Deep- Water/ROV Surveys**

### **3 a) Benthic ROV Transects**

#### **Purpose:**

The purpose of this survey is to collect information to identify the physical habitat characteristics and the flora and fauna living in the deeper portions of the tenure. There are several goals of the sampling, namely:

- 1) to provide a qualitative indication of the biological productivity of the deep portion of the proposed tenure;
- 2) to characterize the physical substrate in terms of sediment size and topography;
- 3) to determine whether any important species or habitats are present and;

- 4) to identify the presence of any existing anthropogenic impacts (eg. wood debris, litter etc)

#### **How DFO Uses this Information:**

1. The underwater footage will be used to assess the general productivity of the deepwater portions of the site by providing a qualitative indication (i.e. general overview) of the species richness and abundance of organisms present at that time.
2. Information obtained about the substrate types will be used to provide an indication on whether the proposed site has depositional tendencies and to identify if there are portions of the tenure where deposition is likely to occur (e.g. pockets of fine silt substrate, *Beggiatoa*).
3. Data collected from the deepwater areas will also be used to identify whether any important species or habitats are present and to determine their location for the purpose of planning and designing a quantitative survey (e.g., deepwater bivalve beds, unique habitats such as sponge reefs).
4. Finally, this video will serve to identify if any existing sediment impacts occur at the site, including the type and amount of impact present.

#### **Recommended Methods**

For deeper areas of the tenure, an underwater video survey is required using an ROV or towed drop camera. Transects need not run perpendicular to shore, but must be spaced such that all habitat types (i.e. bedrock, mud, shell hash etc) present within the tenure are proportionally represented. If less than ten transects is submitted, the number must be justified in the supporting documents. Transects should be individually numbered (and correspondingly labelled on the video), with the commencement points of all transects referenced by differential GPS (dGPS). End points of each transect must also be identified as accurately as possible.

Appropriate measures must be taken to ensure that the camera is well-controlled under water. Video footage must be clear, in focus and well lit throughout the entire survey. The camera should be maneuvered at an appropriate speed (slow) so that all habitat features can be seen easily and clearly. The ROV should not be operated in reverse as this could cause certain fish species and retractable species to be missed. An exception would be during the filming of steep rock walls where it is more practical to face the wall as the camera descends in depth.

A **Species List** must be compiled and submitted along with the video footage and accompanying **text**, including comments on substrate. The locations of the transects and habitat information generated during these transects must be included on the **Habitat map**. See reporting section for further information regarding video requirements.

### **3 b) Benthic Grab Sampling**

#### **Purpose of Survey:**

The purpose of the benthic grab sampling is to provide further information regarding the substrate within the deeper portions of the tenure. The benthic grab sampling results compliment the video sampling data by providing more details on the physical and chemical parameters of the sediment.

#### **How DFO Uses this Information:**

1. Physical and chemical measurements provide an indication of sediment characteristics and, therefore, the potential for deposition and/or assimilation of organic matter at the site.
2. Information yielded from this sampling provides information about the habitat productivity of the site, the types of species that the site can support, and the depositional/erosional nature of the site.

#### **Recommended Methods**

Where substrate type and bottom topography allows, sediment grab samples must be obtained to provide a general idea of sediment quality. A minimum of five grabs is recommended depending on tenure size and sediment variability. Every effort must be made to obtain these samples from the vicinity of the proposed net pen structure. Sediments must be analysed in order to characterize the physical and chemical properties. Parameters to be measured include, but are not limited to, sediment grain size, redox potential, free sulphides, and pH. The report must clearly document how samples were collected, stored, processed and analyzed.

#### **Biological Sampling**

##### ***i) New Site Applications***

Biological analyses are not required at this stage, however proponents should be aware that biological sampling and analyses may be required as part of the pre-operational Baseline Sampling Program (for soft bottom sites) once the site is approved by DFO. The details of the Baseline Program will be developed on a site specific basis according to physical characteristics and net pen locations. If proponents choose to collect biological samples at this stage, they should be properly preserved for later analysis. It is important to note that additional grab sampling may be required at a later point if this is determined to be insufficient or not appropriate for the Baseline Sampling Program.

### ***ii) Replacement of Existing Aquaculture Lease Applications (Renewals)***

When Marine Fish Habitat Information data is being collected for the purpose of **renewing** an Aquaculture Tenure, biological samples must also be collected and preserved for 5 years from each of the benthic sediment sampling stations and the reference sites (established for the *Finfish Aquaculture Waste Control Regulations*). Sediment samples should be sieved through a 1.0 mm screen. Megafauna (large cnidarians, echinoderms, etc) should be counted and returned to the sea and remaining organisms should be preserved for future analysis. If sediment chemistry indicates changes have occurred to the benthic environment, biological analysis will be required.

Where the provincial *Finfish Aquaculture Waste Control Regulations* survey methods fulfill DFO's Deep -Water Survey requirements, this information can be submitted to DFO for review.

## **4. DEPOMOD**

### **Purpose of Survey:**

The computer particle tracking model, DEPOMOD, is a cost-effective means to predict the extent and severity of benthic impacts from fish farms. Farm siting and netpen orientation can be assessed and adjusted to minimize the extent of impacts to sensitive habitats and to explore options to reduce the area of impact by the Proponent and/or by DFO.

### **How DFO Uses this Information:**

1. The predicted footprint in conjunction with the results from the physical and biological assessments will assist the Proponent and/or DFO to site farms away from sensitive habitats.
2. The predicted footprint modelled at 5 g C/m<sup>2</sup>/day will be used as the regulatory threshold to issue a Sec 35(2) Authorization to harmfully alter, disrupt or destroy fish habitat (HADD). Compensatory measures based on the predicted footprint will be a requirement of the Authorization to ensure that DFO's Policy of No Net Loss of Productive Capacity of Habitats is achieved.
3. Monitoring will be a requirement of the Authorization to ensure that the HADD does not exceed the authorized area of impact. The predicted footprint will also form the point of reference to position sampling stations.

### **Recommended Methods**

Please refer to Appendix C for DEPOMOD Methods and Settings.

## **Reporting**

### **Videos**

Underwater videos are essential as they provide a real-time record of the fish habitat characteristics of the site and can be used to assess future impacts based on site monitoring. Videos must be unedited and labeled. The video footage must be referenced with site specific information (transect number, time, date, depth, heading etc.) for later analysis. A written or recorded interpretation must accompany the video. **Unlabelled videos and/or videos with inadequate reference information will not be accepted.**

CD or DVD format is preferred. The resolution must be of high quality, preferably 1024 x 768 or 800 x 600 at a minimum.

#### **NOTE:**

**As stated in the introduction, the purpose of this document is to aid DFO-HM in decision making; it is not intended as a baseline sampling protocol. Detailed baseline habitat information will be required as a condition of authorization and must be collected prior to operations beginning. Once a site is approved in principle, baseline sampling requirements will be decided by DFO-HM and the proponents. These requirements will be outlined in Sec 35(2) Authorization. Baseline information represents the pre-development stage and will be used as a benchmark against which operational monitoring results are compared.**

## Final Report

The final report must include:

- 1) Overview info. Please note that all maps must be done to scale (it is understood that the mapping of substrate and macrophytes will be a professional estimate).
  - a) One Site Location Map 1:50000
  - b) One Basemap showing tenure area boundaries, depth contours, surrounding area (1 km each side of tenure boundary), and data gathered from the Above-Water Shoreline survey (streams, etc).
  - c) One Habitat map showing location of different substrate types, macrophytes, operational infrastructure, transect locations, benthic grab sampling stations, depth contours plus the results of any surveys for *Important species/habitats*. Data gathered from the Nearshore survey, Foreshore Habitat survey and Deep - Water survey must be included on the Habitat map.

**Please note:** The Base Map and the Habitat Map must be as detailed as possible. The scale of 1:5000-1:10000 is recommended for the Habitat Map depending on the lease size.

