Quality Assurance Project Plan for Lake Trout and Forage Fish Sampling for Diet Analysis and/or Contaminant Analysis

Edward H. Brown, Jr. and Gary W. Eck
U.S. Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105-2899

May 1994

Version 1.0

Quality Assurance Project Plan for Lake Trout and Forage Fish Sampling for Diet Analysis and/or Contaminant Analysis

1.0 Project Description

1.1 Introduction

The Great Lakes National Program Office (GLNPO) of the U.S. EPA has initiated a Mass Balance Study for selected toxic contaminants in Lake Michigan. The Mass balance effort will be part of a "Lake Michigan Enhanced Monitoring Program" which includes tributary and atmospheric load monitoring, source inventories, and fate and effects evaluations. In general, the primary goal of this enhanced monitoring program is to develop a sound, scientific base of information to guide future toxic load reduction efforts at the Federal, State and local levels.

A modeling team will construct a mass budget and mass balance model for a limited group of contaminants which are present in Lake Michigan at concentrations which pose a risk to aquatic and terrestrial organisms (including humans) within the ecosystem. Components to the mass balance model will be designed to predict contaminant concentrations in the water column and target fish species over a two-year period, relative to loadings. Predictions of contaminant levels in three species of fish will be calculated as final output of the model. The target fish species include:

Lake trout (*Salvelinus namaycush*)
Coho salmon (*Oncoryhynchus kisutch*)
Bloater chub (*Coregonus hoyi*)

The calibration of the food web model(s) for these target species requires data on contaminant concentrations and fluxes (diet) not only in these species, but also in the supporting trophic levels. The contaminant burden of each prey species varies based on feeding patterns at lower trophic levels. The concentration of contaminants in lake trout and bloater chubs will depend on what prey items they choose to consume. The diet information for lake trout sampled by this project will enable the modelers to quantify the movement of contaminants from their source, through the food web, and ultimately the body burden in lake trout.

The basic design and data requirements for the fish samples have been outlined in Tables 5 and 6 and in Appendix 4 of Lake Michigan Mass Budget/Mass Balance (LMMB) work plan of October 14, 1993. This project addresses a subset of the work objectives for lake trout and bloater chubs, two of the target species described in the LMMB work plan, and for the five principal forage species also described in that work plan, including bloater chub, alewife, smelt, slimy sculpin, and deepwater sculpin, which are consumed by lake trout and coho salmon.

The specific objectives are to:

1. Collect representative samples of lake trout, bloater chubs, alewives, smelt, slimy sculpins, and deepwater sculpins for contaminant analysis.
2. Describe the diet of lake trout in Lake Michigan from May through October 1994.
3. Review past published and unpublished information on the diet of lake trout in Lake Michigan and report on the comparability of the data collected in 1994 to past data.

1.2 Experimental Design

Because of spatial and temporal variations in feeding habits and/or distributions of lake trout, bloater chub, and the other four forage species we will collect them in spring, summer, and fall from each of three Biota Sampling Sites identified in the LMMB work plan of October 1994; these include (1) the northwestern region near Sturgeon Bay, WI, (2) the southeastern region near Saugatuck, MI, and (3) the central Midlake Reef region east of Port Washington, WI (Fig. 1). The bloater chub was identified as both a target species and a forage species for trout and salmon in the LMMB work plan of October 1994. The sampling regimes in Table 1.0 will be followed at each of the three Biota Sites in spring (May to early June), summer (July to early August), and fall (October to early November):

The staff on this project will have the advantage of making all of its targeted fish collections for contaminants and diet analyses from the R/V Cisco which is assigned to the NBS' Lake Michigan Project in the Section of Resource Assessment and Fish Community Dynamics at the GLSC and is stationed at the Saugatuck Vessel Base. The most difficult part will be obtaining all of the specified age and size groups of lake trout and forage fish at all locations and in all seasons, because of vagaries partly associated with changes in weather, stocking densities and locations of the trout reared in Federal Hatcheries, and natural variations and trends in abundance of forage fish. Sampling on the Sheyboygan or Midlake Reef, more than 30 miles offshore of the nearest port (Port Washington), poses the most difficult physical problem because a round trip takes six hours or longer and there is no protection from sudden storms.

1.2.1 Contaminant Sampling

Because of the cost of the analytical chemistry, the total number of lake trout listed in the LMMB Work Plan for contaminant analysis has been reduced from 450 to 225 per season: i.e., 75 per Biota Site (Table 1.0) times three sites. These samples will be packaged as required for contaminant analysis, frozen, and delivered to the GLSC Laboratory of NBS in Ann Arbor.

1.2.2 Diet Sampling

The LMMB Work Plan did not have a sample size objective for describing the diet of lake trout. However, based on recent diet variations observed in coho salmon, Holey and Elliott (1994) estimated that at least 100 salmon per season per region would be necessary to provide a reasonable analysis of the variation. Although past work has shown that higher percentages of lake trout than salmon are found with food in their stomachs, 75 lake trout in addition to those collected for contaminant analysis will be collected per Biota Site per season (Table 1.0). Published information on the diet of Lake Michigan lake trout will also be reviewed to complement and aid in interpretation of that which will be collected in the

present study in 1994.

Both critical and noncritical parameter measurements for the evaluation of contaminants and diet of lake trout and contaminants of bloater chub are summarized in Table 1.1.

Table 1.0. Sample size objectives for the collection of lake trout, bloater chub, and four other forage species in Lake Michigan by season, age or size group, and pending analysis.

Biotic group	Age or size	Number collected for			Total samples
		Contaminants and diet	Contaminants only	Diet only	
Lake trout	2-4 yr	25	-	25	50
	5-7 yr	25	-	25	50
	8-10 yr	25	-	25	50
Bloater chub	0-2 yr	-	25	-	25
	4+ yr	-	25	-	25
Alewife	60-120 mm	-	25	-	25
	>120 mm	-	25	-	25
Smelt	>100 mm	-	25	-	25
Slimy sculpin	-	-	25	-	25
Deepwater sculpin	-	-	25	-	25
Total fish	-	75	175	75	325

Table 1.1. Summary of critical and non-critical parameter measurements for the evaluation of contaminants and diet of lake trout, and contaminants of bloater chub.

Parameter	Sampling Instrument	Sampling Method	Analytical Instrument	Analytical Method	Reporting Units	LOD
Location (critical)	GPS, Loran, Port Location	SOP-1	NA	NA	biota sites	southeast, central and northwest
Sample Date (critical)	none	NA	NA	NA	mo / day / yr xx / xx / xx	day
Lake Trout length (critical)	measuring board ruler	NA	NA	NA	mm	1 mm
Lake Trout weight (critical)	spring or electronic balance	SOP-1	NA	NA	Kg	0.1 Kg
Lake Trout age (critical)	knife and envelope	SOP-1 and Bowen 1983	bi-noc scale projector	SOP-2, 3	years	1 year
Diet Species of Lake Trout (critical)	NA	SOP-1	NA	SOP-2	total number	Species - fish & common invertebrates. Order for less common invertebrates
Diet Item length (critical)	NA	NA	ruler	SOP-2	mm	1 mm
Diet Item weight (critical)	NA	NA	spring or electronic balance	SOP-2	grams	0.1 gram
Bloater age (critical)	NA	SOP-1	scale projector microscope	SOP-2	years	1 year
Sample Depth (non-critical)	echo sounder	operating instructions	NA	NA	meters	0.1 meters
Time of Sample (non-critical)	clock	NA	NA	NA	HH:MM	minutes
Water Temp. when sampled (non-critical)	electronic BT	NA	NA	NA	degrees C	1 degree C

2.0 Project Organization and Responsibilities

Paul Bertram
EPA Project Officer
Biota Co-Chair

John Gannon
NBS
Biota Co-Chair

Lou Blume
EPA QA Manager

Edward Brown
NBS
Project Manager

Gary Eck
NBS
Field Manager

Ralph Stedman
Randall Owens
NBS
Alternate Field Managers

George Boyce
Tim Desorcie
NBS
Field Sampling Analysis

2.1 GLNPO Project Officer and Biota Co-Chair

The GLNPO Project Officer is the Agency official who initiates the grant, evaluates the proposal, and is the technical representative for EPA. The Project officer is responsible for:

Budgeting
Program planning, scheduling, and prioritization
Developing project objectives and data quality objectives
Ensuring that project meet GLNPO missions
Technical guidance
Program and data reviews including audits
Data quality
Final deliverables

2.2 GLNPO QA Manager

The GLNPO QA Manager (QAM) is responsible for ensuring that each project funded by EPA satisfies the Agency's requirements for QA programs. The QAM is responsible for:

Offering guidance on QA techniques
Evaluating QA Project Plans (QAPjPs) and approving QAPjPs for the Agency
Assisting in the coordination of audits

2.3 NBS Biota Co-Chair

The Biota Co-Chair from NBS works in partnership with the GLNPO QA Project Leader to implement the Biota portion of the Lake Michigan Mass Balance Project. Duties are:

Program planning, scheduling, and prioritization
Developing project objectives and data quality objectives
Ensuring that project meets GLNPO missions

2.4 NBS Project Manager

The Project Manager is the NBS official who initiated the proposal to perform the lake trout and forage fish sampling portions of the LMMB project and is responsible for:

Developing the sampling plan for lake trout and forage fish collections
Administration of the lake trout and forage fish segment of the Biota objectives
Overall supervision of field work
Ensures QA objectives are met
Technical supervision
Final deliverables
Data quality assessment

2.5 NBS Field Manager

The Field Manager is the NBS position that will provide daily supervision of the field collection activities and achievement of the QA objectives. This position is responsible for:

Collecting field data
Directly supervise the field crew activities
Reviews progress toward QA objectives
Develops and implements sampling and analytical procedures
Prepares reports and deliverables
Trains field crews on sampling and analytical procedures
Data quality assessments and audits for lab and field segments

2.6 Field Sampling and Analysis Personnel

These positions are responsible for the majority of the field sampling and lab identification. They will receive training and guidance from the Project and Field Managers, who will also audit their work to ensure QA objectives are met.

