# Combined work/quality assurance project plan (CW/QAPP)

*for*

# Fish and Shellfish Monitoring: 2002-2005

**Massachusetts Water Resources Authority**

**Environmental Quality Department**
**Report ENQUAD ms-078**

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# COMBINED WORK/QUALITY ASSURANCE PROJECT PLAN (CW/QAPP)

*for*

## Fish and Shellfish Monitoring: 2002-2005

## Tasks 21, 22, 23, 24 and 25

## MWRA Harbor and Outfall Monitoring Project
## Contract No. S366

*Submitted to*

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**June 2002**
**Report No. ms-078**

# COMBINED WORK/QUALITY ASSURANCE PROJECT PLAN (CW/QAPP)

***for***

## FISH AND SHELLFISH MONITORING: 2002-2005

## MWRA Harbor and Outfall Monitoring Project
## Contract No. S366

## Concurrences and Approvals

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# APPENDICES

APPENDIX A: MWRA Threshold Testing SOP for Fish and Shellfish

## 1.0 PROJECT NAME

Fish and Shellfish Monitoring (2002-2005)
Tasks 21, 22, 23, 24, and 25
MWRA Harbor and Outfall Monitoring Project

## 2.0 PROJECT REQUESTED BY

Massachusetts Water Resources Authority

## 3.0 DATE OF REQUEST

November 7, 2001

## 4.0 DATE OF PROJECT INITIATION

November 7, 2001

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# 7.0 PROJECT DESCRIPTION

## 7.1 Objectives and Scope

The Massachusetts Water Resources Authority (MWRA) is continuing a long-term biomonitoring program for fish and shellfish (MWRA, 1991) for the MWRA effluent outfall that is located in Massachusetts Bay (see Figures 1 through 3). The goal of the biomonitoring is to provide data that may be used to assess potential environmental impact of effluent discharge into Massachusetts Bay. This data will be used to ensure that discharge from the new outfall does not result in adverse impacts by comparing values with established thresholds (MWRA 2001).

The overall objective of the fish and shellfish monitoring is to define the condition of fish and shellfish health in terms of the presence of disease (external and internal), and organic and inorganic (metal) contaminant concentrations in the liver (winter flounder), hepatopancreas (lobster), and edible tissue (winter flounder, lobster and mussel) of these selected organisms. To help determine the body burden of toxic substances and to assess the physiological status of winter flounder (*Pseudopleuronectes americanus*) and lobster (*Homarus americanus*), one survey per species will be conducted in Boston Harbor, Massachusetts Bay, and Cape Cod Bay (hereafter: Boston Harbor and Offshore) during 2002 through 2005 to collect specimens for analysis. To determine body burden and physiological status of blue mussel (*Mytilus edulis*), arrays of mussels will be deployed in Boston Harbor and Offshore and collected in 2002 through 2005. With effluent discharge beginning in September 2000, results from these monitoring activities occurring post-2000 should alert MWRA to potential changes resulting from the relocation of the outfall discharge. The MWRA Contingency Plan (MWRA 2001) specifies numerical or qualitative thresholds that may suggest that environmental conditions offshore may be changing or might be likely to change. The Plan provides a mechanism to confirm that a threshold has been exceeded, to determine the causes and significance of the event, and to identify the action necessary to return the trigger parameter to a level below the threshold (if the change resulted from effluent discharge). Fish and shellfish thresholds have been established for tissue contaminant concentrations (organic and inorganic) and liver disease incidence (MWRA 2001, Appendix A). Specific objectives for each of the five tasks included in this program are described in Sections 7.1.1 through 7.1.5.

This Combined Work/Quality Assurance Project Plan (CW/QAPP) presents the organization, objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities associated with the Fish and Shellfish Monitoring that will be conducted under Tasks 21 through 25 of the MWRA Harbor and Outfall Monitoring Program (Contract S366). This document also describes the specific protocols that will be followed for sampling, sample handling and storage, chain of custody, and laboratory and field analyses. The CW/QAPP was prepared in accordance with EPA guidance documents on CW/QAPP-preparation (EPA 1984, 1988) and is based on the CW/QAPP that guided previous Harbor and Outfall (HOM) fish and shellfish monitoring (Lefkovitz *et al*, 1998; Lefkovitz *et al*, 2001). Separate survey plans developed for each survey will supplement the CW/QAPP. The survey plans will provide the operational details required to conduct each survey, and will describe participating staff, schedule details, and specific equipment.

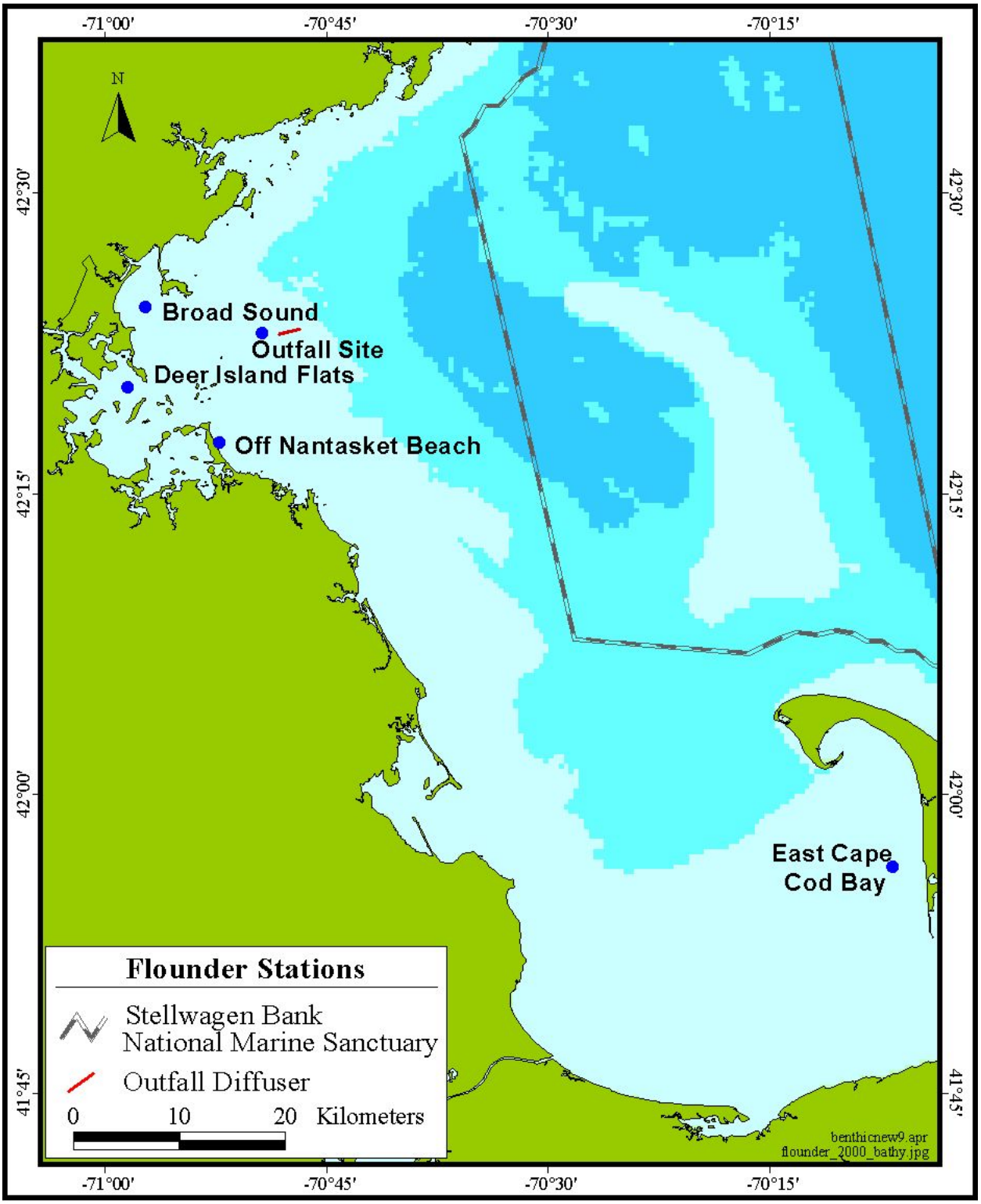



**Figure 1. Flounder Monitoring Locations.**

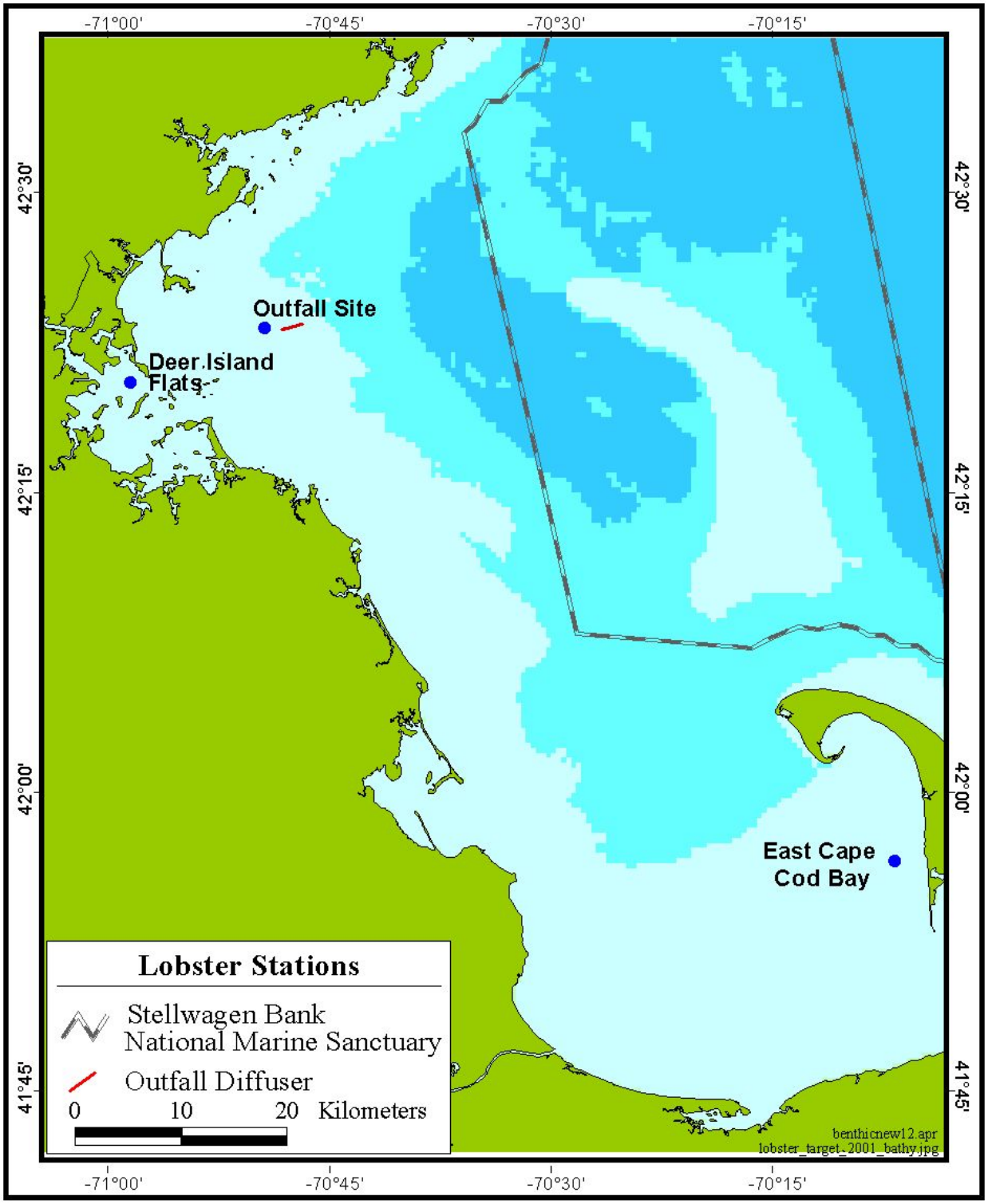



**Figure 2. Lobster Monitoring Locations.**

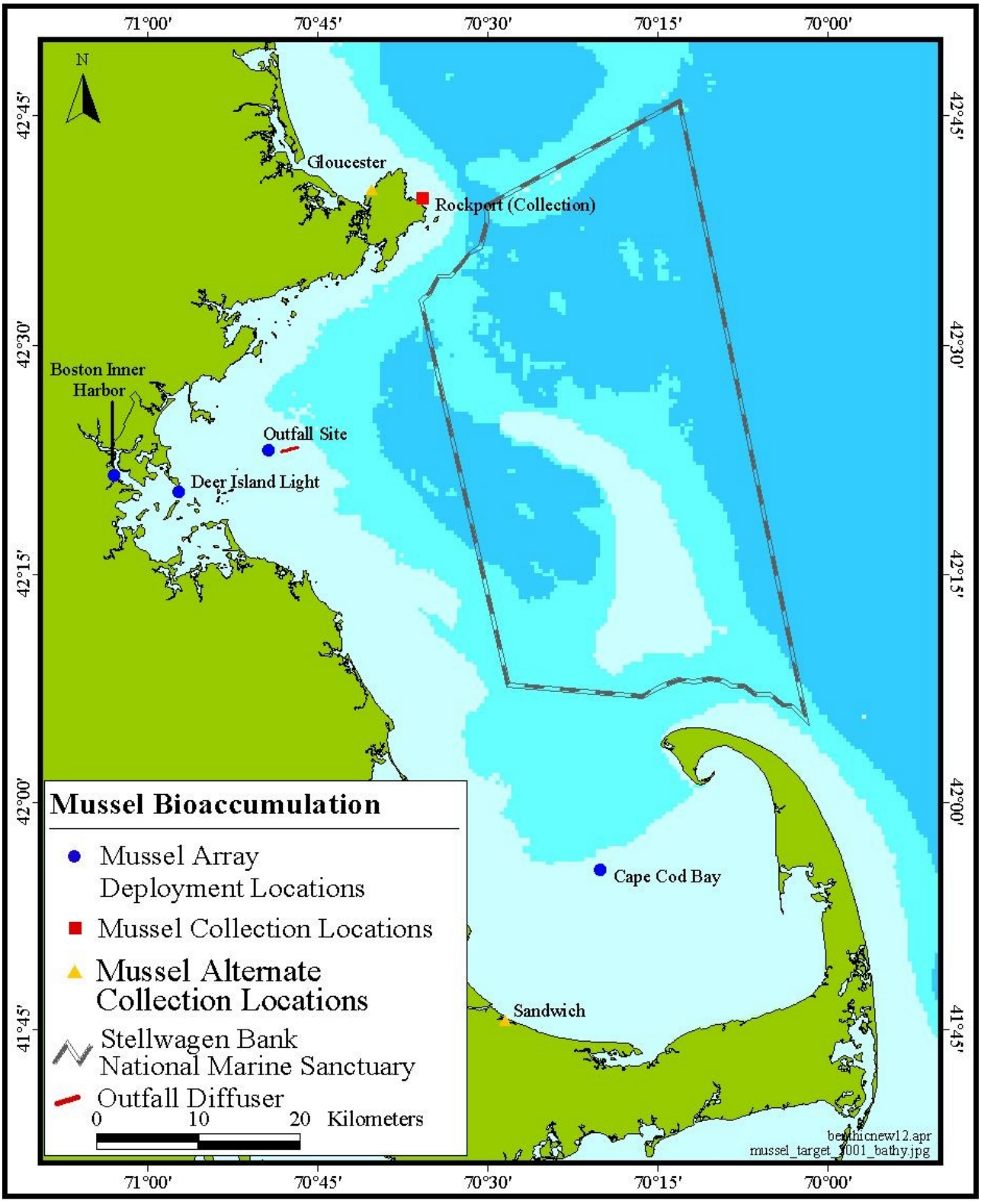



**Figure 3. Mussel Collection and Deployment Locations.**

### 7.1.1 Flounder Survey (Task 21)

The objective of the survey is to obtain specimens of winter flounder *(Pseudopleuronectes americanus)* from five sampling sites in Boston Harbor and Offshore for gross examination, histology, aging, and chemical analyses of tissue to determine sublethal effects of contaminant exposure and tissue burden. Specimens will be collected during surveys conducted in April 2002, 2003, 2004, and 2005. Data generated will be evaluated against established thresholds.

### 7.1.2 Lobster Survey (Task 22)

The objective of the survey is to obtain specimens of lobster *(Homarus americanus)* from three sampling sites in Boston Harbor and Offshore for gross examination and chemical analyses of tissues to determine health and tissue burden of contaminants. Specimens will be collected during surveys conducted in July 2002, 2003, 2004, and 2005.

### 7.1.3 Mussel Bioaccumulation Survey (Task 23)

The objectives of the survey are to obtain, deploy, and recover blue mussels *(Mytilus edulis)* for determination of biological condition and short-term accumulation of anthropogenic contaminants in mussel tissue. Caged mussel arrays will be deployed at four locations in Boston Harbor and Offshore. Specimens will be collected during surveys conducted in June-August 2002, 2003, 2004, and 2005.

### 7.1.4 Tissue Chemical Analyses (Task 24)

The objective of tissue chemical analyses is to determine the body burdens of toxic substances and potential elevations of these body burdens caused by relocation of the outfall. These observations will be made by measuring the concentrations of lipids and organic and inorganic (metal) substances in flounder, lobster, and mussels collected under Tasks 21-23. Data generated will be evaluated against established thresholds.

### 7.1.5 Flounder Histological and Mussel Condition Analysis (Task 25)

The histological analysis is designed to assess the health of the flounder populations in Boston Harbor and Offshore by performing microscopic examinations of tissue sections of the flounders' livers collected under Task 21. The bioeffects of contaminant exposure on the various flounder populations will be determined based on the prevalence and severity of various lesions in the tissues. The objective of the aging analysis is to determine the age composition of the specimens that are examined for histological and chemical analysis.

The mussel condition analysis is conducted to determine the physiological and reproductive status of mussels deployed in Boston Harbor and offshore and to determine if discharge causes unacceptable changes in status. Mussel condition will be performed at the discretion of the MWRA. This will be determined prior to mussel collection and deployment. Adequate amounts of mussels must be collected to perform both chemical analyses and mussel condition analysis.

## 7.2 Data Usage

### 7.2.1 Tissue Chemical Analyses (Task 24)

Chemistry data will be used to determine the concentrations of organic and inorganic (metals) contaminants in flounder liver, lobster hepatopancreas, and flounder, lobster, and mussel edible tissue (fillet; claw and tail meat; and meat, respectively). The contaminant concentrations will also be related to any histological lesions observed or indices of physiological condition.

Results of these analyses will be used to evaluate the impact from the discharge of effluent into Massachusetts Bay and the response of Boston Harbor to the relocated outfall on selected fish and shellfish species. Chemical results will be also be compared to caution and warning threshold values (MWRA 2001, Table 1) to determine if the outfall relocation is causing accumulation of toxic substances in exceedance of expected values or unexpected changes in liver condition of flounder.

**Table 1. Summary of Threshold Values for Fish And Shellfish Thresholds.**

| Organism | Threshold ID | Parameter | Unit of Measure | Threshold Value | | Baseline years |
|---|---|---|---|---|---|---|
| | | | | Caution | Warning | |
| Flounder | FFFCHL | lipid-normalized chlordane | ng/g lipid | 484 | - | 1993-2000* |
| | FFFDDT | lipid-normalized DDT | ng/g lipid | 1552 | - | 1993-2000* |
| | FFFDIEL | lipid-normalized dieldrin | ng/g lipid | 127 | - | 1993-2000* |
| | FFFHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FFFPCB | PCB | ng/g wet | 1000 | 1600 | N/A |
| | FFLIVDIS | liver disease incidence | % | 44.94 | - | 1991-2000 |
| Lobster | FLMCHL | lipid-normalized chlordane | ng/g lipid | 150 | - | 1992-2000 |
| | FLMDDT | lipid-normalized DDT | ng/g lipid | 683 | - | 1992-2000 |
| | FLMDIEL | lipid-normalized dieldrin | ng/g lipid | 322 | - | 1992-2000 |
| | FLMHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FLMPCB | PCB | ng/g wet | 1000 | 1600 | N/A |
| Mussel | FMUCHL | lipid-normalized chlordane | ng/g lipid | 205 | - | 1992-2000** |
| | FMUDDT | lipid-normalized DDT | ng/g lipid | 483 | - | 1992-2000** |
| | FMUDIEL | lipid-normalized dieldrin | ng/g lipid | 50 | - | 1992-2000** |
| | FMUPAH | lipid-normalized PAH | ng/g lipid | 2160 | - | 1992-2000** |
| | FMUHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FMUPB | lead | ug/g wet | 2 | 3 | N/A |
| | FMUPCB | PCB | ng/g wet | 1000 | 1600 | N/A |

* = 1992 flounder data excluded because compositing scheme not compatible with other years.
** = Data for 1995 not available because mussel cages could not be recovered at baseline site.
N/A = Threshold not calculated using baseline data.

### 7.2.2 Flounder Histological and Mussel Condition Analysis (Task 25)

Histological data will be used to assess the sublethal effects of contaminant exposure and tissue burden of the flounder populations in the Boston Harbor and Bay areas sampled. Age data will be used to determine the age of the adult population of winter flounder in the sampling areas prior to the discharge of the effluent. The mussel condition (growth and reproductive) will be used to assess contaminant impacts on mussel populations in the Boston Harbor and Bay areas. Post-outfall relocation data will be compared with baseline data as part of the data evaluation.

Histological results collected after outfall relocation will be compared to baseline measurements and to threshold values (MWRA 2001, Table 1) to determine if the outfall relocation has had a measurable effect on the health of these organisms.

## 7.3 Technical Approach

### 7.3.1 Flounder Surveys (Task 21)

A flounder survey will be conducted annually during April 2002, 2003, 2004, and 2005. A Survey Plan will be prepared for each of the annual surveys. The Survey Plan will detail sampling dates, locations, vessel, personnel, any deviations from the CW/QAPP, and general survey operations. These plans will be delivered to MWRA no later than two weeks before the start of each survey (i.e. March).

Five sites will be sampled during each annual survey to collect winter flounder for histological and chemical analyses (Figure 1):

- Deer Island Flats (Boston Harbor),
- Off Nantasket Beach (chemical analyses in 2002 and 2004[1]),
- Broad Sound (chemical analyses in 2002 and 2004[1]),
- Outfall Site (offshore effluent outfall),
- East Cape Cod Bay.

Table 2 provides the sampling sites and locations, although there may be differences of 1 km or more between collection sites and the indicated position due to the trawling operations. Adjustments in location will be made in the field to ensure that flounder are captured.

**Table 2. Sampling and Locations for Flounder/Lobster/Mussel Surveys.**

| Station # | Sampling Site | Location | | Survey Type | | |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Flounder | Lobster | Mussel |
| DIF | Deer Island Flats (Boston Harbor) | 42°20.4' | 70°58.4' | * | * | |
| DIL | Deer Island Light | 42°20.4' | 70°57.2' | | | * |
| NB | Off Nantasket Beach | 42°17.6' | 70°52.2' | * | | |
| BS | Broad Sound | 42°24.4' | 70°57.2' | * | | |
| OS | Outfall Site | 42°23.1' | 70°49.3' | * | * | |
| OSM | Outfall Site (60 m at OS) | 42°23.15' | 70°47.92' | | | * |
| OSR | Outfall Site (15 m at OS – post diversion) | 42°23.17' | 70°47.68' | | | * |
| ECCB | East Cape Cod Bay | 41°56.2' | 70°06.6' | * | * | |
| IH | Boston Inner Harbor | 42°21.5' | 71°02.9' | | | * |
| GL | Gloucester | 42°40.2' | 70°40.2' | | | R |
| SA | Sandwich/Cape Cod | 41°45.6' | 70°28.5' | | | R |
| RP | Rockport | 42°39.6' | 70°35.7' | | | R |
| CCB | Cape Cod Bay | 41°55.5' | 70°20.0' | | | * |
| LNB | "B" Buoy (2001 onwards only) | 42°22.67' | 70°47.25' | | | * |

* = Sampling Site for Survey
R = Reference Site for Collection of Mussels for Deployment During Bioaccumulation Survey This location will be determined by availability of mussels.

At each of the five designated sampling sites, otter-trawl tows will be conducted to collect 50 sexually mature, 30 – 50 cm (usually 4-5 year old) winter flounder (*Pseudopleuronectes americanus*). If unusually

[1] The additional flounder samples collected in 2003 and 2005 from Nantasket Beach and Broad Sound will be frozen and archived.

large (> 50 cm) flounder are obtained, up to 3 large individuals per site will be retained for processing. Each fish will be assigned a unique identification number to indicate the event, year, survey, and site of collection.

Fish destined for only histological analysis are killed at sea by cervical section and used for histological processing. These fish will be examined externally and their external condition will be noted prior to histological processing. The gross external condition of the flounder ("External Lesions") and fin rot will be subjectively scored on a scale of 0 to 4. The gonads of each flounder will be examined to determine sexual maturity. All specimens will be weighed, and standard and total length (Figure 6) will be determined by measuring fish length according to Battelle SOP 5-175. Scales will be taken from each specimen for age determination. In addition, the liver will be aseptically removed, examined for grossly visible abnormalities, and preserved in 10% neutral buffered formalin. The presence of gross lesions on the liver will be subjectively scored on a scale of 0 to 4 and recorded as "Gross Liver Lesion".

For stations where chemistry analyses are to be conducted, fifteen of the fifty fish will be randomly[2] selected for joint histological and chemical analysis. These fish will be placed alive on ice and transported to Battelle Duxbury Operations for on-shore processing for histological and chemical analysis. Fifteen unique sample identification numbers will be assigned to these fish, however, actual assignment of IDs to individual fish will not occur until the fish are sacrificed at the laboratory. At this time, these fish will also be examined externally, their external condition will be noted (fin rot and external lesions), liver abnormalities noted, and scales removed for age analysis.

In the laboratory, fish will be killed by cervical section. Fillets (muscle) will be removed from the flounder, and the skin will be removed from the fillet. The livers will be removed and examined for visible gross abnormalities (gross liver lesion) as described above. A small section of the liver will be removed and preserved in 10% neutral buffered formalin for histological analysis. Fillet composites will be made from equal aliquots (±10% by weight) of the homogenate of 5 individual fish fillets using approximately equal masses of top and bottom tissue. The liver composite samples will contain approximately equal masses (5 grams) from each of the livers and will correspond to the composites made for the fillets[3]. The composites are then homogenized and stored frozen until analyzed.

Within 2 and 30 days after each flounder survey, an e-mail Survey Summary and Report, respectively, will be prepared and submitted to MWRA. The survey summary shall note completion of the survey and any noteworthy problems or events encountered. This summary will highlight any apparent triggering of monitoring thresholds, or conditions, which, if continued, might lead to such triggering. The report will include a summary of survey operations, number/species of specimens collected at each station for each discrete sampling event (e.g., each otter trawl), number of specimens dissected, observations made during sampling and dissection, and the disposition of the tissue samples. The report will detail any problems encountered or departures from stated protocols and their potential impacts on the program.

### 7.3.2 Lobster Survey (Task 22)

A lobster survey will be conducted annually during mid-July 2002, 2003, 2004, and 2005 or as soon as lobsters are available thereafter. A Survey Plan will be prepared for each of the annual surveys. The Survey Plan will detail sampling dates, locations, vessel, personnel, any deviations from the CW/QAPP, and general

[2]"Random" in the context of this document means not consciously choosing or excluding specific animals. It is not meant to imply that animals were selected using a random numbers program.
[3] In cases where sample mass may be limited (i.e. flounder liver and lobster hepatopancreas), best professional judgment will be used when combining individual samples to form the composite sample so that enough composite sample is available to perform all of the required chemical analyses.

survey operations. These plans will be delivered to MWRA no later than two weeks before the start of each survey (i.e. June).