- 2) Above-Water Shoreline survey
  - a) video of intertidal zone and accompanying table and text
  - b) information digitized on the Base Map
- 3) Intertidal and Shallow Subtidal Habitat surveys
  - a) Nearshore swim video plus accompanying table, text and Species List
  - b) Foreshore transects video (max. number of 10 transects) plus accompanying text, Species List and Depth Profiles.
  - c) Important Species or Habitats Surveys (if applicable).
    - i) see Appendix B.
    - ii) Information should be digitized on the Habitat Map or a separate map of appropriate scale.
- 4) Deep-water/ROV surveys
  - a) Benthic ROV Transects
    - i) Video, Species List and accompanying text
  - b) Benthic grab sampling
    - i) Sediment physical-chemical data and accompanying text
    - ii) Biological samples must be preserved for analysis for Replacement of Existing Aquaculture Lease Applications (Renewals) and may be collected at this time for future Baseline survey requirements for New Site applications.
- 5) DEPOMOD RESULTS
  - a) Contour Plots of the farm "footprint" ( footprint at maximum production and for the average over the production cycle).
  - b) Tables of the Contour Level Area Calculations: footprint area at maximum production and footprint area for the average over the production cycle.
  - c) All Reporting of Results and Data Products as described in Appendix C

Prior to submission, please ensure reports are complete and of a professional nature. If you have any questions regarding the above information requirements please contact your local DFO Habitat Biologist:

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Ph: (250) 756-7325

Shelley Jepps - Port Hardy  
Ph: (250) 902-0429

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# **Appendix A**

## **Examples: Maps, Tables, Depth Profiles**





Species List for the Nearshore Swim Survey\*\* and the Foreshore Transect Survey

Date: \_\_\_\_\_ Site \_\_\_\_\_

Name: \_\_\_\_\_ Surveyor: \_\_\_\_\_

Start Time: \_\_\_\_\_ Transect # \_\_\_\_\_ LWBC # \_\_\_\_\_

Distance (m)	Depth (m)*	Substrate (predominant)	Vegetation	Fauna			Comments
				Common Name	Latin Name	Estimate #	
0-5m along transect line from HW	+ 2.6 to +1.5	Cobble/pebbles/boulder Patches of sand	<i>Mastocarpus papillatus</i>	Limpet Shore Crab Dogwinkle	<i>Lottia sp.</i> <i>Hemigrapsus sp.</i> <i>Nucella sp.</i>	2 4 100+	Wood debris (log)
5-10	+1.5 to +0.8	Boulder/cobble on Sand –some bedrock	<i>Ulva sp.</i> <i>Mastocarpus papillatus</i>	Snail Limpet	<i>Littorina sp.</i> <i>Lottia sp.</i>	+30 5	
10-15	+0.8 to -1.7	Sand with boulders	None	Tube dwelling anemone Green Sea Urchin Red Sea Urchin Black eyed goby	<i>Pachycerianthus sp.</i>  S. droebachiensis S. franciscanus Coryphopterus nicholsi	2  <10 <10 1	
15-23	-1.7 to -4.7	Boulder/cobble on sand	<i>Ulva sp. On boulder</i>	Plumose anemone Spiny Pink Scallop Red Sea Urchin Tube dwelling anemone	<i>Metridium senile</i> <i>Chlamys hastata</i> <i>S. franciscanus</i> <i>P. fimbriatus</i>	3 1 <10 10+	

\*depths are recorded relative to chart datum (eg. -5m = 5 m below chart datum; +1 = 1 m above chart datum)

\*\* Nearshore Swim Survey and Deep-Water ROV Survey will not be recording the distance along transect line but should make note of depths and substrate when encountering 'Important Species'

## **Appendix B**

### **Important Species and Habitat Survey Protocols**

## Appendix B. 1.

### EELGRASS/SURFGRASS BED SURVEY

Surfgrass and eelgrass beds are considered important habitats by DFO. This vegetation provides critical habitat for young fish, invertebrates and other species and stabilises shorelines. There DFO requires that further information is collected to map the location and size of the bed. It is recommended that these surveys take place during the summer growing season to ensure that beds are easily visible.

As an eelgrass or surfgrass bed has been identified in the Intertidal and Shallow Subtidal Habitat Surveys, it is now important to document the size of the bed and relative abundance of eelgrass/surfgrass. This methodology has been adopted from Environment Canada's *Methods for Mapping and Monitoring Eelgrass Habitat in BC* (Precision Identification Biological Consultants, 2002). The entire methodology can be found at <http://www.shim.bc.ca/maps2.html>.

#### 1. Type of Eelgrass Bed

The first step is to classify the type of bed and the species. There are two basic forms of eelgrass beds in the Pacific Northwest; *fringing beds* that occur as relatively narrow bands usually on gentle slopes and more *expansive beds* that cover large areas such a tidal flats.

#### 2. Location and delineation of eelgrass bed

The "edge of bed" can be delineated when the density is less than 1 shoot/m<sup>2</sup> beyond which it continues to decrease. In areas that support a patchy distribution of eelgrass, there may be distances of several metres between patches. In these areas the edge of the bed should be located at the outer edges of the first and last patch.

A scuba diver should swim the bed boundary recording the maximum and minimum depths of the bed (adjusted to chart datum). As the diver swims the perimeter of the bed, pelican floats or similar marking buoys should be placed at approx. 15 m intervals. dGPS readings can then be taken at the various buoys to delineate the bed and create a mapping polygon. The bed polygon must be included in the Habitat Map.

Unedited video footage must be collected when delineating the bed. The video must be clearly labeled to indicate that it is the "delineation of bed" portion of the assessment.

### 3. Distribution

The distribution of eelgrass within the bed may be described as either patchy or continuous. Patchy beds are those that contain isolated groups or patches of plants. Beds, which are not patchy, will be classified as continuous. Refer to Fig 1 through 3.

The diver must swim through the bed in order to assess if it is continuous or patchy. Unedited video must be collected during this assessment. The video must be clearly marked to indicate that this portion of the assessment is to determine the 'patchiness' of the bed. The locations of the transect(s) must be indicated on the Habitat Map.

### 4. Additional Information

The presence of abalone, bivalves (species if known) and motile organisms should be noted when conducting this or any other quantitative assessment.

The assessor should also note any disturbances to the bed (i.e woody debris, prop scour, etc) and if there is a significant layer of epiphytes on the foliage.

### 5. Reference Site (For monitoring changes over time)

This step will be required if follow-up monitoring will be required to evaluate potential impacts to the eelgrass bed adjacent to the aquaculture operation. Please contact the local area DFO Habitat Biologist whether a reference site will be necessary.

In order to account for potential environmental stresses to an eelgrass/surfgrass bed you must establish a reference site. The site must be similar in nature to the bed in question. The type of bed (fringe or expansive), exposure, aspect, minimum and maximum depths, approximate size, and distribution (patchy vs. continuous) should be matched as closely as possible.

Steps # 1 through #4 must be replicated at the reference site within 2 weeks of conducting the survey of the bed in question.

A suggested template for data collection has been attached. However, other methods may be suitable to survey macrophyte beds. It is recommended that proponents contact DFO Habitat Management staff in order to discuss specific situations.





Appendix B. 2.

**Abalone Survey Protocol  
Still under development....**

**In the interim, please refer to the method described in**

Campbell, A and Lessard, J., April, 2004. (Draft) Measuring the impacts of fish farms on abalone populations – Impact assessment protocol. Pacific Biological Station, Stock Assessment Division.

Appendix B. 3.

**Bivalve Survey Protocol  
Still under development....**

# Appendix C

## DEPOMOD Canada Methods and Settings v1.6

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### Introduction and Background

This document details the methodology and generic default settings to be used when applying the aquaculture impact model DEPOMOD to simulate the spatial distribution of wastes from Atlantic Salmon finfish farms in British Columbia, Canada. Reporting requirements for the simulations are also outlined. Detailed modeling recommendations, procedures and guidance are appended to this document.

DEPOMOD was developed at the Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban, Scotland. It was designed to be used by industry, consultants and the regulatory agencies as an objective aid or tool to assist in assessing the potential impact of aquaculture operations on the surrounding benthic environment. The model allows pre- (and in-) operation simulations of the flux of waste material from cage to seabed - predicting the nature and extent of benthic perturbation.

There are currently four versions of DEPOMOD available:

- **DEPOMOD v1.5:** This version is capable of predicting solids impacts and chemical residues that are released from the farm sites in a single dose.
- **DEPOMOD v2.0 (v2.2):** As v1.5 but with the capability to simulate a linear and non-linear time varying discharge. The decay of the released material on the benthos can also be simulated. This version is the most flexible of all versions available.
- **AutoDEPOMOD 1.0.1 (incorporating DEPOMOD v3.0):** This automated version of DEPOMOD was specifically designed for use in the simulation of chemo-therapeutants and the subsequent calculation of consent quantities. The values used in this version apply to UK regulations only.
- **MERAMOD:** This version of DEPOMOD has been developed specifically for use on Sea Bass and Sea Bream aquaculture sites in the Mediterranean.

DEPOMOD predicts the solids deposition on the seabed arising from fish farms and associated changes in the benthic community structure. The model has a structure made up of the following components:

- Grid generation
- Growth and Biomass
- Particle tracking
- Resuspension
- Benthic response

The Grid Generation module allows the user to set up a grid containing information on bathymetry, cage, current meter and sampling station positions for the area of interest. Feeding rates over the production cycle may be determined using the Growth and Biomass module. Given information on production/feeding parameters, wastage rates of fish food and the

hydrodynamics of the near-field area, the initial deposition of particles on the sea bed are predicted in the Particle Tracking module. The particles used in the model are assigned values that describe them in terms of 'solids' or 'organic carbon'. The Resuspension module then redistributes particles according to near-bed current flow fields to predict both the net solids accumulated on the seabed and overall flux of material to the seabed, within the gridded area. From quantitative relationships between benthic community descriptors and solids accumulations, predictions of the level of benthic community impact can be undertaken in the Benthic Response module, given sufficient information on the fish farm. All of the above processes have been successfully validated and reported in peer-reviewed scientific literature – Cromey *et al.* (2002 a and b) provide complete details on the models and field validation experiments. Further information on the model processes are detailed below.