At a minimum, Field Sampling and Analytical Personnel have or, if future hires, will have Bachelors Degrees in biological science, natural resources, or related fields, or appropriate relevant experience. Project and Field Managers who will provide job-specific training all hold Masters Degrees in natural resources or fishery science and have 15 years or more of experience in fishery research, ecology, and management on the Great Lakes.

3.0 Quality Assurance Objectives

As outlined in the Lake Michigan Mass Budget/Mass balance Work Plan, the proposed model output should be within a factor of two of the observed concentrations in the water column and target fish. It is also estimated that the required level of model accuracy can be achieved if loadings and contaminant mass in significant environmental compartment are determined to within ±20 to 30% of the actual value.

3.1 Objectives

1) Within each season and regional biota site, collect as representative samples of lake trout and forage fish as possible so as to minimize the spatial and temporal population uncertainty (Sp) to the extent possible (given the sample size that can be collected with the financial, logistic, and biological constraints of this project).

2) To collect, package, and transport each sample, and to record, summarize, and report each physical measurement with a level of recision, accuracy, deductibility, and completeness that will ensure the Measurement.

Uncertainty (Sm) will be nominal compared to Sp and therefore not affect the interpretation of the results.

The level of population uncertainty can not be determined prior. That the contaminant levels in the lake trout and forage fish collected will be within ±20 to 30% of the actual population values is a function of sample size and the collection procedures. The sample size for contaminants has been established by the LMMB Work Plan and subsequent modifications. The designed collection procedures described here attempt to make the most of the sample size target.

Variability in the diet of Lake Michigan lake trout can be great, especially when examined from a lakewide perspective encompassing large scale spatial and temporal gradients. The desired sample size for determining diet is to a large degree constrained by the difficulty of collecting these fish. Presently lake trout abundance and therefor catch is very low off Saugatuck, a biota site, and some other areas in the southern basin because of changes in interagency stocking protocols (Lake Michigan Lake Trout Technical Committee 1985). Alewife abundance is also low throughout the Lake and they are no longer the dominant forage species that they were in the 1960s and early 1970s (Eck and Wells 1987).

3.2 Measurement Quality Objectives

Measurement quality objectives are designed to control various phases of the measurement process and to ensure that total measurement uncertainty is within ranges prescribed by the DQOs. The MQOs can be defined in terms of data quality attributes; precision, accuracy, completeness, delectability, representativeness, and comparability. The first four can be defined in quantitative terms, while the latter two are qualitative.

Precision. A measure of mutual agreement among multiple measurements of the same property, usually under prescribed similar conditions. Precision will be evaluated through auditing of data collection activities to determine whether activities are performed in a consistent manner, and by

established protocol.
Accuracy. The degree of agreement between a measurement (or an average of measurements of the same thing), and the amount actually present.

Completeness. For this QAPJP, completeness is the measure of the number of valid samples obtained compared to the amount that is needed to meet the DQOS. The completeness goal is 90%.

Detectability. The determination of the low-range critical value of a characteristic that a method-specific procedure can reliably discern or is necessary to meet program objectives.

Representativeness. Expresses the degree to which data accurately and precisely represent characteristic of a population, parameter variations at a sampling point, a proceed condition, or an environmental condition.

Comparability. Expresses the confidence with which one data set can be compared to another.

3.3 Field MQOs

The following information describes the procedures used to control and assess measurement uncertainty occurring during the field sampling. Field parameters in this section will include location, lake trout length, lake trout weight, and lake trout age and forage fish lengths, weights and ages. Since these measurements are straightforward, the measurement quality evaluations will be simple remeasurements.

The majority of the uncertainties occurring in the field can be alleviated by the development of detailed standard operating procedures (SOPs), an adequate training program at appropriate frequency, and a field audit program. SOPs have been developed and training has occurred. Field audits will be implemented during the course of the program implementation.

3.4 Precision

Another term for precision is repeatability. Repeatability in the field is very important to precision, as well as data comparability. Repeatability is controlled by the development of detailed SOPs and adequate training in those SOPS. Field precision will be checked by remeasuring 5% of the samples. Remeasurements must be within the acceptance criteria as stated in Table 3.0. Field precision can also be evaluated through the implementation of field technical systems audits. These audits will be used to evaluate the adherence to the SOPS. Audits are discussed in Section 8.0.

3.5 Accuracy

As stated earlier, accuracy is based on the differences between an estimate derived from data and the true value of the parameter being estimated. For the field measurements, with the exception of location, the true value is dependent on the calibration of the instrument (ruler or scale). Following calibration procedures and precision requirements will provide an indication of accuracy. Following SOPs as written should reduce contamination as much as possible. Accuracy is also based on training. Therefore, during audits the trainer will remeasure 5% of the samples to determine accuracy. If accuracy requirements are not met, the trainer will review the methods with the sampler until agreement is reached.

3.6 Detectability

Detectability in this study is a function of how accurate and repeatable the measuring instruments can be maintained. Rulers or tape measurements, unless broken, will be considered accurate. Therefore, delectability of lake trout length is a function of following the SOPS. Similarly, scales, if calibrated properly, should reflect an accurate weight unless various conditions (wind or rain) create a situation where an accurate weight (within detectable limits) cannot be met. The SOPs will discuss ways to measure samples within the delectability requirements.

3.7 Completeness

Completeness for the field is defined as the successful collection of all viable samples in the appropriate time frame. A viable sample would be defined as any single sample whose integrity has not been effected during the collection process and would therefore not be flagged with a field qualifier. In some cases the sampler has no control on the integrity (e.g., samples remaining in the sun too long) while in other cases the sampler might effect the integrity (e.g., contaminating a sample through improper handling).

In any case, the DQOs are based on the evaluation of a statistically relevant number of samples which are affected by all errors occurring in the field and laboratory. Therefore, the overall goal is a completeness of 90%. The completeness objective for the measurement phase is 100%. As with the other data quality attributes, completeness can be controlled through the adherence to the SOPs in order to minimize contamination and sampling errors.

3.8 Representativeness

Representativeness, with respect to the overall program objectives, is a function of the statistical sampling design and how well this design estimates the measurement parameters to this project. Variation in lake trout diet is expected seasonally but also from year-to-year, depending on the abundance of prey and environmental factors that might affect feeding behavior. Since the sampling period for this project is only one year, the review of past lake trout diet data will assist in determining how representative the 1994 diet of lake trout is to the yearly variation that can be expected.

3.9 Comparability

Comparability will be maintained by the adherence to the SOPs. Adherence to these SOPs by all samplers will allow for comparability of data among sites and throughout the project. Evaluation of comparability occurs through the implementation of the training program and the field technical systems audits.

Measurement quality objectives for the parameters that will be used to evaluate lake trout diet in this project are summarized in Table 3.0.

Table 3.0. Measurement quality objectives for parameters for the evaluation of lake trout diet.

Parameters	Sample Type	Frequency	Acceptance; Other Corrective Action
Location			The accuracy required is to regions of the lake.
Lake Trout Length			
Precision	Remeasurement	5 %	1 cm of original measurement - recalibrate instrument and remeasure sample to compare to closest.
Accuracy	Independent remeasurement	5 %	1 cm of original measurement - review protocols and remeasure another sample.
Completeness		NA	90 %
Lake Trout Weight			
Precision	Remeasurement	5 %	0.1 Kg of original measurement - recalibrate instrument and remeasure sample to compare to closest.
Accuracy	Independent remeasurement	5 %	0.1 Kg of original measurement - review protocols and remeasure another sample.
Completeness		NA	100 % for lake trout collected for contaminant analysis. 0 % for lake trout collected only for diet analysis.
Lake Trout Age			
Precision	Coded-wire tag	100 %	Confirmation with scale aging.
	Re-age, inspection	5 %	Direct match with original.
Accuracy	Independent Re-age, inspection	5 %	Direct match with original.
Completeness		NA	
Diet Species of Lake Trout			
Precision	Re-identify, inspection	5 %	95 % identification, precision will be maintained through training and periodic audits to verity accuracy of identification of prey items.
Accuracy	Re-identify, inspection	5 %	95 % identification, to determine accuracy, samples will be re-identified and compared to reference samples.
Completeness		NA	

Table 3.0. Measurement quality objectives for parameters for the evaluation of lake trout diet. (Cont'd)

Parameters	Sample Type	Frequency	Acceptance; Other Corrective Action
Diet Item Length			
Precision	Remeasurement	5 %	2 mm of original measurement - recalibrate instrument, remeasure sample and compare to closest.
Accuracy	Independent remeasurement	5 %	2 mm of original measurement - review protocols and remeasure another sample.
Completeness		NA	90 %
Diet Item Weight			
Precision	Remeasurement	5 %	0.1 g of original measurement - recalibrate instrument, remeasure sample and compare to closest.
Accuracy	Independent remeasurement	5 %	0.1 g of original measurement - review protocols and remeasure another sample.

4.0 Site Selection and Sampling Procedures

Lake trout and five forage species, bloater chub, alewife, smelt, slimy sculpin, and deepwater sculpin, will be sampled from the NBS's R/V Cisco in spring, summer, and fall at each of the three Biota Sites identified in the Lake Michigan Mass Budget/Mass Balance Work Plan. The precise locations will depend on the differential seasonal distributions of the six species at each site.