Three sites will be sampled to collect lobster for chemical analyses:

- Deer Island Flats (Boston Harbor),
- Outfall Site (offshore effluent outfall),
- East Cape Cod Bay.

Table 2 provides the sampling sites and locations. Figure 2 illustrates the sampling locations in Boston Harbor and Offshore.

Fifteen commercially harvestable (i.e. proper sized, non-berried individuals) lobsters (*Homarus americanus*) at each site will be purchased from commercial lobstermen. If no commercial lobster pots are located within the target site, lobster pots will be deployed at each sampling site by Battelle or by commercial lobstermen. The location of collection by a commercial lobsterman (or by Battelle) will be verified by the presence of a Battelle staff member during collection operations. Individual lobsters retained for analysis will be assigned a unique identification number to indicate event, year, survey, and site of collection. Lobster carapace length and width will be measured (following SOP 5-175) and gender determined. Lobster specimens will be visually examined and the condition noted (black gill, shell erosion, parasites and external tumors) on the lobster sample collection log.

Processing of the hepatopancreas and edible tissue samples for chemical analysis will be conducted in the laboratory. The fifteen lobsters from each site will be randomly assigned to 3 pools of 5 lobsters each. The hepatopancreas and the tail and claw meat (edible tissue) will be removed using titanium, ceramic, or Teflon implements and placed in sample containers that are clearly identified with a conventional label containing the information described above. Homogenized samples of hepatopancreas or edible meat from each lobster in a pool will be quantitatively combined (±10% by weight) to provide two composite samples per pool, one each of hepatopancreas and edible meat[4]. Each composite will be placed in a sample container clearly identified with the unique sample identifier.

An e-mail survey summary and report will be prepared and submitted within 2 and 30 days after each lobster survey, respectively, to MWRA. The summary shall note completion of the survey and any noteworthy problems or events encountered. This summary will highlight any apparent triggering of monitoring thresholds, or conditions, which, if continued, might lead to such triggering. Each report will include a summary of survey operations, number/species of specimens collected at each station, number of specimens dissected, observations made during sampling and dissection, and the disposition of the tissue samples. The report will detail any problems encountered or departures from stated protocols and their potential impacts on the program.

### 7.3.3 Mussel Bioaccumulation Survey (Task 23)

A mussel bioaccumulation survey will be conducted annually between June and August 2002, 2003, 2004, and 2005. A Survey Plan will be prepared for each of the annual surveys. The Survey Plan will detail sampling dates, locations, vessel, personnel, any deviations from the CW/QAPP, and general survey

[4] In cases where sample mass may be limited (i.e. flounder liver and lobster hepatopancreas), best professional judgment will be used when combining individual samples to form the composite sample so that enough composite sample is available to perform all of the required chemical analyses.

operations. These plans will be delivered to MWRA no later than two weeks before the start of each survey (i.e. May).

Each year, live blue mussels (*Mytilus edulis*) approximately 6 cm in length will be collected from the reference site (Rockport)[5]. Thirty mussels will be randomly selected for biological condition analysis and 75 mussels for chemical contaminant analysis. The remaining mussels will be deployed and retrieved at four sites[6]:

- Deer Island Light (~2 m above bottom),
- Outfall Site – approximately 60 ± 15 m from the offshore outfall (depth of 10-15 m above bottom, water depth ~ 30 m (MLW)),
- Boston Inner Harbor (1.5 – 4.5m above bottom - Rise and fall with tide, so that it is at a constant depth below the water surface),
- Cape Cod Bay (10-15 m above bottom).

Table 2 provides the sampling sites and locations, although the exact location of the deployment may differ by 1 km (or more) from the indicated position. Figure 3 illustrates the sampling locations in Boston Harbor and Massachusetts Bay. Table 3 lists the minimum numbers of mussels that need to be collected from the reference site and which will be deployed at each location[7].

Mussels will be deployed in June in replicate arrays at four sites. Mussels will be retrieved on two occasions (i.e., partial deployment period 40 days after deployment, and full deployment period after 60 days). Upon retrieval, a record of mortality and degree of fouling of the cages will be made. Thirty live mussels will be randomly selected for examination of biological condition and the remaining live mussels frozen for chemical analysis.

An e-mail survey summary and report will be prepared and submitted within 2 and 30 days after the final retrieval, respectively, to MWRA. The summary shall note completion of the survey and any noteworthy problems or events encountered. This summary will highlight any apparent triggering of monitoring thresholds, or conditions, which, if continued, might lead to such triggering. Each report will include number/species of specimens collected at each station, number of specimens dissected, observations made during sampling and dissection, and the disposition of the tissue samples. The report will detail any problems encountered or departures from stated protocols and their potential impacts on the program.

### 7.3.4 Tissue Chemical Analysis (Task 24)

Chemical analysis will be performed on composite samples of flounder, lobster, and mussel tissue. Composite samples will be prepared through random selection of samples and homogenization of tissue. Table 4 lists the types and numbers of tissue samples to be collected during each survey and the chemical analyses to be performed. The following number of samples will be prepared and used for chemical analysis.

[5] Previously sampled locations in Gloucester or Sandwich may be substituted, depending on availability of mussels.
[6] The locations of specific arrays may be dropped or moved at the discretion of MWRA.
[7] If reference mussels are collected from Rockport (or another, single location), these mussels will be deployed and analyzed for both organics and metals. If reference mussels are collected from Gloucester and Sandwich, the Gloucester mussels will be deployed and analyzed for organics and the Sandwich mussels will be deployed and analyzed for metals.

**Flounder -** Chemical analyses will be performed on samples from three sites in 2003 and 2005 (Deer Island Flats, Outfall Site, and Cape Cod Bay), and for all five sites in 2002 and 2004. Three groups of 5 individual fish each will be pooled from the 15 collected to create three pooled samples per site. Two tissue types (fillet, liver) are to be analyzed. This will result in 30-pooled samples (3 pools x 5 sites x 2 tissue types) in 2002 and 2004 and 18 pooled samples in 2003 and 2005. The same fish will be composited for both liver and fillet chemistry to ensure comparability between tissue types. The chemical analyses to be performed on sample and tissue types are indicated in Table 4. Tissue from off Nantasket Beach and Broad Sound collected in 2003 and 2005 will be archived (dissected).

**Table 3. Minimum Number of Mussels to Collect and Deploy.**

| Site | Array | Total[a] | Organics[b] | Metals[b] |
|---|---|---|---|---|
| Reference Mussels (pre-deployment) | | 120 | 80 | 40 |
| Boston Inner Harbor (40–day recovery) | 1 | 120 | 80 | 40 |
| Boston Inner Harbor (60–day recovery) | 2 | 120 | 80 | 40 |
| Boston Inner Harbor (extra) | 3 | 120 | 80 | 40 |
| Deer Island Light (40–day recovery) | 1 | 120 | 80 | 40 |
| Deer Island Light (60–day recovery) | 2 | 120 | 80 | 40 |
| Deer Island Light (extra) | 3 | 120 | 80 | 40 |
| Outfall Site (40–day recovery) | 1 | 165 | 110 | 55 |
| Outfall Site (60–day recovery) | 2 | 165 | 110 | 55 |
| Outfall Site (extra) | 3 | 165 | 110 | 55 |
| Outfall Site (extra) | 4 | 165 | 110 | 55 |
| Cape Cod Bay (40–day recovery) | 1 | 165 | 110 | 55 |
| Cape Cod Bay (60–day recovery) | 2 | 165 | 110 | 55 |
| Cape Cod Bay (extra) | 3 | 165 | 110 | 55 |
| Cape Cod Bay (extra) | 4 | 165 | 110 | 55 |
| Minimum required to harvest | | 2160 | 1440 | 720 |
| 10% additional for mortality | | 216 | 144 | 72 |
| Total to be harvested | | 2376 | 1584 | 792 |

[a]If reference mussels are collected from Rockport (or another single location), this is the number of mussels to be deployed and analyzed for both organics and metals.
[b]If reference mussels are collected from Gloucester and Sandwich, this is the number of mussels to be deployed and analyzed for organics (Gloucester mussels) and for metals (Sandwich mussels).

**Lobster –** Three groups of 5 commercially marketable lobsters each will be pooled from the 15 collected to create 3 pooled samples per site. Two tissue types are to be analyzed per site (claw and tail meat, hepatopancreas), resulting in 18 pooled samples (3 pools x 3 sites x 2 tissue types). The same lobster will be composited for both meat and hepatopancreas chemistry to ensure comparability between tissue types. The chemical analyses to be performed on sample and tissue types are indicated in Table 4.

**Mussels –**Mussels will be analyzed for organic and inorganic parameters[8]. Composites for chemical analysis will be created as follows:

- Reference Mussels = 5 composites of 15 mussels
- Boston Inner Harbor = 5 composites of 15 mussels
- Deer Island Light = 5 composites of 15 mussels
- Outfall Site = 8 composites of 15 mussels
- Cape Cod Bay = 8 composites of 15 mussels

Homogenized composite samples will be split into appropriate containers for organic and inorganic analyses. This results in 31 composite samples (5 composites of pre-deployed mussels + 5 composites ∗ 2 sites + 8 composites ∗ 2 sites) for both organic and inorganic analyses. The chemical analyses to be performed on mussel samples are indicated in Table 4.

**Table 4. Summary of Chemistry Parameters to be Measured by Organism.**

| Sample Type | Number of Samples | Metals (other than Hg and Pb) | Hg | Pb | PCBs | PAHs | Pesticides | Lipids |
|---|---|---|---|---|---|---|---|---|
| Flounder Meat | 9[1] | | * | | * | | * | * |
| Flounder Liver | 9[1] | * | * | * | * | * | * | * |
| Lobster Meat | 9 | | * | | * | | * | * |
| Lobster Hepatopancreas | 9 | * | * | * | * | * | * | * |
| **Mussel Tissue** | | | | | | | | |
| Organic | 31 | | | | * | * | * | * |
| Inorganic | 31 | | * | * | | | | |

[1] 15 samples during the 2002 and 2004 surveys.

The results of the analyses of flounder, lobster, and mussel tissue carried out under Tasks 24.2, 24.4, 24.8, and 24.9 will be reviewed. If the wet weight concentration of any contaminant in a composite sample exceeds an FDA "action level" (Table 5), the MWRA Project Manager will be notified for authorization to analyze (at additional cost) individual samples making up that composite (retained under tasks 24.2.4 and 24.8). If mercury is the contaminant exceeding the FDA action level, this analysis shall include organic mercury. If required, the data from these analyses of individuals shall be incorporated into the relevant Tissue Chemistry Data Report (prepared under Task 24.14) and Fish and Shellfish annual synthesis report (prepared under Task 33). Any additional analyses would be submitted separately from the data report and due one month after the due date of the data report. The due data for the synthesis report will be extended by one month.

**Table 5 . FDA Action Levels in Wet Weight.**

| Total PCB | Total DDT | Total Chlordane | Dieldrin | Mercury | Lead |
|---|---|---|---|---|---|
| 2000 ng/g | 5000 ng/g | 300 ng/g | 300 ng/g | 1 μg/g | 3.75 μg/g |

[8] In years where pre-deployed mussels are collected from two separate locations (i.e. Gloucester for organics and Sandwich for mussels), the mussels will be processed as follows. For organic analyses of deployed mussels, ten mussels will be pooled from each site to create either 5 or 8 pooled samples per site, depending on the original number of mussels deployed. For inorganics (Hg and Pb) of deployed mussels, 5 mussels will be pooled from each site to create either 5 or 8 pooled samples per site, depending on the original number of mussels deployed. This results in 31 pooled samples (5 pools of pre-exposed mussels + 5 pools x 2 sites + 8 pools x 2 sites) for both organic and inorganic analyses. The chemical analyses to be performed on mussel samples are indicated in Table 4.

### 7.3.5 Flounder Histological and Mussel Condition Analysis (Task 25)

**Flounder Histology –** The fifty flounder from each of the 5 sampling sites will be analyzed for the suite of histological parameters. One 5 μm thick section from each of three transversely cut portions of livers from each flounder collected during each survey will be examined histologically. A total of 250 slides each containing 3 liver sections, will be prepared and examined each year (2002, 2003, 2004, 2005). Lesions to be scored include vacuolation (tubular hydropic, centrotubular, focal hydropic), macrophage aggregation, biliary duct proliferation, neoplasia, and apoptotic lesions.

The age of each specimen will be determined by reading the number of annuli on a scale from that specimen.

**Mussel Condition Analysis –** At least thirty mussels will be selected from each of the sites and analyzed for the following parameters: shell length, shell weight, total tissue weight (wet and dry), gonadal tissue weight (wet and dry), and survival. From these analyses, two condition factors (gonad condition index and condition index) will be calculated (SOP 5-031).

## 7.4 Monitoring Parameters, Collection Frequency and Sample Collection Requirements

Table 4 summarizes the primary chemical parameters that will be measured for each organism or sample type (Task 24). Table 6 summarizes the number of organisms and the types of analyses that will be conducted on samples collected from each station as well as the sample container and preservation requirements. Table 7 lists the specific analytes that will be measured.

## 7.5 Whale Observations

During every field activity under this Project conducted between January 1 to May 31 and December 1 to December 31 each field year, and during all Nearfield water column surveys carried out under Task 9, whale observations will be conducted using trained dedicated observers. Therefore, whale observations will be collected during the Task 21 flounder survey each year, mentioned in the survey summary, and the results detailed in the survey report.

# 8.0 PROJECT FISCAL INFORMATION

This project is being carried out under the Harbor and Outfall Monitoring contract (Contract No. S366) between MWRA and Battelle.

# 9.0 SCHEDULE OF ACTIVITIES AND DELIVERABLES

The schedule of activities and deliverables for this project is tied to survey activities. Table 8 provides the 2002-2005 planned schedule for all survey plans, survey cruises, survey reports, and data reports required for Tasks 21, 22, 23, 24, and 25. The deliverables are survey plans, survey reports, and data reports for each of the three surveys per year. Data synthesis will occur under Task 33. Draft and final Annual Fish and Shellfish Reports will be prepared for each year. The due dates for the data reports are shown in Table 8.

**Table 6. Monitoring Parameters, Collection Frequency, Sample Containers, and Preservation Requirements.**

| Organism | Parameter | Numbers of Sampling Units Total[a]/Sample[b] | Container | Shipboard or Laboratory Processing/Preservation | Holding Time from Collection |
|---|---|---|---|---|---|
| Winter flounder | Chemistry<br>- liver<br>- edible tissue | <br>15/3<br>15/3 | Clean, labeled jar;<br>Organics: Glass<br>Inorganics: pre-cleaned polystyrene | Laboratory: Freeze, if not processed immediately | One year<br>(Not frozen - Hg: 28-d; inorganics: 6-mo) |
| | Histology | 50/50 | Clean, labeled jar | Laboratory, Shipboard: 10% neutral buffered formalin | NA |
| | Age (scales) | 50/50 | Age envelope | Laboratory, Shipboard: Clean mucous from sampling area of fish before taking scales | NA |
| | Visual | 50/50 | N/A | Laboratory, Shipboard: Describe qualitatively | NA |
| | Biometrics<br>- weight<br>- standard length<br>- total length<br>- sex | 50/50 | N/A | Laboratory, Shipboard: Describe quantitatively | NA |
| Lobster | Chemistry<br>- hepatopancreas<br>- edible tissue | <br>15/3<br>15/3 | Clean, labeled jar;<br>Organics: Glass<br>Inorganics: pre-cleaned polystyrene | Laboratory: Freeze, if not processed immediately | One year<br>(Not frozen - Hg: 28-d; inorganics: 6-mo) |
| | Visual | 15/15 | N/A | Shipboard: Describe qualitatively | NA |
| | Biometrics<br>- weight<br>- carapace length<br>- sex | 15/15 | N/A | Laboratory: Process immediately | NA |
| Mussel | Chemistry<br>- soft tissue | 50/5, 80/8[c]<br>or 25/5, 40/8[c] | Clean, labeled jar;<br>Organics: Glass<br>Inorganics: pre-cleaned polystyrene | Laboratory: Freeze if not processed immediately | One year<br>(Not frozen - Hg: 28-d; inorganics: 6-mo) |
| | Biometrics<br>- shell length and weight<br>- shell volume<br>- total tissue wt (wet/dry)<br>- gonadal tissue wt (wet/dry)<br>- condition index<br>- gonad condition index<br>- survival | 30/30 | Clean, labeled container | Laboratory: Process immediately | NA |

a = total individual specimens collected per station.
b = total pooled (composite) samples to be analyzed per station.
c = total mussel numbers for Outfall and Cape Cod Bay stations only.

**Table 7. Specific Chemical Analytes Included in Tissue Chemistry Analyses.**

| Chemical Analytes | |
|---|---|
| **Trace Metals**[a] | **Polynuclear Aromatic Hydrocarbons (PAHs)** (continued) |
| Ag Silver | $C_1$-Phenanthrenes/anthracene |
| Cd Cadmium | $C_2$-Phenanthrenes/anthracene |
| Cr Chromium | $C_3$-Phenanthrenes/anthracene |
| Cu Copper | $C_4$-Phenanthrenes/anthracene |
| Hg Mercury[b,e] | Dibenzothiophene |
| Ni Nickel | $C_1$-dibenzothiophenes |
| Pb Lead[e] | $C_2$-dibenzothiophenes |
| Zn Zinc | $C_3$-dibenzothiophenes |
| **Polychlorinated biphenyls (PCBs)**[c,d] | Fluoranthene |
| 2,4′-$Cl_2$(8) | Pyrene |
| 2,2′,5-$Cl_3$(18) | $C_1$-fluoranthenes/pyrene |
| 2,4,4′-$Cl_3$(28) | $C_2$-fluoranthenes/pyrene |
| 2,2′,3,5′-$Cl_4$(44) | $C_3$-fluoranthenes/pyrene |
| 2,2′,5,5′-$Cl_4$(52) | Benz[*a*]anthracene |
| 2,3′,4,4′-$Cl_4$(66) | Chrysene |
| 3,3′,4,4′-$Cl_4$(77) | $C_1$-chrysene |
| 2,2′4,5,5′-$Cl_5$(101) | $C_2$-chrysene |
| 2,3,3′,4,4′-$Cl_5$(105) | $C_3$-chrysene |
| 2,3′,4,4′5-$Cl_5$(118) | $C_4$-chrysene |
| 3,3′,4,4′,5-$Cl_5$(126) | Benzo[*b*]fluoranthene |
| 2,2′,3,3′,4,4′-$Cl_6$(128) | Benzo[*k*]fluoranthene |
| 2,2′,3,4,4′,5′-$Cl_6$(138) | Benzo[*a*]pyrene |
| 2,2′4,4′,5,5′-$Cl_6$(153) | Dibenzo[*a,h*]anthracene |
| 2,2′3,3′,4,4′,5-$Cl_7$(170) | Benzo[g,h,i]perylene |
| 2,2′,3,4,4′,5,5′-$Cl_7$(180) | Indeno[1,2,3-*c,d*]pyrene |
| 2,2′,3,4′,5,5′,6-$Cl_7$(187) | Perylene |
| 2,2′,3,3′,4,4′,5,6-$Cl_8$(195) | Biphenyl |
| 2,2′,3,3′4,4′,5,5′,6-$Cl_9$(206) | Benzo[*e*]pyrene |
| Decachlorobiphenyl-$Cl_{10}$(209) | Dibenzofuran |
| **Polynuclear Aromatic Hydrocarbons (PAHs)**[a,d] | Benzothiazole |
| Naphthalene | **Pesticides**[c,d] |
| $C_1$-naphthalenes | Hexachlorobenzene |
| $C_2$-naphthalenes | Lindane |
| $C_3$-naphthalenes | Heptachlor |
| $C_4$-naphthalenes | Endrin |
| 1-methylnaphthalenes[f] | Aldrin |
| 2-methylnaphthalenes[f] | Heptachlorepoxide |
| 2,6-methylnaphthalenes[f] | cis-Chlordane |
| 2,3,5-methylnaphthalenes[f] | trans-Nonachlor |
| Acenaphthylene | Dieldrin |
| Acenaphthene | Mirex |
| Fluorene | 2,4′-DDD |
| $C_1$-fluorenes | 4,4′-DDD |
| $C_2$-fluorenes | 2,4′-DDE |
| $C_3$-fluorenes | 4,4′-DDE |
| Phenanthrene | 2,4′-DDT |
| 1-methylphenanthrene[f] | 4,4′-DDT |
| Anthracene | DDMU |
| | **Lipids**[c,d] |

[a] Flounder liver; lobster hepatopancreas
[b] Flounder and lobster edible tissue
[c] Flounder edible tissue and liver; lobster edible tissue and hepatopancreas
[d] Mussel soft tissue (Gloucester or Rockport)
[e] Mussel soft tissue (Sandwich or Rockport)
[f] Required for mussels only.

## 10.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Fish and Shellfish Monitoring tasks will be accomplished through the coordinated efforts of several organizations. Figure 4 presents the Project Management structure and the major tasks necessary to complete the scope of work. Each element of the tasks has been assigned a separate subaccount with budget and milestones, and these accounts will be used to track costs against progress. Battelle's Project Management Plan describes the management policies that will be applied to all HOM 4 activities (Battelle, 2002).

Dr. Andrea Rex is the Director of the MWRA Environmental Quality Department. Dr. Michael Mickelson is the MWRA Project Manager. Mr. Maury Hall is the MWRA Project Area Manager for all Fish and Shellfish activities. Mr. Ken Keay is the Deputy Project Manager and serves as backup to both Dr. Mickelson and Mr. Hall. They will be informed of all matters pertaining to work described in this CW/QAPP. Ms. Wendy Leo is the MWRA EM&MS Database Manager and Quality Assurance Officer.

Ms. Ellen Baptiste-Carpenter is the Battelle Project Manager. She is responsible for ensuring that products and services are delivered in a timely and cost-effective manner that meets MWRA's expectation, and for the overall performance of this project. Dr. Carlton Hunt is the Battelle Technical Director and is responsible for ensuring that data collection and interpretation are scientifically defensible, and for responding to technical challenges as they arise. Ms. Jeanine Boyle is the Battelle Deputy Project Manager. The Battelle Quality Assurance Officer for the project is Ms. Rosanna Buhl. For this task, Ms. Buhl is responsible for reviewing data reports and QA Statements submitted by subcontractors for quality completeness and adherence to the CW/QAPP. She is also responsible for reviewing the data and synthesis reports for accuracy and completeness. Mr. Wayne Trulli is the Battelle Field Manager, responsible for the overall field program. Mr. Chris Gagnon is the Deputy Field Manager and is responsible for all day-to-day field activities conducted by Battelle for the project. Ms. Deirdre Dahlen, Battelle's Laboratory Manager, is responsible for overseeing all laboratory activities in the contract. Ms. Ellie Baptiste-Carpenter is also Battelle's Database Manager for this project. The key contacts at each of the supporting laboratories are shown in Figure 4. Addresses, telephone (and fax) numbers, and Internet addresses, as well as specific project roles and responsibilities, are presented in the HOM 4 Program Management Plan.

Ms. Lisa Lefkovitz is the Battelle Senior Scientist responsible for the conduct of the fish and shellfish monitoring tasks described in this CW/QAPP.

Dr. Michael Moore (WHOI) is the Senior Scientist for the Flounder Survey. Histological slides will be prepared at Experimental Pathology Laboratories under subcontract to WHOI. Dr. Moore will examine the histological slides, analyze and reduce the histological data, and add them to the ongoing temporal and spatial data summaries. Dr. Robert Hillman (Battelle) will serve as the back-up to Dr. Moore.

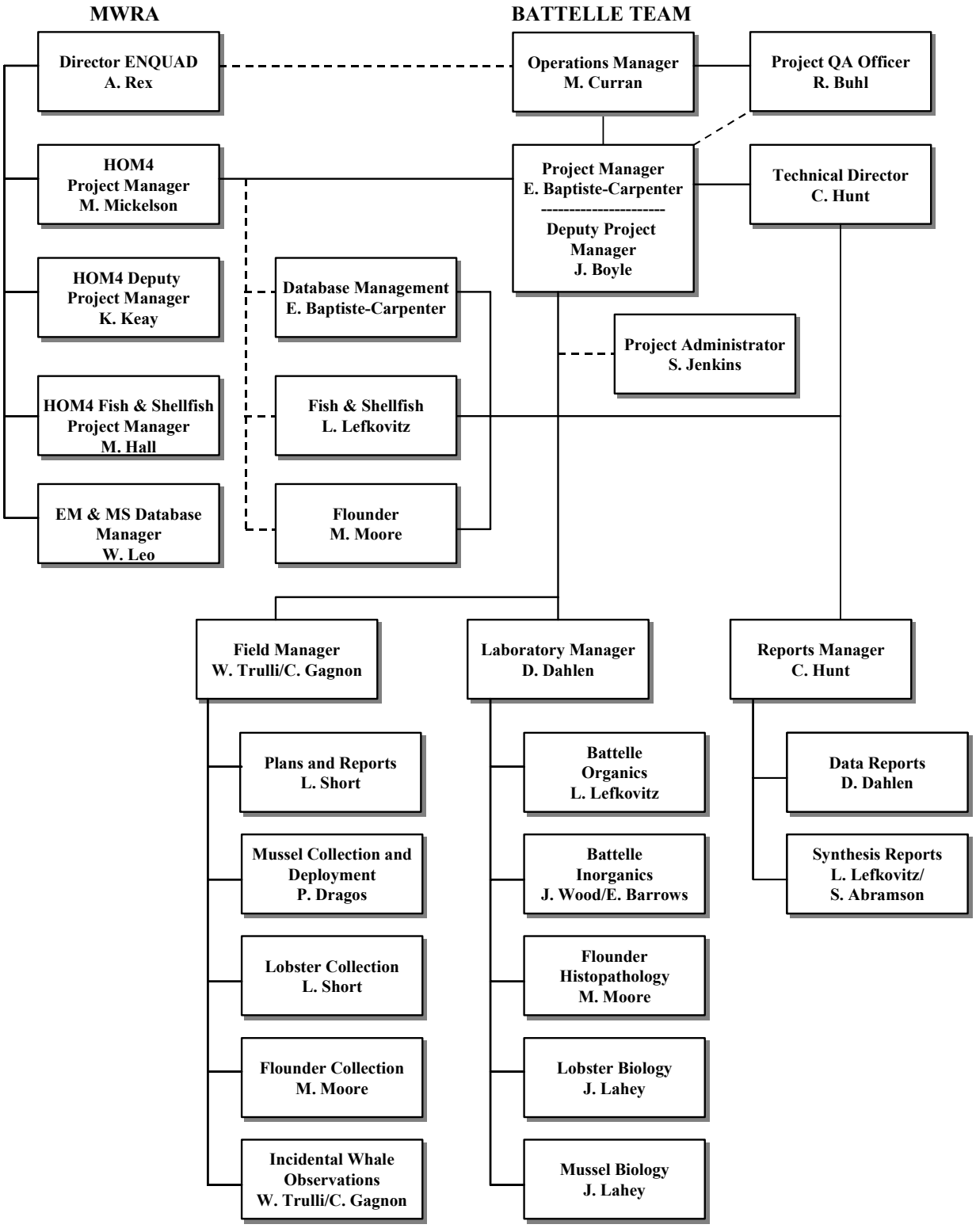



**Figure 4. Organizational Chart.**

**Table 8. Schedule of Deliverables.**

| Task | Deliverable | Due Date |
|---|---|---|
| Flounder Survey (Task 21) | Survey Plan<br>Survey Cruise<br>Survey E-mail<br>Survey Report | March of each field year<br>April of each field year<br>2 days after each survey<br>May of each field year |
| Lobster Survey (Task 22) | Survey Plan<br>Survey Cruise<br>Survey E-mail<br>Survey Report | June of each field year<br>July of each field year<br>2 days after each survey<br>August of each field year |
| Bioaccumulation Study (Task 23) | Survey Plan<br>Mussel Collection/Array Deployment Survey<br>Mussel Retrieval Survey 1<br>Mussel Retrieval Survey 2<br>Survey E-mail<br>Survey Report | May of each field year<br>June of each field year<br>40 days after deployment<br>60 days after deployment<br>2 days after each survey<br>September of each field year |
| Tissue Chemical Analyses (Task 24) | Flounder Chemistry Data Report<br>Lobster Chemistry Data Report<br>Mussel Chemistry Data Report | July 15 (or 75 days after survey)[1]<br>Oct. 15 (or 75 days after survey)[1]<br>Nov. 15 (or 75 days after survey)[1] |
| Flounder Histology and Mussel Condition Analysis (Task 25) | Histology Data Report<br><br><br>Mussel Biological Condition Report | August 15 (temporary data report for liver disease incidence at Outfall Site – 60 days after survey)<br>November 15 |
| Fish and Shellfish Annual Report (Task 33) | Report Outline<br>Synthesis Report | January of the following year<br>February of the following year |

[1] Whichever date is later.