**(N.B. THE BENTHIC RESPONSE MODULE VALIDATION IS APPLICABLE TO SCOTTISH WATERS ONLY - FURTHER VALIDATION IS REQUIRED FOR USE IN BRITISH COLUMBIA WATERS)**

The output of the model is generally presented in the form of a 'footprint of deposition' which describes the areal distribution of wastes on the seabed around the farm site. Predictions of the 'footprint' of farm wastes (represented as either total solids or organic carbon) may be output as total accumulation over a specified time period or as fluxes.

It should always be borne in mind that the results obtained must be evaluated with regard to the capabilities and limitations of the model. There may be occasions when the methods and procedures described within this document cannot adequately predict the distribution of wastes on the sea bed. In some cases, subjective judgement may be needed to justify model results.

### **Modeling Strategy**

Two scenarios for the farm operation should be simulated, both using organic carbon as the output parameter. The first model simulation is based on the maximum daily feed rate for the grow-out period. The second simulation is based on the average feeding rate over the grow-out period.

The maximum daily feed rate simulation is considered to represent the "worst case" scenario because waste production is at a maximum for the farm site. The value of the maximum daily feed rate used for this simulation should be obtained from the operator or the farm's Aquaculture Management Plan. It should be equivalent to the maximum instantaneous daily food input for the permitted biomass production of the farm site.

The second simulation is considered to represent the waste flux averaged over the grow-out period and provides a longer term estimate of waste flux to the seabed. The average waste flux is calculated using the total feed budget for the grow-out period and the duration of the grow-out period as detailed in the farm's management plan.

### **Model Details, Requirements and Settings**

#### **Grid Generation Module**

The first step in preparation for running the model is the creation of a bathymetric grid for the site in the 'GRIDGEN' module. The model requires data on the bathymetry of the area around the farm site. This information is obtained from external sources and input into the model as regularly spaced depth data into a file known as the MAJOR grid. From this information, the model then creates a MINOR grid through linear interpolation of the data at a user defined resolution. It is on the MINOR grid that all model calculations are performed.

The data used in the creation of the MAJOR grid may be obtained from a variety of sources. It is considered that the Canadian Hydrographic Service (CHS) navigational charts generally lack the detail and accuracy near the coastline to be useful in the modeling process. Instead, it is recommended that CHS field sheets be used, as they have greater resolution and contain many more depth soundings (especially near the shore) than the CHS navigational charts. [Paper copies of the CHS field sheets may be purchased from CHS Chart Distributions office at the Institute of Ocean Sciences, Sidney, B.C.]. If the farm operator has undertaken a detailed

bathymetric survey of the site, then the data from this survey will likely be densely spaced and provide the best available information from which to create a bathymetric grid. If data from a high resolution bathymetric survey are used in the model, all data should be corrected to Chart Datum. A brief report on the methods and instrumentation used along with calibration documentation should be provided.

#### Determination of model domain

Fish cage groups are typically 150m to 250m long. To allow for a tidal inequality in the residual flow, the deposition footprint may be offset by 100m (if not further). Thus a minimum model domain might be in the order of 500m in length. A standard grid of twice this distance (1km x 1km centred on the cage group) should be adopted in order that predictions can be made of waste deposition further afield due to particles at the slowest end of the settling velocity distribution.

Additionally, the site specific current meter data used to generate the flow field in DEPOMOD are collected at a single location and applied to the entire model domain. As such, the degree to which the current meter data are representative of the whole model grid will depend on additional factors such as the complexity of the bathymetry, topographical features and distance from the location of the observations. Consequently, the model domain should not exceed the 1km x 1km size.

#### Determination of model resolution

DEPOMOD defines cage locations relative to a sub-grid of ten times the resolution of the MAJOR grid. By selecting a MAJOR grid resolution of 25m, cage locations are calculated to a 2.5m resolution.

DEPOMOD calculates particle positions relative to a sub-grid of ten times the resolution of the MINOR grid. By selecting a MINOR grid resolution of 10m, particles are thus calculated to a 1m resolution. This results in a nominal accuracy for the depositional area calculations of 1m<sup>2</sup>.

From the above, it should be apparent that the MINOR grid **must** be smaller than the MAJOR grid. For a MAJOR grid of 1km x 1km at 25 metre spacing, there will be 40 nodes – the MINOR grid should be set at 99 nodes at 10m spacing with both grid origins at the same location.

The MAJOR and MINOR grids should be contoured and displayed in order to verify the bathymetry and the placement of the farm, current meter and sampling stations. There are several contouring software packages available for this purpose, but the model file structure and features have been developed with the software SURFER (Golden Software Inc.) in mind.

It is the user's responsibility to determine the suitability of the raw depth data for use in the modeling exercise. Gridding and interpolation of distant data points can in itself introduce artefacts into the data than do not necessarily exist in reality. **Caution should always be applied when applying depth data to the Gridgen module.**

#### Procedures and Guidance References

- DCG110 Major Grid Generation
- DCP120 GRIDGEN Module

#### Settings

- BATHYMETRIC DATA
  - All data should be recorded 'positive' depths recorded to Chart Datum
  - Shorelines should be assigned value of '-4'
  - Land areas should be assigned value of '-10'
- MAJOR GRID DIMENSIONS
  - Number of grid cells (i and j) – **40**
  - Length of grid cells (i and j) – **25m**
- MINOR GRID
  - Number of grid cells (i and j) – **99**

- Length of grid cells (i and j) – **10m**
- CAGE POSITION/SAMPLE STATION INFORMATION
  - Cage centre and sample station locations should be input as accurately as possible in metres (x and y) from the MAJOR GRID origin – **USER DEFINED**

### Particle Tracking Module

After the MAJOR and MINOR grids have been created, the next stage in the modeling process is to define the particle information (mass, digestibility, carbon and moisture content, and settling velocities), cage set-up (feed input and sizes), current velocity data (the advective flow field through which the particles settle), the turbulence characteristics of the water column and the number of particles to be modeled.

All the above processes are carried out within the Particle Tracking Module 'PARTRACK'. The output of this module describes the initial deposition patch of waste from the farm on the seabed.

The trajectories of individual particles are modeled as the sum of an advective and a turbulent component. The advective component is based on the current meter observations at different depths in the water column, whilst the turbulent component is modeled as a random walk process parameterized with dispersion coefficients. Waste solids are divided into two categories, waste feed – food pellets not ingested by the fish – and faecal particles. Within the faecal fraction a distribution of settling velocities and mass proportions may be applied. Simulations then entail the individual tracking of many ( $\sim 10^5$ ) waste particles at discrete time steps until they settle onto the seabed.

### Feed and Waste Parameter Settings

As described above, two sets of model simulations should be undertaken. The first using the maximum daily feed input value for the grow-out period while the second uses the average daily feed rate over the grow-out period. The average daily feed rate is calculated by dividing the total feed budget for the grow-out period by the duration of the grow-out period. In both simulations, the daily feed rate per cage should be proportioned on a cage volume basis.

Food wastage rates are difficult to quantify as they are not routinely monitored and may vary considerably with the husbandry practices adopted by the different farm operators. The recent literature appears to consistently report that food wastage rates are less than 5% (Brooks and Mahnken 2003 and Cromey *et al* 2002), consequently for all simulations a feed wastage rate of 3% should be used.

Feed formulations have tended towards high digestibility and low moisture content. At present, the settings are 90% and 10% for feed digestibility and moisture content respectively.

In simulations for carbon flux, the most up-to-date information on the carbon content of the feed pellets should be used. Sutherland *et al* (2001) reported a carbon content of 57%. In the faecal material of juvenile Atlantic salmon Chen *et al* (1999) reported the carbon content to be in the 32% to 35% range. A value of 33% should be used unless more recent analyses are available.

The sinking rate of waste feed pellets range from 6 to 16 cm s<sup>-1</sup> (Cromey *et al* 2002 and Findlay and Watling 1994) depending upon the diameter of the pellet. A single food group using the default sinking rate of 11 cm s<sup>-1</sup> should be used in the simulations.

For faecal particles, the sinking rates are lower than for waste feed pellets. There appears to be some consensus in the literature (Cromey *et al* 2002, Panchang *et al* 1997) supporting a mean sinking rate of around 3 cm s<sup>-1</sup>. The default settings consisting of normally distributed sinking velocities having a mean of 3.2 cm s<sup>-1</sup> and a standard deviation of 1.1 cm s<sup>-1</sup> should be used.

Changes in feed formulations, feeding systems, fish health and husbandry practices will result in changes to the characteristics of the feed, faeces and feed wastage rates. Also new determinations of the sinking rates of feed pellets and faecal particles will result in improved parameterizations of these sinking wastes. Where deviations from the default settings are appropriate, the justification and supporting literature references should be included in the modeling report.

### Hydrographic Data Quality

High quality hydrographic data are critical to the application of DEPOMOD in assessing the distribution of waste material on the seabed. If the HG data used do not accurately represent the overall current flow field around the farm site then any model output using these data should be regarded with a high degree of scepticism. Guidance on assessing the suitability of HG data to be used in DEPOMOD is provided in the appended document DCG105.