4.1 Sampling Procedures and Sample Custody

Each entire fishing operation or cruise in each season will be permanently documented in considerable detail in the Captain's Log and in the Section of Resource Assessment and Fish Community Dynamics' Research Vessel Catch Information System (RVCAT). An overview of this system is given in Appendix 4.

Fishing operation data (e.g., location, gear, total catch and effort by species) and biological data and measurements on individual fish are now entered directly into a laptop computer aboard the vessel. This has eliminated the need for much of the hand recording on a detailed set of field data forms that was done in the past. Each lake trout or other predator species, for example, is uniquely identified by an individual I. D. Number, while the catch from which it came is identified by a unique Serial Number. The data entry screens used aboard the vessel are shown in Appendix 5.

Samples of individual fish and composite samples of several or more fish will be labeled with tags bearing the information shown in Appendix 6. Any temporary or permanent change in the custody of these samples will be recorded on the Chain of Custody Record shown as Appendix 7. Any detected changes in the quality of these samples which might compromise their intended use(s) will be indicated by an appropriate FLAG (See list in Section 10) in the Chain of Custody Record, and corrective action to prevent it happening again will be taken by the Field Manager and reported to

the Project Manager who will take additional reinforcing action if warranted. In either case, emphasis will be placed in identifying the cause and whether it resulted from an inherent system or procedural problem or from negligence. Training to correct the situation will be provided by the Managers if appropriate. A separate set of Custody records will be filed with each of the Projects or Sections at the GLSC of NBS in Ann Arbor that played a significant role in collection and or temporary or final custody of the given samples.

4.2 Contaminant Sampling

All of the lake trout and forage species (identified above) to be used in contaminant analysis will be collected from the NBS's R/V Cisco, using gradedmesh gill nets to obtain the trout and a standard 12 meter bottom trawl to obtain the forage fish. The field sample preparation procedures are described in SOP 1. An NBS biologist will be on board during all of the fishing operations to insure proper handling of the samples. Immediately after they are processed, packaged, and labeled (Appendix 6), all samples of lake trout and forage fish will be frozen in a chest freezer aboard the vessel. If freezer capacity is exhausted, the fish will be held on ice for up to about eight hours so that they can be frozen and stored temporarily at a shore facility or transported frozen in coolers to either the Saugatuck Vessel Base of NBS for temporary storage in chest freezers or directly to the GLSC in Ann Arbor, Michigan for storage in a walkin freezer. All samples will be transported in an NBS vehicle. Custody forms will be used for transfer of samples between authorized individuals, showing the dates(s) when frozen and subsequently delivered, and the receiving location/facility. The number of samples and the range of 1.D. numbers, if individual fish, will also be recorded on the Chain of Custody form. A set of Custody records will be filed with the Lake Michigan Project at the GLSC of NBS in Ann Arbor; a duplicate set of records will be filed as backup in another appropriate location at the GLSC.

4.3 Diet Analysis

Stomachs for lake trout diet analysis will be removed with their contents intact from the fish being processed and packaged above in accordance with SOP 1 (Appendix 1). The stomachs will be frozen individually, labeled (Appendix 6), stored, transported, and transferred as described under contaminant sampling of the whole fish above. Diet analysis will take place in the laboratory at GLSC in Ann Arbor after field work is completed.

All members of the Lake Michigan Project at GLSC including the Project Manager for this segment of NBS's LMMB Projects, Edward Brown, the Field Manager, Gary Eck, alternate Field Managers, Ralph Stedman and Randall Owens, and Biological Technicians, Tim Desorcie and George Boyce, will participate in part or all of the field sampling in various capacities. These and other qualified staff whose services may become available later will collect and label all field samples.

5.0 Analytical Procedures and Calibration

Analytical procedures will generally follow those outlined in Bowen 1983, Elliott 1994, Miller and Holey 1992, and others. Details of the various analytical procedures that will be used in the field and laboratory are contained in SOPs 1 and 2 in (Appendices 1 and 2). Measurements of length and weight are the basic analytical procedures to be conducted for this project. Lengths of lake trout and their diet items will be measured to the nearest mm with a measuring board or ruler. Weight will be measured to the nearest 0.1 Kg for lake trout and 0.1 gram (g) for their diet items.

Tables of calibration equipment, technique, and frequency are also given in SOPs 1 and 2 for the respective field and laboratory operations. Lake trout will be aged by reading coded-wire tags (see SOP-3, Appendix 3).

6.0 Data Reduction, Validation, and Reporting

The main responsibility for data reduction, validation, and reporting will be shared by Edward Brown and Gary Eck with assistance from other qualified staff. Following is a description of the step by step procedure used to reduce the raw diet data into summary statistics, verify those statistics, and report them as products that describe the diet of lake trout in the manner required for this project.

6.1 Overview and Summary of Method

The raw data as entered and described in SOP 2 (Appendix 2) will be reduced so that the average diet of all lake trout within a given stratum (age-region season) can be reported. Diet will be reported for both lake trout that are sampled for contaminants, and for those that are sampled for diet alone (Table 1.0). The primary descriptive statistic calculated and reported will be the percent that each prey type contributes to the average wet weight of all prey found in the stomachs. The range and frequency distribution of individual weight values and percent weight values from which the average values are calculated will indicate the variance associated with these data. The range and distribution of site specific and biological variables will characterize the lake trout sample within each major stratum. Length distributions of prey fish in the diet will describe the characteristics of each species found in the stomachs of lake trout.

Data collected and results reported during other diet studies of Lake Michigan lake trout will be reviewed to provide a reference framework with which to help evaluate the representativeness of the diet information collected during this project.

It is assumed that the sampling design will provide samples of lake trout that are representative, especially in regard to diet, of all trout available to the sampling gear in each of the three age strata, at each of the three sampling sites, and in each of the three seasons. The samples combined across age strata would not be representative of all fish available to the gear in those strata combined, however, unless the samples in each stratum were first weighted by the relative abundance at the sampling sites of fish in those age intervals.

6.2 Reduction Procedures

The following procedures will be discussed:

– testing between samples
– combining or averaging samples, etc.

Using the database developed in SOP 2 (Appendix 2), calculate the percent that each prey type contributes to the average wet weight of all prey found in the stomach as follows.

Within each stratum (age, region, season), group lake trout and their associated data by general location (port) and date-specific groups.

For each of the location-date specific groups, calculate the average weight (0.1g) per stomach, and percent (0.1%) of the total weight, for each prey category. Also calculate the percent (1%) of the stomachs found empty or void of prey. Omit data flagged as outliers from these and subsequent calculations.

Use Wilcoxon-Mann Whitney two sample tests and Chi-square tests of independence to determine if and where significant differences in the diet exist between the location-date groups.

If significant differences between groups exist, compute a grand average of all location-date specific average weight values. Then calculate the percent that these average prey weights are of the total grand average weight of all prey combined.

If no significant differences between groups exist, combine data for all lake trout sampled within that strata, recalculate average weights, and then calculate the percent that these average prey weights are of the total average weight of all prey combined.

For each stratum, calculate the range and the frequency distribution of individual weight values and percent weight values for each prey species. If necessary, adjust the weight value intervals to reflect fresh weights using conversion formula determined in SOP 2.4.3.

For each stratum, calculate the range and the frequency distribution of prey lengths for each prey fish species. If necessary, adjust the lengths to reflect fresh lengths using conversion formula determined in SOP 2.4.3.

For each stratum, calculate the range and frequency distribution of site specific and biological variables (lake trout length, weight, sex, time, water depth, capture depth, temperature, where captured etc.).

Maintain updated/backed up independent copies of the reduced data (hard drive, disk, and hard copy printout) in the same manner as is done for the raw database (SOP 2.4.4) for the duration of the project.

6.3 Validation Procedures

Verification of the raw database is described in SOP 2.4.4. Validation of reductions/calculations is divided into two procedures: validation of correctness, and validation of representativeness.

6.4 Validation of Correctness

Reductions/calculations result from manipulations of the database by a personal computer using a set sequence of commands and formula (a program). This ensures that all reductions/calculations are consistent and not subject to random error. Verify that the values resulting from the reduction/calculation procedures are correct by reproducing by hand the process carried out by the computer for a randomly selected portion of the database.

6.5 Validation of Representativeness

To determine if the results of the reductions/calculations of this data set are representative of the diet of lake trout in Lake Michigan for this year and for other years in recent history, data collected

and results reported during other diet studies of Lake Michigan lake trout will be summarized and compared to the results produced from this database.

6.6 Reporting Procedures

The average size and variability of lake trout and the size, variability, and contribution of the diet taxa to the total diet within age-season-region strata will be reported (Table 6.1), based on reduction of the raw data as detailed above. The raw data itself will be permanently archived in RVCAT computer files at the NBS GLSC. Copies of all files are held separately at the NOAA Great Lakes Environmental Research Laboratory for backup protection against fire, vandalism, and computer failure.

Table 6.1. Reported statistics associated with each biotic element.

Biotic element	Strata	Measurement	Statistic
Lake trout	age, season, region	length, weight	mean, standard error, range, sample size
Lake trout diet	age, season, region, diet taxon	number, wet weight, length	mean, frequency of occurrence, percent by weight of all prey, standard error, range, sample size

This information together with QA findings will be reported to the GLNPO, PO, QAM, and Biota Group.

7.0 Internal Quality Control Checks

Quality assurance for this project will be achieved primarily through specific training both prior to sampling and during the sampling season. Several persons on the GLSC staff are experienced in diet sampling (Eck and Wells 1983, Gary Eck, and Edward Brown, Cruise Reports of the R/V Cisco on file at GLSC of NBS, Ann Arbor), and will provide training on procedures before the sampling begins and while it is in progress. Less experienced field staff will work with experienced staff until such time that the quality of their work justifies them working independently. The quality of field staff work will be checked by the Field Manager or Project Manager sampling at least once or twice during each sampling cruise throughout the duration of the project. Additional checks will be made whenever needed.