## 11.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

To ensure that all data generated during the conduct of surveys, analyses, and reporting are of the highest quality, data will be examined in terms precision, accuracy, completeness, comparability, and representativeness. These terms are defined in the HOM4 Quality Management Plan (Battelle, 2002). The application of these measures of data quality is described below.

**Accuracy** - the extent of agreement between the measured value and the true value
**Precision** - the extent of agreement among independent, similar, or related measurements
**Completeness** - measure of the amount of data acquired relative to the amount of data required to fulfill the objectives and statistical criteria for the intended use of the data
**Comparability** - the extent to which data from one study can be compared directly to similar studies
**Representativeness** - the extent to which sample locations and measurements represent true systems

## 11.1 Navigational Data

### 11.1.1 Precision and Accuracy

All dGPS units have a design positional accuracy of 15 m. Based on manufacturer specifications or Battelle's experience, precision and accuracy objectives for navigation and station depth are presented in Table 9. Section 12 provides details on relevant sampling procedures to ensure data quality, and Section 14 discusses instrument calibration methods.

**Table 9. Accuracy and Precision of Instrument Sensors.**

| Sensor | Units | Range | Accuracy | Precision |
|---|---|---|---|---|
| Echosounder (depth) | m | 0 to 200 | 2 | 0.1 |
| dGPS Navigation | degree | Coastal | $9x10^{-5}$ deg (10 m) | $1.8x10^{-5}$ deg (2 m) |
| Loran-C Navigation | nautical mile | Coastal | 0.1-0.25 nm | 18 – 90 m |

### 11.1.2 Completeness

For mussel surveys, Battelle's navigation system will be used; for most flounder and lobster surveys, the fishing vessel's navigation system will be used. Battelle's navigation software system outputs navigation positions at an interval of 2–s. The software system will display all position fixes and save these fixes in an electronic file during fish tows and sampling operations. The project's time interval requirement for obtaining positions during sampling is 1–min. Thus, even with a few bad data streams from the dGPS navigation system to the computer, the software will provide enough fixes within each 1-min period for 100% data collection.

For the flounder and lobster surveys, navigation data will be 100% complete. The initial and final coordinates of each flounder trawl and the actual coordinates of each lobster pot will be hand recorded on field logsheets. For mussel deployments where the Battelle vessel is not used, a laptop computer loaded with the NavSam© Data Collection system will be used. The location of the mussel collections and array deployments will be recorded onto the Station Log using a hand-held GPS (SOP 3-164).

Depth measurements will be recorded at each station.

### 11.1.3 Comparability

Latitude/longitude positions will be comparable to positions obtained by previous MWRA monitoring activities as well as by other researchers that have used or are using differentiated GPS at these stations. The station locations are targets and sampling for flounder and lobster will be conducted within 300 m of the targets but will ultimately be based on the availability of individuals. The deployment of mussels will be conducted within 15 m of the targets as visualized on the BOSS navigation display.

### 11.1.4 Representativeness

The representativeness of the sampling program design is detailed in the Outfall Monitoring Plan (MWRA 1997) and defined by the results collected since 1992. Representativeness will also be ensured by proper handling, storage, and analysis of samples so that the materials analyzed reflect the collected material.

## 11.2 Flounder Collection (Task 21)

At each station, 50 winter flounder specimens will be collected. Samples of liver will be taken from all 50 specimens for histological analysis. Samples of liver and edible tissue will be taken from 15 of the flounder from each site for chemical analyses.

### 11.2.1 Accuracy

Traditional measures of accuracy do not apply to fish collection procedures. To ensure that specimens are accurately identified, fish keys, such as *Guide to Some Trawl-Caught Marine Fishes from Maine to Cape Hatteras, North America* (Flescher 1980) and field guides will be used. The guaranteed accuracy of the "Normark" fish scale is 50 g. The accuracy of the fish measuring board is 0.1 cm.

### 11.2.2 Precision

The precision of fish length and weight measurements will be monitored through the re-measurement of at least 10% of the specimens collected at each sampling site. If agreement between the length or weight measurements is within 1 cm or 5 g, respectively, measurements will continue. If measurements or weights differ by more than the above-stated criteria, the cause will be identified and all specimens measured since the last acceptable precision measurement will be re-measured or re-weighed. The precision of the weight data transcription for flounder will be enhanced by using a scale (OHAUS® dial scale) with a maximum reading pointer (MRP) that retains the weight reading of the fish until another fish is put on the scale.

### 11.2.3 Completeness

The objective is to obtain 50 sexually mature specimens from each sampling site. Otter-trawl tows will be conducted until at least 50 specimens are collected at each sampling site. Sampling will be 100% complete when this is accomplished. In the event of sample loss or equipment malfunction, the Chief Scientist will determine the need for appropriate corrective action (e.g., re-sampling using a different otter trawl). The corrective action taken by the Chief Scientist will be recorded in the survey records. In the event of inadequate numbers of fish, three hours of bottom time will be the maximum effort expended at any one station. In the event of 3 hours bottom time failing to yield 50 fish, additional fish from other stations may, at the discretion of the MWRA, be sampled to generate a total of 250 fish for the survey.

### 11.2.4 Comparability

Winter flounder have been routinely used by other researchers working in Massachusetts Bay and similar environments to determine health and tissue burden of contaminants. Collection of winter flounder that are sexually mature will allow a comparison of the health of adult specimens at each sampling site. The methods of collection and visual analyses are comparable to methods used by Dr. Michael Moore for previous studies on winter flounder from these sampling sites. Otter trawls have been used by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) and the Massachusetts Division of Marine Fisheries since the 1960s and 1970s, respectively, as a method to sample finfish. All otter-trawl tows will be conducted for approximately 30 minutes at a speed of 1.5 to 2 kt. The sampling design of this survey is comparable to the design of previous surveys.

### 11.2.5 Representativeness

Representativeness is primarily addressed through sample design. The sampling sites represent previously sampled locations and represent the population of winter flounder that may be found within Massachusetts and Cape Cod Bays.

## 11.3 Lobster Collection (Task 22)

At each station, 15 lobster specimens will be collected. Samples of hepatopancreas and edible tissue will be taken from each specimen for chemical analysis.

### 11.3.1 Accuracy

Traditional measures of accuracy do not apply to lobster collection procedures. The accuracy of the Ohaus balance used for weight determination is 0.01 g. The accuracy of the calipers is 1 mm.

### 11.3.2 Precision

The precision of lobster carapace length and lobster weight measurements will be monitored through the re-measurement of at least 10% of the specimens collected at each sampling site. If agreement between the measurements (length or weight) is within 1 mm or 1.0 %, respectively, measurements will continue. If measurements or weights differ by more than the above-stated criteria, cause will be identified and all the specimens measured since the last acceptable precision measurement will be re-measured or weighed.

### 11.3.3 Completeness

The sampling objective is to obtain 15 commercially harvestable specimens representative of their location. Lobsters will be purchased from commercial lobstermen. In the event of sample loss or equipment malfunction, the Battelle Chief Scientist will determine the need for appropriate corrective action. The corrective action taken will be recorded in the survey records. If every reasonable effort to acquire the required number of lobster has been made, the 100% completeness goal may be waived.

### 11.3.4 Comparability

Lobster have been routinely used by other researchers working in Massachusetts Bay and similar environments to determine health and tissue burden of contaminants. Lobster pots are routinely used by commercial fishermen to collect lobster. The sampling design of this survey is comparable to the design of previous surveys.

### 11.3.5 Representativeness

Representativeness is primarily addressed through sample design. The sampling sites represent previously sampled locations and represent the population of lobsters that may be found within Boston Harbor and Offshore.

## 11.4 Mussel Collection (Task 23)

At each station 80 or 110 mussels for organics and 40 or 55 mussels for inorganics will be collected from the deployed arrays (Table 3). The mussels will be used for biological analyses (30 mussels) and chemical analyses (50 or 80 mussels for organics and 25 or 40 mussels for inorganics).

### 11.4.1 Accuracy

Traditional measures of accuracy do not apply to mussel collection procedures. Accuracy of mussel measurements is addressed under Task 25 (Section 11.6.1).

### 11.4.2 Precision

The precision of mussel shell length measurements will be monitored through the re-measurement of a minimum of 10% of the mussel soft tissue weights and shell dimensions. If agreement between the measurements is within 0.01 g and 1 mm, respectively, measurements will continue. If measurements differ by more than the above-stated criteria, the cause will be identified and all the specimens measured since the last acceptable precision measurement will be re-measured.

### 11.4.3 Completeness

The deployment arrays will contain excess numbers of mussels at the start of the incubation and a portion of mussels will be retrieved midway in the incubation period. Completeness will be 100% after recovery of the 60-day deployment. In the event of array or sample loss, the Senior Scientist, in consultation with MWRA, will determine the need for appropriate corrective action. The correction action taken by the Senior Scientist will be recorded in the survey records.

### 11.4.4 Comparability

The deployment and retrieval of caged mussels for short-term bioaccumulation is identical to the design of previous surveys. Mussels from established reference sites will be relocated to different environments (station locations). Various reference station locations may be used, depending on mussel availability: Rockport (organics and trace metals), or Gloucester (organics) and Sandwich (trace metals). These have each been used previously in the MWRA program.

### 11.4.5 Representativeness

The sampling sites represent previously sampled locations and are representative of the expected short-term bioaccumulation conditions for mussels.

## 11.5 Tissue Chemical Analysis (Task 24)

Table 10 provides the data quality objectives for accuracy, precision, completeness and comparability for chemical analyses.

### 11.5.1 Accuracy

Analytical accuracy will be evaluated based on percent recoveries of analytes in National Institute of Standards and Technology (NIST) or National Research Council Canada (NRC) standard reference materials (SRM), blank and matrix spike samples, and the surrogate internal standards (SIS) that are added to every sample (organics only), as well as the results of the procedural blanks that will be analyzed with each batch of up to 20 field samples.

Deviations from the above analytical scheme will require approval by the Battelle Senior Scientist and will be reported with the analytical data. All QC data will be reported with the hard copy sample data. Accuracy will be measured by calculating the percent recovery of surrogate spikes (organics only), blank and matrix spikes, and standard reference materials (SRMs). Percent recovery will be calculated as shown in Section 15.2.3. Method detection limits (MDL) for analytes of interest have been calculated and are presented in Table 11 (PCB/Pests), Table 12 (PAH), and Table 13 (Metals). Specific accuracy goals are provided in Table 10.

**Table 10**. **Data Quality Objectives.**

| QC Type and Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|
| **Procedural Blanks**<br>Organics 1 per 20 samples<br>Metals<br>Lipids | < 5X MDL<br>< 5X MDL<br>< 0.1 % | Results examined by lab manager and senior scientist. Reextraction, reanalysis, or justification documented. |
| **Accuracy** | | |
| **Matrix Spike/ Blank Spikes**<br>Organics 1 per 20 samples<br>Metals | 50-150% recovery<br>70-130% recovery | Document, justify deviations. |
| **Surrogate Internal Standards (SIS)** | 50-150% recovery | Document, justify deviations |
| **SRMs**<br>Organics 1 per 20 samples<br>Metals | PD ± 30% vs. certified values, not to exceed 35% for more than 30% of analytes<br>PD ± 20% vs. certified values | Results examined by lab manager and senior scientist.<br>Re-extraction, re-analysis, or justification documented. |
| **Precision** | | |
| **Duplicates**<br>Organics (MS/MSD) 1 per 20 samples<br>Metals (Lab Duplicates)<br>Lipids | ≤ 30% RPD<br>RPD=± 25% individual analytes, ± 30% mean<br>≤ 25% RPD | Document, justify deviations. |
| **FLOUNDER/LOBSTER/MUSSEL MEASUREMENTS AND HISTOLOGY** | | |
| **Precision**<br>Duplicate Measurements 10% | Flounder Weight: ± 5 grams<br>Flounder Total and Standard Length: ± 1 cm<br>Lobster total weight: ± 1%<br>Lobster carapace lengths: ± 1 mm<br>Mussel soft tissue weight: ± 0.01 grams<br>Length: ± 1 mm | Check calibration of instrument if applicable. Perform re-measurement. |

MDL=Method Detection Limit; PD=Percent Difference; SIS=Surrogate Internal Standard; RSD=Relative Standard Deviation; SRM=Standard Reference Material; RPD=Relative percent Difference.

**Table 11. Polychlorinated Biphenyls/Pesticides Method Detection Limits for Tissues.**

| Polychlorinated biphenyls (PCBs) | MDL (ng/g dry wt.) |
|---|---|
| 2,4,-$Cl_2$(8) | 0.604 |
| 2,2′,5-$Cl_3$(18) | 0.151 |
| 2,4,4′-$Cl_3$(28) | 0.104 |
| 2,2′,3,5′-$Cl_4$(44) | 0.122 |
| 2,2′,5,5′-$Cl_4$(52) | 0.090 |
| 2,3′,4,4′-$Cl_4$(66) | 0.457 |
| 3,3′,4,4′-$Cl_4$(77) | 0.770 |
| 2,2′4,5,5′-$Cl_5$(101) | 0.987 |
| 2,3,3′,4,4′-$Cl_5$(105) | 0.337 |
| 2,3′,4,4′5-$Cl_5$(118) | 0.846 |
| 3,3′,4,4′,5-$Cl_5$(126) | 0.247 |
| 2,2′,3,3,4,4′-$Cl_6$(128) | 0.424 |
| 2,2′,3,4,4′,5′-$Cl_6$(138) | 1.061 |
| 2,2′4,4′,5,5′-$Cl_6$(153) | 1.021 |
| 2,2′3,3,4,4′,5-$Cl_7$(170) | 0.317 |
| 2,2′,3,4,4′,5,5′-$Cl_7$(180) | 0.914 |
| 2,2′,3,4,5,5′,6-$Cl_7$(187) | 0.372 |
| 2,2′,3,3′,4,4′,5,6-$Cl_8$(195) | 0.222 |
| 2,2′,3,3′4,4′,5,5′,6-$Cl_9$(206) | 0.210 |
| Decachlorobiphenyl-$Cl_{10}$(209) | 0.310 |
| **Pesticides** | **MDL (ng/g dry wt.)** |
| Hexachlorobenzene | 0.115 |
| Lindane | 0.070 |
| Heptachlor | 0.298 |
| Endrin | 0.328 |
| Aldrin | 0.073 |
| Heptachlorepoxide | 0.121 |
| cis-Chlordane | 0.582 |
| trans-Nonachlor | 0.164 |
| Dieldrin | 0.598 |
| Mirex | 0.142 |
| 2,4′-DDD | 0.224 |
| 4,4′-DDD | 0.399 |
| 2,4′-DDE | 0.539 |
| 4,4′-DDE | 0.957 |
| 2,4′-DDT | 0.651 |
| 4,4′-DDT | 0.424 |
| DDMU | 0.298 |

**Note: MDL concentrations for PCBs and pesticides are based on surrogate corrected data. These MDLs are representative. MDLs are updated annually and are available on request.**

**Table 12. Polynuclear Aromatic Hydrocarbons Method Detection Limits for Tissues.**

| Polynuclear Aromatic Hydrocarbons (PAHs) | MDL (ng/g dry wt.) |
|---|---|
| Naphthalene | 0.577 |
| $C_1$-naphthalenes | 0.787 |
| $C_2$-naphthalenes | 0.509 |
| $C_3$-naphthalenes | 0.408 |
| $C_4$-naphthalenes[b] | 0.600 |
| 1-methylnaphthalenes[b] | 0.593 |
| 2-methylnaphthalenes[b] | 0.787 |
| 2,6-methylnaphthalenes[b] | 0.589 |
| 2,3,5-methylnaphthalenes[b] | 0.380 |
| Acenaphthylene | 0.537 |
| Acenaphthene | 0.612 |
| Fluorene | 0.444 |
| $C_1$-fluorenes | 0.444 |
| $C_2$-fluorenes | 0.444 |
| $C_3$-fluorenes | 0.444 |
| Phenanthrene | 0.351 |
| 1-methylphenanthrene[b] | 0.472 |
| Anthracene | 0.331 |
| $C_1$-Phenanthrenes/anthracene | 0.472 |
| $C_2$-Phenanthrenes/anthracene | 0.472 |
| $C_3$-Phenanthrenes/anthracene | 0.472 |
| $C_4$-Phenanthrenes/anthracene | 0.472 |
| Dibenzothiophene | 0.222 |
| $C_1$-dibenzothiophenes | 0.222 |
| $C_2$-dibenzothiophenes | 0.222 |
| $C_3$-dibenzothiophenes | 0.222 |
| Fluoranthene | 0.570 |
| Pyrene | 0.594 |
| $C_1$-fluoranthenes/pyrene | 0.594 |
| $C_2$-fluoranthenes/pyrene[b] | 0.594 |
| $C_3$-fluoranthenes/pyrene[b] | 0.594 |
| Benzo[*a*]anthracene | 0.806 |
| Chrysene | 0.497 |
| $C_1$-chrysene | 0.497 |
| $C_2$-chrysene | 0.497 |
| $C_3$-chrysene | 0.497 |
| $C_4$-chrysene | 0.497 |
| Benzo[*b*]fluoranthene | 0.678 |
| Benzo[*k*]fluoranthene | 0.556 |
| Benzo[*a*]pyrene | 0.924 |
| Dibenzo[*a,h*]anthracene | 0.461 |
| Benzo[*g,h,i*]perylene | 0.510 |
| Indeno[1,2,3-*c,d*]pyrene | 0.663 |
| Perylene | 0.356 |
| Biphenyl | 0.356 |
| Benzo[*e*]pyrene | 0.803 |
| Dibenzofuran | 0.260 |
| Benzothiazole | 0.500[a] |

**Note: MDL concentrations for PAHs are based on surrogate corrected data. These MDLs are representative. MDLs are updated annually and are available on request.**

[a] Estimated based on response of low standard.

[b] Compounds monitored in 1998-2001; analysis of these compounds is not required by project contract but will be analyzed in 2002-2005, HOM 4.

**Table 13. Metals Method Detection Limits for Tissues.**

| Trace Metals | MDL (µg/g dry wt.) |
|---|---|
| Ag Silver | 0.1 |
| Cd Cadmium | 0.1 |
| Cr Chromium | 0.1 |
| Cu Copper | 0.2 |
| Hg Mercury | 0.02 |
| Ni Nickel | 0.3 |
| Pb Lead | 0.1 |
| Zn Zinc | 0.1 |

All field samples, blanks, and matrix QC samples processed for organics analysis will be spiked with the appropriate SIS before extraction. Quantification of the SIS will be based on the recovery internal standards (RIS) added to the final extract just before instrumental analysis. Acceptable SIS ranges are provided in Table 10. It is considered acceptable if one of the PAH surrogate internal standards lies outside this range as long as the others are within the acceptable range. Because samples are quantified relative to the recovery of the SIS, which is added before extraction, any loss of analytes during processing should be corrected by a comparable loss of the SIS. Therefore, SIS recoveries outside of the data quality objectives listed in Table 10 may be considered acceptable. Each sample showing low recoveries will be individually examined by the laboratory manager or laboratory task leader to determine the necessity of re-extraction or reanalysis and the proposed action discussed with the Battelle Senior Scientist. All corrective actions will be documented. When a sample does not meet the acceptance criteria and is not reanalyzed, the justification for this decision will be documented. QC exceedances will be reported to MWRA in the QA/QC Corrective Action Log.

### 11.5.2 Precision

Analytical precision will be determined using the concentrations of duplicate samples (matrix spikes for organics samples, field or laboratory duplicates for metals samples), with the percent differences between duplicate analyses (RPD) serving as a measure of precision. Target RPDs are provided in Table 10. The RPD will be calculated by the formula given in Section 14.4.1.1.

### 11.5.3 Completeness

The completeness of chemical analyses will be ensured by comparing the chain-of-custody forms received by the laboratory with the list of samples analyzed. Samples will be analyzed for the parameters listed in Table 7.

Completeness of chemical analyses will depend directly upon the amount of sample available. A minimum of 5 g (wet weight) of tissue is normally necessary to perform all of the required analyses. If inadequate tissue biomass is available, then the MWRA Project Area Manager will be contacted prior to sample analyses for guidance. One possible solution to the inadequate sample amount is that analyses may be conducted on lower weights (with potentially higher MDLs). Three pools of 5 liver samples will be prepared. One hundred percent of the samples collected for tissue chemistry analysis are expected to be analyzed, either individually or as composites.

### 11.5.4 Comparability

The SRM, when processed and analyzed with samples, will quantify the comparability characteristic for laboratory measurements.

The data generated for this project will be directly comparable to data generated for the NS&T Mussel Watch project because the same analytical protocols are being used. Additionally, the methods used by this project are directly comparable to the methods used for in earlier work on this MWRA study.

### 11.5.5 Representativeness

The monitoring program was designed to ensure that results will be representative (MWRA 1997). Representativeness will also be ensured by adequate sample homogenization, where required, and appropriate sample storage.

## 11.6 Flounder Histological and Mussel Condition Analysis (Task 25)

### 11.6.1 Accuracy

Traditional measures of accuracy do not apply to flounder histology and mussel condition analyses. Flounder scales and otoliths will be read by National Marine Fisheries Service (NMFS) scientists that are experienced in aging winter flounder.

Mussel shell dimensions will be determined with a Vernier caliper, which is accurate to 0.1 mm. Total soft tissue, gonadal tissue, and non-gonadal tissue will be measured on an electronic balance accurate to 0.01 g wet weight.

### 11.6.2 Precision

A percentage of the scales will be reread to verify age determinations. Histological observations of tissue abnormalities and scores assigned to these abnormalities are somewhat subjective based on the opinion of the pathologist reading the slides. Precision and accuracy of the measurements are therefore difficult to define quantitatively. However, an intercomparability exercise carried out in 1993 documented that 2 trained pathologists looking at the same material, identified roughly equivalent frequencies and severities of lesions (Hillman *et al.* 1994). Another comparability study was performed by Moore *et al.* (1993) in which a blind re-evaluation of 1989 slides was performed in 1993 showing 100% agreement. These findings suggest that, although quantification of the accuracy and precision of the protocols is difficult, it is measurable and has been demonstrated to be acceptable.

### 11.6.3 Completeness

For sufficient data for the statistical analyses needed to assess the health of the flounder populations, and to make inter-site comparisons of the lesion prevalence, lesion scores from three slides from each of 50 flounder livers from each site will be calculated.

Large numbers of mussels are deployed in arrays, which should provide sufficient mussels for biological and chemical analyses. An early (i.e., 40 day) retrieval is conducted to ensure sufficient material is available for each site.

### 11.6.4 Comparability

The lesions scored, the method of scoring, and the data reduction and analyses will be similar to what has been done in previous years under the HOM program. Scales will be read as a courtesy by NMFS scientists that have aged winter flounder during the previous studies. Comparability of flounder liver histology data has been confirmed in a number of studies described in section 11.6.2. Several slides will be studied with Dr. Robert Hillman to assure that observations are comparable to those made during studies conducted previously.

The determination of the shell length and weight, body and gonadal weight and reproductive condition of the mussels will be conducted in the same manner as in previous years.

### 11.6.5 Representativeness

The program design and objectives ensure representativeness.

## 12.0 SAMPLING AND ANALYTICAL PROCEDURES

Methods for collection and analysis of samples are described in the following sections.

### 12.1 Navigation

Vessel positioning during sampling operations using Battelle's equipment will consist of a Northstar 941XD Navigation system. This system combines a 12-channel GPS satellite receiver with a Differential GPS (dGPS) receiver. The system is capable of tracking 12 GPS satellites and also monitoring land-based dGPS stations simultaneously. The output of the 941XD is interfaced with the NavSam© Data Collection system to provide real-time position fixes for the NavSam© electronic log. To correct the GPS calculations, the Northstar dGPS will receive correction data from one of three USCG dGPS broadcast sites: Montauk Point, NY; Chatham, MA; and Portsmouth Harbor, NH (see Figure 5 for coverage). This capability ensures strong signal reception, and accurate and reliable positioning with 2-s updates.

In the case of the flounder and lobster collection surveys, navigation data will be collected from dGPS and/or LORAN aboard the vessel used and will be hand recorded on a field logsheets.

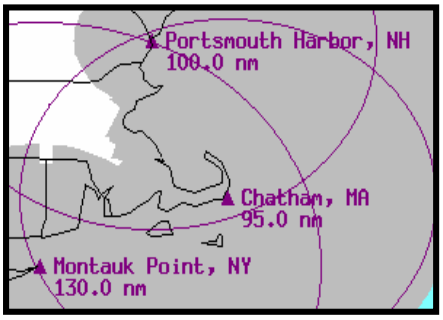



**Figure 5. dGPS Master Stations Coverage.**

## 12.2 Winter Flounder Collection and Processing

Winter flounder specimens will be collected and processed as described in the sections that follow.

### 12.2.1 Collection

1. A commercial otter trawl will be towed by a commercial dragger beginning at the site center of each sampling site listed in Table 2. The tows will be conducted for 15-30 minutes at a speed of 1.5 to 2 kt in a direction parallel to lobster-pot trawls in the area to avoid interaction with lobster pots. Tows will be conducted until at least 50 specimens have been collected at each sampling site. At the start and completion of each tow, the time and vessel position will be recorded by differential GPS and/or LORAN.

2. At the completion of each tow, the otter trawl will be brought on board using a mechanical winch and the contents of the trawl unloaded onto the aft deck of the vessel. It may be necessary to conduct more than one otter-trawl tow at a sampling site if the required number of specimens greater than 30 cm total length (50) is not collected during the first tow. If the required number of flounder is not collected after one 30-minute tow and three 1 hour tows at an appropriate adjacent site, collections at that site will be terminated for the survey period (though individual tows may be up to 1 hour if necessary). If the number of fish in the first hour of towing is less than five, the effort will be deferred for two to four weeks. This strategy has proven to be efficient in previous years.

3. All specimens will be sorted by species, however, only winter flounder will be retained; other species will be returned to the environment. If unusually large (> 50 cm) winter flounder are obtained, up to three (3) large individuals per site will be retained for processing. With the approval of MWRA's Project Manager, some such individuals may be analyzed under Tasks 24 and 25 as extra units.

4. Fish held for chemical analysis will be kept on ice and hand-delivered to Battelle Duxbury Operations. If a fish is collected and assigned a sample ID but then dies, a comment will be made on the flounder collection form (Figure 7). Data will not be collected from this individual.