### Hydrographic (HG) Data Settings

DEPOMOD uses synchronous current velocity observations from several depth layers (maximum 5 layers) to determine the advective flow field through which the ejected particles settle. However, B.C. Ministry of Water, Air and Land Protection (WALP) "Protocols for Marine Environmental Monitoring" require current meter data to be collected at only two depths (15m below the surface and 5 m above the seabed). Thus, the full potential of DEPOMOD to simulate particles settling through a sheared water column is not realized. Moreover, it appears common that the two HG data sets (shallow and near-bottom) are obtained at different times and from different locations. In such situations, the two HG data sets should **NOT** be used simultaneously in the simulations.

Separate simulations should be run using the shallow and deep current meter records independently. The waste footprint will generally be smaller in area but with larger waste flux values when using the deep meter record, as the near-bottom currents are usually weaker than those collected closer to the surface. [NOTE: The resuspension option in the Resuspension module should only be enabled for the deep current meter record].

In order for model to use the HG data to produce the advective flow field through which the particles settle, the current meter data files must be reformatted to a standard DEPOMOD format (see appended document DCP125). HG data may be expressed as either speed and direction or in vector component form (i.e. EW & NS). It is important to know if the data have been corrected for magnetic variation. The model provides an option which allows the user to specify the correction for magnetic variation.

WALP "Protocols for Marine Environmental Monitoring" require that a data set of *at least* 30 days length be recorded. For modeling purposes, if the HG data record is in excess of 30 days, then the most suitable and representative, contiguous 30 day data set should be extracted from the raw data. The 30 day data represents two neap-spring tidal cycles which will be repeated throughout the modeling exercise. This data set may be hourly averaged unless the variability in the current flow field at time steps less than 60 minutes is considered to have a significant effect on the modeling output.

A full report on instrumentation, methods and procedures used to collect, process and quality control the HG data should be submitted if this information is not included in the farm management plan.

### Particle Trajectory Settings

An important input parameter in the particle tracking module of DEPOMOD is the number of particles which are released per particle group per cage per time step (part/group/cage/?t). In the model, wastes are divided into two groups; faecal particles and waste feed (uneaten food pellets) particles. In reality, a very large number of particles are released from a fish farm site. Following the principle that ensembles of these particles (often with different settling velocities) will follow similar paths, a representative number of particles that describes the behaviour of the ensemble of particles is defined. If the number of particles released during a model run is small, then, depending on the number of time steps, an inaccurate simulation of deposition could result. Thus, the model result could be a poor description of the real particle deposition footprint. Increasing the number of particles released will generally increase the 'accuracy' of the model result. However, this increase in accuracy is not limitless. There will be a point in any simulation, beyond which, no significant increase in accuracy will be gained from an increase in

part/group/cage/?t. In addition, increasing part/group/cage/?t increases the time required to achieve a model run result.

In an effort to balance computational time against estimates of accuracy, and achieve consistency between sites, a value of 10 part/group/cage/?t should be used when running the model.

### Turbulence Model Settings

In this module, the effects of turbulence are simulated through the use of random walk model (Allen, 1982) applied to horizontal and vertical dispersion co- efficients. The turbulence model should be used in all simulations with the default settings of  $0.1 \text{ m}^2 \text{ s}^{-1}$  and  $0.001 \text{ m}^2 \text{ s}^{-1}$  for the horizontal (x and y) and vertical (z) dispersion coefficients respectively (after Gillibrand and Turrell, 1997)

### Procedures and Guidance References

- DCG105 Hydrographic Data QA/QC
- DCP125 HG Data Formatting and Input
- DCP130 PARTRACK Module – Carbon

### Settings

- PARTICLE INFORMATION
  - Water content of food – **10%**
  - Digestibility – **90%**
  - Food wasted as % of food fed – **3%**
  - Carbon as % of food pellets (dry weight) – **57%**
  - Carbon as % of faeces – **33%**
  - Define SETTLING VELOCITIES
    - Food Particles Mean  **$11.0 \text{ cm s}^{-1}$**
    - Faecal Particles Mean  **$3.2 \text{ cm s}^{-1}$**  S.D  **$1.1 \text{ cm s}^{-1}$**   
**Normal Distribution**
- CAGE SET-UP
  - Type of release – **CONTINUOUS**
  - FOOD LOADING
    - Feeding rate in kg/cage/day – **SITE SPECIFIC**
  - DIMENSIONS
    - Specify cage dimensions in metres - **SITE SPECIFIC**
- CURRENT VELOCITY DATA
  - Time step of current velocity data in seconds (1 hour = 3600s) – **USER DEFINED**
  - Length of current velocity data – number of time steps (30 days hourly averaged = 720) – **USER DEFINED**
- TURBULENCE MODEL – **ON**
  - x and y =  **$0.1 \text{ m}^2 \cdot \text{s}^{-1}$**
  - z =  **$0.001 \text{ m}^2 \cdot \text{s}^{-1}$**
- PARTICLE TRAJECTORY MODEL
  - Number of particles – **10**
  - Trajectory evaluation accuracy – **HIGH**
- MEAN TIDAL HEIGHT
  - Specify in metres – **SITE SPECIFIC**

### Resuspension Module

The output of the Particle Tracking Module describes the initial deposition footprint on the seabed of the particles ejected from the farm site. The Resuspension Module addresses the observed though poorly understood resuspension and further advection of this deposited material. DEPOMOD re-uses the near-bed current meter data to simulate the conditions on the seabed that can lead to resuspension events occurring.

The critical values for resuspension and redeposition are currently 'hard-coded' into the model and cannot be user defined. The quantity of material that is available for resuspension is determined by the initial deposition patch and consolidation time. The consolidation time is the length of time that a particle on the seabed is available for resuspension. If a particle is on the sea bed for longer than the consolidation time it cannot be eroded and resuspended. The proportion of this material that is resuspended from the seabed is defined by a linear relationship between near-bed current velocity and the (hard coded) Erodibility Constant.

The hard coded parameters of the resuspension model are:

- Critical Shear Stress for Resuspension –  $0.0179 \text{ N m}^{-2}$  (approx  $9.5 \text{ cm s}^{-1}$ )
- Critical Shear Stress for Re-Deposition -  $0.004 \text{ N m}^{-2}$  (approx  $4.5 \text{ cm s}^{-1}$ )
- Erodibility Constant –  $7 \cdot 10^{-7} \text{ kg m}^{-2} \text{ s}^{-1}$

A consolidation time of 4 days should be used when running the resuspension model. The above model parameters have been validated using a tracer study and using benthic data from several fish farm sites (see DEPOMOD Manual for details).

The “*Use Next Level of Accuracy*” option instructs the model to calculate the quantities of material on the seabed at the next level higher (e.g. if using kg then the model will undertake all calculations in grams before reporting values in kg). This option should always be turned ON. When this setting is used in DEPOMOD v2.0 a numerical error may occur. This is not a bug in the software as such, the model simply runs into rounding errors. The numerical method used to improve accuracy cannot be used in every situation

The resuspension model should be run for at least two loops to allow the model to reach a steady state for continuous releases.

#### Procedures and Guidance References

- DCP140 Resuspension Module

#### Settings

- MODELS
  - RESUSPENSION – **ON**
    - Consolidation time or particles – **4 days**
    - Use next highest level of accuracy – **ON** (unless the model errors in integer flow)
  - G Model – **OFF**
  - Primary Production – **OFF**
  - Wind Wave – **OFF**
  - Memory Saver – **OFF**
  - NUMBER OF LOOPS – **2**
- OUTPUT MODELLED – Flux/Total Deposition – **USER DEFINED**
- MASS UNITS – **g**

#### Model Output Processing

The output of the model to be used in subsequent calculations is in the form of an x,y,z array. These data require interpolation and gridding processes to produce a “footprint of deposition”. Since the data take the form of a regular grid, a minimal amount of interpolation is required.

#### **Procedures and Guidance References**

- DCP150 – Model Output processing

## **Brief Guidance on Assessment of Model Results**

### **Mass Balance Calculations**

At sites characterised by energetic flow fields, typically where the near surface current speeds are very high and/or the near-seabed current speeds are in excess of the critical velocity for resuspension for more than 10% of the data record, a proportion of the excreted material may be exported from the model domain through an open boundary.

A mass balance should be performed to determine the quantity of material lost (i.e. the difference between applied load and the quantity remaining within the model domain) (see DCP 150 for guidance). In cases where a significant proportion of the material has been removed from the model domain, an assessment of the likely fate of the material should be undertaken. Additionally, consideration should be made over the suitability of using the model results in these situations.

### **Assessment of the footprint**

The predicted footprint from each site modelled should be assessed on a case by case basis. As a guide the model output should be reviewed with respect to:

- placement of the footprint relative to the farm cages taking into consideration the magnitude and direction of the residual flow.
- The bathymetry and coastline of the surrounding area, in particular, whether unrealistic accumulations at headlands or on sudden depth changes have occurred.