Measurements of length and weight required for this project are straight forward, and their variation will be a function of the ruler or weight scale used rather than the person taking the measurements. Measuring boards or rulers will be examined prior to field work to ensure that the error between them is less than ±2 mm. As indicated in Table 1.1, the readability of the weight scales used is 0.1 g for small fish and diet items measured in g, and 50 grams for most lake trout which are much larger and therefore measured in Kg.

In the field, the Project and Field Manager will make independent measurements and Field Sampling Analysts will make remeasurements as detailed in SOP 1 (Appendix 1) for at least 5% of the samples from each season/region stratum. Similarly, in the lab, the Field Manager will make independent measurements and Field Sampling Analysts will make remeasurements as detailed in SOP 2 (Appendix 2) for at least 5% of the samples from each season/region stratum. The resulting data will be recorded on separate Field and Lab Data Sheets, as described in SOPs 1 and 2, and identified as QC Audits. Using these data and data from original measurements, precision, accuracy, and completeness will be calculated for all parameters identified in Table 3.0.

During the diet analysis of lake trout stomach contents in the lab, examples of each species of prey fish and taxonomic group of invertebrate consumed by the trout will be preserved in glass jars with 5% formalin for reference in identification. Examples should cover the range in stages of digestion of the different sizes of prey observed. These specimens will aid in documenting the methods of identification and quantification used in the stomach contents analysis. Each sample will be labeled as to its source (Sample 1. D. No.), taxonomic identification, and measurement values (i.e. length and weight, etc.).

In addition, identification criteria will be developed during training when no good ones exist.

8.0 Performance and Systems Audits

Specific audits will not be conducted as part of this sampling project. Procedures required for the project are straight forward and uncomplicated. The duration of the project is also short enough that at least one or two checks per field trip and per month in the laboratory on performance of the field and lab staff will serve as audit checks for the project. The number of staff involved in this project will be small, therefore, the ability to control the quality of the project will not require elaborate auditing procedures. Quality control audits at each stage of the field sampling and analysis will be conducted by the Project Manager, the Field Manager, or the EPA QA Manager. The auditing will focus mainly on the precision, accuracy, and completeness of the parameter measurements identified in Table 3.0 as well as on the proper handling and processing of the contaminant and diet samples. The auditing will involve remeasurement and independent measurement procedures listed in Table 3.0 and discussed as to frequency in Section 8.0, and observation of the sampling/processing operation and the condition of the samples. Audit reports will be kept on file at the GLSC of NBS and available for review at any time. Moreover, EPA may audit at any time.

Inadequacies in sampling procedures or the quality of the data collected will immediately be addressed immediately by the Project Manager or Field Manager when discovered. All previous and current data collected by the person when the inadequacies were first discovered will be reviewed for accuracy. Additional training and supervision will then be provided until the quality of work is adequate. In addition, an audit form for this project will be developed.

9.0 Calculation of Data Quality Indicators

This QA Plan has defined the DQOs and MQOs (Section 3.0). This section describes the statistical assessment procedures that are applied to the data and the general assessment of the data quality accomplishments.

9.1 Precision

The precision will be evaluated by performing duplicate analyses. Various types of duplicate samples are described in Section 3.0. Precision will be assessed by relative percent difference (RPD).

Relative Percent Difference (RPD)

$$RPD = \frac{(X_1 - X_2) * 100}{(X_1 + X_2)/2}$$

Relative standard deviation (RSO) may be used when aggregating data.

Relative Standard Division (RSD)

$$RSD = (s/\bar{y}) * 100$$

Where: s = *standard deviation*
$\bar{y}$ = *mean of replicate analyses*

Standard deviation is defined as follows:

$$s = \sqrt{\sum_{n=1}^{n} \frac{(y_1 - \bar{y})^2}{(n-1)}}$$

Where: y_1 = *measured value of the i the replicate*
$\bar{y}$ = *mean of replicate analyses*
n = *number of replicates*

9.2 Accuracy

Accuracy will be based upon expert remeasurements of a percentage of samples.

Accuracy will be evaluated by determining whether the measurements are within the acceptance limits. Deviations beyond the acceptance criteria could be justification for retraining technicians.

Bias can be estimated from the theoretical "true" value of the expert measurement. "System" bias for the study may be calculated from individual samples and is defined:

$$Bias = \frac{\sum (Y_{ik} - R_i)}{n}$$

Where: Y_{ik} *= the average observed value for the i the audit sample and k observations.*
R_i *= is the theoretical reference value*
n = the number of reference samples used in the assessment

9.3 Completeness

Completeness for most measurements should be 90%. Completeness is defined:

$$Completeness = \frac{V}{n} \times 100$$

Where: V = number of samples judged valid
n = total number of measurements necessary to achieve project objectives

The 90% goal means that the objectives of the survey can be met, even if 10% of the samples are deemed to be invalid. An invalid sample is defined by a number of combination of flags associated with the sample. This value will be reported on an annual basis.

9.4 Representativeness

Based upon the objectives, the three seasonal collections (spring, summer, fall) represent different lake trout diet conditions. In order to determine whether a change is statistically significant, the samples must be representative of the population, and the samples must be collected and analyzed in a consistent manner.

Representativeness will be evaluated through variance estimates of routine sample in comparison to previous years estimates if the latter are available. These estimates would be performed at within-site and between-site levels, as appropriate. Analysis of variance (ANOVA) will be used to determine whether variances are significantly different.

9.5 Comparability

Comparability is very similar to representativeness in that comparability is ensured through the use of similar sampling and analytical techniques. Comparability will be assessed through the evaluation of precision and accuracy measurements and technical systems audits.

10.0 Corrective Action

The possible corrective actions that can be anticipated in advance have been covered and discussed in Table 3.0 and in Sections 7.0 and 8.0. If any nonroutine corrective action is required it will be initiated and implemented by the Project Manager, Edward Brown, or by the Field Manager (Gary Eck, Ralph Stedman, or Randall Owens) as appropriate. Such action will be documented in audit reports, through data flags listed in Table 10.0 or yet to be developed, in revisions of the QA Plan if methods must be changed, and in the final report.

Table 10.0. List of data flags.

LAC	Laboratory accident	There was an accident in the laboratory that either destroyed the sample or rendered it not suitable for analysis.
FAC	Field accident	There was an accident in the field that either destroyed the sample or rendered it not suitable for analysis.
ISP	Improper sample preservation	Due to improper preservation of the sample, it was rendered not suitable for analysis.
CON	Consensus	Consensus to report a range of ages.
UNK	Unknown sex	In the case of species, indicates undetermined sex.
EER	Entry error	The recorded value is known to be incorrect but the correct value cannot be determined to enter a cortecton.
OTL	Data point outlier	When a series of data are plotted and anaylzed, this point is obviously not within the normal distribution of data, and eliminated from further analysis.

11.0 Quality Control Reports to Management

A progress report outlining the achievement of the Quality Assurance Objectives will be provided to the Program Manager, the QA Manager, and the Project Co-coordinators at the end of the project. The Project Manager will be notified immediately, however, if substantive changes are made to the QAPJP. The Quality Control Report will include a summary of the results of audits that were conducted, data quality assessment, and the corrective actions that were taken. In short, the degree to which the targeted precision, accuracy, and completeness goals were met will be indicated in the Final Report.

12.0 References

12.1 Bowen , S.H. 1983. Quantitative description of the diet, p. 325-336. In Nielson, L. A. and Johnson, D. L. (eds.) Fisheries Techniques. American Fisheries Society, Bethesda, MD. 468 pp.

12.2 Eck, Gary W. and Wells, L. 1983. Biology, population structure, and estimated forage requirements of Lake Trout in Lake Michigan. Technical Papers of the U- S. Fish & Wildlife Service, No. 111, 18 pp.

12.3 Eck, Gary W. and Wells, L. 1987. Recent changes in Lake Michigan's fish community and their probable causes, with emphasis on the role of the alewife (*Alosa pseudoharengus*). Can. J. Fish. Aquat. Sci. 44 (Suppl. 2): 53-60.

12.4 Elliott, Robert F. 1993. Feeding habits of chinook salmon in eastern Lake Michigan. M.S. Thesis, Michigan State University, Lansing, MI, 108 pp.

12.5 Holey, Mark E. and Elliott, Robert F. 1994. Quality assurance project plan for coho sampling for contaminant and diet analysis in Lake Michigan. Biota Work Group, Lake Michigan Mass Budget/Mass Balance Project, 21 pp. Mimiog.

12.6 Lake Michigan Lake Trout Technical Committee. 1985. A draft lakewide management plan for lake trout rehabilitation in Lake Michigan. Minutes of Lake Michigan Committee, Great Lakes Fishery Commission, 1985 Annual Meeting, Ann Arbor, Michigan, March 1985.

12.7 Miller, Michael A. and Holey, Mark E. 1992. Diets of lake trout inhabiting nearshore and offshore Lake Michigan environments. J. Great Lakes Res. 18(l.): 51-60.

12.8 Nielson, L.A. and Johnson, D.L. eds. 1983. Fisheries Techniques. American Fisheries Society, Bethesda, MD. 468 pp.

Appendix 1.

SOP-1: Sampling Lake Trout and Forage Fish for Contaminant Analysis and for Diet Analysis of the Trout

1.0 SAMPLING LAKE TROUT AND FORAGE FISH FOR CONTAMINANT ANALYSIS AND FOR DIET ANALYSIS OF THE TROUT

This SOP provides the step by step procedure for collecting, measuring, preserving, and transporting Lake Trout and forage fish and stomach contents removed from lake trout for the Enhanced Monitoring Program Lake Michigan Mass Balance Study.