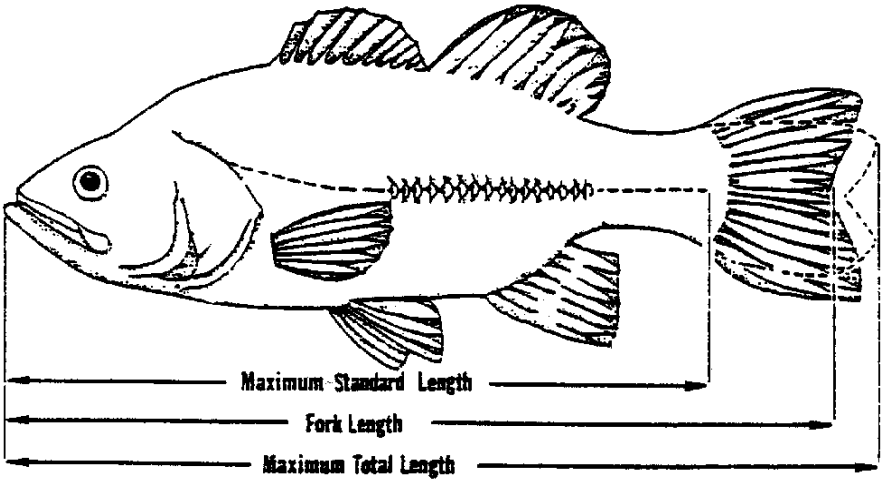



**Figure 6. Length Measurements for Flounder.**

## 12.2.2 Tissue Sample Processing

Processing will be conducted in the laboratory for the 15 fish for histology and tissue chemistry analysis and on board the collection vessel for the 35 or 50 fish for only histology analyses.

### 12.2.2.1 Sample Processing for Histology Analyses

1. The fish from each site will be processed for histology analyses immediately, (this process may continue while proceeding to the next sampling site). The fish will be killed by means of a cervical section prior to processing.
2. The weight, standard length, and total length will be determined (see Figure 6 and SOP 5-175). Each flounder will be examined for external evidence of disease (fin rot and external lesions) and notes will be recorded on the flounder sampling log (Figure 7).
3. Scales will be collected from specimens on board the vessel. Scales will be removed after first removing any mucus, debris, and epidermis from the dorsum of the caudal peduncle by wiping in the direction of the tail with a blunt-edged table knife. Scales will be collected from the cleaned area by applying quick, firm, scraping motions in the direction of the head. Scales will be placed in the labeled age-sample envelope by inserting the knife between the liner of the sample envelope and scraping off the scales.
4. The livers will be removed and examined for visible gross abnormalities (gross liver lesion). They will be preserved in 10% neutral buffered formalin for histological analysis. Liver samples from each fish will be placed in a separate clearly labeled sample container.

### 12.2.2.2 Sample Processing for Tissue Chemistry

Because contaminant-free conditions cannot be found on board the vessel used for flounder collection, the fish used for chemical analysis will be returned to the laboratory for organ dissection. Of the 50 flounder collected from each site for histopathological analysis, 15 fish will be designated for tissue chemical

Station #:_____
Station ID:_____
Collection Date/Time:_____

2001 Flounder Histology Data MWRA Harbor and Outfall Monitoring Program

| | | | Chain of Custody: | Check applicable sample type | Scale: _____ Histology: _____ | Chem Liv: ___ Fil:___ | Relnq___/__/__ Rec'd___/__/__ | _____ . _____ | Relnq___/__/__ Rec'd___/__/__ | _____ . _____ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Event | ID | STN | Composite # | Total Length mm | Standard Length mm | Weight. (g) | Sex | Age | Liv. col.* | Fin (0 to 4) | Gross Liver Lesion (0 to 4) | | External Lesions (0 to 4) |
| F00 | 1001 | DIF | | | | | | | | | | | |
| F00 | 1002 | DIF | | | | | | | | | | | |
| F00 | 1003 | DIF | | | | | | | | | | | |
| F00 | 1004 | DIF | | | | | | | | | | | |
| F00 | 1005 | DIF | | | | | | | | | | | |
| F00 | 1006 | DIF | | | | | | | | | | | |
| F00 | 1007 | DIF | | | | | | | | | | | |
| F00 | 1008 | DIF | | | | | | | | | | | |
| F00 | 1009 | DIF | | | | | | | | | | | |
| F00 | 1010 | DIF | | | | | | | | | | | |
| F00 | 1011 | DIF | | | | | | | | | | | |
| F00 | 1012 | DIF | | | | | | | | | | | |
| F00 | 1013 | DIF | | | | | | | | | | | |
| F00 | 1014 | DIF | | | | | | | | | | | |
| F00 | 1015 | DIF | | | | | | | | | | | |

Date Collected:__/__/__ Page __ of __

Scientist:_____ QA Officer:_____

*Y: yellow, YB: Y Brown, B: Brown, DB: Dark B. Date:__/__/__

**Figure 7. Sample Collection Log — Winter Flounder.**

analysis. The fish will be held on ice, and stored in separate, site-specific coolers, until they are returned to the laboratory.

The flounder tissues will be removed in the laboratory under contaminant-free conditions. Tissue processing will be conducted in Battelle's tissue laboratory. Fish will be processed for histology analysis as described in Section 12.2.2.1, then, using a pre-cleaned (i.e., rinsed with 10% HCL, Milli-Q (18 megohm) water, acetone, DCM, and hexane) stainless steel knife, the fillets (muscle) will be removed from the flounder and the skin will be removed from the fillet. Composites will be composed of equal weights of the homogenates of 5 individual fish that are prepared using approximately equal masses of top and bottom tissue. Homogenization will be performed using a stainless steel TEKMAR® tissuemizer. Each composite will be placed in a sample container clearly identified with the unique sample identifier.

At least one homogenization blank will be carried out for each batch of ≤ 20 tissue samples to assess for sample contamination during the homogenization process. For the blank sample, a known quantity of (about 100 ml) Milli-Q water will be transferred to a clear glass jar, "tissuemized" for two minutes, and analyzed for both PCB/Pests and Hg (fillet measurements only).

Livers from the 15 fish selected for chemical analyses will be removed using a titanium or ceramic knife and will also be analyzed for chemical parameters. Following the processing for histology analysis, the livers will be individually homogenized by finely chopping with the titanium or ceramic knife and divided into three separate composites to correspond to the composites made for the fillets. This is done to ensure comparability between fillet and liver chemical analyses. Each composite will be placed in a sample container clearly identified with the unique sample identifier. Note: The liver composite samples will contain approximately equal masses (5 grams) from each of the livers being used in the composite. For fish with extremely small livers (< 5g wet weight), all available liver tissue will be used from such fish.

Following processing of livers for histology analysis, the homogenized tissue and liver samples will be frozen and stored. Any remaining tissue from each specimen will be archived frozen should additional analysis be required under Task 24.13.

## 12.3 Lobster Collection and Processing

Lobster specimens will be collected and processed according to the procedures described in the sections below.

### 12.3.1 Collection

1. Following visual observation and documentation of the location of source lobster pots (within 2 km of target site), up to 15 legal-sized lobsters will be obtained from commercial lobstermen for a sampling site[9]. Specimens will be processed as described below.
2. Upon retrieval, lobster pots will be brought alongside the vessel to the gunnel (side railing). Specimens will be removed and measured on the gunnel. No specimens will be brought on board the vessel until it is determined that they have a carapace length of at least 3.25 in (legal

[9] If no commercial lobster pots are located within the target site, a string of 25 to 30 lobster pots will be deployed for up to three days at each sampling site by Battelle or by commercial lobstermen. The pots will be deployed in a direction parallel to other pots in the area. When the pots are deployed and retrieved, the time and vessel position will be recorded.

length). In addition, any specimens that are of legal length but also contain eggs (berried) will be returned to the environment immediately.

3. Calipers will be used to measure specimens after it is determined that they are of harvestable size. These measurements and inspections will be made immediately upon capture to improve chances of survival. [Note: The measurements and inspections are identical with commercial practice.]
4. Fifteen specimens retained for processing will be banded with one band per claw. Sampling location information will be recorded from the dGPS system. During the survey, lobster specimens will be stored away from commercial lobsters in a separate container with site water. During transport from the dock to the laboratory for processing, lobster specimens will be stored on ice.

### 12.3.2 Lobster Processing for Chemistry

Lobsters will be collected from three sites. Once at the laboratory, specimens will be frozen until processing can begin. In the laboratory, carapace length will be determined by measuring the distance from the posterior of the eye socket to the midpoint of the posterior of the carapace with calipers (see Figure 8 and SOP 5-175). Measurements will be recorded to the nearest millimeter. Specimen weight will be recorded to the nearest gram. Specimens will be visually examined for the presence and severity of gross external abnormalities, such as black gill disease, shell erosion, parasites, and external tumors. Data for each specimen will be recorded on lobster sample collection logs (Figure 9), including site, project survey type, sample identification number, date and time, and sampler's initials. The hepatopancreas will be removed using titanium, ceramic, or Teflon implements and frozen for chemical analysis. The tail and claw meat (edible tissue) will be stored frozen in the shells until processed in the laboratory. Samples will be placed in sample containers that are clearly identified with a conventional label containing the information described above.

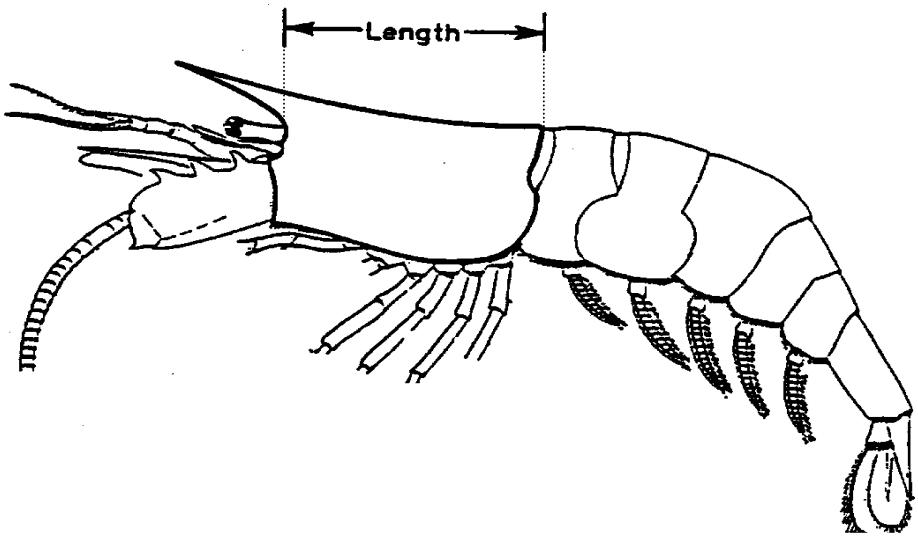



**Figure 8. Length Measurement of Lobster.**

Event: _____
Station #: _____
Station ID: _____
Collection Date/Time: _____

**Baattelle Duxbury**
**MWRA HOM3 — Fish and Shellfish**
**April 1998**

**Sample Collection Log — Lobster**

| Specimen No. | Carapace length (cm) | Weight (gm) | Sex (M/F) | Black Gill [a] | Shell Erosion [a] | Parasites [a] | External Tumors [a] | Samples Taken (check) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |
| | | | | | | | | liver ___<br>tissue ___ |

Entered by: _____ Date: _____

[a]Codes: 0 - 4 (absent - extreme)

**Figure 9. Sample Collection Log – Lobster.**

The fifteen lobsters from each site will be randomly assigned to 3 pools of 5 lobster each. Homogenized samples of hepatopancreas or edible meat from each lobster in a pool will be quantitatively combined (±10% by weight) to provide two composite samples per pool, one each of hepatopancreas and edible meat. Each composite will be placed in a sample container clearly identified with the unique sample identifier.

## 12.4 Mussel Bioaccumulation Survey

Mussel specimens will be deployed and retrieved according to the procedures described in the sections below.

### 12.4.1 Mussel Deployment

In June, mussels will be collected for testing purposes from reference sites (Depending on availability: Rockport, MA – both organics and inorganics, Gloucester, MA – organics, Sandwich, MA – inorganics). Mussels will be harvested during low tide and individually checked for length. Mussels that have a total average length of 55-65 mm will be used in the deployment. Mussels will be randomly distributed to plastic cages for deployment as an array (i.e., set of cages) in sufficient number to provide the necessary biological material. At least 10% additional mussels will be included to account for potential mortality. A subsample of 105 live mussels will be randomly selected and set aside for pre-deployment biological and chemical analyses.

Mussel array systems will be deployed at up to four locations (Table 2, Figure 3). At each location a minimum of 3 arrays will be deployed except for the offshore locations (Outfall Site and Cape Cod Bay) where 4 arrays will be deployed. Each array will be deployed on a separate mooring and each with enough mussels to provide sufficient tissue to complete the study. The locations of the arrays will be recorded using dGPS.

### 12.4.2 Mussel Collection

Table 14 lists the minimum numbers of mussels that will be recovered from each location for each type of analysis at the 40 and 60-day collections.

After approximately 40 days, up to one half of the mussels (one array) will be recovered to provide biological material in the event of a failure of the 60-day collection. The amount of biofouling of the arrays will also be assessed at 40 days. If necessary, arrays will be retrieved, cleaned, and re-deployed at the site. At the end of 60 days, the remaining mussels (the additional array) will be collected. The mussels for chemical analysis will be placed in a clean container and frozen (prior to shucking).

### 12.4.3 Mussel Processing

A random subsample of mussels (see Table 14) will be selected from the pre-deployment mussels and from each of the 4 stations' 60-day mussel harvest (or 40-day harvest if the 60-day harvest is unavailable). Replicate chemical analysis samples will be prepared as composites of fifteen mussels. In years when pre-deployment mussels are collected from two separate locations (i.e. Gloucester for organics and Sandwich for metals), replicate organic chemical analysis samples will be prepared as composites of ten mussels and replicate inorganic chemical analysis samples will be prepared as composites of five mussels. Each individual mussel will be cleaned of attached material, all byssal threads removed, and all soft tissue including fluids placed directly into an appropriate container (500-ml I-Chem Certified clean bottle). Mussel composite samples will be prepared for chemical analyses by homogenization using a titanium TEKMAR® "tissuemizer", that has been rinsed with methanol and deionized water prior to use. Sample homogenates will then be split into appropriate containers for metals and organic analyses.

**Table 14. Minimum Numbers of Mussels Collected at Each Location.**

| Site | Organic Chemistry | Inorganic Chemistry | Biological Condition[a] |
|---|---|---|---|
| Reference Mussels (pre-deployment) | 50 | 25 | ≥30 |
| Boston Inner Harbor (40–day recovery) | 50 | 25 | ≥30 |
| Boston Inner Harbor (60–day recovery) | 50 | 25 | ≥30 |
| Deer Island Light (40–day recovery) | 50 | 25 | ≥30 |
| Deer Island Light (60–day recovery) | 50 | 25 | ≥30 |
| Outfall Site (40–day recovery) | 80 | 40 | ≥30 |
| Outfall Site (60–day recovery) | 80 | 40 | ≥30 |
| Cape Cod Bay (40–day recovery) | 80 | 40 | ≥30 |
| Cape Cod Bay (60–day recovery) | 80 | 40 | ≥30 |

[a] When reference mussels from both Gloucester (organics) and Sandwich (inorganics) are used, 30 Gloucester mussels and 15 Sandwich mussels will be used for biological condition analyses.

In the event that sufficient mussels are not retrieved at 60 days, the MWRA Project Area Manager will be immediately notified to determine if the 40-day deployed mussels will be analyzed. If sufficient mussels are not retrieved from either the 40 or 60 day deployments a revised approach to mussel analyses shall be determined following consultation of the MWRA Project Area Manager and Battelle.

## 12.5 Tissue Chemical Analyses (Task 24)

Table 15 summarizes the analyses of tissue samples collected under Tasks 21-23. Three composites each of flounder samples (liver and edible tissue) and lobster samples (hepatopancreas and edible tissue) and five or eight composites of mussel soft tissue will be analyzed per site (see Sections 12.2 and 12.3 for details on pooling). For flounder and lobster, individual specimens will be homogenized separately and then equal wet aliquots of each homogenate will be pooled to create a composite[10]. The newly formed composite will be homogenized prior to splitting the sample into aliquots for the various analyses. The chemical analytes of interest for Task 24 are listed in Table 7. Table 15 lists the analysis methods, units of measurement and method reference.

### 12.5.1 Organic Analyses

**Sample Extraction** - Tissues will be extracted and cleaned following procedures in Battelle SOP 5-190. Approximately 30-g of tissue homogenate will be weighed into a Teflon extraction jar, spiked with the appropriate surrogate internal standard (SIS), combined with 75 mL DCM and sodium sulfate, macerated with a Tissumizer and centrifuged. An aliquot of the original sample will also be taken for dry weight determination. The extract will be decanted into an Erlenmeyer flask. This process is repeated once using 75 mL DCM. After each maceration (total of two solvent additions), the centrifuged solvent extracts will be combined in the Erlenmeyer flask. An additional extraction will be performed using 50 mL DCM and

[10] In cases where sample mass may be limited (i.e. flounder liver and lobster hepatopancreas), best professional judgment will be used when combining individual samples to form the composite sample so that enough composite sample is available to perform all of the required chemical analyses.

shaking techniques, the sample centrifuged a third time, and the extract combined with the other two. A 10-mL aliquot of the combined extracts will be removed for lipid weight determination (as described in SOP 5-190). The combined extract will be dried over sodium sulfate, processed through an alumina cleanup column, and concentrated to approximately 900-µL for additional HPLC cleanup. Raw extracts (post-alumina) will be fractionated by HPLC (BOS SOP 5-191). The post-HPLC extract will be concentrated under nitrogen to approximately 0.5 mL, and spiked with recovery internal standards (RIS).

The flounder liver, lobster hepatopancreas, or mussel tissue final extract will be split for analysis, one half remaining in DCM for PAH analysis, and the other half solvent-exchanged with hexane for PCB and pesticide analysis. The entire final extract of flounder or lobster edible tissue will be solvent-exchanged with hexane for PCB and pesticide analysis only.

Dry weight determinations will be performed by drying a portion of each composite sample.

Lipid results will be gravimetrically measured by evaporating an aliquot of the organic extract and weighing the remaining residue. Results will be reported in percent dry wt.

**Table 15. Fish and Shellfish Sample Analyses.**

| Parameter | Lab | Unit of Measurement | Method | Reference |
|---|---|---|---|---|
| **Organic Analyses** | | | | |
| Organic Extraction | Battelle | NA | Peven and Uhler (1993) | Battelle SOP 5-190 |
| Polynuclear Aromatic Hydrocarbons (PAH) | Battelle | ng/g dry wt. | GC/MS | Battelle SOP 5-157 |
| Polychlorinated Biphenyls (PCB)/Pesticides | Battelle | ng/g dry wt. | GC/ECD | Battelle SOP 5-128 |
| **Metals Analyses** | | | | |
| Digestion: Ag, Cd, Cr, Cu, Hg, Ni, Pb | Battelle | NA | Aqua regia and/or Nitric acid | Battelle SOP MSL-I-024 |
| Analysis: Ag, Cd, Cr, Cu, Ni, Pb, Zn | Battelle | ug/g dry wt | ICP-MS | Battelle SOP MSL-I-022 |
| Analysis: Ag, Cr | Battelle | ug/g dry wt | GFAA (as required) | Battelle SOP MSL-I-029 |
| Analysis: Selected metals (Ag, Cd, Cr, Cu, Pb, Zn) | Battelle | ug/g dry wt | ICP-AES (as required) | Battelle SOP MSL-I-027 |
| Analysis: Hg | Battelle | ug/g dry wt. | CVAA-FIAS (Hg) | Battelle SOP MSL-I-016 |
| **Ancillary Parameters** | | | | |
| Lipids | Battelle | % by dry weight | gravimetric | Battelle SOP 5-190 |
| Wet Weight/Dry Weight Ratio | Battelle | NA | gravimetric | Battelle SOP 3-160 (balance)<br>Battelle SOP 5-190 |
| Flounder Length<br>Weight | WHOI/Battelle | mm<br>grams | calipers<br>gravimetric | Battelle SOP 5-175<br>Battelle SOP 3-160 (balance) |
| Lobster Length<br>Weight | Battelle | mm<br>grams | calipers<br>gravimetric | Battelle SOP 5-175<br>Battelle SOP 3-160 (balance) |
| Mussel Biological Condition | Battelle | mm<br>grams | calipers<br>gravimetric | Battelle SOP 5-031 |

**PAH Analysis -** Trace level organic compounds (PAH) are identified using electron impact gas chromatography/mass spectrometry (GC/MS). Target compounds are separated using an HP 5890 Series II gas chromatograph or HP 6890 equipped with a 60-m x 0.25-mm-inner diameter (0.25-um film thickness) DB-5 column (J&W Scientific) and measured using a HP 5972a or HP 6890 mass selective detector operated in the selective ion monitoring (SIM) mode following Battelle SOP 5-157. Concentrations for all target analytes will be determined by the method of internal standard, using surrogate internal standards (SISs) for quantification. All PAH results will be reported in ng/g dry wt.

**PCB/Pesticide Analysis** - Pesticides and PCB congeners will be analyzed and quantified using gas chromatography/electron capture detection (GC/ECD) (Hewlett Packard 5890 Series 2 GC or HP 6890) using a 60-m DB-5 column and hydrogen as the carrier gas following Battelle SOP 5-128, including a second column for confirmation. Concentrations for all target analytes will be determined by the method of internal standard, using surrogate internal standards (SISs) for quantification. All PCB and pesticide results will be reported in ng/g dry wt.

### 12.5.2 Metal Analyses

**Tissue Digestion -** Mussel tissue, flounder liver and fillet, and lobster hepatopancreas and edible tissue will be digested using an aqua regia procedure according to Battelle SOP MSL-I-024 *Mixed Acid Tissue Digestion*. To prepare tissue samples for metals analysis, samples are first freeze-dried and homogenized in a ball-mill. A 200- to 300-mg aliquot of each dried, homogeneous sample is combined with aqua regia (nitric and hydrochloric acids at a ratio of 5.0 mL:3.5 mL) in a Teflon bomb and heated in an oven at 130 ºC (±10 ºC) overnight. After heating and cooling, deionized water is added to the acid-digested tissue to achieve analysis volume and the digestates are submitted for analysis.

Alternatively, in cases where hydrochloric acid in the digestion procedure can be found to cause chloride interferences with certain metals during ICP-MS analysis, tissue samples may be processed using a nitric acid-only digestion procedure, Battelle SOP MSL-I-024 *Mixed Acid Tissue Digestion*. An approximately 300-mg aliquot of each dried, homogeneous tissue sample and nitric acid are combined in a glass vial. The vials are loosely capped and heated on a hot plate at a temperature just high enough to boil the acid, without boiling over or evaporating the sample to dryness. After heating and cooling, deionized water is added to the acid-digested tissue to achieve analysis volume and the digestates are submitted for analysis.

**CVAA Analysis of Hg** - Sample digestates will be analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016 *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*, which is based on EPA Method 245.6 *Determination of Mercury in Tissues by Cold Vapor Atomic Absorption Spectrometry* (EPA 1991a). Results are reported in units of µg/g on a dry-weight basis.

**ICP-MS Analysis of Ag, Cd, Cr, Cu, Ni, Pb, and Zn** - For analysis of multiple metals simultaneously, sample digestates will be analyzed for Ag, Cd, Cr, Cu, Ni, Pb, and Zn using inductively coupled plasma - mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022 *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. This procedure is based on two methods modified and adapted for analysis of solid sample digestates, EPA Method 1638 *Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma - Mass Spectrometry* (EPA 1996) and EPA Method 1640 *Determination of Trace Elements in Water by Preconcentration and Inductively Coupled Plasma - Mass Spectrometry* (EPA 1997). Results are reported in units of µg/g on a dry-weight basis.

**GFAA Analysis of Selected Metals** - Sample digestates may also be analyzed by graphite furnace atomic absorption (GFAA) for a single element, particularly Ag or Cr, when samples are found to have particularly high metals concentrations or if results of QC samples do not meet data quality objectives. GFAA analysis will be conducted according to Battelle SOP MSL-I-029 *Determination of Metals in Aqueous and Digestate Samples by GFAA*. This procedure is based on EPA Method 200.9 *Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry* (EPA 1991b). Results are reported in units of μg/g on a dry-weight basis.

**ICP-AES Analysis of Selected Metals -** Sample digestates may also be analyzed by inductively coupled plasma-atomic emission spectrometry (ICP-AES) for a single element (except Hg), when samples are found to have particularly high metals concentrations or if results of QC samples do not meet data quality objectives. ICP-AES analysis will be conducted according to Battelle SOP MSL-I-027 *Determination of Metals in Aqueous and Digestate Samples by ICP-AES*. This procedure is based on EPA Method 200.7 *Determination of Metals and Trace Elements by Inductively Coupled Plasma-Atomic Emission Spectrometry* (EPA 1994) and SW-846 Method 6010B *Inductively Coupled Plasma-Atomic Emission Spectrometry* (update 12/96). Results are reported in units of μg/g on a dry-weight basis.

## 12.6 Flounder Histological and Mussel Condition Analysis (Task 25)

Flounder histology and mussel biological analyses will follow the procedures described in the section below.

### 12.6.1 Flounder Histology

Livers of 50 flounder from each site will be processed for histological analysis by Experimental Pathology Laboratories in Herndon, VA as described below. The age of each flounder will be determined by NMFS scientists through analysis of growth rings (annuli) on the scales removed during the conduct of the Flounder Collection (Task 21) as described in CW/QAPP Section 12.2.2.

Transverse sections of flounder livers fixed as part of Tissue Sample Processing (see CW/QAPP Section 12.2.2) will be removed from the buffered formalin after at least 24 hours, rinsed in running tap water, dehydrated through a series of ethanols, cleared in xylene, and embedded in paraffin. Paraffin-embedded material will be sectioned on a rotary microtome at a thickness of 5 μm. Each block will be sectioned at one level, resulting in one slide per fish and a total of 250 slides per year. The sections will be stained in hematoxylin and eosin.

Each slide will be examined by Dr. Moore at WHOI under bright-field illumination at 25x, 100x, and 200x to quantify the presence and extent of:

- Three types of vacuolation (centrotubular, tubular hydropic, and focal hydropic)
- Macrophage aggregation
- Biliary duct proliferation
- Neoplasia
- Apoptotic lesions (i.e. balloon cells)

The severity of each of the above listed lesions will be rated on a scale of 0 to 4, where: 0 = absent; 1 = minor; 2 = moderate; 3 = severe; and 4 = extreme. For each lesion and each fish, a histopathological index will then be calculated as a mean of scores from three slices on one slide. Prevalence or the presence of each lesion, to any degree will then be calculated.

### 12.6.2 Mussel Biological Condition

For biological analyses, a random subsample of 30 mussels (see Table 14) will be selected from the pre-deployment mussels and from each of the four stations' 60-day collection. Mussels for biological analyses will be processed to obtain total shell length (Figure 10), total wet and dry weight, gonad dry weight, shell weight, and reproductive condition, following Battelle SOP 5-031.

In the laboratory, each mussel will be cleaned of attached material (barnacles, byssal threads, etc.). The total shell length (greatest distance in an anterior-posterior direction along a line approximately parallel to the hinge axis) will be measured with a Vernier caliper (to the nearest 0.1mm). The total soft tissue, gonadal tissue, and the non-gonadal tissue weights will be measured on an electronic balance to the nearest 0.01g wet weight.