## **Reporting of Results and Data Products**

The report on the model simulations for a proposed farm site should include the following information, products and data:

- Complete description of farm site (name, company, latitude and longitude, BC lands tenure number, etc.) and contact name for information regarding the model simulations.
- Contour plot of the major or minor bathymetric grid showing the shoreline, depth contours and the placement of the farm net pens and locations of the current meter mooring(s). If the farm operator has conducted a high resolution bathymetric survey of the tenure and used these data in the generation of the grid then a geo-referenced map of the site should be included together with a report documenting the instrumentation and procedures used to acquire, process and quality control the bathymetric data.
- Table listing all the farm net pen specifications and configurations such as; number of net pens, type (polar or square), net pen dimensions, grouping, orientation and total surface area.
- Tables summarizing parameter settings for simulations at maximum daily feeding rate and average daily feeding rate of the grow-out period. Information summary should include; species cultured, harvest biomass, length of grow-out period, feed characteristics, food dispensed per day, waste food per day, faecal material generated per day, carbon wastes generated per day, and waste particle sinking rates.
- Contour plots of the farm “footprint” in terms carbon fluxes to the bottom are the most appropriate method to display the results of the model simulations. Separate contour plots of the footprint for the maximum daily feed rate and for the average feeding rate over the grow-out period should be presented. Units of  $\text{g m}^{-2} \text{d}^{-1}$  should be used for the carbon fluxes. Note that because the resuspension module does not provide output of carbon fluxes in units of  $\text{g m}^{-2} \text{d}^{-1}$  the output file needs to be converted. In total 2 separate contour plots are required for each non-synchronous current meter record.
- In order to have a quantitative estimate of the area of the footprint, the areas within given contour levels should be calculated and tabulated for both scenarios. The contouring package SURFER has the ability to compute areas and volumes of contoured fields. Contour levels suggested are 1, 2, 5, 10, 15, 20, etc.  $\text{g m}^{-2} \text{d}^{-1}$  for carbon fluxes

- Electronic files from the following DEPOMOD modules as detailed below:
  - a) GRIDGEN
    - the configuration file (\*.cfg) for the generation of the major and minor grids as well as the farm configuration and current meter mooring locations
    - the major and minor data files (\*.dat)
  - b) CURRENTS
    - the data file (\*.dat) and calibration file (\*.cal) for each current meter record used in the simulations. (Note: A full report on instrumentation, and procedures used to collect, process and quality control the current meter data should be submitted if this information is not included in the farm management plan.)
  - c) PARTRACK
    - configuration files (\*.cfg) for each simulation. The configuration files contain information on 1) the feed and faecal waste characteristics, their settling velocities, 2) current velocity files, time steps and length of time series, 3) cage setup - daily feeding rates per cage, type and dimensions of the cages, 4) turbulence model setting and 5) particle trajectory model settings.
  - d) RESUS
    - configuration files (\*.cfg) for each simulation. The configuration files contain information on the settings used within the model run.
    - the model output file (\*.sur) for each simulation. These files contain the raw model output prior to any interpolation and gridding techniques being applied.

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## DEPOMOD Canada – DOCUMENTS

List of DEPOMOD Canada Methods (DCM), Procedures (DCP) and Guidance (DCG) documents.

DCP101

	List of DEPOMOD Canada Methods (DCM), Procedures (DCP) and Guidance (DCG) documents	DCP101
	DEPOMOD Installation, Folder Structure and File Naming Conventions	DCG102
	Hydrographic Data QA/QC	DCG105
	MAJOR Grid Generation	DCP110
	GRIDGEN Module	DCP120
	HG Data Formatting and Input	DCP125
	PARTRACK Module – Carbon	DCP130
	RESUS Module	DCP140
	Model Output processing(in progress)	DCP150

# DEPOMOD Canada - Fish Farm Modeling

DEPOMOD Installation, Folder Structure and File Naming  
Conventions

DCP102

## Introduction

It would greatly assist the file transfer and auditing process if all users adhered to the same file structure when installing and operating DEPOMOD. Experienced users of the model have found the following file structure to be the most intuitive and user/sharing friendly.

## Installation

DEPOMOD v2.2 should be installed on a Hard Disk partition named C:\. Although the DEPOMOD installation location suggested by the installer is:

**C:\Program Files\DEPOMODv2\**

it is recommended that this is changed to:

**C:\DEPOMODv2**

as shown below:

Each folder within the DEPOMOD structure should contain the executable (\*.exe) and system (\*.sys) files for the module.

## Site Folder Structure

The files used and created in the actual modeling process should be maintained in a separate folder structure named Modeling within the root C:\ directory as shown below:

This folder structure allows all data associated with a particular site is maintained under a common *sitename* folder. It permits simple separation of the different farms being modeled whilst maintaining a common approach such that data can be exchanged between computers and users with the same set-up and the files examined without further associations having to be created.

The sub-folder structure is detailed below:

- \Sitename\**: files and subfolders relating to a particular site
  - \Benthic\**: files relating to the DEPOMOD benthic module (not used at present)
  - \Currents\**: files relating to the hydrographic data analysis AND the hourly averaged current meter data to be used in the model
  - \Data\**: files relating to the creation of the Major grid
  - \Gridgen\**: files relating to the Depomodv2 Grid generation module
  - \Mail\**: email and communications files relating to the site
  - \Partrack\**: files relating to the DEPOMODv2 Particle tracking module
  - \Raw\**: files containing raw information relating to the site

\Resus\ : files relating to the DEPOMODv2 Resuspension module

\Surfer\ : files relating to post-processing interpolation of the model output data.

### **File Naming Protocol**

It is recommended that file names are kept as short as possible whilst allowing the user to identify the different model set-ups.

A recommended file naming protocol is outlined below, separated into the different stages of the modeling process:

#### Gridgen prep

*Sitename-bathy.xls*

*Sitename-cagesetup.xls*

*Sitename-bathy.grd*

*Sitename-bathy-out.grd*

*Sitename-srf*

*Sitename-maj.dat*

#### Gridgen

*Sitename-min.dat*

#### Partrack

*Sitename -####-C-s/m/b.fil/cfg*

*Where ##### = the daily feeding rate in kg*

*C = Carbon*

*s = surface current meter*

*m = mid-depth current meter*

*b = bottom current meter*

#### HG data files

*Sitename-HGDA.xls*

*Sitename-s/m/b.dat*

#### Resus

*Sitename-####-C-s/m/b.out/cfg*

#### Post processing – remove g0

*Sitename-####-C-s/m/b-gm2day*

Different grids should be assigned new *sitenames*.

# DEPOMOD Canada – Fish Farm Modeling Guidelines

Hydrographic Data QA/QC

DCG105v1

## Requirements

- EXCEL Hydrographic data analysis toolkit “HGDA.XLS”
- current meter data files with minimum of 30 days of contiguous data

## Introduction

High quality hydrographic (HG) data are critical to the application of DEPOMOD in assessing the distribution of waste material on the seabed. The HG data used to simulate the advection of particles within the model should accurately represent the overall current flow field around the farm site. The following provides guidance on assessing the suitability of HG data sets for use in the model. The order of assessment begins with a review of the documentation of the current meter data set, then proceeds to a visual analysis of various graphical and statistical representations of the data sets. If the assessments of the current meter data identify concerns or irregularities then further analysis may be required to assess their suitability for modelling purposes.

**NOTE:** Near surface and near bottom current meter data sets from the same site should be considered separately in the first instance – after which, comparisons between the data should be made.

## Documentation

Documentation is an important and often overlooked aspect in the assessment of the current meter data set. The various components of the documentation are detailed below along with a brief description of how this information may be used to assess the quality of the current meter data set. The B.C. Ministry of Water, Air and Land Protection (WALP) “Protocols for Marine Environmental Monitoring” for the most part require the documentation described below.

- 1 Location, depth and surroundings  
The geo-referenced (latitude and longitude or UTM coordinates) location of the current meter mooring is required to assess how close the measurements are to the proposed or actual location net cage structures. The usefulness of the current meter data set may be called into question if the measurements are either too close (<30m) to existing net pens and in a position that is biased by the physical presence of the net pens, or too far away (~300m) to be representative of the flow at the location of net pens.
- 2 Current meter mooring  
The mooring configuration is an important aspect of the measurement system because it can affect the current meter measurements. Manufacturers of current meters provide guidance for the proper mooring of their instruments. The mooring design used in the collection of the current meter data will be reviewed and concerns identified. In general, the use of surface floatation should be avoided because the motion of the surface float can be transmitted down the mooring line to the current meter thus biasing and/or introducing noise into the speed and direction measurements. Other considerations include, but not limited to, the use of insufficient buoyancy in a sub-surface mooring, attachment of the mooring to other structures, magnetic distortion caused by proximity to large iron objects.
- 3 Current meter make, model, specifications, calibrations, maintenance and sampling configuration.

This set of information will be reviewed to determine that the current meter sensors have up-to-date calibrations; the instrument has been maintained and set up (sampling interval, averaging interval, etc.) in an appropriate configuration for the sampling of a 30 day record.