1.1 Overview

Lake trout and forage fish samples will be collected at the three Biota Sites identified in the Lake Michigan Mass Balance Work Plan of October 14, 1993. These samples will be used to measure contaminant concentrations in the fish tissue of PCBs, Mercury, and trans-nonachlor and to examine the diet of the trout by evaluating their stomach contents. The following critical and noncritical information associated with the samples will be recorded:

Critical	Noncritical
1. Location	1. Gear
2. Date of sample	2. Sampling depth
3. Sample length	3. Time sampled
4. Sample weight	4. Water temperature
5. Fin clip (Or absence of clip)	

The lake trout and forage fish samples to be collected for contaminant analysis are of primary importance and therefore must be prepared and preserved as soon after collection as possible for transport to the laboratory for analysis. During the field processing, stomachs will be removed from the lake trout and preserved for diet analysis in the laboratory.

1.1.1 Summary of Method

Lake trout will be sampled with graded-mesh gill and forage fish with trawls fished from the NBS's R/V Cisco on the bottom at each of the three Biota Sites in spring, summer, and fall. The numbers of fish specified in the LMMB Work Plan together with the extracted stomachs of the trout will be transported frozen to the GLSC laboratory of NBS in Ann Arbor, Michigan for contaminants and diet analyses. Individual lake trout will be aged at GLSC from coded wire tags inserted in their snouts and indicated by adipose fin clip or from other fin clips or scales. Bloater chubs, one of the three target species, will be aged

from scales.

1.2 Safety

In any field operation, emphasis must be placed on safety. Samplers must be aware of the potential safety hazards to which they are subjected. Follow all safety protocols and equipment guidelines, and be prepared for emergency situations. The sampler is primarily responsible for his/her safety from potential hazards.

1.3 Equipment check and calibration

The following is a list of all needed equipment and consumables.

1.3.1 Equipment

Serviceable Equipment

Fishing vessel equipped with
-Locational instruments (GPS, Loran, Radar)
-Sampling gear (gill nets, bottom and midwater trawls)
-Electronic BT
Ice chests and bagged ice
Measuring board (mm markings required)
Plastic buckets (3- and 5-gallon)
Spring scale (1-10 Kg; Kg markings required)
Beam balance scale (0.1 to ? g; g markings required)
Calibrating weight
Dissecting pan (contaminant fish sampling only)
Dissecting knives
Thermometer (contaminant fish sampling only)
Lap-top computer

Consumable Equipment

Dissecting gloves (contaminant fish sampling only)
Aluminum foil (contaminant fish sampling only)
Plastic fish storage bags (contaminant fish sampling only)
Whirl-pac bags
Sample labels (contaminant fish sampling only)
Marking tools (pencils & permanent markers)
Fish scale envelopes
Cleaning sponge and brush
Rubber gloves for
-preserving fish
-handling fish

1.3.2 Calibration and Standardization

Equipment necessary for calibration and the required frequency can be found in Table 1.

Table 1. Equipment necessary for calibration and the required frequency.

Instrument	**Calibration technique**	**Frequency**	**Acceptance criteria**
Thermometer	Ice bath and boiling water	1/year	+/- 2 degrees C
Locational device	Calibration to a standard of known Lat and Long	per trip	+/- 0.25 Km
Measuring Board	Check against second device	1/year	+/- 2mm
Scale	Check against standard S class weights; 1,5,10,25 kgs	daily	+/- 0.1 kg

1.4 Procedures

1.4.1 Collection of Contaminant Samples

Contaminant samples will be collected onboard the NBS's R/V Cisco, using gill nets for lake trout and trawls for forage fish. Because age of fish will only be roughly approximated in the field based on length, the Field Manager should oversample as necessary to help insure that the specified sample sizes are met for both contaminants and diet analyses (Table 1.0).

1.4.1.1 Daily location, weather, and fishing operation data are routinely recorded by the Vessel Captain in the Ship's Log. Detailed information on location, gear, fishing effort, catch (total number and weight by species), length frequencies of selected species, predator-prey data including size and stomach contents of selected species such as lake trout, etc, were formerly recorded on a detailed set of field forms, but are now entered directly into a lap-top computer for later transferral to the GLSC's RVCAT data base. (See RVCAT overview in Appendix 4 and Data Entry Screens in Appendix 5 of the QAPP). Surface to bottom water temperature profiles are taken with an electronic BT when each gear is set and are later downloaded in table format.

1.4.1.2 For each lake trout collected and each composite sample of each forate species, record the following site and sample indentification data on two I.D. Labels, and on a whirl-pac bag (see Appendix 6 of the QAPP Planfor data required on label). Note: The recorded data will include: Sampling objective (contaminant, diet, audit), Date, Lake, Location (including Biota Site & Port), Serial No., Species, Sample I.D. No., Age/Size Group, Field Qualifier Flag, Collector's Name, and Preservative.

1.4.1.3 For all lake trout sampled determine and record the following in the field or in the laboratory of GLSC if indicated otherwise.

-Maximum Total Length (mouth closed and caudal fin dorso-ventrally compressed) to nearest mm using the measuring board.
-Total Weight (to the nearest 0.1 Kg. using the spring balance) of fish taken for diet only; fish for both contaminant and diet analyses will be weighed in the GLSC laboratory.
-Fin clips will be recorded in the field for diet samples only; fish for both contaminants and diet will have clips recorded in the laboratory.

1.4.1.4 For each lake trout referred to in Section 1.3 that is 600 mm and longer remove at least five scales (from just above the lateral line and below the posterior insertion of the dorsal fin) with a clean knife when fin clips are recorded and place the scales in a scale envelope. Label the envelope.

1.4.1.5 Line the examination tray with aluminum foil and place a lake trout in the tray. Make a 3-5 inch incision with a clean knife in the belly of the fish. Pull out and remove the stomach (anterior esophagus to pyloric sphincter) and all its contents. The spleen and any other organs or excess flesh that may be attached to the stomach should be placed back inside the fish. If the stomach appears empty, open it to verify that it is completely void. Indicate so in the predator-prey file in the Lap-Top Computer. Void stomachs need not be kept. Pack the whirl-pac bag with the stomach and its contents and preserve them in the chest freezer.

1.4.1.6 Wrap each lake trout completely with the foil lining the examination tray and attach one I.D. label to the foil, while being careful to retain all body fluids within the foil. Place wrapped fish in a 4 mil polyethylene (Arcan Manufacturing, Plainwell, MI), seal the bag and attach the other I.D. label.

1.4.1.7 Place the bagged fish in Vessel's chest freezer for preservation, or in a cooler and pack with ice until it can be transferred to another freezer.

1.4.1.8 Thoroughly clean and rinse all equipment that comes in contact with sampled fish between sampling individual fish.

1.4.1.9 Keep all samples in your possession in their preserved state (frozen or on ice) until they have been delivered to the GLSC laboratory of NBS in Ann Arbor where subsequent analysis will be conducted. Transport only in NBS approved vehicles. Initiate a Chain of Custody form showing date of delivery and state of preservation, etc. (See a copy of the form in Appendix 7 of the QAPP). Flags if appropriate should be included in the Remarks or Comments columns of the Custody form.

1.4.1.10 Wrap Forage Fish including the Bloater Chub, which is categorized as both a target and forage species in the LMMB PLAN, in the aggregate in aluminum foil. Make no incisions in these fish. Then place them in the polyethylene bags in the aggregate by species and age/size groups specified in the PLAN. Label each bag inside and out with the information shown in Appendix 6 of the QAPP, except for Sample No. which is applicable only for individual predator species (e.g. lake trout), and preserve them in the chest freezer or a cooler with ice. Keep these samples in possession in accordance with instructions for lake trout in 1.4.1.9 above.

1.4.1.11 Within the constraints of the demarcation of forage fish for diet sampling into the age and size groups specified in the LMMB Plan of October 14, 1993, special care must be taken to assure that these fish are representative by size (and hence age) of all fish caught of the various categories being sampled.

1.4.1.12 When the trawl catch is small, the entire catch is retained and sorted by species on the sorting table in the bow of the R/V Cisco. When the catch is large, however, it is first randomly subsampled in the stern of the boat after running it into plastic fish boxes that hold about 50 lbs. each. The randomization is accomplished by running the fish box or boxes back over a 5 gallon bucket or buckets while fish are slowly "pouring" from the box. The subsample in the buckets is sorted into species in the lab, and each species is counted and weighed. The numbers and weight of the individual species in the total trawl catch are estimated from the total weight of the trawl catch and the proportions (weights and numbers) of the individual species in the subsample.

1.4.1.13 A sample of the catch of fish in each diet group will then be obtained by first mixing and spreading all fish in a given group on the sorting table. All fish on a section of the table will then be retained for the diet sample. This procedure is intended to avoid the inevitable bias that occurs when the sorter picks fish individually from the catch.

1.4.1.14 Because the age of bloater chubs will not be known in the field, a length cut-off based on sampling in recent years will be used to obtain an approximate separation by age into the specified age categories for chubs of 0-2 years and 4 + years of age.

1.4.1.15 As for lake trout as described in 1.4.1.9 above, keep all field samples of forage fish for contaminant analysis in your possession in their preserved state (frozen or on ice) until they have been delivered to the GLSC laboratory of NBS in Ann Arbor where the analysis will be conducted. Transport only in NBS approved vehicles. Initiate a Chain of Custody form showing date of delivery and state of preservation, etc. (See copy of the form in Appendix 7 of the QAPP). Flags if appropriate should be included in the Remarks or Comments columns of the Custody Form.

Appendix 2.