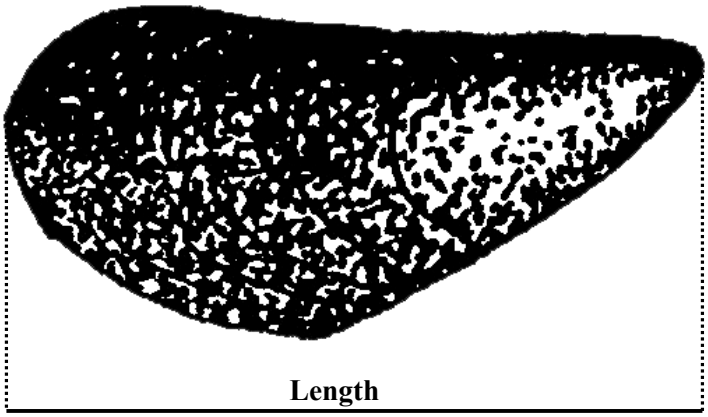



**Figure 10. Length Measurement of Mussels.**

## 13.0 SAMPLE CUSTODY

A unique eight character *Sample ID,* will identify samples collected in the field. The *Sample ID* will identify the sample collected (i.e. a single flounder, or a single lobster, or a mussel composite). The five character *Event ID* will be unique to each survey, such as "FF021", with "FF" indicating that it is a Flounder survey, "02" indicating the survey year, and "1" signifying the first survey of the year. For individual flounder and lobster, the *Sample ID* will consist of the *Event ID*, the Station ID, and a three digit sequential number (001-050 for flounder and 001-015 for lobster). For mussels, the *Sample ID* will consist of the *Event ID*, the Station ID, and the *Composite ID*. The *Composite ID* is a four place alphanumeric laboratory ID (XX00) that also serves as the *Bottle ID*. Unique *Bottle ID*s are assigned to edible tissue and hepatopancreas/liver tissue from each fish or lobster.

### 13.1 Custody of Electronic Data

### 13.1.1 Navigation Data

Custody of electronic navigation data will be the responsibility of the Chief Scientist during the field activity and of Battelle's Field Manager at the laboratory. For the flounder surveys, navigation data, including survey ID, date, time, trawl number, and vessel position at start and completion of each sampling event, will be hand-recorded in the survey logbook. For lobster surveys, navigation data, including survey ID, date,

time, and position of each lobster pot, will be hand-recorded in the survey logbook. The Battelle Field Manager must receive a complete copy of the survey log for each survey.

### 13.1.2 Laboratory Data

Battelle and WHOI will produce electronic data under this task. At Battelle, the electronic files for chemical data will remain in the custody of the analysts until all analyses are completed and data have gone through the Battelle Quality Assurance Unit. The electronic data will be transferred the HOM4 Database Manager for entry into the MWRA database.

## 13.2 Flounder, Lobster, and Mussel Samples

During field collection, custody forms will be completed. Manual entries will be recorded in indelible ink in the data section of the chain-of-custody. Based on the types of samples that will be collected, chain-of-custody forms will be generated for each sample type to track samples from collection to laboratory. Figure 11 shows an example of a chain-of-custody form that will be used.

The samples will remain in the custody of the Chief Scientist (designated for each survey) while in the field. Custody forms will accompany the samples when transferred from the field to the laboratory. All samples will be distributed to the appropriate laboratory personnel by hand or by Federal Express. When samples arrive at the laboratory, custody will be relinquished to the Laboratory Custodian. Upon receipt of the samples, the laboratory Sample Custodian will examine the samples, verify that sample-specific information recorded on the custody forms is accurate and that the sample integrity is uncompromised, log the samples into the laboratory tracking system, complete the custody forms, and sign the custody form so that transfer of custody of the samples is complete. Completed custody forms must be faxed to the Battelle custodian within 24 hours of sample receipt. Any discrepancies between sample labels and transmittal forms, and unusual events or deviations from the project CWQAPP will be documented in detail on the custody form and the Senior Scientist and Laboratory Manager notified. The original custody forms will be submitted to the Battelle MWRA Laboratory Manager with the data and maintained in the MWRA project files. Due to the complexity of the field IDs, unique laboratory specific sample IDs may be assigned to individual composite samples during sample Log-in.

## 13.3 Histology Samples

The laboratory custodian of samples for histologic analyses will be Dr. Michael Moore, of WHOI. He will be responsible for shipping the samples to be histologically processed to Experimental Pathology Laboratories in Herndon, VA, where chain-of-custody forms will be signed by the receiving histology technician Keith Rogers. The tissue slices will be embedded in the same tissue cassettes labeled at the time of collection. Sample numbers will be copied from the cassettes to the slides at the time of sectioning the embedded blocks. The blocks and slides will be returned to Dr. Moore, chain-of-custody forms signed again and all histology material thereafter will be archived at WHOI.

## 13.4 Samples for Tissue Chemistry

The laboratory custodian of samples for chemical analyses will be Ms. Jessica Fahey of Battelle. He will be responsible for receiving samples (by signing the chain-of-custody) for tissue chemical analysis. Unique laboratory sample identification numbers will be used to track samples through the chemistry laboratory. When samples are composited, a compositing form will be completed (see Figure 12). Tissue composites for inorganic analysis will be shipped to Battelle's Marine Sciences Laboratory in Sequim, Washington and will be accompanied by a chain-of-custody form to be signed by the receiving laboratory custodian at Sequim.

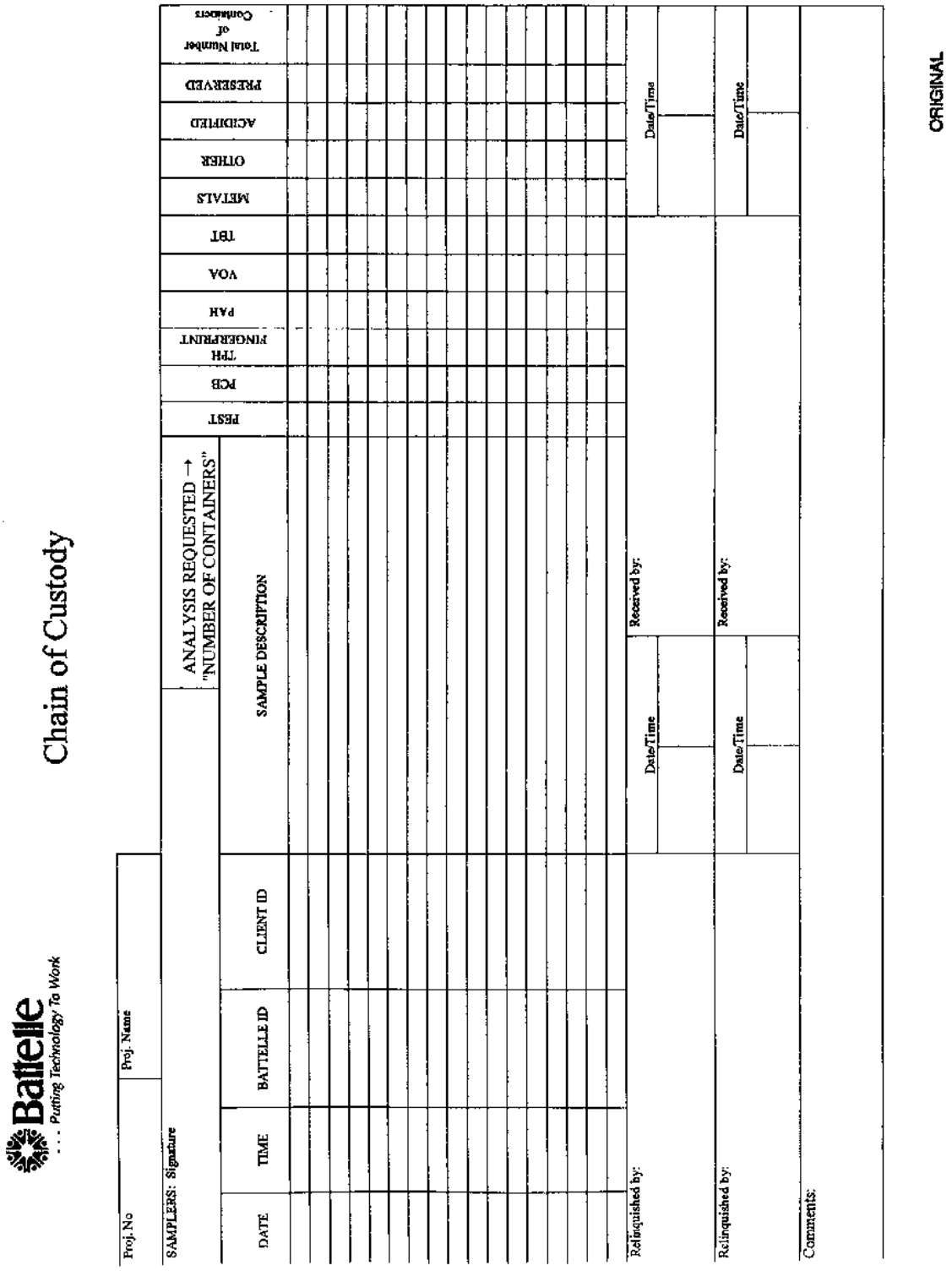
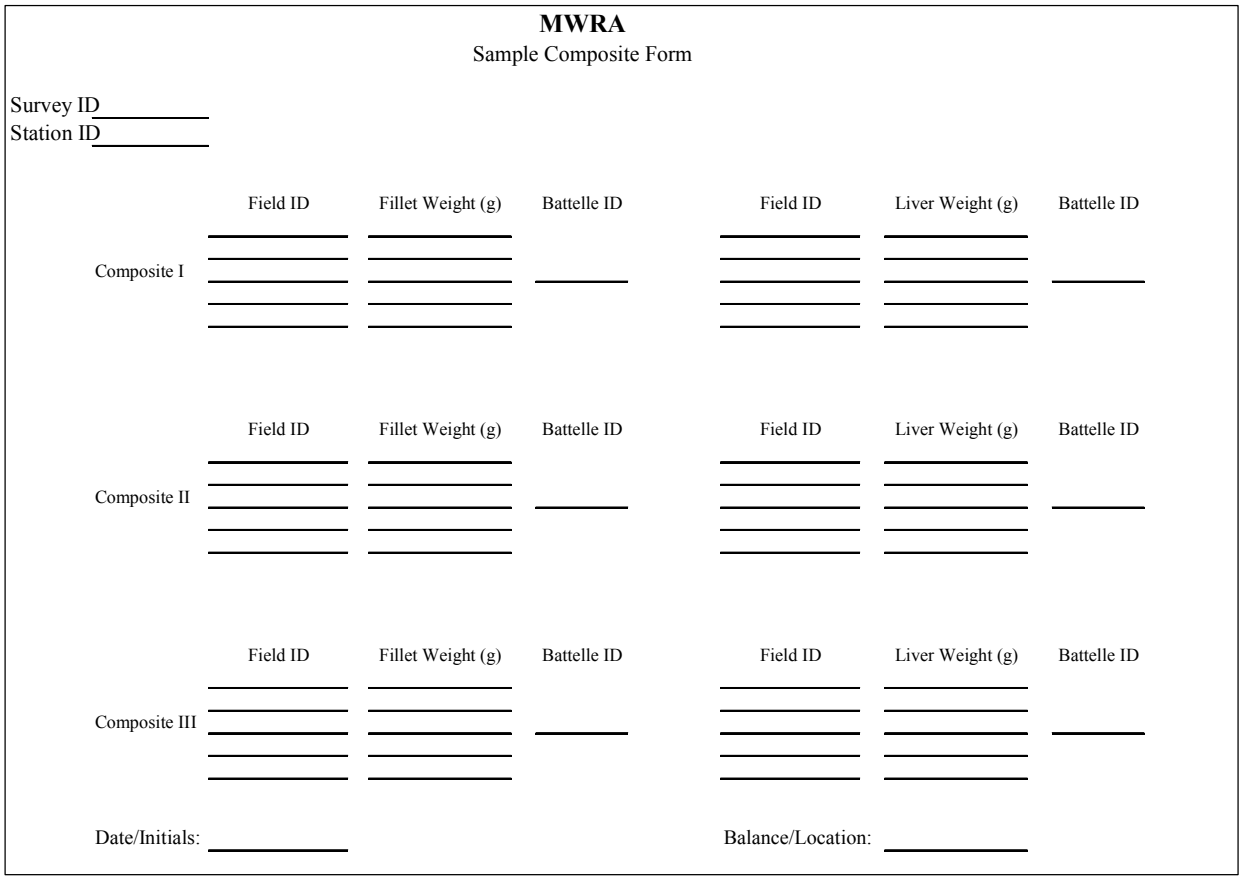



**Figure 11. Field Chain of Custody Record.**



**MWRA**

Sample Composite Form

Survey ID_____

Station ID_____

| | Field ID | Fillet Weight (g) | Battelle ID | Field ID | Liver Weight (g) | Battelle ID |
|---|---|---|---|---|---|---|
| Composite I | | | | | | |
| Composite II | | | | | | |
| Composite III | | | | | | |

Date/Initials: _____ Balance/Location: _____

**Figure 12. Example Sample Compositing Log – Flounder**

## 14.0 CALIBRATION PROCEDURES AND PREVENTIVE MAINTENANCE

Logs of maintenance, calibrations, and any repairs made to instruments will be maintained by the respective subcontractors. Maintenance of and repairs to instruments will be in accordance with manufacturers' manuals and facility SOPs.

### 14.1 Navigation Equipment

Once the 12 VDC power supply for the Northstar 941XD navigation system has been switched on, there is typically no other setup interaction necessary between the Seasoft operator and the navigation system. The GPS will conduct an automatic self-test, and then begin acquiring satellites and a beacon. This process normally takes 2 to 5 minutes. An error message will be displayed if the system has trouble acquiring satellites or a beacon. For each survey, the GPS position will be verified by comparing it to previously located benchmarks. At a minimum, the position will be verified once, at the dock. In addition, the geometry and number of satellites will be checked periodically throughout the survey. Cable connections and antenna mounts and brackets will be inspected and secured at regular intervals. The navigation system calibration will be checked twice per day at a land-based location.

## 14.2 Field Equipment

Equipment will be monitored and/or calibrated according to the following methods:

- Measuring boards used to measure flounder will be wiped dry after measuring every 10th specimen or as needed and will be rinsed after sampling has been completed at each sampling site.
- The OHAUS® dial scale, Model No.8014 MA, will be dried after weighing every 10th fish or as soon as water starts to accumulate and will be calibrated with a known weight after sampling has been completed at each sampling site. The scale will be inspected prior to measuring each fish to ensure that it reads zero.
- The knife used to remove scales from flounder will be wiped clean after collecting samples from each specimen.
- Calipers used to measure the carapace length of specimens will be wiped dry after sampling has been completed at each sampling site.

## 14.3 Histological Equipment

The primary analytical instrument used for the histological analyses is a Zeiss photomicroscope. No calibrations are required. When not in use, the microscope will be covered to prevent excess dust from settling on it. The lenses will be cleaned periodically with lens cleaning fluid.

## 14.4 Chemical Analytical Equipment

All laboratory equipment will be calibrated and maintained according to Battelle Standard Operating Procedures (SOPs). Procedures are described below. Table 16 summarizes the calibration requirements for laboratory equipment.

### 14.4.1 Organic Analysis

#### 14.4.1.1 GC/MS

Instrumental calibration, operation, maintenance, and QC procedures for the GC/MS analysis of samples for PAH will be performed according to Battelle SOPs 3-092 and 5-157, a modification of NOAA status and trends methodology. The GC/MS will be tuned with perfluorotributylamine (PFTBA) before the initiation of the sample sequence. Analytical instruments will be calibrated before sample analysis and response factors (RF) will be generated for each PAH target analyte (Table 7).

The GC/MS system calibrations will be verified using a mid-range calibration check. Using the mean RF of each analyte from the initial calibration, the percent difference between those mean values and the RFs from the midrange calibration checks will be calculated. If the percent difference between the RFs is greater than the acceptability criteria, remedial maintenance will be performed on the instrument, and a new calibration check standard analyzed. If the check standard then meets the acceptance criteria, the affected samples will be reanalyzed. If the check standard still does not meet the acceptance criteria then a new initial calibration will be performed, and the affected batch of samples will be reanalyzed, at the discretion of the Senior Scientist. Because GC/MS analysis is a multi-component analysis, it may not be necessary to reanalyze all bracketed samples if a mid-range calibration check standard does not meet the acceptability criteria. This decision will be based on a comparison of the analytes detected in the samples vs. the target analytes, which did not meet the mid-check acceptability criteria. Reanalysis will only be necessary if RFs for the analytes that are detected in a sample did not meet the criteria. Reanalysis will be

performed at the discretion of the Senior Scientist. Deviations from calibration or data objectives will be documented in the project files.

**Table 16. Laboratory Instrument Calibration Procedures.**

| | | Initial Calibration | | | Continuing Calibration | | |
|---|---|---|---|---|---|---|---|
| Parameter | Instrument Type[a] | No. Stds | Acceptance Criteria | Frequency | Acceptance Criteria | Frequency | Corrective Action |
| PAH | GC/MS | ≥5 | RSD ≤25% mean RSD ≤15% | prior to analytical run | PD from initial ≤25%; mean PD ≤15% | every 10 samples | Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify. |
| PCB/ Pesticide | GC/ECD | ≥5 | r ≥ 0.995 | prior to analytical run | PD from true value ≤25%; mean PD ≤15% (for concentrations) | every 10 samples | Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify. |
| Metals-Tissue | ICP-MS (other than Hg) | ≥3 (4) | r ≥ 0.995 | prior to analytical run | PD ≤15% of initial | every 10 samples | Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify. |
| | ICP-AES | ≥3 | r ≥ 0.995 | | PD ≤15% of initial | every 10 samples | |
| | GFAA (as required) | ≥3 | r≥0.995 | | PD ≤15% of initial | every 10 samples | |
| | CVAA (Hg); | ≥3 (5) | r ≥ 0.995 | | PD ≤15% of initial | every 10 samples | |

NA: Not Available.
[a] Analytical procedures are described in Section 12.0 and listed in Table 15.

Samples analyzed by GC/MS will be bracketed by two acceptable calibrations, initial or check. Analytes will be quantified by using the average RFs for that individual PAH analyte generated from the initial calibration following the method of internal standards, using surrogate internal standard (SIS) compounds.

Response factors (RF) will be generated for each target analyte using the following equation:

$$RF = \frac{A_x}{A_{is}} x \frac{C_{is}}{C_x}$$

where:
$A_x$ = peak area of the analyte in the calibration standard
$A_{is}$ = peak area of the appropriate internal standard in the calibration standard
$C_x$ = concentration of the analyte in the calibration standard
$C_{is}$ = concentration of the appropriate internal standard in the calibration standard.

Using the mean RF of each analyte from the initial calibration, the percent difference between those mean values and the RFs from the midrange calibration checks will be calculated.

The percent difference (PD) is calculated by:

$$PD = [(RF_i - RF_r) / RF_i] \times 100$$

where $RF_i$ = average response factor from the initial calibration, and
$RF_r$ = response factor from the midrange calibration check.

#### 14.4.1.2 GC/ECD

Instrumental calibration, operation, maintenance, and QC procedures for gas chromatography with electron capture detection (GC/ECD) will be performed in accordance with Battelle SOPs 3-116 and 5-128, a modification of NOAA status and trends methodology. Dual-column analysis will be performed. Data acquired from the second column will be used qualitatively. Analytical instruments will be calibrated before sample analysis and a calibration curve using the quadratic equation method will be generated for each PCB and pesticide target analyte (Table 7).

A mid-level calibration check standard will be analyzed to verify the GC/ECD system calibration during analysis. This check standard will be quantified in the same manner as field and QC samples. If the percent difference between the detected and true concentrations of the target pesticides and PCB congeners is greater than the acceptability criteria, remedial maintenance will be performed on the instrument, and a new calibration check standard analyzed. If the check standard then meets the acceptance criteria, the affected samples will be reanalyzed. If the check standard still does not meet the acceptance criteria then a new initial calibration will be performed, and the affected batch of samples will be reanalyzed, at the discretion of the Senior Scientist. Because GC/ECD analysis is a multi-component analysis, it may not be necessary to reanalyze all bracketed samples if a mid-range calibration check standard does not meet the acceptability criteria. This decision will be based on a comparison of the analytes detected in the samples vs. the target analytes, which did not meet the mid-check acceptability criteria. Reanalysis will only be necessary if percent differences for the analytes that are detected in a sample did not meet the criteria. Reanalysis will be performed at the discretion of the Senior Scientist. Deviations from calibration or data objectives will be documented in the project files.

Samples analyzed by GC/ECD will be bracketed by two acceptable calibrations, initial and check. Analytes will be quantified using the calibration curve generated from the initial calibration following the method of internal standards, using surrogate internal standard (SIS) compounds. All target analytes run by GC/ECD will be qualitatively confirmed by a second column.

### 14.4.2 Metal Analysis

#### 14.4.2.1 CVAA

Instrument calibration, operation, and maintenance procedures for CVAA analysis of tissue samples for Hg will be conducted according to Battelle SOP MSL-I-016 *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The instrument is maintained by the analyst, with the assistance of service personnel from Thermo-Separation Products. The soda lime trap and reagents (stannous chloride, 3% nitric acid, and rinse water) are checked daily and changed weekly under constant use. The carbon trap and filters are checked weekly and changed bimonthly under constant use. The sample injection syringe, tubing, connectors, and lamp are checked weekly and changed as needed, and the autosampler arm should be cleaned and lubricated bimonthly.

#### 14.4.2.2 ICP-MS

Instrument calibration, operation, and maintenance procedures for ICP-MS analysis of tissue samples for metals will be conducted according to Battelle SOP MSL-I-022 *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The instrument is maintained by the analyst, with the assistance of a service engineer from Perkin-Elmer, under a maintenance agreement. The argon supply pressure, base and operating vacuum, temperature of cooling chiller, and nebulizer flow are checked daily by the analyst. Instrument sensitivity and stability are checked each day of operation.

#### 14.4.2.3 GFAA

Instrument calibration, operation, and maintenance procedures for GFAA analysis of tissue samples for metals will be conducted according to Battelle SOP MSL-I-029 *Determination of Metals in Aqueous and Digestate Samples by GFAA*. The instrument is maintained by the analyst, with the assistance of a service engineer from Perkin-Elmer on an as-needed basis. Argon supply pressure is checked by the analyst daily. Other daily maintenance includes inspection of the furnace tube, contact rings, and optical windows.

#### 14.4.2.4 ICP-AES

Instrument calibration, operation, and maintenance procedures for ICP-AES analysis of tissue samples for metals will be conducted according to Battelle SOP MSL-I-027 D*etermination of Metals in Aqueous and Digestate Samples by ICP-AES*. The instrument is maintained by the analyst, with the assistance of a service engineer from Perkin-Elmer on an as-needed basis. Maintenance of the ICP-AES instrumentation will include complete cleaning of sample and skimmer cones, replacing sampling tubes, and optimizing the instrument sensitivity by adjusting and cleaning the lenses. The base vacuum, operating vacuum, and gas flow rates will also be checked and adjusted as necessary.

## 15.0 DATA DOCUMENTATION, REDUCTION, AND REPORTING

### 15.1 Documentation

Documentation will include sample collection logs, chain-of-custody forms, and laboratory records. Sample collection information will be recorded on standard forms that, at a minimum, should include sample location, time and date, sampler's identification, and sample ID number. Examples of sample collection logs are given in Section 12.0. Chain-of-custody records are discussed in Section 13.0.

All data will be initially recorded either (1) electronically onto computer storage media from BOSS or other laboratory systems or (2) manually into bound laboratory notebooks or onto established data forms. All notes will be written in black ink. Corrections to hand-entered data will be initialed, dated, and justified. Completed data forms or other types of hand-entered data will be signed and dated by the individual entering the data. Direct-entry and electronic data entries will indicate the person collecting or entering the data. It will be the responsibility of the laboratory managers to ensure that all data entries and hand calculations are verified in accordance with procedures described in Section 16 (below). In addition to these documentation procedures, station logs or copies there of and associated with field custody forms will be kept in a survey notebook for each survey. These notebooks will be stored under the supervision of Ms. Jeanine Boyle. Laboratory tracking forms will be kept with the analytical data packages for each batch.

## 15.2 Data Reduction

Data reduction involves the process of converting raw numbers into data that have direct physical, biological, or chemical meaning and can be compared statistically. The data discussed in this section are those data that require some manipulation before being submitted to Battelle data management for entry into the EM and MS database.

### 15.2.1 Navigation Data

Navigation data are recorded to 7 decimal places. No data reduction is performed. During surveys where NavSam© is not used, all sample IDs and sample collection information will be recorded by hand and transferred to an electronic format (i.e. MS Excel) with date, time, and concurrent dGPS/LORAN vessel-position data.

### 15.2.2 Histopathological and Morphological Data

**Flounder Field Data** – The Catch Per Unit Effort (CPU – fish caught per minute of bottom time) will be calculated at each flounder sampling station. CPU is calculated as the total number of flounder caught per unit of bottom trawl time. The gross external condition ("External Lesions") of each flounder is rated on a scale of 0 to 4. The severity of fin rot and gross liver lesions are scored from 0 to 4, where: 0 = absent; 1 = minor; 2 = moderate; 3 = severe; and 4 = extreme.

**Flounder Liver Histology –** From the prepared liver sections, the severity of each flounder liver lesion will be rated on a scale of 0 to 4, where: 0 = absent; 1 = minor; 2 = moderate; 3 = severe; and 4 = extreme. For each lesion and each fish, a severity index will then be calculated as a mean of scores from three slides. Data resulting from the assignment of scores to the various lesions will be transferred in electronic format to database personnel.

### 15.2.3 Mussel Biological Condition Data

Mussel biological condition data will be recorded manually in laboratory notebooks. Data will then be entered into a standard format Excel spreadsheet for reduction that includes calculating the shell volume, gonadal condition index, and the condition index. For the mussel biological condition data, the effective density of the mussel cavity contents is assumed to be 1 g/cm$^3$, based on the work of Lawrence, *et al*. (1982).

$$\text{Shell Volume (cm}^3\text{)} = \text{Weight (g)} - \text{Shell Weight, Wet (g)}$$

$$\text{Gonad Condition Index} = \text{Dry Gonad Weight (g)}/\text{Total Dry Weight of Meat (g)} * 100$$

$$\text{Condition Index} = \text{Total Dry Weight of Meat (g)}/\text{Shell Volume (cm}^3\text{)} * 100$$

These standardized Excel spreadsheets will be submitted for entry into the database.

### 15.2.4 Tissue Chemistry Data

#### 15.2.4.1 Chemical Data Acquisition

The GC/ECD data are collected and processed on the Labsystems X-Chrom data system. This system allows data acquisition from the instruments with either analog or digital signals. The data are calibrated and processed with either a linear or quadratic equation. The data tables are generated in Excel from electronically transferred data from the X-Chrom system.

GC/MS data are collected and processed using the HP EnviroQuant Environmental Data Analysis software. Processed data is electronically transferred to an Excel database program for transmittal to Battelle data management for loading into EM&MS.

Data for metals analysis by GVAA, ICP-MS, ICP-AES, and GFAA are collected and processed by the instruments' software systems. Laboratory will report the mean value of the laboratory duplicate analysis, for all target compounds, to the database. Processed data are electronically transferred to Excel spreadsheet format for transmittal to Battelle data management for loading into EM&MS.

#### 15.2.4.2 Statistical Evaluation of Chemical Data

Statistical evaluations will be performed on all QC samples. Percent recoveries of the spiked analytes will be calculated for all matrix spike and matrix spike duplicate samples, and surrogates as follows:

$$\%Recovery = \frac{Concentration\ Detected(ng)}{Concentration\ Expected(ng)} x100$$

Additionally, RPD between the MS and MSD samples will be calculated as follows:

$$RPD = \frac{2x(A_{MS} - A_{MSD})}{A_{MS} + A_{MSD}} x100$$

where $A_{MS}$ = amount of analyte detected in MS sample
$A_{MSD}$ = amount of analyte detected in MSD sample.

The RPD between sample duplicates will be calculated as follows:

$$RPD = \frac{2x(C_1 - C_2)}{(C_1 + C_2)} x100$$

where $C_1$ = concentration (ng/g) of analyte detected in sample 1
$C_2$ = concentration (ng/g) of analyte detected in sample 2

The percent difference (PD) of standard reference material (SRMs) will be calculated as follows:

$$PD = \frac{Certified\ Value - Concentration\ Detected}{Certified\ Value} * 100$$

Data quality objectives for these calculations are presented in Table 10.

The surrogate (SIS) recovery data are placed in the QC_RESULTS table in the EM&MS database. This table has the same structure as the Analytical Results table.