4 Data processing

Most current meter manufacturers provide software to download the data from their instruments, to process the raw data into engineering units, to correct for magnetic variations, and to display and summarize the current velocity data. It is important to know how the raw current meter data were processed (e.g. correction for magnetic variation, editing of spikes) as it may aid in the interpretation of current meter data particularly when there are concerns with the trustworthiness of the data.

5 Field notes pertaining to the deployment and recovery of the instruments

Written notes from the field personnel about the current meter deployment and recovery operations may explain deficiencies in the current meter records or conversely provide supporting information that the operations proceeded normally. Observations about the presence or absence of tangles in the mooring lines, obstruction or fouling of current meter sensors will could provide valuable information for the interpretation of the current meter data sets.

### **Visual Data Analysis**

The procedure for carrying out simple 'Visual Analysis' requires the data to be presented in a number of graphical formats. A number of data manipulations are necessary prior to plotting:

- Calculation of the orthogonal easterly and northerly vector components from the raw current speed and direction data (where these are not directly available from the instrument or any interface software).
- Frequency analysis of speed and direction

The data should be presented in the following graphical formats for assessment:

- Time series plot of speed and direction
- Scatter plot of speed and direction or and vector components
- Cumulative vector plot (Progressive Vector Diagrams)
- Histogram of direction
- Plot of current velocity and percentile analysis

The following assessments of the data should be made and if the data fail to meet one or more of the following criteria then the current meter record may be unsuitable for modelling purposes. This is in no way an exhaustive list of assessments nor should the data automatically be considered suitable if all the following criteria are met.

The data in each plot should be considered in concert with other projections of the data in order to carry out a complete assessment.

**NOTE:** A hydrographic data analysis toolkit "HGDA.XLS" has been created to carry out the above calculations and produce the required plots of the data. Instructions for use of data input and use of toolkit are provided in the README sheet.

6 The time series plots of speed and direction should illustrate:

- varying current speeds throughout the record. Prolonged periods of zero or 'fixed' flow indicate fouling of meter or malfunctioning sensors and consequently a flawed current meter record.
- varying current directions throughout the record. Extended periods of uni-directional flow indicate fouling of the current meter or malfunctioning sensors and consequently a flawed current meter record.
- presence of a tidal signal, i.e. ebb and flood flows, that occur twice per day

for most locations on the BC coast. Absence of a visible tidal signal should flag the current meter record as suspicious and subject it to more quantitative analysis (see section on Harmonic Analysis below).

- Presence of fortnightly variation (spring – neap cycle) in the speed time series. The maximum current speeds during neap tides (small tides) should be smaller than during spring tides (large tides). Absence of this modulation in the strength of the tidal currents at the fortnightly time scale could indicate problems with the current meter data.
- major current directions (bimodal i.e. ebb and flood directions) that should align with the shoreline and/or bathymetry. (See not below with regard to alignment of principal axis of flow with shoreline/bathymetry).
- Current velocities that are relatively consistent with adjacent tidal records and realistic for the location – i.e. smooth rather than spiky data

7 The scatter plot of EW and NS components should exhibit:

- a principal axis of flow passing through the origin showing ebb and flood tide direction (bi-modal direction). Absence of predominant ebb and flood directions (i.e. a noisy scatter plot) indicate a problematic current meter record. Possible causes are instrument malfunction, obstruction of sensors or contamination of the current meter measurements by mooring motion (i.e. surface floatation).
- alignment of the principal axis (ebb and flood directions) with the shoreline and/or bathymetry. In general, a principal axis of flow that is not aligned with the shore or bathymetry indicates a serious problem with the current meter data. A convoluted shoreline and complex bathymetry could create confused flow directions. Calibrations for the compass and correction for magnetic variation should be rechecked.

8 The cumulative vector plot should depict:

- a continuous relatively smooth track of the summed vector components (no large individual spikes should be observed).
- an overall representation of the residual flow at the location. In general, the residual flow direction should also align with the shoreline/bathymetry.

9 The histogram of direction should demonstrate:

- a bimodal distribution of current direction with peaks that align with the shoreline and/or bathymetry. In general, a principal axis of the flow that is not aligned with the shore or bathymetry indicates there is a serious problem with the current meter data. A convoluted shoreline and complex bathymetry may create confused flow directions. Calibrations for the compass and correction for magnetic variation should be rechecked.

10 The plot of current speed and percentile analysis should show:

- the range of current velocities from zero to a realistic maximum in a representative distribution. Unrealistically large speeds should be edited by replacement with interpolated values.

11 Comparison of data sets collected from the same site

- generally, the mean and maximum current velocities should be less in the near bottom data compared to the near surface data.
- the principal axis of flow should be 'similar' in both data sets except where shoreline and/or bathymetric features can be seen to be causing variations.

12 Data Timing

- The current meter records should be regularly spaced in time over the entire

required 30 day duration of the current meter record. There may be gaps or missing records in the current meter data time series caused by instrument malfunction. Individual missing records should be corrected by simple interpolation but long gaps in the time series are problematic. If the gap is longer than 12 hours in duration the data should be flagged.

### **Further Data Analysis**

The analyses detailed below are more complex and quantitative in nature. The harmonic analysis of the data should be carried when the presence of a tidal signal is not clearly visible or there are major concerns with the current meter record. (D. Stucchi or J. Chamberlain should be contacted to perform the analyses)

#### 13 Harmonic Analysis

- on the B.C. coast the majority of the energy in the current is from the tides. The tidal analysis of the current meter record will report on the proportion of the energy that is tidal and if it is <50% then the current meter record should be flagged as suspicious.
- the tidal analysis will also partition the tidal signal amongst the various tidal constituents. On the BC coast the semi-diurnal (twice daily) tidal constituent M2 (period 12.4 hours) is usually the largest. Failure of the analysis to identify the M2 constituent as the dominant constituent is strong evidence supporting the rejection of the current meter data record.

# DEPOMOD Canada - Fish Farm Modeling

MAJOR Grid Generation

DCP110

## Requirements

- EXCEL tool "CageSetup.xls"
- EXCEL tool "Macro40x40.xls"
- SURFER contouring and mapping software from Golden Software Inc.
- Files containing the digitized bathymetry, coastline and land data in (x, y, z) format to a nominal grid reference. These data must encompass an area in excess of the 1km<sup>2</sup> centred on the farm site.
- Information on the positions of cages and current meter in metres relative to the origin of the digitized bathymetric data.

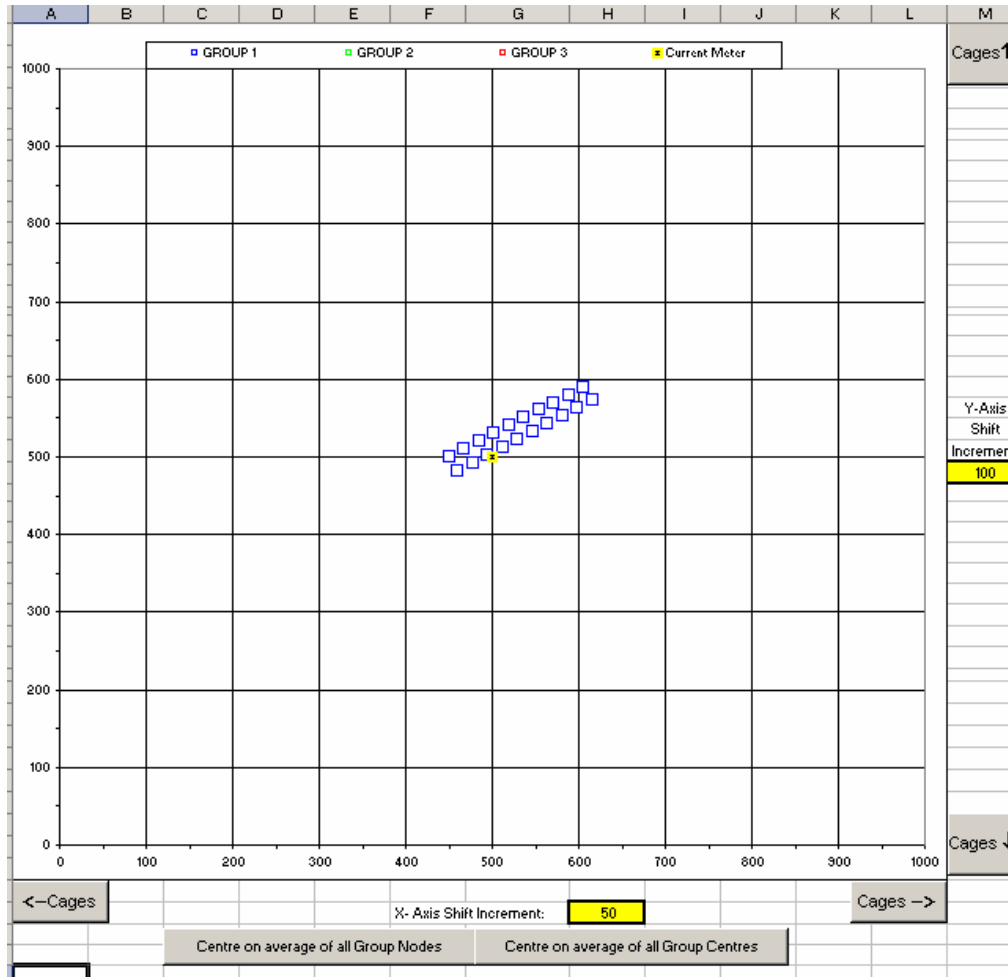
This procedure details the steps required to create the 1km<sup>2</sup> MAJOR grid and the location of the cages therein. Two spreadsheet tools have been created (CageSetup.xls and Macro40x40.xls) to aid this process.