SOP-2: Lab Analysis of Lake Trout Stomachs and Data Entry

2.0 LAB ANALYSIS OF LAKE TROUT STOMACHS AND DATA ENTRY

This SOP is intended to provide a step by step procedure for examining and quantifying the contents of the stomachs sampled, and then entering all data on the computer as part of determining the diet of lake trout for the Enhance Monitoring Program Lake Michigan Mass Balance Study.

2.1 Overview

2.1.1 Summary of method

2.2 Safety

In any laboratory operation, emphasis must be placed on safety. Personnel must be aware of the potential safety hazards to which they are subjected. Follow all safety protocols and equipment guidelines, and be prepared for emergency situations. Each person is primarily responsible for his/her safety from potential hazards.

2.3 Equipment Check and Calibration Check

Check to insure that all equipment and supplies are available in required amounts. The following is a list of all needed equipment and consumables.

2.3.1 Equipment

Serviceable Equipment

Fume hood
Rinse water supply and rinsing bath
Rinse tray
Dissecting tray and tools (scalpel, forceps, scissors)
Dissecting microscope
Electronic balance and calibration weights
Plastic ruler (mm divisions)
Glass specimen jars
Scale press
Scale projector/reader
Computer & printer (with hard drive, disk drive, and necessary software)

Consumable Equipment/Supplies

Formalin (5%)
Rubber gloves
Impression acetate
Paper toweling
Plastic bags (2-5)
Reporting sheets and marking devices

2.3.2 Calibration and Standardization

Equipment necessary for calibration and the required frequency can be found in Table 2.1.

Table 2.1 Equipment necessary for calibration and required frequency

Instrument	**Calibration technique**	**Frequency**	**Accepted criteria**
Plastic ruler	Check against second device	Start-End/ season	+/- 1 mm
Electronic balance	Use calibration weight (300 g) and slope adjust	Daily	+/- 0.1 g
Computer	Virus scan	Every boot-up	No viruses

2.4 Procedures

The following procedures will be discussed:

Sample preparation
Identification and quantification of prey items
-Numeration and estimation (for invertebrates)
-Length measurement and
-Weight measurement and estimation
Archiving representative samples
Mounting and aging scales
Data recording
Verifying data
Determining conversion data and developing formula

2.4.1 Analysis of Stomach Contents

Proceed with the following steps in a well ventilated (fume hood operating if necessary) area intended for such work. Wear rubber gloves when handling preserved prey items. Have equipment set up, calibrated, and ready for use, and start with and maintain a clean work area.

2.4.1.1 Identify each prey fish to species, assign it a percent digested state, and measure (nearest mm) and weigh (nearest 0.1 g) it. Record data as indicated on the lab data sheet. Measure length to the level of precision allowed by the amount of fish remaining. Order of priority is: 1) maximum total length, 2) standard length, 3) vertebral column length, 4) length of a multiple of 5 vertebrae (preferably near the caudal region). For those fish or parts of fish that cannot be positively identified, record as unidentified remains.

2.4.1.2 Identify and group invertebrates into appropriate taxa and weigh (nearest 0.1 g) each taxon as a group. Either count all individuals in a group or estimate the total number based on weight (at least 0.5 g or 25 individuals) of a known number representative of the group. Record data as indicated on a lab data sheet.

2.4.1.3 Repackage stomach contents in their whirl-pac bag and freeze. To facilitate sample retrieval and verification under quality control, store groups (10-25) of the whirl-pool bags containing the individual samples from similar locations and dates together in clear plastic bags in freezer storage.

2.4.1.4 Make several photo copies of each completed Lab Data Sheet and file at separate designated locations.

2.4.2 Aging Lake Trout and Bloater Chubs from Scales

The methods for preparing scales for aging fish and for verifying age are adequately described in Fisheries Techniques (Nielson and Johnson 1983) and in the published literature. The following highlight the procedure.

2.4.2.1 Make an impression of at least 5 lake trout scales from each scale envelope on an acetate slide and return the scales and slide to the envelope after checking the slide for clarity and detail.

2.4.2.2 Age each fish by counting annuli observed on a clear impression of one of the scales viewed on a scale projector. Record the age in years using the convention that a fish is age O in the year hatched and becomes one on January 1st of each subsequent year of life.

2.4.2.3 Follow the same procedure for bloater chubs. However, if detail needed for aging is incomplete, the scales may be placed between glass slides, cleared with water, and read direct with the scale projector.

2.4.2.4 At least 5% of the fish should be reaged by the original person making the determination and by a second person. Assign and record final age on the envelope based on consensus reached by both of these individuals or by the majority if a third independent reader is necessary. A length at age frequency distribution based on known-age lake trout as determined from coded-wire tags may be used to locate possible outliers for reaging, but allowance must be made for previously observed differences in growth rate between Biota Sites (e.g. growth has been slower on the Midlake

Reef).

2.4.3 Standard Measurements for Developing Conversion Equations

To allow reconstruction of total prey length and weight from partial length measures, and to allow the conversion of total length and weight of preserved prey to length and weight of fresh prey (or vice-versa), the following procedures will be followed.

2.4.3.1 For up to 50 intact individuals representing all sizes of each prey fish species (5 per 1/10 of size range encountered from preserved stomachs), measure total length and weight, and then dissect the fish and measure (nearest mm) the standard length, the vertebral column length, and the length of 5 vertebrae from the posterior and anterior regions of the vertebral column; also count the total number of vertebrae. Record these measures on a separate lab data sheet and identify as Standard Measures.

2.4.3.2 When in the field, the Project Field Manager will conduct independent measurements of enough stomach contents (steps 2.4.1.2 and 2.4.1.2 of SOP 2) so that at least 50 prey fish representing all sizes and digested states be identified and measured prior to preservation for later lab analysis. These data will be recorded on a lab data sheet identified as Standard Measurements.

2.4.3.3 Enter all data from Standard Measurements Data Sheets into prescribed fields of the appropriate data base.

2.4.3.4 Develop the following conversion equations with associated errors for each prey species:

Vertebrae length to vertebral column length and total length
Vertebral column length to standard length and total length
Standard length to total length
Total length to wet weight
Preserved total length to fresh total length
Preserved wet weight to fresh wet weight

2.4.3.5 Compare to similar equations developed from other studies to determine validity.

2.4.4 Data Entry and Verification

2.4.4.1 Maintain three independent copies of the data (on hard drive, on disk, and hard copy printout) in different locations and update/backup each on a daily basis when altered.

2.4.4.2 Record all data generated in the laboratory on lake trout diet and age on special Lab Data Sheets that will be designed for that purpose. Record complementary observations and qualitative data in a Lab Log Book. On a daily basis if practical, enter these data from the data sheets into the RVCAT data base from which it can be accessed and analyzed with the aid of personal computers.

2.4.4.3 Using equations determined in 2.4.3:

-Calculate missing total length measures from partial length measures and add to the database.

-If entered data are from both fresh and preserved prey, transform one and add to the database so that a consistent measure is entered for all.

2.4.4.4 Identify and correct inaccuracies in data recording and entry, and identify outliers as follows:

1) Plot data variables, identify peripheral values, and cross-reference with original data records. Example plots include:

-Predator length vs weight
-predator length vs date
-Prey length vs date
-prey length vs weight (by length type)

2) Query all data fields for values above and below expected values and cross-reference with original data records.

3) Visually compare and verify each computer record with field and lab records on original data sheets.

4) Resolve with the data collector any possible errors in recording.

5) Flag as an outlier any data that after completing the above, still appears to be outside the range of expected values.

Appendix 3.

SOP-3, Coded Wire Tags (CWT)

STANDARD OPERATING PROCEDURE (Modified from Lake Ontario SOP)

Lake Michigan

Purpose:
Use of a coded wire tag (CWT) injected into the snout for marking hatchery-reared lake trout stocked into Lake Michigan began in earnest in 1985. Lake trout marked with CWTs have also been stocked into Lakes Erie, Huron, and Ontario. Chinook salmon have been marked with CWTs and stocked into Lakes Michigan and Ontario. Evaluation of the returns from fish injected with CWTs provides information about growth, movement, and mortality of populations of hatchery-reared fish released to the lakes.

Marking Convention:
The Great Lakes Fishery Commission has reserved the adipose fin clip, as a single clip, for lake trout that receive a CWT. For fish that do not receive a CWT the adipose fin may be clipped in combination with another fin. Sometimes hatchery personnel fail to clip the adipose fin or clip some other fin of fish that are injected with a CWT. In addition, a dorsal, pectoral, or pelvic fin may be injured, malformed, or congenitally missing. Thus, a few fish with no clip or a mark other than an adipose clip may have a CWT in their snout. An electronic wand used to detect and signal the presence of metal in the snouts of fish may be used either in the field or in the laboratory to help verify the presence of CWTs in individual fish.

Field Procedure:
Record total length (mm), weight (g), fin clips, sex, maturity, sea lamprey wounds and scars, and stomach contents using the computer or standard field data entry form.

If there is a possibility that a fish has been marked with a CWT, cut off the snout behind the eye sockets, and place the snout in a compartmented polypropylene box. Each box should have a unique number engraved on the lid and front, and each compartment should be permanently numbered. Record the box and compartment numbers on the field data form in the space provided.

If the snout is too large for the compartmcnt, or if no compartmented box is available, place the snout in a jar or plastic bag (one snout per container). Record the sample, serial number and fish number on a waterproof label and place the label in the bag or jar and securely close the top.

Freeze the collection of snouts. In the special circumstance that a fish identified as containing a CWT is also a fish required for contaminant analysis, the fish is left intact and handled according to the contaminant analysis protocol in force. The CWT is extracted later at the laboratory under joint responsibility of Lake Michigan and Contaminant Monitoring personnel.