## 15.3 Data Entry, Loading, and Reporting

### 15.3.1 Data Loading Applications

The data reporting for analytical and experimental data begins with the Battelle Data Management Team who will populate a loading application for each laboratory. The loading applications are populated with the Sample_ID numbers and analysis protocols extracted from the Access database containing data from field activities that is delivered to the data manager at the conclusion of each survey. A separate loading application will be prepared for each data deliverable.

### 15.3.2 Population of Loading Applications by Battelle

Analytical laboratories with existing data processing capabilities (Battelle Duxbury and Battelle Sequim) will provide their laboratory's final computer-generated data spreadsheets to Battelle. The data from field activities will be delivered to the data manager as an Access database. The Battelle data management team will use a loading application to run the necessary quality control checks and load the data provided into the ORACLE database. Battelle uses generic loading applications that are designed to process large analytical datasets that are received in spreadsheet form and converts them into the correct format for entry into the ORACLE database. Each laboratory will have to meet its own internal laboratory format for the data to load successfully.

### 15.3.3 Population of Loading Applications by Other Laboratories

When data contributors (Woods Hole Oceanographic Institution) open the database within the appropriate loading application, they will be presented with a form that already contains the Sample_ID numbers and a parameter list for the required data submittal. The laboratory will enter the results of the analyses and other supporting information such as data qualifier codes. All entries will be constrained by the rules of EM&MS. Errors will be caught on entry and fixed by the data contributor. Primary keys will be in place so duplication cannot occur. Entry applications will be developed for each analytical laboratory. Laboratory staff receive one day of training on the application prior to analysis of the lab's first set of samples. When data entry is complete, the database will be sent back to Battelle.

The loading application will provide the laboratory with several function buttons. These include hard copy report, quality control checks, exception report, and analysis summary. The hardcopy report function button will allow the laboratory to create a hardcopy report to check for entry errors and to submit a final hardcopy report to Battelle along with the electronic data deliverable. The quality control checks will be comprised of the applicable sections of EM&MS check script and will also perform checks for outliers. This report will provide the data contributor a chance to confirm the reasonableness of the data prior to its submission to Battelle. The exception report will check the data that was expected against the results that were loaded. The data contributor must account for any entries in the exception report. The analysis report will produce a report of the number of analyses by analyte. A copy of this report will be included with the data deliverable and with the invoice for the analyses.

Within the loading application, the data entered by the laboratory will be translated into the correct codes and inserted into database tables with the same structure as the matching EM&MS table. Analytical parameters and database codes for the analytes collected under this task are shown in Table 17. Table 18 shows the morphological parameters and database codes. Histopathological parameters and database codes for this task are shown in Table 19. Table 20 describes the database codes to be used by the laboratories. The laboratories will have the ability to add additional codes to describe their results but the new codes will be highlighted in the exception report. Battelle will notify MWRA concerning the new qualifier and will adjust the code table in the application to agree with any changes to the EM&MS code_list table. MWRA is responsible for maintaining the code list for the EM&MS.

**Table 17. Analytical Parameters and Database Codes for Fish and Shellfish Monitoring.**

| PARAM_CODE | DESCR | METH_CODE | INSTR_CODE |
|---|---|---|---|
| 1022-22-6 | 4,4 DDD OLEFIN (DDMU) | BSOP5-128DUAL | GCECD |
| 118-74-1 | HEXACHLOROBENZENE | BSOP5-128DUAL | GCECD |
| 120-12-7 | ANTHRACENE | BSOP5-157 | GCMS |
| 127330-66-9 | DIBENZOTHIOPHENE | BSOP5-157 | GCMS |
| 129-00-0 | PYRENE | BSOP5-157 | GCMS |
| 132-64-9 | DIBENZOFURAN | BSOP5-157 | GCMS |
| 191-24-2 | BENZO(G,H,I)PERYLENE | BSOP5-157 | GCMS |
| 192-97-2 | BENZO(E)PYRENE | BSOP5-157 | GCMS |
| 193-39-5 | INDENO(1,2,3-C,D)PYRENE | BSOP5-157 | GCMS |
| 198-55-0 | PERYLENE | BSOP5-157 | GCMS |
| 205-99-2 | BENZO(B)FLUORANTHENE | BSOP5-157 | GCMS |
| 2051-24-3 | DECACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 206-44-0 | FLUORANTHENE | BSOP5-157 | GCMS |
| 207-08-9 | BENZO(K)FLUORANTHENE | BSOP5-157 | GCMS |
| 208-96-8 | ACENAPHTHYLENE | BSOP5-157 | GCMS |
| 218-01-9 | CHRYSENE | BSOP5-157 | GCMS |
| 2245-38-7 | 2,3,5-TRIMETHYLNAPHTHALENE | BSOP5-157 | GCMS |
| 2385-85-5 | MIREX | BSOP5-128DUAL | GCECD |
| 24143-69-9 | TRANS_NONACHLOR | BSOP5-128DUAL | GCECD |
| 309-00-2 | ALDRIN | BSOP5-128DUAL | GCECD |
| 31508-00-6 | 2,3',4,4',5-PENTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 32598-10-0 | 2,3',4,4'-TETRACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 32598-13-3 | 3,3',4,4'-TETRACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 32598-14-4 | 2,3,3',4,4'-PENTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 34883-43-7 | 2,4'-DICHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 35065-27-1 | 2,2',4,4',5,5'-HEXACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 35065-28-2 | 2,2',3,4,4',5-HEXACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 35065-29-3 | 2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 35065-30-6 | 2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 35693-99-3 | 2,2',5,5'-TETRACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 37680-65-2 | 2,2',5-TRICHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 37680-68-5 | 2',3,5-TRICHLOROBIPHENYL (surrogate) | BSOP5-128DUAL | GCECD |
| 37680-73-2 | 2,2',4,5,5'-PENTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |

**Table 17. Analytical Parameters and Database Codes for Fish and Shellfish Monitoring, continued.**

| PARAM_CODE | DESCR | METH_CODE | INSTR_CODE |
|---|---|---|---|
| 38380-07-3 | 2,2',3,3',4,4'-HEXACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 40186-72-9 | 2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 41464-39-5 | 2,2',3,5'-TETRACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 50-29-3 | P,P-DDT | BSOP5-128DUAL | GCECD |
| 50-32-8 | BENZO(A)PYRENE | BSOP5-157 | GCMS |
| 5103-71-9 | CIS-CHLORDANE | BSOP5-128DUAL | GCECD |
| 52663-68-0 | 2,2',3,4',5,5',6-HEPTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 52663-78-2 | 2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 53-70-3 | DIBENZO(A,H)ANTHRACENE | BSOP5-157 | GCMS |
| 56-55-3 | BENZ(A)ANTHRACENE | BSOP5-157 | GCMS |
| 56558-16-8 | 2,2',4,6',6-PENTACHLOROBIPHENYL (surrogate) | BSOP5-128DUAL | GCECD |
| 57465-28-8 | 3,3',4,4',5-PENTACHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 58-89-9 | LINDANE | BSOP5-128DUAL | GCECD |
| 581-42-0 | 2,6-DIMETHYLNAPHTHALENE | BSOP5-157 | GCMS |
| 60-57-1 | DIELDRIN | BSOP5-128DUAL | GCECD |
| 60145-21-3 | 2,2',4,5',6-PENTACHLOROBIPHENYL (surrogate) | BSOP5-128DUAL | GCECD |
| 7012-37-5 | 2,4,4'-TRICHLOROBIPHENYL | BSOP5-128DUAL | GCECD |
| 72-20-8 | ENDRIN | BSOP5-128DUAL | GCECD |
| 72-54-8 | P,P-DDD | BSOP5-128DUAL | GCECD |
| 7439-92-1 | LEAD | MSL-I-022 | ICPMS |
| 7439-92-1 | LEAD | MSL-I-027 | ICPAES |
| 7439-97-6 | MERCURY | MSL-I-016 | CVAA |
| 7440-02-0 | NICKEL | MSL-I-022 | ICPMS |
| 7440-22-4 | SILVER | MSL-I-022 | ICPMS |
| 7440-22-4 | SILVER | MSL-I-027 | ICPAES |
| 7440-22-4 | SILVER | MSL-I-029 | GFAA |
| 7440-43-9 | CADMIUM | MSL-I-022 | ICPMS |
| 7440-43-9 | CADMIUM | MSL-I-027 | ICPAES |
| 7440-47-3 | CHROMIUM | MSL-I-022 | ICPMS |
| 7440-47-3 | CHROMIUM | MSL-I-027 | ICPAES |
| 7440-47-3 | CHROMIUM | MSL-I-029 | GFAA |
| 7440-50-8 | COPPER | MSL-I-022 | ICPMS |
| 7440-50-8 | COPPER | MSL-I-027 | ICPAES |
| 7440-66-6 | ZINC | MSL-I-022 | ICPMS |
| 7440-66-6 | ZINC | MSL-I-027 | ICPAES |
| 74472-36-9 | 2,3,3',5,6-PENTACHLOROBIPHENYL (surrogate) | BSOP5-128DUAL | GCECD |
| 75-55-9 | P,P-DDE | BSOP5-128DUAL | GCECD |
| 789-02-6 | O,P-DDT | BSOP5-128DUAL | GCECD |
| 83-32-9 | ACENAPHTHENE | BSOP5-157 | GCMS |
| 832-69-9 | 1-METHYLPHENANTHRENE | BSOP5-157 | GCMS |
| 85-0108 | PHENANTHRENE | BSOP5-157 | GCMS |
| 86-73-7 | FLUORENE | BSOP5-157 | GCMS |
| 90-12-0 | 1-METHYLNAPHTHALENE | BSOP5-157 | GCMS |

**Table 17. Analytical Parameters and Database Codes for Fish and Shellfish Monitoring, continued.**

| PARAM_CODE | DESCR | METH_CODE | INSTR_CODE |
|---|---|---|---|
| 91-20-3 | NAPHTHALENE | BSOP5-157 | GCMS |
| 91-57-6 | 2-METHYLNAPHTHALENE | BSOP5-157 | GCMS |
| 92-52-4 | BIPHENYL | BSOP5-157 | GCMS |
| 95-16-9 | BENZOTHIAZOLE | BSOP5-157 | GCMS |
| D10-85-0108 | PHENANTHRENE-D10 (surrogate) | BSOP5-157 | GCMS |
| D12_218-01-9 | CHRYSENE-D12 (surrogate) | BSOP5-157 | GCMS |
| D8_91-20-3 | NAPTHALENE-D8 (surrogate) | BSOP5-157 | GCMS |
| LIPID | Lipids | BSOP5-190 | BAL |
| MWRA10 | C3-NAPHTHALENES | BSOP5-157 | GCMS |
| MWRA11 | C4-NAPHTHALENES | BSOP5-157 | GCMS |
| MWRA24 | HEPTACHLOREPOXIDE | BSOP5-128DUAL | GCECD |
| MWRA25 | HEPTACHLOR | BSOP5-128DUAL | GCECD |
| MWRA33 | O,P-DDD | BSOP5-128DUAL | GCECD |
| MWRA34 | O,P-DDE | BSOP5-128DUAL | GCECD |
| MWRA4 | C2-CHRYSENES | BSOP5-157 | GCMS |
| MWRA5 | C2-DIBENZOTHIOPHENES | BSOP5-157 | GCMS |
| MWRA52 | C3-PHENANTHRENES/ANTHRACENES | BSOP5-157 | GCMS |
| MWRA54 | C4-PHENANTHRENES/ANTHRACENES | BSOP5-157 | GCMS |
| MWRA57 | C2-PHENANTHRENES/ANTHRACENES | BSOP5-157 | GCMS |
| MWRA6 | C2-FLUORENES | BSOP5-157 | GCMS |
| MWRA64 | C1-NAPHTHALENES | BSOP5-157 | GCMS |
| MWRA65 | C1-FLUORENES | BSOP5-157 | GCMS |
| MWRA66 | C3-FLUORENES | BSOP5-157 | GCMS |
| MWRA67 | C1-PHENANTHRENES/ANTHRACENES | BSOP5-157 | GCMS |
| MWRA68 | C1-DIBENZOTHIOPHENES | BSOP5-157 | GCMS |
| MWRA69 | C1-FLUORANTHRENES/PYRENES | BSOP5-157 | GCMS |
| MWRA7 | C2-NAPHTHALENES | BSOP5-157 | GCMS |
| MWRA70 | C1-CHRYSENES | BSOP5-157 | GCMS |
| MWRA71 | C3-CHRYSENES | BSOP5-157 | GCMS |
| MWRA72 | C4-CHRYSENES | BSOP5-157 | GCMS |
| MWRA83 | C2-FLUORANTHENES/PYRENES | BSOP5-157 | GCMS |
| MWRA84 | C3-FLUORANTHENES/PYRENES | BSOP5-157 | GCMS |
| MWRA9 | C3-DIBENZOTHIOPHENES | BSOP5-157 | GCMS |
| PCTDRYWT | Percent weight of the sample which is dry | BSOP5-190 | BAL |
| PCTDRYWT | Percent weight of the sample which is dry | MSL-C-003 | BAL |

**Table 18. Morphological Parameters and Database Codes for Fish and Shellfish Monitoring.**

| SPECIES | PARAM_CODE | DESCR | UNIT_CODE | METH_CODE |
|---|---|---|---|---|
| HOMARUS AMERICANUS | CARAP_LEN | Carapace Length | mm | BSOP5-175 |
| HOMARUS AMERICANUS | SEX | Gender | | VISUAL |
| HOMARUS AMERICANUS | WEIGHT | Wet Weight of Organism | g | LWEIGHT |
| MYTILUS EDULIS | COND_IDX | Condition Index | | BSOP5-031 |
| MYTILUS EDULIS | GON_COND_IDX | Gonad Condition Index | | BSOP5-031 |
| MYTILUS EDULIS | GONWT_M_D | Dry Weight, Gonad, Mantle | g | BSOP5-031 |
| MYTILUS EDULIS | GONWT_M_W | Wet Weight, Gonad, Mantle | g | BSOP5-031 |
| MYTILUS EDULIS | NGON_WT_D | NonGonadal Dry Weight | g | BSOP5-031 |
| MYTILUS EDULIS | NGON_WT_W | NonGonadal Wet Weight | g | BSOP5-031 |
| MYTILUS EDULIS | SHEL_WT_D | Dry Shell Weight | g | BSOP5-031 |
| MYTILUS EDULIS | SHELL_LEN | Shell Length | mm | BSOP5-175 |
| MYTILUS EDULIS | SHELL_VOL | Shell Volume | cm3 | BSOP5-031 |
| MYTILUS EDULIS | TSTW_D | Total Soft Tissue Weight – Dry | g | BSOP5-031 |
| MYTILUS EDULIS | TSTW_W | Total Soft Tissue Weight – Wet | g | BSOP5-031 |
| MYTILUS EDULIS | WEIGHT | Wet Weight of Organism | g | BSOP5-031 |
| PSEUDOPLEURONECTES AMERICANUS | AGE | Chronological age of specimen | y | SCALE |
| PSEUDOPLEURONECTES AMERICANUS | SEX | Gender | | VISUAL |
| PSEUDOPLEURONECTES AMERICANUS | STAN_LEN | Standard length of a fish. From upper jaw tip to posterior end of the hypural bone. | mm | BSOP5-175 |
| PSEUDOPLEURONECTES AMERICANUS | TOTAL_LEN | Total Length | mm | BSOP5-175 |
| PSEUDOPLEURONECTES AMERICANUS | WEIGHT | Wet Weight of Organism | g | PWEIGHT |

**Table 19. Histopathological Parameters and Database Codes for Fish and Shellfish Monitoring.**

| SPEC_CODE | DESCR | FRACTION_CODE | PARAM_CODE | DESCR |
|---|---|---|---|---|
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | BALLOONS | Apoptopic lesion prevalence, rated on a scale from 0-4. |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | BIL_PROLIF | Biliary proliferation |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | CENTRO_HV | Centrotubular hydropic vacuolation |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | FOCAL_HV | Focal hydropic vacuolation |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | MACROPHAGE | Macrophage aggregation, rated on a scale from 0-4. |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | NEOPLASM | Neoplasia prevalence, rated on a scale from 0-4. |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | LIVER_SECTION | TUBULAR_HV | Tubular hydropic vacuolation |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | WHOLE_BODY | FIN_ROT | Fin rot score |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | WHOLE_BODY | GROSS_LIV_LESIONS | Gross lesions visible on whole flounder liver |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | WHOLE_BODY | EXT_LESIONS | Gross external lesions on flounder body |
| 8857041504 | PSEUDOPLEURONECTES AMERICANUS | WHOLE_BODY | LIVER_COL | Liver color |
| 6181010201 | HOMARUS AMERICANUS | WHOLE_BODY | BLACK_GILL | Black gill disease |
| 6181010201 | HOMARUS AMERICANUS | WHOLE_BODY | EXT_TUMORS | External tumors |
| 6181010201 | HOMARUS AMERICANUS | WHOLE_BODY | PARASITES | Parasite prevalence, rated on a scale from 0-4. |
| 6181010201 | HOMARUS AMERICANUS | WHOLE_BODY | SHELL_EROS | Shell erosion |

**Table 20. Database Codes For Fish and Shellfish Monitoring.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| ANAL_LAB_ID | BOS | Battelle Ocean Sciences |
| ANAL_LAB_ID | BSQM | Battelle Marine Sciences Laboratory |
| ANAL_LAB_ID | WHO4 | Woods Hole Oceanographic-M. Moore |
| FRACTION_CODE | FILLET | Fillet of fish (edible tissue) |
| FRACTION_CODE | HEPATOPANC | Hepatopancreas |
| FRACTION_CODE | INDIVIDUAL | Measurement was made on an individual animal |
| FRACTION_CODE | LIVER | Analysis done on liver only |
| FRACTION_CODE | LIVER_SECTION | Analysis done on section of liver |
| FRACTION_CODE | MEAT | Edible meat from lobster (tail and claw) |
| FRACTION_CODE | SOFT_TISSUE | Entirety of organisms soft tissue |
| FRACTION_CODE | WHOLE_BODY | Entire body or part of body described at PARAM_CODE level |
| GEAR_CODE | ARRAY | Mussel deployment array |
| GEAR_CODE | OTT | Otter trawl tow |
| GEAR_CODE | TRAP | Lobster trap |
| INSTR_CODE | BAL | Balance |
| INSTR_CODE | CVAA | Cold vapor atomic absorption |
| INSTR_CODE | GCECD | Gas chromotograph electron capture detector |
| INSTR_CODE | GCMS | Gas chromotograph/mass spectometer |
| INSTR_CODE | GFAA | Graphite furnace atomic absorption |
| INSTR_CODE | ICPAES | Inductively coupled plasma atomic emission spectrometer |
| INSTR_CODE | ICPMS | Inductively coupled plasma mass spec |
| MATRIX_CODE | 5507010101 | Mytilus edulis |
| MATRIX_CODE | 5507010101_C | Composite of Mytilus edulis |
| MATRIX_CODE | 6181010201 | Homarus americanus |
| MATRIX_CODE | 6181010201_C | Composite of Homarus americanus |
| MATRIX_CODE | 8857041504 | Pseudopleuronectes americanus |
| MATRIX_CODE | 8857041504_C | Composite of Pseudopleuronectes americanus |
| METH_CODE | BSOP5-128DUAL | Battelle Ocean Sciences SOP No. 5-128, PCB/pesticides by GCECD, dual column |
| METH_CODE | BSOP5-157 | Battelle Ocean Sciences SOP No. 5-157, PAH by GCMS |
| METH_CODE | BSOP5-175 | Battelle Ocean Sciences SOP No. 5-175, Length Measurements of Fish and Shellfish |
| METH_CODE | BSOP5-190 | Battelle Ocean Sciences SOP No. 5-190, Tissue Extraction, Lipids by gravimetric means |
| METH_CODE | BSOP5-031 | Battelle Ocean Sciences SOP No. 5-031, Determining Biol. Condition Index and Gonad Condition Index of Mollusks |
| METH_CODE | FSF98 | Method for pathology parameters described in Fish and Shellfish CW/QAP, 1998: ENQUAD MS-49 |
| METH_CODE | LWEIGHT | Lobster weight to the nearest gram using conventional scale (model 70-2030) |
| METH_CODE | MSL-C-003 | Percent dry weight |
| METH_CODE | MSL-I-016 | Total mercury in tissues and sediments by CVAA |
| METH_CODE | MSL-I-022 | Determination of elements in aqueous and digestate samples by ICP/MS |
| METH_CODE | MSL-I-027 | Determination of metals in aqueous and digestate samples by ICP-AES |
| METH_CODE | MSL-I-029 | Determination of metals in aqueous and digestate samples by graphite furnace atomic absorption (GFAA) |
| METH_CODE | PWEIGHT | Flounder wt measurement mentioned in CW/QAPP for Fish and Shellfish Monitoring Sec 11.2.ENSR 1997 |

**Table 20. Database Codes For Fish and Shellfish Monitoring, continued.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| METH_CODE | SCALE | Aging by scales |
| METH_CODE | VISUAL | Visual inspection mentioned in CW/QAPP for Fish and Shellfish Monitoring Sec 11.2/11.3.ENSR 1997 |
| QC_CODE | QC | Qc sample |
| QC_CODE | SAMP | Normal sample |
| SPEC_CODE | 5507010101 | Mytilus edulis |
| SPEC_CODE | 6181010201 | Homarus americanus |
| SPEC_CODE | 8857041504 | Pseudopleuronectes americanus |
| UNIT_CODE | cm3 | Cubic centimeters |
| UNIT_CODE | g | grams |
| UNIT_CODE | mm | millimeters |
| UNIT_CODE | ng/g | nanograms per gram |
| UNIT_CODE | PCT | PERCENT |
| UNIT_CODE | PCTDRYWT | Percent dry weight |
| UNIT_CODE | ug/g | micrograms per gram |
| UNIT_CODE | y | years |
| VAL_QUAL | 0 | Absent |
| VAL_QUAL | 1 | Present |
| VAL_QUAL | 1 | Minor |
| VAL_QUAL | A | Value above maximum detection limit, e.g. too numerous to count or beyond range of instrument |
| VAL_QUAL | a | Not detected - value reported as negative or null |
| VAL_QUAL | aG | Not detected, value is null, co-eluting compound |
| VAL_QUAL | aGs | Not detected, value is null, co-eluting compound, suspect/invalid, not fit for use |
| VAL_QUAL | aGx | Not detected, value is null, co-eluting compound, matrix interference |
| VAL_QUAL | aL | Below MDL; value reported as negative or null, analytical conc. reported from dilution |
| VAL_QUAL | aLs | Not detected, analytical conc. reported from dilution, suspect/invalid, not fit for use. |
| VAL_QUAL | aq | Not detected - value reported as negative or null. May be invalid, under investigation (Do not use). |
| VAL_QUAL | as | Not detected - value reported as negative or null, and not fit for use |
| VAL_QUAL | ax | not detected, value is null, matrix interference |
| VAL_QUAL | B | Blank corrected, blank >= 5x MDL |
| VAL_QUAL | b | Not blank corrected, blank>=5x MDL |
| VAL_QUAL | Bf | Blank corrected, blank >= 5x MDL, value reported < detect_limit |
| VAL_QUAL | bs | Not blank corrected, blank >=5x MDL, suspect/invalid, not fit for use |
| VAL_QUAL | D | Surrogate recovery < 50% or > 150% |
| VAL_QUAL | Ds | Surrogate recovery < 50% or > 150%, suspect/invalid, not fit for use |
| VAL_QUAL | e | Results not reported, value given is NULL. Explanation in COMMENTS field |
| VAL_QUAL | eq | Not reported, may be invalid, under investigation (Do not use). |
| VAL_QUAL | f | Value reported is below method detection limit |
| VAL_QUAL | fG | Reported value below MDL and co-eluting compound interferes with peak of interest |
| VAL_QUAL | fL | Value reported is between zero and MDL, analytical conc. reported from dilution |
| VAL_QUAL | fq | VALUE reported is below method detection limit. May be invalid, under investigation (Do not use). |

**Table 20. Database Codes For Fish and Shellfish Monitoring, continued.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| VAL_QUAL | fs | VALUE reported is below method detection limit, not fit for use |
| VAL_QUAL | fsx | Value reported below detection limit, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | fx | Below method detect limit, matrix interference |
| VAL_QUAL | G | Co-eluting compound interferes with peak of interest |
| VAL_QUAL | g | Recovery outside data objectives |
| VAL_QUAL | gq | Recovery outside data objectives. May be invalid, under investigation (Do not use). |
| VAL_QUAL | Gs | Co-eluting compound, suspect/invalid, not fit for use |
| VAL_QUAL | Gsx | Co-eluting compound, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | L | Analytical Concentration Reported From Dilution |
| VAL_QUAL | Lq | Analytical concentration reported from dilution. May be invalid, under investigation (Do not use). |
| VAL_QUAL | Ls | Analytical concentration reported from dilution, suspect/invalid, not fit for use |
| VAL_QUAL | Lsx | Diluted, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | q | Possibly suspect/invalid and not fit for use. Investigation pending. |
| VAL_QUAL | s | Suspect/Invalid. Not fit for use. |
| VAL_QUAL | sx | Matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | w | This datum should be used with caution, see comment field |
| VAL_QUAL | x | Matrix interference |

### 15.3.4 Loading Analytical and Experimental Data into the Harbor and Outfall Studies Database

Data submissions from the laboratory will consist of final electronic spreadsheets or final loading applications as discussed above. The submissions will be logged in upon receipt and a copy of the login will be maintained on file under the login id. Data will be loaded into a temporary table by striking a button on the application. A transfer script will copy the data into the proper table in Battelle's copy of the EM&MS. Data from the laboratories will receive a quality assurance review by Battelle after the data have been synthesized into a data report. Any issues will be corrected in the database and the script output will be supplied to MWRA with the export of the database. The MWRA check script will be run on the database prior to export. Any issues will be sent to the Battelle Data Manager via email. Any irresolvable issues in the database as a result of quality control checks (for example, stations more than specified distance from target) will also be submitted to MWRA with the data export. Processing of data and development of data reports are defined in MWRA SOP 007-01.

Field personnel will submit the sample collection data electronically as Excel spreadsheets or NavSam© files (see Section 15.2.1). The data will be loaded into EM&MS from Excel spreadsheets or downloaded from the NavSam© system, as applicable.

#### 15.3.4.1 Loading Composite Sample Information

Flounder, lobster, and mussel homogenates will be composited and tracked in the COMPOSITE table. A conceptual procedure is outlined (Figure 13) to show the logic behind the treatment of composites in the EM&MS database. In this example, lobsters are collected from the field and the chemical contaminants from their tissues are analyzed. To get enough material for the analysis, and to minimize the effect of

random variation among lobsters, the tissues from 5 lobsters are pooled. Because the concentrations of chemical contaminants are known to vary substantially among the different organs of a lobster, different organs are analyzed separately.

Each lobster collected is assigned a SAMPLE_ID in the SAMPLE table (Step 1) with a matrix code identifying them as individual lobsters (6181010201) and then a BOTTLE_ID in the BOTTLE table (Step 2) denoting that each lobster is intact (WHOLE_BODY).

Even though the hepatopancreas and tail and claw meat are dissected from the five lobsters individually (two are shown in Figure 13) and then composited by fraction, we treat the processes in the database as if the five lobsters were composited before the various fractions are removed. A single composite SAMPLEC_ID is created in the COMPOSITE table (Step 3) that represents all the lobsters in the composite sample. There will be one record in the COMPOSITE table for each individual in the composite (five in this example, two shown in the figure).

A new record is added to the SAMPLE table with SAMPLE.SAMPLE_ID equal to COMPOSITE.SAMPLEC_ID with a MATRIX_CODE indicating that this sample is a composite lobster (6181010201_C) (Step 4). The other fields in the SAMPLE table are filled with information best describing the composite sample. For example, DEPTH would have the deepest of the five individual sample depths while DEPTH_TOP would have the most shallow.