- 1 Open the spreadsheet tool "CageSetup.xls". This spreadsheet allows the user to enter information related to the site cage layout and characteristics, and HG data current meter position (see Site Information Table). The tool formats information on up to three cage groups and displays their relative positions within a 1km<sup>2</sup> grid.
- 2 The 'Cage Layout' sheet is composed of two key sections – the first of these is the Data Input Section (see below). As stated on the sheet, only the yellow boxes must be completed. The green boxes show derived information.
- 3 Data to be entered into this sheet and important derived information includes:  
Box A - the orientation of the longest axis of the cage group in degrees relative to GRID NORTH  
Box B – digitised co-ordinates of the first cage centre.  
Box C – distance between cage centres in longitudinal and transverse directions.  
Box D – command buttons to switch symmetry of cages around corner position  
Box E – digitised co-ordinates of current meter position  
Box F – number of cages in longitudinal ("R") and transverse ("C") directions  
Box G – command button to centre grid on corner node of centre of group  
Box H – tick box to change between round and square cages  
Box I – co-ordinates of the minimum and maximum extents of the proposed MAJOR grid.

Data Input Section

0 (Fill in Yellow Boxes)			
<b>N.B. Green Boxes Show Derived Information</b>			
<b>CURRENT METER</b>			
RCM NGR	E(m)	500	
	N(m)	500	
<b>A</b>	<b>GROUP 1</b>	20	Cages
	Cage Orientation (degrees)	60	C: <input type="checkbox"/> 2
<b>B</b>	NGR	E(m)	450
		N(m)	500
	Longitudinal Spacing	x(m)	20
<b>C</b>	Transverse Spacing	y(m)	20
	Change Symmetry	1	2
<b>D</b>	Around Corner Cage	<input type="checkbox"/>	circular
		<input type="checkbox"/>	Aggregate
	<b>GROUP 2</b>	0	Cages
	Cage Orientation (degrees)	180	C: <input type="checkbox"/> 0
	NGR	E(m)	300
		N(m)	300
	Longitudinal Spacing	x(m)	20
	Transverse Spacing	y(m)	20
	Change Symmetry	1	2
	Around Corner Cage	<input type="checkbox"/>	circular
		<input type="checkbox"/>	Aggregate
	<b>GROUP 3</b>	0	Cages
	Cage Orientation (degrees)	260	C: <input type="checkbox"/> 0
	NGR	E(m)	300
		N(m)	200
	Longitudinal Spacing	x(m)	20
	Transverse Spacing	y(m)	20
	Change Symmetry	1	2
	Around Corner Cage	<input type="checkbox"/>	circular
		<input type="checkbox"/>	Aggregate
<b>OUTPUT</b>			
<b>N.B. Green Boxes Show Derived Information</b>			
Grid Origin Easting	E(m)	0	
Grid Origin Northing	N(m)	0	
<b>MAP - EXTENTS</b>			
		Easting	Northing
Minimum		0	0
Maximum		1000	1000

- Many of the buttons outlined above manipulate the second key section of the Cage Layout sheet – which is shown below.
- This section displays the configuration and location of the cages, and the location of the current meter, on the 1km square model grid area. The centres of the cages (but not the size or orientation) are represented by Excel chart symbols. Square or rectangular cages are represented by square symbols. Circular cages are represented by circular symbols. Easting co-ordinates are given on the x-axis or the chart with northings given on the y-axis.
- Important features of this section are detailed below:  
 Box J – These buttons can shift the y-axis up or down (making the cages appear to move up or down) by the increment (in metres) entered in the yellow box.  
 Box K – These buttons can shift the x-axis to the left or right (making the cages appear to move left or right) by the increment (in metres) in the yellow box.  
 Box L – These buttons are similar to those described for Box G above but applies to all groups used.



7 Enter the positions of the HG meter and cage centre positions. Set the number, spacing (between cage centres) and type of cages as required. (where extra groups are not used, the set the number of rows and columns to zero).

8 Using the control buttons, position the cages on the grid to the most suitable position for the site.

**AS A GUIDE, IT IS BEST TO TRY AND MINIMISE THE ESCAPE OF PARTICLES FROM THE MODEL GRID AREA. CONSIDERATION OF THE HYDROGRAPHIC DATA, AND KNOWLEDGE OF THE COASTLINE GEOMETRY, MAY HELP IN THIS REGARD, CENTERING THE CAGES IS A GOOD STARTING POSITION BUT IT MAY NOT ALWAYS BE THE OPTIMAL SOLUTION.**

9 It is recommended that the X- and Y- direction minimum and maximum values should be set to a 'useful' value (e.g. nearest 10m or 25m) using the shift axis feature (described in boxes J and K above).

These values are used in the creation of the MAJOR grid as the grid limits - they should be noted for use later in this procedure (Step 14).

10 The positions of all cages relative to the nominal grid origin are presented in the 'site-cages' sheet. These values are used in the creation of a SURFER Post file for overlying the cage positions on the DEPOMOD output plot.

11 The positions of all cages relative to the MAJOR grid origin are presented in the

'Depo-cage input' sheet. These values are used when entering the cage positions in the GRIDGEN module. A 'Shrink Window' feature has been included such that this sheet may be viewed on screen along with the GRIDGEN cage location input sheet.

- 12 Save this file as *sitename-cagesetup.xls*.
- 13 In a new EXCEL sheet, amalgamate the shoreline, land and bathymetry files and enter the appropriate sounding as the z coordinate. All data points should be saved in the first three columns of an Excel file (no headers). It is useful to save information about the data in text box next to the data columns
  - Land points should be assigned values of -10
  - Coastlines (higher high water) should be assigned values of -4 (this value should be greater than the highest astronomical tide – thereby never being wetted).

Convert the depth/sounding values to positive metres and save the EXCEL file as *sitename-bathymetry.XLS*. This EXCEL file contains the x,y,z bathymetric data that will be gridded in SURFER.

- 14 Using SURFER, *Grid* the data using *Kriging* interpolation method. All data should be included in these calculations. The X- and Y- direction minimum and maximum values should be set to the grid limits determined in Step 9 of this procedure. As DEPOMOD requires depth values at the *centre* of each grid cell – the following routine should be Settings should be applied.
- 15 The grid line geometry spacing should be set to HALF the desired major grid array spacing increment (12.5m to produce 25m grid). Save this file as 'sitename.grd' in SURFER7 (\*.grd) format (default). Use the *Grid>Extract* utility in SURFER to select data points at 25m spacing beginning with the first node in the centre of the most south-westerly grid. First, select the first and last ROW (Y) to be extracted and read every 2nd node. Then select the first and last COLUMN (X) to be extracted and read every 2nd node.

At 25m spacing for a 1km x 1km grid – this should result in 40 nodes in both directions. (e.g. if extracting data points between 500m-1500m, the minimum position should reside at (512.5, 512.5) and maximum at (1487.5,1487.5)).

This should be saved as '*sitename-out.grd*' in GS ASCII format.

*For information only:*

*Although the GC ASCII file 'sitename-out.grd' contains all the data required for the major grid it cannot be easily transformed into a major grid file having the GRIDGEN format. To facilitate the transformation of the GS ASCII grid file into a DEPOMOD major grid file an EXCEL macro has been written to manipulate the data into the format required by DEPOMOD.*

- 16 Open the EXCEL file "Macro40x40.xls" and push the large button. Open the '*sitename-out.grd*' file. The macro reorganizes the data into the Gridgen format. The Macro prompts the user to provide a filename for the data – this should be saved as '*sitename-maj.dat*' format. The Macro also adds three header lines to the data, containing the filename, the x and y extremes of the data (this is calculated by adding/subtracting 12.5m values to SW and NE corners respectively. Additionally, information on the spacing (25m) and number of nodes (40 x 40) is also included in these headers.
- 17 The data can now be loaded into Gridgen as the Major grid file.