Laboratory Procedure:
Prepare a solution of sodium hydroxide (effective concentration of 15%). Warning - Sodium hydroxide is caustic and should be handled with extreme care. When preparing the solution, laboratory gloves, lab coat and eye protection should be worn. Sodium hydroxide solution is to be slowly added and stirred into the water, NOT the reverse; that is, water is NOT to be added to the solution. Remember that a highly

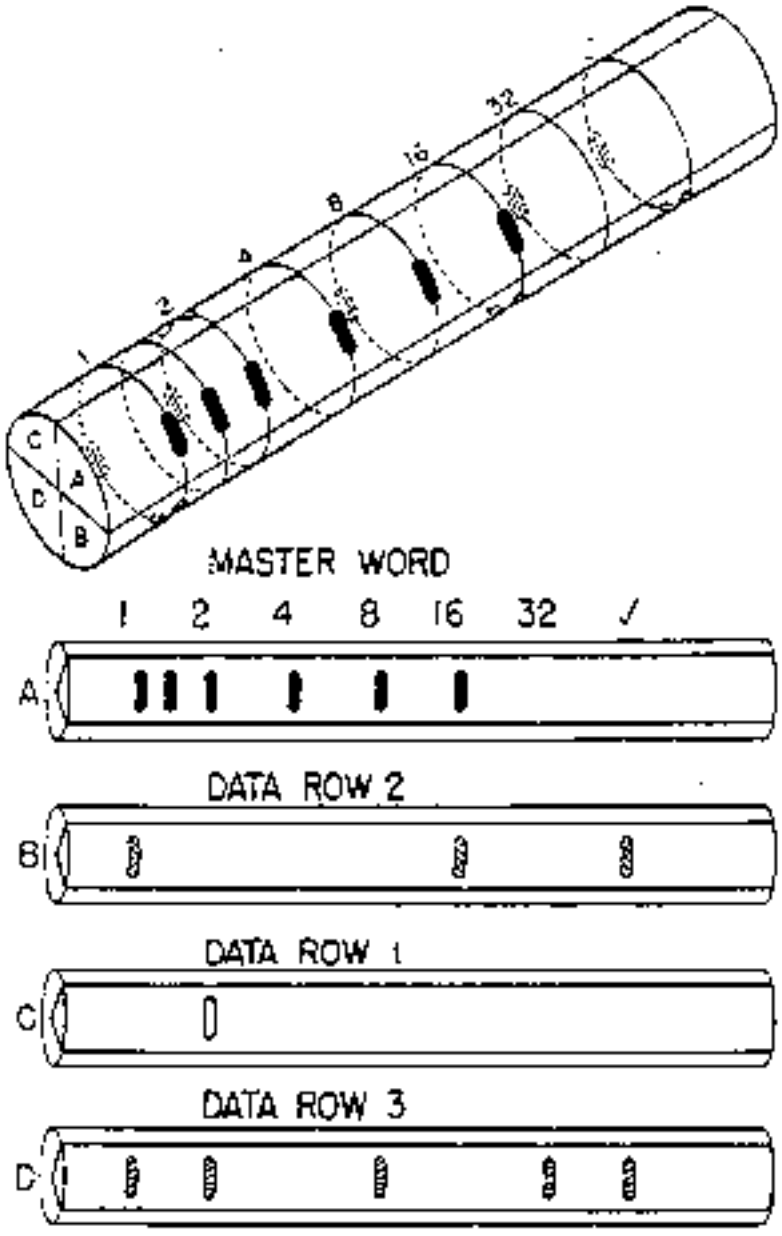
exothermic reaction results from adding sodium hydroxide to water so be careful about the integrity of the containers used to carry the solution. Refer to the Material Safety Data Sheet (MSDS) in the Laboratory Safety Manual. Cover each snout with the sodium hydroxide solution and let stand until the flesh is liquified (usually overnight). Remove the CWT from the solution with a magnetic stirring rod. Rinse the stirring bar/CWT in vinegar and then in water and transfer the CWT to a magnetic pencil.

Using a tag-reading jig and a binocular microscope, decipher the code. A procedure provided by the tag manufacturer for deciphering the CWT code is attached.

Record the six-digit code in the space provided on the field data form. Affix the CWT to the field data form adjacent to the code using a double strip of clear adhesive tape.

A second reading by an independent observer without reference to the code recorded on first reading is required. If the two readings do not agree, another reading by each of the observers should resolve the disagreement.

BINARY CODED MICRO-TAG



BINARY CODED TAG FORMAT

Data is carried on binary coded wire tags in six binary-digit words, or numbers. Consider the number 1066. It might similarly be called a four decimal-digit word, and can be written in columns as follows:

1000s	100s	10s	1s
1	0	6	6

Said another way, it means the sum of 1 thousand, no hundreds, six tens, and six ones.

Binary-digit words, or numbers, can be written in columns in the same way:

32s	16s	8s	4s	2s	1s
1	1	0	1	0	1

The binary number 110101 thus means the sum of 1 thirty two, 1 sixteen, O eights, 1 four, 0 twos, and 1 one, or 110101 binary = 53 decimal.

The binary coded wire tag material is marked with four six-digit binary words written lengthwise on the wire, 90° apart around its circumference. Three of these words carry the data, and following them is a seventh digit in each row which is used as an error check as explained below. The fourth word is known as the master word and is always the same. Its purpose is to mark the beginning of the data words and to identify the direction in which they are to be read.

The information is carried by notches on the wire spaced .0048" apart. Notches are read as binary 1; no notch is read as binary 0. At the standard length .042", this means that there are at least 8 visible mark positions on a tag. The logic in the coding system is such that tags as short as .030" guarantee unambiguous data recovery. (A similar, but not identical, scheme is used to mark "half-length" or .020" tags. Reading instructions for half-length tags are available request.)

The data format on a coded wire tag is keyed to the seven-bit word which we call the master word. This word, always the same, is unusual in that it contains an extra, in-between, mark, i.e., the word looks like

00111M.

The half-interval mark between the first and second normal marks is instantly apparent. Every tag bears this word, although it may start and end in different places, e.g., 11M001, as a result of the random nature of the cutting process.

To read a coded wire tag, find the master word and orient the tag horizontally so that the master word reads in the correct direction, 00111M. Then the remaining data are to be read according to the following conventions:

1. The column labels for the data words are derived from the master word:

0	0	1	1	1	1	1	1	MASTER
Ck	32	16	8	4	2		1	COLUMN IDENTIFICATION

2. With the master word on top of the wire and running in the proper direction, rotate the tag on its axis so that the master word moves up, As the three data words come into view, they are, in order:

    1. DATA WORD 1
    2. AGENCY CODE
    3. DATA WORD 2

If one were to imagine the surface of the tag unrolled as if it were a sheet or paper, it would look like this:

Check	32s	16s	8s	4s	2s		1s	COLUMN IDENTIFICATION
0	0	1	1	1	1	1	1	MASTER WORD
1	1	0	1	1	0		1	DATA 1 = DECIMAL 45
1	0	0	1	1	1		1	AGENCY = DECIMAL 15
0	1	1	0	0	1		0	DATA 2 = DECIMAL 50

The convention adopted for the seventh column, the check bit, is that the sum of the notches in each of the three data rows must always be <u>odd</u>. This provides a check against coding errors in the data. For example, if the required number was

101101 (six bit word),

there are four binary ones, or notches; the sum is, therefore, even; and the check bit must also be a one. The data would appear on the tag wire as

1101101.

If the data were to be

010110,

the checked data would appear on the tag wire as

0010110

since the data word already has an odd number of bits, and the check bit must be zero.

The information on each of the four sides of the tag wire is repeated continuously every seven spaces. Since tags are cut off every 8.5 spaces, actual tags may be cut at any point in the word. An example of a tag cut between the 4s and the 8s columns follows:

4s	2s		1s	Ck	32s	16s	8s	COLUMN IDENTIFICATION
1	1	1	1	0	0	1	1	MASTER
1	0		1	1	1	0	1	DATA 1 = DECIMAL 45
1	1		1	1	0	0	1	AGENCY = DECIMAL 15
0	1		0	0	1	1	0	DATA 2 = DECIMAL 50

APPENDIX 4.

Research Vessel Catch Information System (RVCAT)

Introduction

RVCAT - System Overview

This is an overview of the information system used by the Resource Assessment Section of the National Fisheries Center - Great Lakes. The system will be referred to simply as RVCAT (Research Vessel Catch Information System). It is a living and growing system pulling raw data from the Great Lakes and producing information of use to the Lakes Community. The purpose of RVCAT is to provide clear, consistent and easy access to research vessel data for vessel biologists.

Research vessel data was first collected on Lake Superior in 1953 and each year since the vessel base was established in 1957. Data was collected from Lake Michigan in 1954, 1955 and annually since 1960. Collections were made in 1956, 1969 and regularly beginning in 1972 on Lake Huron. The Lake Erie Vessel base was established in 1959 with collections made as well in 1957 and 1958. The Lake Ontario station was begun in 1977 with vessel operations beginning in 1978.

The intended computer hardware platform for RVCAT is any system which supports Statistical Analysis System (SAS Institute, Cary, NC) and ORACLE (ORACLE Corp., Belmont, CA) software. Currently, RVCAT is implemented an a Data General MV series mini-computer and IBM-PC compatible micro-computers. One goal of RVCAT is to be transportable to diverse computing environments, so that it is not limited by hardware or software which becomes out of date, or of differing capacities.

ORACLE is used for all basic data management and reporting functions, and SAS is used for statistical analysis. Other software may be used as well for specialized needs.