The composite sample can now be subsampled, creating new bottles for each fraction. Since we need a bottle from which to subsample, a new bottle is created for the composite sample with a fraction code of WHOLE_BODY (Step 5). Bottles are created from this bottle for each of the fractions that will be analyzed, the fractions being recorded in the FRACTION_CODE (Step 6). In this example, fraction codes of HEPATOPANC and MEAT are used.

Using this method for creating composites with fractioned sub-samples, the analytical results from different fractions from the same group of bottles will all have the same SAMPLE_ID. This facilitates queries that bring together results from different fractions coming from the same pooled bottles.

Flounder are composited in the same way. The MATRIX_CODEs for flounder are 8857041504 and 8857041504_C. The FRACTION_CODEs for flounder bottles are WHOLE_BODY, FILLET, LIVER, and LIVER_SECTION.

Mussels are treated differently, because no morphology or pathology measurements are made on the individual mussels making up the chemistry composite. A SAMPLE_ID is assigned to the group of mussels composited for chemical analysis, but the information about which mussels made up the composite is not stored in the composite table. The MATRIX_CODE indicates that these are composite samples (5507010101_C). Bottles from composite mussel samples have a FRACTION_CODE of SOFT_TISSUE.

When biological condition data are collected, those individual mussels are each given a SAMPLE_ID (so that there are sample records for each mussel, as well as those for the composite mussels.) The MATRIX_CODE is 5507010101 and the FRACTION_CODE is INDIVIDUAL.

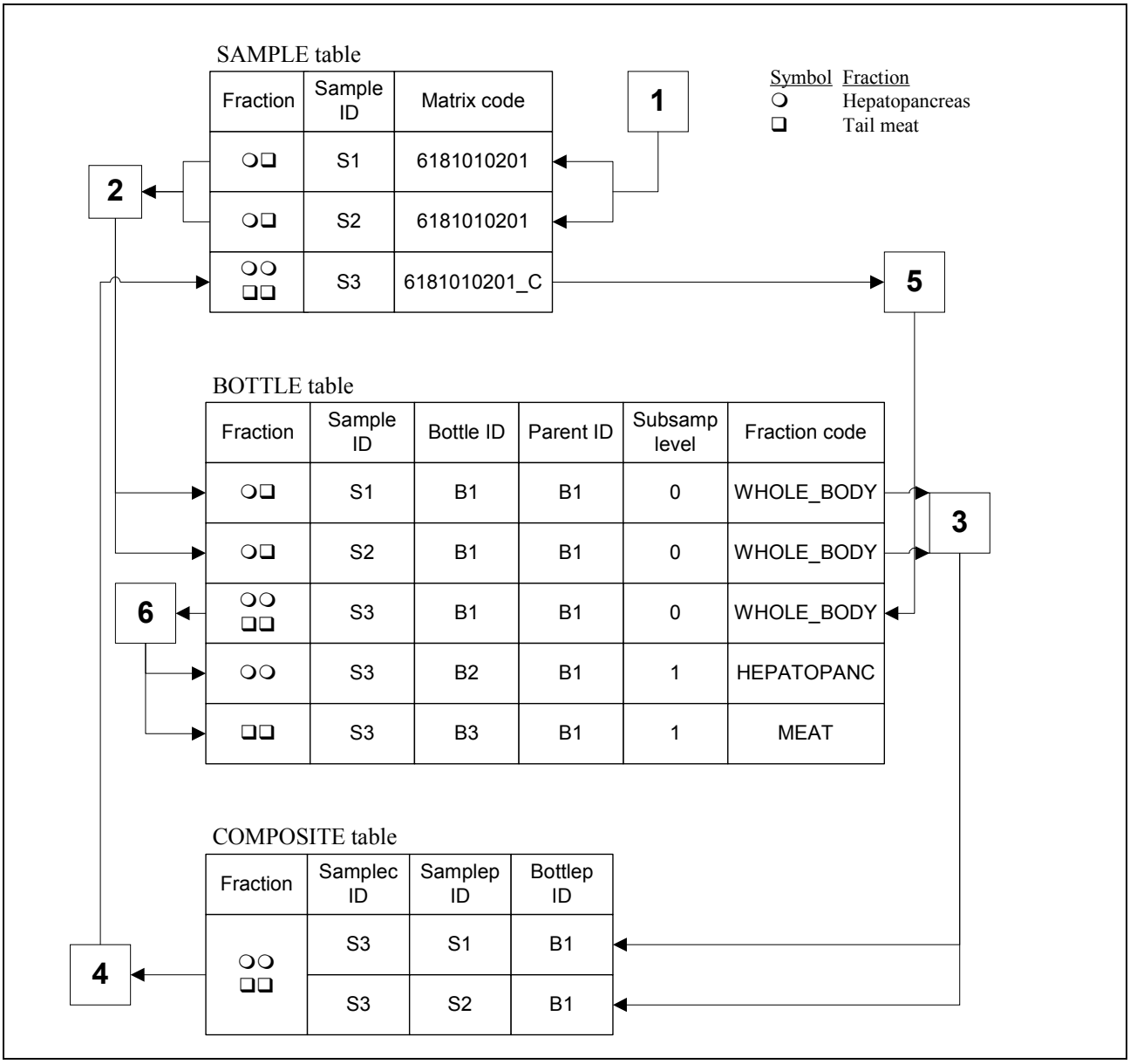



**Figure 13. Conceptual Procedure for Reporting of Composite Samples.**

### 15.3.5 Data Report Quality Control Checks

Prior to data submission to MWRA, Battelle will perform a series of data report quality control checks. These include range checks of various parameters against previously accepted data for tissue chemistry, morphology, and histopathology. The fish and shellfish area senior scientist, Ms. Lisa Lefkovitz, will review the results of the checks prior to submission of the data report. Table 21 presents a list of preliminary QC checks that will be performed on fish and shellfish data.

**Table 21. Fish and Shellfish Data Report QC Checks**

**General:**

For each data report a table of:

- Planned analyses against actual number of analyses
- Count of samples with non-detectable results
- Number of null values
- List of missing samples

| | Type of quality Control Check | | |
|---|---|---|---|
| **Parameter** | **Flounder**<br>**Each tissue type** | **Lobster**<br>**Each tissue type** | **Mussels** |
| ***Length*** | Range check against longest and shortest flounder from previously acceptable data.<br>Flag organisms outside of this range. | Range check against longest and shortest flounder from previously acceptable data.<br>Flag organisms outside of this range. | NA |
| ***Weight*** | Range check against longest and shortest flounder from previously acceptable data.<br>Flag organisms outside of this range | Range check against longest and shortest flounder from previously acceptable data.<br>Flag organisms outside of this range | NA |
| ***Age*** | Plot Age vs. Length and Weight.<br>Flag outliers and re-evaluate measurement. | NA | NA |
| ***Morphology*** | 0-4 range check for each morphological measure.<br>Flag organisms outside of this range. | 0-4 range check for each morphological measure.<br>Flag organisms outside of this range. | As appropriate for mussel conditions parameters.<br>Flag organisms outside of this range. |
| ***Liver Histopathology*** | 0-4 range check for each histopathology parameter.<br>Flag organisms outside of this range. | NA | NA |
| ***Individual metal concentrations***<br>***Total PCB***<br>***Individual pesticides***<br>***Total DDT***<br>***Total Chlordane***<br>***HMW PAH***<br>***LMW PAH***<br>***Total PAH***<br>***Lipid*** | Range check against highest and lowest dry weight value (each composite sample, not individuals) from previously acceptable data.<br>Flag samples outside of this range. | Range check against highest and lowest dry weight value (each composite sample, not individuals) from previously acceptable data.<br>Flag samples outside of this range. | Range check against highest and lowest dry weight value (each composite sample, not individuals) from previously acceptable data.<br>Flag samples outside of this range. |

### 15.3.6 Fish and Shellfish Threshold Evaluation

One of the requirements of the discharge permit is to test the current environmental conditions against baseline conditions to detect any noticeable changes. These thresholds are defined in the Contingency Plan (MWRA 2001). Battelle's requirement under HOM4 in regard to threshold testing is to:

- Maintain threshold, threshold_baseline, and threshold_test tables in the local copy of EM&MS
- Import new threshold and threshold_baseline tables if MWRA makes changes
- Maintain current version of threshold test scripts as provided by MWRA
- Run current version of threshold test script on newly loaded data as appropriate
- Maintain a record of all threshold runs in local copy of threshold_test table
- Report running of threshold tests in monthly progress report
- Report results of threshold tests run on data being reported in data report
- Notify MWRA as to any potential exceedances

The documentation for each threshold test is maintained by MWRA in a series of SOPs. The SOPs pertinent to the fish and shellfish task area are found in Appendix A. The threshold evaluation is performed as part of the data report.

### 15.3.7 Reporting Data to MWRA

The data contained in each hard copy data report will be submitted to MWRA as a database export; hard copy data reports will be prepared following Battelle SOP MWRA 007-01 Loading and Reporting Fish and Shellfish Data. The supporting documentation files will be included with the data submission. Data deliverables will be combined only with permission from MWRA.

## 16.0 DATA VALIDATION

The data validation procedures for this project are defined in the HOM4 Quality Management Plan. As a part of data validation, each Laboratory Manager ensures that:

- Any data that are hand-entered (*i.e.,* typed) are 100% validated by qualified personnel prior to use in calculations or entry into the database.

- All manual calculations are performed by a second staff member to verify that calculations are accurate and appropriate.

- Calculations performed by software are verified at a frequency sufficient to ensure that the formulas are correct, appropriate, and consistent, and that calculations are accurately reported. All modifications to data reduction algorithms are verified prior to submission of data to the Authority.

Electronic data loading and transfer are swift and routine; data fields and formats are defined in the CW/QAPPs. Electronic submissions are loaded to temporary files prior to incorporation into the database, and are analyzed selectively using methods such as scatter plots, univariate and multivariate analyses, and range checks to identify suspect values. Routine system back-ups are performed daily.

Once data have been generated and compiled in the laboratory, senior project scientists review data to identify and make professional judgments about any suspicious values. All suspect data are reported with a qualifier. This data may not be used in calculations or data summaries without the review and approval of a knowledgeable Senior Scientist. No data measurements are eliminated from the reported data or database and data gaps are never filled based on other existing data. If samples are lost during shipment or analysis, it is documented in the data reports to the Authority and noted in the database. The methods used to identify suspect values for each type of data are defined in Table 21.

A series of reviews by technical personnel will be implemented to ensure that the data generated for Tasks 21-25 meet the data quality objectives. These reviews will include the following activities.

- Data and related project records will be reviewed by laboratory personnel at the end of each working day to ensure that analytical activities are completely and adequately documented.
- The Laboratory Supervisors will be responsible for reviewing analytical results and supporting documentation.

The results of QC sample analyses will be compared to pre-established criteria as a measure of data acceptability.

The review of quality control data is a critical step in the data validation process because quality control data that are within the QAPP acceptance criteria indicate that the sample processing and analysis systems are in control. Section 11.0 discusses the quality control program for the fish and shellfish monitoring study. The quality control procedures and any applicable corrective action for out-of-control quality control data and instrumentation calibrations are described in Section 11. All quality control data that do not meet the data quality objectives will be flagged and brought to the attention of the Senior Scientist (Lisa Lefkovitz) who will determine the appropriate corrective action (e.g., re-analysis or data reported with qualifiers). As an additional data validation step, the Senior Scientist will review all data for

technical reasonableness. The Battelle Field Manager will be responsible for validation of the navigation data.

## 17.0 PERFORMANCE AND SYSTEM AUDITS

The Battelle QA Officer for the Harbor and Outfall Monitoring Project is Ms. Rosanna Buhl. She will direct the conduct of at least one systems audit to ensure that Tasks 21-25 are carried out in accordance with this CW/QAPP. A systems audit will verify the implementation of the HOM4 Quality Management Plan and this CW/QAPP.

Tabular data reported in deliverables, and associated raw data generated by Battelle will be audited under the direction of the Project QA Officer. Raw data will be reviewed for completeness and proper documentation. For electronically acquired data (e.g., analytical chemistry data), Ms. Buhl will verify that computer software used to process the data has been validated. Errors noted in data audits will be communicated to analysts and corrected data verified.

Audits of the data collection procedures at subcontractor laboratories will be the responsibility of the Subcontractor. Each subcontractor is fully responsible for the QA of the data it submits. Data must be submitted in CW/QAPP-prescribed formats; no other will be acceptable. During the time work is in progress, an inspection will be conducted by the subcontractor QA Officer or their designee to evaluate the laboratory data-production process. All data must be reviewed by the subcontractor QA Officer prior to submission to the Battelle Database Manager and must be accompanied by a signed QA statement that describes the types of audits and reviews conducted and any outstanding issues that could affect data quality and a QC narrative of activities.

The Battelle QA Officer will conduct an initiation audit and, as needed, a laboratory inspection to access compliance with the Quality Management Plan and this CW/QAPP. Performance audits, in the form of SRMs, will be used to determine quantitatively the accuracy of the total measurement system or its components, will be in addition to internal performance evaluation samples and participation in external certification programs.

## 18.0 CORRECTIVE ACTION

All technical personnel share responsibility for identifying and resolving problems encountered in the routine performance of their duties. Ms. Ellen Baptiste-Carpenter, Battelle's Project Manager, will be accountable to MWRA and to Battelle management for overall conduct of the Harbor and Outfall Monitoring Project, including the schedule, costs, and technical performance. She is responsible for identifying and resolving problems that (1) have not been addressed timely or successfully at a lower level, (2) influence multiple components of the project, (3) necessitate changes in this CW/QAPP, or (4) require consultation with Battelle management or with MWRA.

Identification of problems and corrective action at the laboratory level (such as meeting data quality requirements) will be resolved by laboratory staff and Senior Scientist with the Laboratory Manager. Issues that affect schedule, cost, or performance of Tasks 21-25 will be reported to the Senior Scientist or to the Battelle Project Manager. They will be responsible for evaluating the overall impact of the problem on the project and for discussing corrective actions with the MWRA Project Manager.

Problems identified by the QA Officer will be reported and corrected as described in Section 17.0 and the Quality Management Plan (Battelle, 2001).

# 19.0 REPORTS

Reports that will be generated under Tasks 21 - 25 include survey plans and survey reports for each of the three surveys conducted under Tasks 21-23 and data and synthesis reports (described below).

## 19.1 Survey Plans, Summaries, and Reports

Each survey plan will follow the new guidelines established by EPA for use of the OSV *Anderson.* Two copies of the final survey plan will be submitted to MWRA at least two weeks prior to the survey. No draft survey plans will be prepared. Survey summaries will be delivered by e-mail to MWRA's Task Manager within two (2) business days of survey completion.

All survey reports prepared under Tasks 21 – 23 will contain a table which demonstrates to the MWRA that Battelle has in digital form all information specific to an individual survey (including but not limited to date, time, survey id, sample types, etc.) which is required to readily load the resulting monitoring data into MWRA's database. Survey reports will describe survey dates, vessel, personnel, methods that deviate from the CWQAPP, survey operations, results, problems encountered, corrective actions, and recommendations. The number of samples collected (versus planned) will be tabulated, and maps of the survey track lines will be provided. Observations of whales, whether noted by the whale observer or as incidental, will be described in the flounder survey report. Any unusual observations of environmental conditions, especially those with implications for the later testing of Contingency Plan thresholds, will be emphasized. Survey reports will be submitted to MWRA (two copies) within two weeks after each survey demobilization. Survey plans and reports will be produced double-sided and 3-hole punched on 20 lb paper.

## 19.2 Tissue Chemistry Data Reports (Task 24)

Tissue chemistry data reports[11] will be a table of results of the analyses for a given study (flounder, lobster, mussel) in a year, produced as an EM &MS database output, and a brief discussion of any deviations from this CW/QAPP. Results of the QC checks related to the tissue chemistry data for flounder, lobster, and mussels will be included with these data reports. The chemical surrogate data is reported in a separate QC data table. Results of database QC checks will be included with each data report.

Data from chemical analyses of tissues will also be used in reports to be prepared under Task 33, specifically the fish and shellfish monitoring annual synthesis report (Task 33.8) and the annual toxics review (Task 33.11).

[11] Data reports will be submitted as double-sided copy on 3-hole 20 lb paper. The database export will accompany the data report.

## 19.3 Histology Data Reports (Task 25)

Histological data reports[11] (Task 25) will be a table of results and a brief discussion of any deviations from this CW/QAPP. In addition, data from Outfall Site are due 60 days after survey completion in a temporary data report that must be Quality Assured but need not meet all the requirements set forth in the General Conditions for Tasks 1-34. The temporary data report will include a calculation of the trigger parameter (i.e. liver disease incidence). The temporary data report will be discarded after the complete data report is received in August. Results of the QC checks related to flounder morphology and histopathology will be included in the final data reports. The histopathology will be discussed under the annual fish and shellfish monitoring synthesis report (Task 33.8).

## 19.4 Mussel Biological Condition Data Reports (Task 25)

Mussel Biological Condition data reports[11] (Task 25) will be a table of results and a brief discussion of any deviations from this CW/QAPP. Results of the QC checks related to the mussel biological condition data will also be included with these data reports. The mussel condition data will be discussed under the annual fish and shellfish monitoring synthesis report (Task 33.8).

## 19.5 Fish and Shellfish Monitoring Annual Synthesis Report (Task 33.8)

There will be four (4) fish and shellfish synthesis reports delivered under the HOM4 contract, one for each field year (2002-2005). This annual report will include all data collected as part of the fish and shellfish program under Tasks 21-25. This report will contain an evaluation of the year's results against all relevant monitoring thresholds (Table 1), and will devote particular attention to thresholds that may have been exceeded. Such evaluation would include comparison to the baseline data, as well as whether and/or to what extent such exceedances might be attributable to MWRA discharges, and the likely environmental impact of the exceedance. The report will include an evaluation of the spatial and temporal trends in contaminants, morphology, and pathology in flounder, lobster, and mussel tissue. The conclusions from flounder, lobster, and mussel will be summarized and integrated in the report, and the merits of different approaches used will be discussed.

### 19.5.1 Histopathology Data Analysis

For each liver lesion type, the percent prevalence will be calculated by station based on the three liver sections from each fish. The equation for percent prevalence is the number of fish showing any one lesion (in any of the three liver sections) divided by the number of fish examined and multiplied by 100. The percent prevalence of centrotubular hydropic vacuolation (CHV) is calculated as the number of fish showing any degree of CHV (in any of the three liver sections) divided by the number of fish examined and multiplied by 100. Analysis of variance will be used to compare lesions from site to site and annually from 2002-2005.

### 19.5.2 Analytical Chemistry Data Totals

Several chemistry data parameters are reported in the Fish and Shellfish Monitoring Annual Synthesis Report as totals, including Total Polychlorinated Biphenyls (PCBs), Total DDT, Total Chlordane, and Total Polynuclear Aromatic Hydrocarbons (PAHs). Values for data totals are not stored in the EM&MS database but are calculated by querying and summing the appropriate individual analytes (Table 22).

**Table 22. Individual Chemistry Analytes Included in the Chemistry Data Totals.**

| CHEMICAL ANALYTE TOTALS AND INDIVIDUAL ANALYTES | | |
|---|---|---|
| **Total Polychlorinated Biphenyls (PCBs)** | **Total Low Molecular Weight PAHs (cont.)** | **Total Historical Low Molecular Weight PAHs** |
| 2,4'-$Cl_2$(8) | C1-Naphthalenes | 1-Methylnaphthalene[a] |
| 2,2′,5-$Cl_3$(18) | C1-Phenanthrenes/Anthracenes | 1-Methylphenanthrene[a] |
| 2,4,4′-$Cl_3$(28) | C2-Dibenzothiophenes | 2,3,5-Trimethylnaphthalene[a] |
| 2,2′,3,5′-$Cl_4$(44) | C2-Fluorenes | 2,6-Dimethylnaphthalene[a] |
| 2,2′,5,5′-$Cl_4$(52) | C2-Naphthalenes | 2-Methylnaphthalene[a] |
| 2,3′,4,4′-$Cl_4$(66) | C2-Phenanthrenes/Anthracenes | Acenaphthene |
| 3,3′,4,4′-$Cl_4$(77) | C3-Dibenzothiophenes | Acenaphthylene |
| 2,2′4,5,5′-$Cl_5$(101) | C3-Fluorenes | Anthracene |
| 2,3,3′,4,4′-$Cl_5$(105) | C3-Naphthalenes | Biphenyl |
| 2,3′,4,4′5-$Cl_5$(118) | C3-Phenanthrenes/Anthracenes | Fluorene |
| 3,3′,4,4′,5-$Cl_5$(126) | C4-Naphthalenes[a] | Naphthalene |
| 2,2′,3,3',4,4′-$Cl_6$(128) | C4-Phenanthrenes/Anthracenes | Phenanthrene |
| 2,2′,3,4,4′,5-$Cl_6$(138) | Dibenzofuran | **Total Historical High Molecular Weight PAHs** |
| 2,2′4,4′,5,5′-$Cl_6$(153) | Dibenzothiophene | Benz(a)Anthracene |
| 2,2′3,3',4,4′,5-$Cl_7$(170) | Fluorene | Benzo(a)Pyrene |
| 2,2′,3,4,4′,5,5′-$Cl_7$(180) | Naphthalene | Benzo(b)Fluoranthene |
| 2,2′,3,4',5,5′,6-$Cl_7$(187) | Phenanthrene | Benzo(e)Pyrene |
| 2,2′,3,3′,4,4′,5,6-$Cl_8$(195) | **Total High Molecular Weight PAHs** | Benzo(g,h,I)Perylene |
| 2,2′,3,3′4,4′,5,5′,6-$Cl_9$(206) | Benz(a)Anthracene | Benzo(k)Fluoranthene |
| Decachlorobiphenyl-$Cl_{10}$(209) | Benzo(a)Pyrene | Chrysene |
| **Total DDT** | Benzo(b)Fluoranthene | Dibenzo(a,h)Anthracene |
| 2,4′-DDD | Benzo(e)Pyrene | Fluoranthene |
| 4,4′-DDD | Benzo(g,h,i)Perylene | Indeno(1,2,3-c,d)Pyrene |
| 2,4′-DDE | Benzo(k)Fluoranthene | Perylene |
| 4,4′-DDE | C1-Chrysenes | Pyrene |
| 2,4′-DDT | C1-Fluoranthrenes/Pyrenes | |
| 4,4′-DDT | C2-Chrysenes | |
| **Total Chlordane** | C2-Fluoranthenes/Pyrenes[a] | |
| Heptachlor | C3-Chrysenes | |
| Heptachlorepoxide | C3-Fluoranthenes/Pyrenes[a] | |
| cis-Chlordane | C4-Chrysenes | |
| trans-Nonachlor | Chrysene | |
| **Total Low Molecular Weight PAHs** | Dibenzo(a,h)Anthracene | |
| Acenaphthene | Fluoranthene | |
| Acenaphthylene | Indeno(1,2,3-c,d)Pyrene | |
| Anthracene | Perylene | |
| Biphenyl | Pyrene | |
| C1-Dibenzothiophenes | | |
| C1-Fluorenes | | |

[a] Compounds monitored in 1998 – 2001; analysis of these compounds is not required by project contract but will be analyzed for in 2002 – 2005, HOM4.

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# Appendix A

# MWRA Threshold Testing SOP for Fish and Shellfish

To: Wendy Leo, Maurice Hall, Andrea Rex
From: Joe LoBuglio, Suh Yuen Liang
Date: September 10, 2001
Revised: December 4, 2001
Subject: Calculation methods for threshold values and baselines for fish and shellfish.

---

There are seventeen thresholds related to chemical burdens in fish and shellfish tissues and one threshold concerning flounder liver disease. Threshold values for mercury, lead, and PCBs are based on EPA regulations while those for chlordane, DDT, dieldrin, PAHs, and liver disease are based on measurements taken during baseline years. The thresholds for chlordane, DDT, PCB, and PAH are based on the sum of concentrations of several chemicals.

Revision History:

Revision 1: Mussel bioaccumulation outfall site station is now called 'M4' exclusively.

| Organism | Threshold ID | Parameter | Unit of Measure | Threshold Value | | Baseline years |
|---|---|---|---|---|---|---|
| | | | | Caution | Warning | |
| Flounder | FFFCHL | lipid-normalized chlordane | ng/g lipid | 484 | | 1993-2000* |
| | FFFDDT | lipid-normalized DDT | ng/g lipid | 1552 | | 1993-2000* |
| | FFFDIEL | lipid-normalized dieldrin | ng/g lipid | 127 | | 1993-2000* |
| | FFFHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FFFPCB | PCB | ng/g wet | 1000 | 1600 | N/A |
| | FFLIVDIS | liver disease incidence | % | 44.94 | | 1991-2000 |
| Lobster | FLMCHL | lipid-normalized chlordane | ng/g lipid | 150 | | 1992-2000 |
| | FLMDDT | lipid-normalized DDT | ng/g lipid | 683 | | 1992-2000 |
| | FLMDIEL | lipid-normalized dieldrin | ng/g lipid | 322 | | 1992-2000 |
| | FLMHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FLMPCB | PCB | ng/g wet | 1000 | 1600 | N/A |
| Mussel | FMUCHL | lipid-normalized chlordane | ng/g lipid | 205 | | 1992-2000** |
| | FMUDDT | lipid-normalized DDT | ng/g lipid | 483 | | 1992-2000** |
| | FMUDIEL | lipid-normalized dieldrin | ng/g lipid | 50 | | 1992-2000** |
| | FMUPAH | lipid-normalized PAH | ng/g lipid | 2160 | | 1992-2000** |
| | FMUHG | mercury | ug/g wet | 0.5 | 0.8 | N/A |
| | FMUPB | lead | ug/g wet | 2 | 3 | N/A |
| | FMUPCB | PCB | ng/g wet | 1000 | 1600 | N/A |

* 1992 flounder data excluded because compositing scheme not compatible with other years.

** Data for 1995 not available because mussel cages could not be recovered at baseline site.

N/A Threshold not calculated using baseline data.