# DEPOMOD Canada – Fish Farm modeling

GRIDGEN Module

DCP120

<b>Requirements</b>	
	<ul style="list-style-type: none"> <li>• MAJOR grid of area in DEPOMOD format (DCP110)</li> <li>• Cage locations in metres from MAJOR grid origin (DCP110)</li> </ul>
1	Open a new data input configuration file
2	Load the MAJOR grid file ( <i>sitename-maj.dat</i> )
3	View the MAJOR grid and header lines using 'Edit depth array' button. Ensure that all data is correct for the site to be modeled.
4	Specify the filename of the minor grid file to be created within GRIDGEN ( <i>sitename-min.dat</i> ).
5	Set the MAJOR grid dimensions as specified in the GRIDGEN section of Methods and Settings.
6	Set the MINOR grid dimensions as specified in the GRIDGEN section of Methods and Settings.
7	Set the location of MINOR GRID on MAJOR GRID as specified in the GRIDGEN section of Methods and Settings.
8	All contouring options should be checked and the ' <i>Number representing cage symbol</i> ' set to 5.
9	Specify the number of cages and location of cage centres through the Cage Position Data dialog box. These may be input either individually from the 'Depo-cage input' sheet of the ' <i>Sitename-CageSetup.xls</i> ' file or using just the cage end positions, calculated within the module using the Specify Lines of Cages option. This involves specifying the number of lines, end cage positions, number of cages in each line, cage spacing and line orientation (NOTE that orientation cannot exceed 180deg in these calculations).
10	RUN MODEL – save configuration file as <i>sitename-min.cfg</i>

# DEPOMOD Canada – Fish Farm modeling

HG Data Formatting and Input

DCP125

<b><u>Requirements</u></b>		
	<ul style="list-style-type: none"><li>• Hydrographic data hourly averaging tool – ‘*min-hrav-data.xls’</li><li>• Contiguous 30 day raw hydrographic data</li></ul>	
1	After the HG data has been quality checked using the HGDA toolkit (DCG105) the contiguous 30 day data set to be used in the model should be input into the appropriate hourly averaging tool (depending on time interval).	
2	The procedure detailed in the README sheet should be followed.	
3	Compare the plots of raw and hourly averaged data to ensure that no significant loss of resolution has occurred during the averaging procedure.	
4	Save the whole file as “ <i>sitename-s/m/b-*min-hrav-data.xls</i> ”. The hourly averaged data sheet should be saved as a space delimited (*.prn) file with file name format “ <i>sitename-DEPO-HG-s/m/b.dat</i> ”. The whole file should then be re-saved again as an Excel file (*.xls) as “ <i>sitename-s/m/b-*min-hrav-data.xls</i> ”.	

# DEPOMOD Canada – Fish Farm Modeling

PARTRACK module - Carbon

DCP130

## Requirements

- Minor Grid file created in GRIDGEN *sitename-min.dat* (and associated files)
  - Maximum daily feed input value for grow-out period (Simulation 1) from Site Information Table
  - Average daily feed input for grow out period (Simulation 2) calculated from total feed budget and duration of grow-out period as specified in Site Information Table
  - 30 day hourly averaged (unless otherwise specified) hydrographic data from the farm site at 15m below the surface and 5 m above the seabed formatted as specified in DCP125
- 1 Open a new Carbon – Continuous Release of Food (food input defined as a time series (dialog method)) data configuration file
  - 2 Load the MINOR grid file (*sitename-min.dat*). View the MINOR grid file data and summary information using the buttons provided. Ensure that all information loaded is correct.
  - 3 Set the particle characteristics by selecting the Particle Information CHANGE button
    - Set Model Units to Carbon
    - Set food and faecal material and settling velocity characteristics as specified in the PARTRACK section of Methods and Settings.
  - 4 Set the cage characteristics by selecting the cage set-up CHANGE button
    - Set the type of release as specified in the PARTRACK section of Methods and Settings
    - Select the Food Loading dialog – set the Feeding Rate value (kg/cage/day) as either equal quantity for every cage or different values for individual cages (portioned on cage volume basis). This value will be the maximum daily feed input value for grow out period for Simulation 1 and the average daily feed rate for grow out period for Simulation 2.
    - Select the Dimensions dialog- set the cage type (circular/rectangular) and the dimensions (length/width or diameter and depth) of each cage either equal for the group or individually.
  - 5 Define the hydrographic data file(s) to be used for the simulation. Specify the depth of water, height of meter(s) above seabed, data format and magnetic correction. Where asynchronous HG data records are used, individual simulations should be undertaken for each record.
  - 6 Specify the time step and length of the HG data record.
  - 7 Set the Turbulence Model and Particle Trajectory Model as specified in the PARTRACK section of Methods and Settings
  - 8 Specify the mean tidal height for the local area
  - 9 Set the output file containing particle information to:  
*Sitename-(applied feed load)-C(for carbon)-s/m/b(HG meter used).fil*
  - 10 Run model – set the configuration filename to the above format

# DEPOMOD Canada – Fish Farm Modeling

RESUS Module

DCP140

## Requirements

- Data files created in Particle tracking module
- 1 Open a new data input configuration file
  - 2 Load the data file created in the particle tracking module (*Sitename-(applied feed load)-C(for carbon)-s/m/b(HG meter used).inp*)
  - 3 Specify the output filename (same as above except in RESUS folder). Set the output data as specified in the RESUS section of Methods and Settings
  - 4 Check the resuspension tick box and ensure that the settings within this sub-model are as specified in the RESUS section of Methods and Settings
  - 5 Run model – set the configuration filename to the above format.

# DEPOMOD Canada – Fish Farm Modeling

Model Output Processing

DCP150

## Requirements

- Data files created in Resuspension module
- either
- Bathymetric Grid File at 12.5m spacing
  - *Sitename-cagesetup.xls*
- or
- *Sitename-min.sur* file created in Gridgen module
- 1 Using *Surfer, Grid* the data file "*sitename-####-C-s/m/bg0.sur*" created in the RESUS folder using the settings below. (This file contains comma separated data containing the output of the model in terms of x,y,z co-ordinates where x and y are the positions relative to the grid origin and z is the flux value in  $\text{g.m}^{-2}.\text{yr}^{-1}$ .)
    - X – Column A
    - Y – Column B
    - Z – Column C
    - Gridding Method - Nearest Neighbour
    - Output file – "*sitename-####-C-s/m/b.grd*" in the SURFER folder
    - Grid line geometry
      - X direction Min=0 Max=1000 Spacing=10 # of lines=101
      - Y direction Min=0 Max=1000 Spacing=10 # of lines=101
  - 2 These data require to be converted from  $\text{g.m}^{-2}.\text{yr}^{-1}$  to  $\text{g.m}^{-2}.\text{d}^{-1}$ . Using *Surfer, Grid – Math* and open the file created above.
    - Output Grid File C should be saved as "*sitename-####-C-s/m/b-gm2d.grd*" in the SURFER folder.
    - The FUNCTION should be **C=A/365**
  - 3 All data should now be in the correct format to produce a plot illustrating the footprint of deposition.
  - 4 Using *Surfer* create the following plots:

### Bathymetry

- *Map – Contour Map – New Contour Plot*
- Open the *sitename-bathy.grd* file
- Load or create an appropriate level (\*.lvl) file that illustrates the land boundary and depth contours.

### Cage Positions

- *Map – Post Map – New Post Map*
- IF *CageSetup.xls* has been used the open this file and select the sheet 'site-cages'. In the Post Properties dialog box, select the following options:

- X Coord – Column A
- Y Coord – Column B
- Symbol – Column E
- Angle – Column C
- IF another approach has been used to site the cages, open the *sitename-min.sur* file (comma separated) in the GRIDGEN folder. In the Post Properties dialog box select columns and settings as appropriate.

#### Footprint

- *Map – Contour Map – New Contour Map*
- Open the "*sitename-####-C-s/m/b-gm2d.grd*" file created above.
- Load or create an appropriate level (8.lv) file that illustrates the patch of deposition.

Overlay all maps using the *Edit – Select All* and then *Map – Overlay Maps* function.

**NOTE – if the grids have been created with reference to different origins use the *Grid – Transform* function to align and locate all grids on the same scale.**

- 5 Save the plot as "*sitename-####-C-s/m/b-gm2d.srf*" in the SURFER folder. Refer to the 'Brief Guidance on Assessment of Model Results' section above for quality checks on the plot.
- 6 To calculate the PLANAR AREA enclosed by the contour of a specified flux rate:
  - *Grid – Volume* function
  - Select the grid file for analysis
  - Set the Z level to the required flux quantity
  - From the 'Areas' section of the report produced, the required value is the "Planar Area – Positive Planar Area [cut]" in m<sup>2</sup>.
- 7 To calculate the quantity of Carbon within the model grid:
  - *Grid – Volume* function
  - Select the grid file for analysis
  - Set the Z level to 0 (zero)
  - From the 'Volumes' section of the report produced, the required value is the "Cut & Fill Volumes – Positive Volume [cut]" in g Carbon day<sup>-1</sup>.

If all the Carbon released from the farm during the simulation is within the model domain, this value should approximate to:

$$0.044 \times \text{Total Feed Quantity per day (kg)} \times 1000$$

(this is calculated from the settings in the feed module of the PARTRACK model where for every 100 kg of food fed, 1.5 kg of Carbon is wasted and 2.9 kg of Carbon is excreted.)

If this value above is below 75% of the expected value then a significant proportion of the material is being exported from the model domain through resuspension. In such cases, the fate of this exported material should be taken into consideration.