Table 1: Summary of threshold values for fish and shellfish thresholds

Data Source (Data from the EM&MS database):

Tissue Body Burdens:

- Laboratory data from the Fish and Shellfish study for the parameters shown in table 2 for the various groups are used. These data are stored in the ANALYTICAL_RESULTS table with supporting data in the BOTTLE and SAMPLE tables.

| Group (Group Code) | Parameter Code | Parameter Description | Parameter Abbreviation |
|---|---|---|---|
| Chlordane (CHLOR) | 5103-71-9 | CIS-CHLORDANE | |
| | MWRA25 | HEPTACHLOR | |
| | MWRA24 | HEPTACHLOREPOXIDE | |
| | 24143-69-9 | TRANS_NONACHLOR | |
| DDT | MWRA33 | O,P-DDD | 2,4'-DDD |
| | MWRA34 | O,P-DDE | 2,4'-DDE |
| | 789-02-6 | O,P-DDT | 2,4'-DDT |
| | 72-54-8 | P,P-DDD | 4,4'-DDD |
| | 75-55-9 | P,P-DDE | 4,4'-DDE |
| | 50-29-3 | P,P-DDT | 4,4'-DDT |
| DIELDRIN | 60-57-1 | DIELDRIN | |
| LEAD | 7439-92-1 | LEAD | Pb |
| MERCURY | 7439-97-6 | MERCURY | Hg |
| PAH (PAH_NOAA_PRE1995) | 90-12-0 | 1-METHYLNAPHTHALENE | |
| | 832-69-9 | 1-METHYLPHENANTHRENE | |
| | 2245-38-7 | 2,3,5-TRIMETHYLNAPHTHALENE | |
| | 581-42-0 | 2,6-DIMETHYLNAPHTHALENE | |
| | 91-57-6 | 2-METHYLNAPHTHALENE | |
| | 83-32-9 | ACENAPHTHENE | |
| | 208-96-8 | ACENAPHTHYLENE | |
| | 120-12-7 | ANTHRACENE | |
| | 56-55-3 | BENZ(A)ANTHRACENE | |
| | 50-32-8 | BENZO(A)PYRENE | |
| | 205-99-2 | BENZO(B)FLUORANTHENE | |
| | 192-97-2 | BENZO(E)PYRENE | |
| | 191-24-2 | BENZO(G,H,I)PERYLENE | |
| | 207-08-9 | BENZO(K)FLUORANTHENE | |
| | 92-52-4 | BIPHENYL | |
| | 218-01-9 | CHRYSENE | |
| | 53-70-3 | DIBENZO(A,H)ANTHRACENE | |
| | 206-44-0 | FLUORANTHENE | |
| | 86-73-7 | FLUORENE | |
| | 193-39-5 | INDENO(1,2,3-C,D)PYRENE | |
| | 91-20-3 | NAPHTHALENE | |
| | 198-55-0 | PERYLENE | |
| | 85-0108 | PHENANTHRENE | |
| | 129-00-0 | PYRENE | |
| PCB | 34883-43-7 | 2,4'-DICHLOROBIPHENYL | CL2(8) |
| | 37680-65-2 | 2,2',5-TRICHLOROBIPHENYL | CL3(18) |
| | 7012-37-5 | 2,4,4'-TRICHLOROBIPHENYL | CL3(28) |
| | 41464-39-5 | 2,2',3,5'-TETRACHLOROBIPHENYL | CL4(44) |
| | 35693-99-3 | 2,2',5,5'-TETRACHLOROBIPHENYL | CL4(52) |
| | 32598-10-0 | 2,3',4,4'-TETRACHLOROBIPHENYL | CL4(66) |
| | 32598-13-3 | 3,3',4,4'-TETRACHLOROBIPHENYL | CL4(77) |
| | 37680-73-2 | 2,2',4,5,5'-PENTACHLOROBIPHENYL | CL5(101) |
| | 32598-14-4 | 2,3,3',4,4'-PENTACHLOROBIPHENYL | CL5(105) |
| | 31508-00-6 | 2,3',4,4',5-PENTACHLOROBIPHENYL | CL5(118) |
| | 57465-28-8 | 3,3',4,4',5-PENTACHLOROBIPHENYL | CL5(126) |
| | 38380-07-3 | 2,2',3,3',4,4'-HEXACHLOROBIPHENYL | CL6(128) |
| | 35065-28-2 | 2,2',3,4,4',5-HEXACHLOROBIPHENYL | CL6(138) |
| | 35065-27-1 | 2,2',4,4',5,5'-HEXACHLOROBIPHENYL | CL6(153) |
| | 35065-30-6 | 2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL | CL7(170) |
| | 35065-29-3 | 2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL | CL7(180) |
| | 52663-68-0 | 2,2',3,4',5,5',6-HEPTACHLOROBIPHENYL | CL7(187) |
| | 52663-78-2 | 2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL | CL8(195) |
| | 40186-72-9 | 2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL | CL9(206) |
| | 2051-24-3 | DECACHLOROBIPHENYL | CL10(209) |

Table 2: Parameters used for body burden calculations.

- Data are segregated by species using the first ten characters of the MATRIX_CODE in the SAMPLE table and the FRACTION_CODE in the bottle table.

| Species | MATRIX_CODE | FRACTION_CODE |
|---|---|---|
| Lobster | 6181010201 | MEAT |
| Flounder | 8857041504 | FILLET |
| Mussel | 5507010101 | SOFT_TISSUE |

Table 3: Matrix and Fraction Codes Used in Threshold Calculations

- Data are stored in the database as a dry weight concentration. The thresholds are based on lipid normalized values or wet weight percentages. A conversion is made using the measurement of percent dry weight and percent lipids. These values are stored in the ANALYTICAL_RESULTS table with PARAM_CODES of 'PCTDRYWT' and 'LIPID'.

Flounder Liver Disease:

- Centrotubular hydropic vacuolation severities (PARAM_CODE = 'CENTRO_HV') are used to measure flounder liver disease. These data are stored in the PATHOLOGY table with supporting data in the BOTTLE and SAMPLE tables.
- The samples are identified by the MATRIX_CODE for flounder shown in table 3 and a FRACTION_CODE of 'LIVER_SECTION'.

Data to be used in the analysis:

Tissue Body Burdens:

- Data from the outfall station are used for baseline and threshold testing. (STAT_ID = '4' for flounder and lobster, STAT_ID = '4M' for mussels).
- The baseline years are shown in table 1. One year, 1992, was excluded from the baseline calculation for flounder because the compositing scheme is incompatible with subsequent years.

Flounder Liver Disease:

- Data from the Deer Island Flats station are used for baseline calculation (STAT_ID = '1')
- Data from the Outfall Site are used for threshold testing calculation. (STAT_ID = '4').
- Data from 1991 to 2000 was used in calculating the baseline value.

Both Analyses:

- Data qualified as invalid/suspect (those having qualifiers including 's') are excluded. No other exclusions are made. The existence of data that are qualified as "possibly suspect/invalid, investigation pending" (those having qualifiers including 'q') will prevent a calculation from occurring.
- Data qualified as below detection limit ('a' qualifier) are treated as zero values.

Data Aggregation:

Tissue Body Burdens:

- The average of all analytical replicates for each parameter is calculated for each bottle (subsample).
- The average of all bottle averages for each parameter is calculated for each sample. A sample is a composite of flounder, lobster, or mussels comprising some of the individuals from a station, composited as described in the combined work/quality assurance project plan for Fish and shellfish monitoring (see Lefkowitz and Moore, 1998, ENQUAD report ms-049.)
- The sample average for each parameter is converted to a lipid normalized value or a wet weight value using the sample average percent dry weight or lipid percent dry weight value. The unit code in Table 1 indicates how each parameter is treated.

  Lipid Normalized Value = SAMPLE_AVERAGE * 100 / SAMPLE_AVERAGE_LIPID
  Wet Weight Value = SAMPLE_AVERAGE * SAMPLE_AVERAGE_PCTDRYWT / 100
- Annual averages for each parameter are calculated by averaging across samples for a given year for each parameter.
- The annual values for chlordane, DDT, PCB, and PAH are calculated by summing the annual averages of the parameters listed in table 2.

Flounder Liver Disease:

- If any liver section in a given flounder sample has a centrotubular hydropic vacuolation count greater than 0, the sample is assigned a value designating it as diseased; otherwise it is assigned a value designating it as nondiseased.
- The annual percent prevalence is computed as 100 times the number of fish with disease divided by the total number of fish.

Baseline Calculation (FFLM_BASE.SQL):

Tissue Body Burdens:

- The average of annual values for all years shown in table 1 are used to calculate the baseline average for chlordane, DDT, dieldrin, and PAHs.
- The threshold value for these groups is calculated as twice the baseline average.

Flounder Liver Disease:

- The average of the annual percent prevalence for the Deer Island Flats station (station 1) is the baseline average and the threshold value.

Threshold Testing (FFLM.SQL):

Tissue Body Burdens:

- The annual value for each post-discharge year (reported to three significant figures) is compared to the threshold value. If the annual value is greater, a threshold exceedance is recorded.

Flounder Liver Disease:

- The annual percent prevalence at station 4 for each post-discharge year is compared to the threshold value and, if it is greater, an exceedance is recorded.

Approvals:

| | | |
|---|---|---|
| Written by: | _____ | _____ |
| | Suh Yuen Liang | Date |
| | _____ | _____ |
| | Joseph LoBuglio | Date |
| Data Group Manager: | _____ | _____ |
| | Wendy Leo | Date |
| MWRA Manager Responsible for Fish and Shellfish Data: | _____ | _____ |
| | Maurice Hall | Date |

# COMBINED WORK/QUALITY ASSURANCE PROJECT PLAN (CW/QAPP) ADDENDUM 1

***for***

## FISH AND SHELLFISH MONITORING: 2002-2005

## MWRA Harbor and Outfall Monitoring Project Contract No. S366

## Concurrences and Approvals

| | |
|---|---|
| _____ | _____ |
| Ms. Ellen Baptiste-Carpenter<br>Battelle Project Manager | Date |
| _____ | _____ |
| Carlton Hunt, Ph.D.<br>Battelle Technical Director | Date |
| _____ | _____ |
| Ms. Rosanna Buhl<br>Battelle Project QA Officer | Date |
| _____ | _____ |
| Dr. Michael Mickelson<br>MWRA Project Manager | Date |
| _____ | _____ |
| Mr. Maury Hall<br>MWRA Project Area Manager | Date |
| _____ | _____ |
| Ms. Wendy Leo<br>MWRA EM & MS Manager | Date |

- Sections 12.4.1 and 12.4.2 have been reorganized and are replaced with the following sections to reflect the actual collection locations of pre-deployment mussels.

### 12.4.1 Mussel Collection and Deployment

In June, mussels will be collected from reference sites for deployment in Boston Harbor and Offshore. Mussel collection sites have varied in the past (Rockport, MA or Stover's Point, ME – both organics and inorganics, Gloucester, MA – organics, Sandwich, MA – inorganics) due to the availability of adequate amounts of mussels for analysis and deployment (~2400 mussels). Stover's Point, ME was the mussel collection site in 2002 and 2003. Before a new collection site can be selected, chemical analyses must be performed on pre-deployment mussels from the new collection site to verify that the background concentration of contaminants is low.

Mussels will be harvested during low tide and individually checked for length. Mussels that have a total average length of 55-65 mm will be collected and used in the deployment. Mussels will be randomly distributed to plastic cages for deployment as an array (i.e., set of cages) in sufficient number to provide the necessary biological material. At least 10% additional mussels will be included to account for potential mortality. A subsample of 105 live mussels will be randomly selected and set aside for pre-deployment chemical analyses. Mussel array systems will be deployed at up to four locations (Table 2, Figure 3). At each location a minimum of 3 arrays will be deployed except for the offshore locations (Outfall Site and Cape Cod Bay) where 4 arrays will be deployed. Each array will be deployed on a separate mooring and each with enough mussels to provide sufficient tissue to complete the study. The locations of the arrays will be recorded using dGPS.

### 12.4.2 Mussel Recovery

Table 14 lists the minimum numbers of mussels that will be recovered from each location for each type of analysis at the 40 and 60-day collections. After approximately 40 days, up to one half of the mussels (one array) will be recovered to provide biological material in the event of a failure of the 60-day collection. The amount of biofouling of the arrays will also be assessed at 40 days. If necessary, arrays will be retrieved, cleaned, and re-deployed at the site. At the end of 60 days, the remaining mussels (the additional array) will be collected. The mussels for chemical analysis will be placed in a clean container and frozen (prior to shucking).

- In 2002 and 2003, Stover's Point, ME was the mussel reference site for the Mussel Bioaccumulation Survey (Task 23). Table 2 and Figure 3 have been modified to reflect the location of this mussel collection site.

**Table 2. Sampling and Locations for Flounder/Lobster/Mussel Surveys.**

| Station # | Sampling Site | Location | | Survey Type | | |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Flounder | Lobster | Mussel |
| DIF | Deer Island Flats (Boston Harbor) | 42°20.4' | 70°58.4' | * | * | |
| DIL | Deer Island Light | 42°20.4' | 70°57.2' | | | * |
| NB | Off Nantasket Beach | 42°17.6' | 70°52.2' | * | | |
| BS | Broad Sound | 42°24.4' | 70°57.2' | * | | |
| OS | Outfall Site | 42°23.1' | 70°49.3' | * | * | |
| OSM | Outfall Site (60 m at OS) | 42°23.15' | 70°47.92' | | | * |
| OSR | Outfall Site (15 m at OS – post diversion) | 42°23.17' | 70°47.68' | | | * |
| ECCB | East Cape Cod Bay | 41°56.2' | 70°06.6' | * | * | |
| IH | Boston Inner Harbor | 42°21.5' | 71°02.9' | | | * |
| GL | Gloucester | 42°40.2' | 70°40.2' | | | R |
| SA | Sandwich/Cape Cod | 41°45.6' | 70°28.5' | | | R |
| RP | Rockport | 42°39.6' | 70°35.7' | | | R |
| CCB | Cape Cod Bay | 41°55.5' | 70°20.0' | | | * |
| SP | Stover's Point, ME** | 43º45.1' | 69º59.9' | | | R |
| LNB | "B" Buoy (2001 onwards only) | 42°22.67' | 70°47.25' | | | * |

* = Sampling Site for Survey

** New in HOM4 (2002 and 2003)
R = Reference Site for Collection of Mussels for Deployment During Bioaccumulation Survey This location will be determined by availability of mussels.

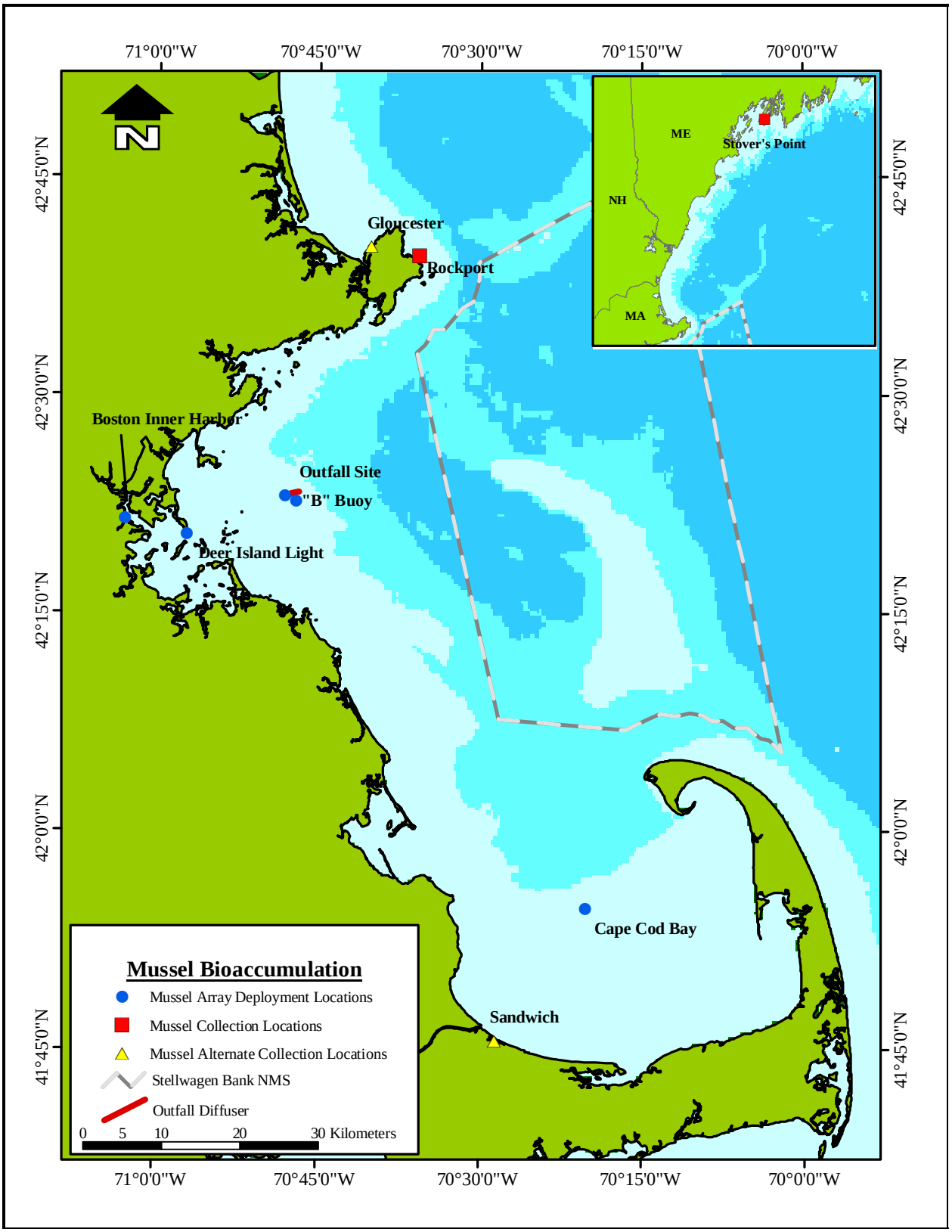


**Figure 3. Mussel Collection and Deployment Locations.**

- In Table 10, the DQO requirement for surrogate recovery of Naphthalene d8 has been changed to 40% - 150%. During 2002 and 2003, the Surrogate Internal Standards (SIS) recovery criteria were 50 – 150% for all compounds, and there were no exceedances of these criteria. However, any potential chemical analysis done by Battelle in 2004 and 2005 will use the revised criteria noted in Table 10.

**Table 10**. **Data Quality Objectives.**

| QC Type and Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|
| **Procedural Blanks**<br>Organics 1 per 20 samples<br>Metals<br>Lipids | <br>< 5X MDL<br>< 5X MDL<br>< 0.1 % | Results examined by lab manager and senior scientist. Reextraction, reanalysis, or justification documented. |
| **Accuracy** | | |
| **Matrix Spike/ Blank Spikes**<br>Organics 1 per 20 samples<br>Metals | <br>50-150% recovery<br>70-130% recovery | Document, justify deviations. |
| **Surrogate Internal Standards (SIS)** | 50-150% recovery<br>Naphthalene d8: 40-150% recovery* | Document, justify deviations |
| **SRMs**<br>Organics 1 per 20 samples<br><br><br>Metals | <br>PD ± 30% vs. certified values, not to exceed 35% for more than 30% of analytes<br>PD ± 20% vs. certified values | Results examined by lab manager and senior scientist.<br>Re-extraction, re-analysis, or justification documented. |
| **Precision** | | |
| **Duplicates**<br>Organics (MS/MSD) 1 per 20 samples<br>Metals (Lab Duplicates)<br><br>Lipids | <br>≤ 30% RPD<br>RPD=± 25% individual analytes, ± 30% mean<br>≤ 25% RPD | Document, justify deviations. |
| **FLOUNDER/LOBSTER/MUSSEL MEASUREMENTS AND HISTOLOGY** | | |
| **Precision**<br>Duplicate Measurements<br>10% | <br>Flounder Weight: ± 5 g<br>Flounder Total and Standard Length: ± 1 cm<br>Lobster total weight: ± 1%<br>Lobster carapace lengths: ± 1 mm<br>Mussel soft tissue weight: ± 0.01 g<br>Length: ± 1 mm | Check calibration of instrument if applicable. Perform re-measurement. |

* Data quality objectives for this compound are different as it is more susceptible to loss (volatile).

MDL=Method Detection Limit; PD=Percent Difference; SIS=Surrogate Internal Standard; RSD=Relative Standard Deviation; SRM=Standard Reference Material; RPD=Relative percent Difference.

- Per the discretion of the MWRA, mussel condition analysis was not performed in 2003 or subsequent years. All references to mussel condition analysis should be removed from Section 7.1.5 and all subsequent sections for years 2003 and forward.

- The Value Codes in Table 20 were incorrect and have been updated as follows:

**Table 20. Database Codes For Fish and Shellfish Monitoring.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| ANAL_LAB_ID | BOS | Battelle Ocean Sciences |
| ANAL_LAB_ID | BSQM | Battelle Marine Sciences Laboratory |
| ANAL_LAB_ID | WHO4 | Woods Hole Oceanographic-M. Moore |
| FRACTION_CODE | FILLET | Fillet of fish (edible tissue) |
| FRACTION_CODE | HEPATOPANC | Hepatopancreas |
| FRACTION_CODE | INDIVIDUAL | Measurement was made on an individual animal |
| FRACTION_CODE | LIVER | Analysis done on liver only |
| FRACTION_CODE | LIVER_SECTION | Analysis done on section of liver |
| FRACTION_CODE | MEAT | Edible meat from lobster (tail and claw) |
| FRACTION_CODE | SOFT_TISSUE | Entirety of organisms soft tissue |
| FRACTION_CODE | WHOLE_BODY | Entire body or part of body described at PARAM_CODE level |
| GEAR_CODE | ARRAY | Mussel deployment array |
| GEAR_CODE | OTT | Otter trawl tow |
| GEAR_CODE | TRAP | Lobster trap |
| INSTR_CODE | BAL | Balance |
| INSTR_CODE | CVAA | Cold vapor atomic absorption |
| INSTR_CODE | GCECD | Gas chromotograph electron capture detector |
| INSTR_CODE | GCMS | Gas chromotograph/mass spectometer |
| INSTR_CODE | GFAA | Graphite furnace atomic absorption |
| INSTR_CODE | ICPAES | Inductively coupled plasma atomic emission spectrometer |
| INSTR_CODE | ICPMS | Inductively coupled plasma mass spec |
| MATRIX_CODE | 5507010101 | Mytilus edulis |
| MATRIX_CODE | 5507010101_C | Composite of Mytilus edulis |
| MATRIX_CODE | 6181010201 | Homarus americanus |
| MATRIX_CODE | 6181010201_C | Composite of Homarus americanus |
| MATRIX_CODE | 8857041504 | Pseudopleuronectes americanus |
| MATRIX_CODE | 8857041504_C | Composite of Pseudopleuronectes americanus |
| METH_CODE | BSOP5-128DUAL | Battelle Ocean Sciences SOP No. 5-128, PCB/pesticides by GCECD, dual column |
| METH_CODE | BSOP5-157 | Battelle Ocean Sciences SOP No. 5-157, PAH by GCMS |
| METH_CODE | BSOP5-175 | Battelle Ocean Sciences SOP No. 5-175, Length Measurements of Fish and Shellfish |
| METH_CODE | BSOP5-190 | Battelle Ocean Sciences SOP No. 5-190, Tissue Extraction, Lipids by gravimetric means |
| METH_CODE | BSOP5-031 | Battelle Ocean Sciences SOP No. 5-031, Determining Biol. Condition Index and Gonad Condition Index of Mollusks |
| METH_CODE | FSF98 | Method for pathology parameters described in Fish and Shellfish CW/QAPP, 1998: ENQUAD MS-49 |
| METH_CODE | LWEIGHT | Lobster weight to the nearest gram using conventional scale (model 70-2030) |
| METH_CODE | MSL-C-003 | Percent dry weight |
| METH_CODE | MSL-I-016 | Total mercury in tissues and sediments by CVAA |
| METH_CODE | MSL-I-022 | Determination of elements in aqueous and digestate samples by ICP/MS |
| METH_CODE | MSL-I-027 | Determination of metals in aqueous and digestate samples by ICP-AES |
| METH_CODE | MSL-I-029 | Determination of metals in aqueous and digestate samples by graphite furnace atomic absorption (GFAA) |

**Table 20. Database Codes For Fish and Shellfish Monitoring, continued.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| METH_CODE | PWEIGHT | Flounder wt measurement mentioned in CW/QAPP for Fish and Shellfish Monitoring Sec 11.2.ENSR 1997 |
| METH_CODE | SCALE | Aging by scales |
| METH_CODE | VISUAL | Visual inspection mentioned in CW/QAPP for Fish and Shellfish Monitoring Sec 11.2/11.3.ENSR 1997 |
| QC_CODE | QC | Qc sample |
| QC_CODE | SAMP | Normal sample |
| SPEC_CODE | 5507010101 | Mytilus edulis |
| SPEC_CODE | 6181010201 | Homarus americanus |
| SPEC_CODE | 8857041504 | Pseudopleuronectes americanus |
| UNIT_CODE | cm3 | Cubic centimeters |
| UNIT_CODE | g | grams |
| UNIT_CODE | mm | millimeters |
| UNIT_CODE | ng/g | nanograms per gram |
| UNIT_CODE | PCT | PERCENT |
| UNIT_CODE | PCTDRYWT | Percent dry weight |
| UNIT_CODE | ug/g | micrograms per gram |
| UNIT_CODE | y | years |
| VALUE_CODE | 0 | Absent |
| VALUE_CODE | 1 | Minor or present or pre-spawning |
| VALUE_CODE | 2 | Moderate or ripe or mature; severe concerning gross score. |
| VALUE_CODE | 3 | Severe or running eggs or undeveloped. |
| VALUE_CODE | 4 | Extreme or post-spawning |
| VALUE_CODE | B | Brown |
| VALUE_CODE | DB | Dark brown |
| VALUE_CODE | F | female |
| VALUE_CODE | M | male |
| VALUE_CODE | Y | Yellow |
| VALUE_CODE | YB | Yellow brown |
| VAL_QUAL | A | Value above maximum detection limit, e.g. too numerous to count or beyond range of instrument |
| VAL_QUAL | a | Not detected - value reported as negative or null |
| VAL_QUAL | aG | Not detected, value is null, co-eluting compound |
| VAL_QUAL | aGs | Not detected, value is null, co-eluting compound, suspect/invalid, not fit for use |
| VAL_QUAL | aGx | Not detected, value is null, co-eluting compound, matrix interference |
| VAL_QUAL | aL | Below MDL; value reported as negative or null, analytical conc. reported from dilution |
| VAL_QUAL | aLs | Not detected, analytical conc. reported from dilution, suspect/invalid, not fit for use. |
| VAL_QUAL | aq | Not detected - value reported as negative or null. May be invalid, under investigation (Do not use). |
| VAL_QUAL | as | Not detected - value reported as negative or null, and not fit for use |
| VAL_QUAL | ax | not detected, value is null, matrix interference |
| VAL_QUAL | B | Blank corrected, blank >= 5x MDL |
| VAL_QUAL | b | Not blank corrected, blank>=5x MDL |
| VAL_QUAL | Bf | Blank corrected, blank >= 5x MDL, value reported < detect_limit |
| VAL_QUAL | bs | Not blank corrected, blank >=5x MDL, suspect/invalid, not fit for use |

**Table 20. Database Codes For Fish and Shellfish Monitoring, continued.**

| FIELD NAME | CODE | DESCRIPTION |
|---|---|---|
| VAL_QUAL | D | Surrogate recovery < 50% or > 150% |
| VAL_QUAL | Ds | Surrogate recovery < 50% or > 150%, suspect/invalid, not fit for use |
| VAL_QUAL | e | Results not reported, value given is NULL. Explanation in COMMENTS field |
| VAL_QUAL | eq | Not reported, may be invalid, under investigation (Do not use). |
| VAL_QUAL | f | Value reported is below method detection limit |
| VAL_QUAL | fG | Reported value below MDL and co-eluting compound interferes with peak of interest |
| VAL_QUAL | fL | Value reported is between zero and MDL, analytical conc. reported from dilution |
| VAL_QUAL | fq | VALUE reported is below method detection limit. May be invalid, under investigation (Do not use). |
| VAL_QUAL | fs | VALUE reported is below method detection limit, not fit for use |
| VAL_QUAL | fsx | Value reported below detection limit, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | fx | Below method detect limit, matrix interference |
| VAL_QUAL | G | Co-eluting compound interferes with peak of interest |
| VAL_QUAL | g | Recovery outside data objectives |
| VAL_QUAL | gq | Recovery outside data objectives. May be invalid, under investigation (Do not use). |
| VAL_QUAL | Gs | Co-eluting compound, suspect/invalid, not fit for use |
| VAL_QUAL | Gsx | Co-eluting compound, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | L | Analytical Concentration Reported From Dilution |
| VAL_QUAL | Lq | Analytical concentration reported from dilution. May be invalid, under investigation (Do not use). |
| VAL_QUAL | Ls | Analytical concentration reported from dilution, suspect/invalid, not fit for use |
| VAL_QUAL | Lsx | Diluted, matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | q | Possibly suspect/invalid and not fit for use. Investigation pending. |
| VAL_QUAL | s | Suspect/Invalid. Not fit for use. |
| VAL_QUAL | sx | Matrix interference, suspect/invalid, not fit for use |
| VAL_QUAL | w | This datum should be used with caution, see comment field |
| VAL_QUAL | x | Matrix interference |


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