RVCAT is implemented and maintained jointly by Vessel Biologists of Resource Assessment and Biometrics and Computer Services staff. The system has been partitioned into 12 compartments. A list of Responsible People and their suggested assignments is included elsewhere in this manual.

RVCAT Background

The RVCAT system began in 1972 as a collection of miscellaneous batch programs written for the IBM 1130. As the need arose for specific reports, new programs were added. Several users took part in designing these reports and the new data record formats needed to enter data into the system. Data were originally stored on punched cards.

In 1976, the laboratory gained access to the University of Michigan MTS computing system, as a remote batch station.

Programs and data files were gradually transferred to that system and backed on magnetic tapes. Edit programs were written to provide greater control over data accuracy.

Over the years, it became necessary to change record formats, and programs had to be modified in various ways to accommodate changing needs. In 1978, the entire data base was rewritten in the new format.

Then, in 1984, it was decided that the programs should be rewritten to be interactive, giving users various options in the way data was to be organized and tabulated. At the same time, data retrieval programs were written to allow users to retrieve subsets of data from the original master files, and routines were developed to permit users to run the various programs associated with the data. This system was called RVCAT I.

In the spring of 1985, Viking Forms Management software was purchased for IBM-XTs to replace key-to-card data entry with key-to-disk data entry.

In the fall of 1985, a Data General MV4000 mini-computer was purchased to replace the 1130 system, and it became necessary to transfer programs and data to a new operating system. Data files were converted from the tape format used by MTS to a form acceptable by the Data General, and transferred to the new system. At the same time, various report format changes were decided upon, and the need for more flexibility in running the programs was recognized. To meet these needs, the system called RVCAT II was developed, and became operational in September, 1986.

In January, 1988, a committee was formed to completely review and revise RVCAT. A relational database management system (ORACLE) was identified which would permit the development of a system which would be compatible between the field stations and the Center. It was projected that ORACLE could provide DBMS needs and Statistical Analysis System (SAS) could provide statistical support. Automated data entry on the research vessels was proposed including digital measuring devices.

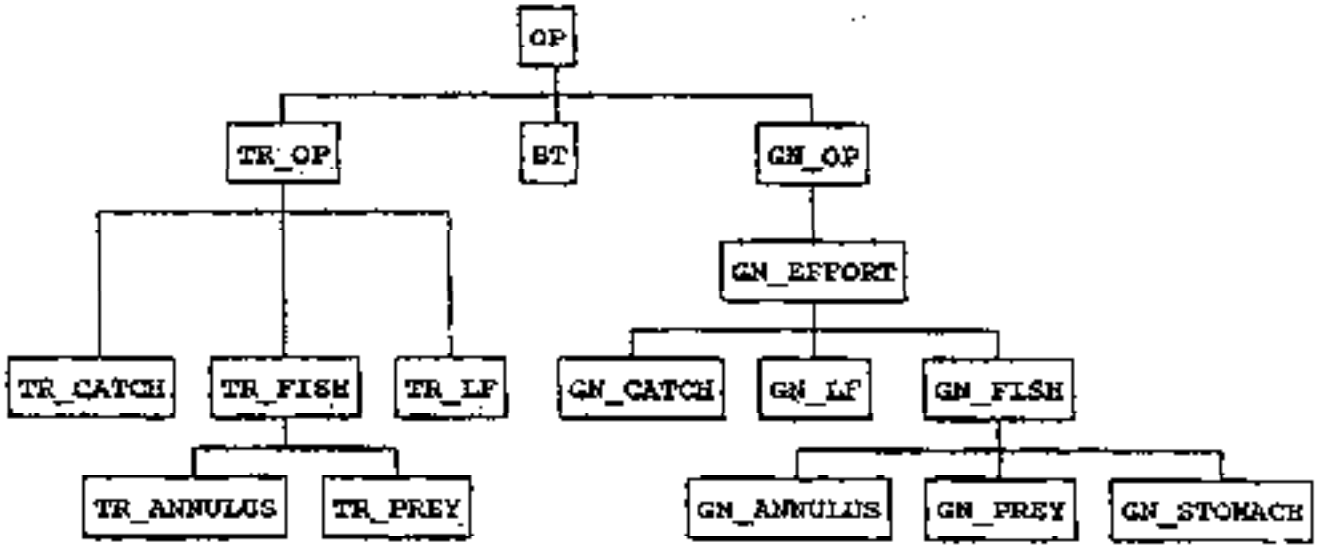
In the fall of 1988, ORACLE was purchased as part of a GCMS purchase and installed on the mini-computer, The process of designing database tables was completed in the spring of 1989. At that point, the process of loading existing data into the database was begun.

In the fall of 1989, 80386 micro-computers and ORACLE were purchased for the field stations. The field stations were then nearly identical in computing capability with the Center.

By March, 1990, data tables were designed, loading of card image data into the tables was progressing, and a prototype data selection and reporting system was demonstrated.

In June 1990, proposals were circulated specifying how a more comprehensive approach to implementing the RVCAT system might be handled. In July, manuals and starter systems were circulated to the field stations. The starter system included table definitions, a data entry form, a data selection system, and trawl length frequency report linked to the selection system.

Data Tables (Hierarchical)



Lookup Tables (alphabetical - no schema)

Data Selection Tables (hierarchical)

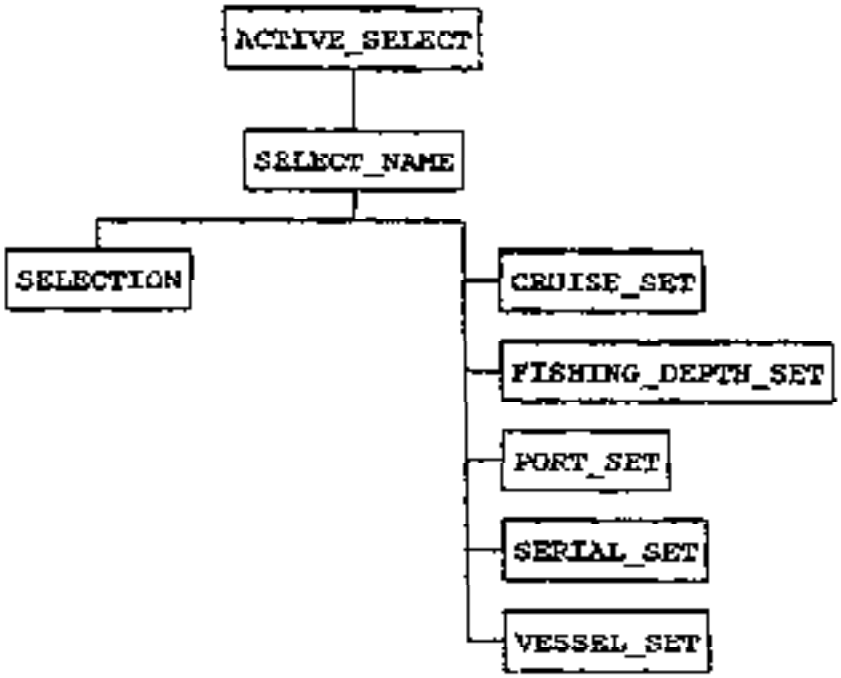


Table Definitions

This document defines the Research Vessel Catch Information System tables. It is divided into these sections:

Naming Conventions
Abbreviations
Table Schemas
Data Table Definitions
Lookup Table Definitions
Selection Table Definitions
Report Table Definitions

Naming Conventions

Table names are in capital letters and column names are in lower case. Next to each table name is the table pneumonic used in report specifications. There are four groups of tables: Data, Lookup, Selection, and Report. Tables are listed in hierarchical or alphabetical order. Listed below each table name are: the column number (used for report definitions), column name, the data type and size, and the primary key - not null designator. The primary key (pk) is a column or group of non-superfluous columns that insure the uniqueness of rows within a table. Columns designated primary key are assumed not null unless otherwise specified.

1. Table names are unique.
2. Column names are unique within a table.
3. Names are descriptive and meaningful.
4. Names will be displayed on terminals and hardcopy.
5. Users will be familiar with and will use names to communicate with the system.
6. Names are brief, using whole names where possible.
7. Names are consistent between tables.

Abbreviations

acro	acronym
ave	average
bt	bathy thermograph slide number
cu	chub management unit
cwt	coded wire tag
dc	diameter at capture
gn	gillnet
id	identification number (system assigned key)
lf	length frequency
lw	length weight
n	number or frequency
nn	not null
op	operation
pk	primary key
sci	scientific
sd	statistical district
sta	station
temp	temperature

tr trawl
wfu whitefish management unit

Table Descriptions

This document describes the system of tables as defined in the document "Table Definitions". The model captures the spirit of the method described in "Relational Database Design". The model minimizes redundancy (it is impossible to eliminate redundancy), update anomalies are eliminated, and it has a high degree of maintenance-resistance (the model will stand the test of time, will be widely accepted, and will require few alterations other than additions). Non-loss data reduction has been achieved. Goals of the design process are simplicity, use-ability, and efficiency.

A data model is a collection of constructs, operators and integrity rules which together support a dynamic representation of real-world objects and events, The only construct in a relational model is the table. Operators are add, change, delete, select, project, join, group, and so forth. Integrity rules include no null, primary key and no duplicate; and serve to maintain order and consistency in the database.

The scope of this document is construct and integrity. Beyond the scope of this document are operators which are used by data entry and report tools for input and output, and values that can be calculated from table values.

Many of the tables composing this model are lookup tables, They have one numeric column containing the code, and one or two columns containing the description(s). These tables are largely static in the content. They are used for system integrity and to provide labels when output is generated.

The remaining tables are those which will contain the actual Research Vessel data. They will continue to grow in content as data are collected and entered. Each table models a particular kind of data, and is related to the other tables in a clear and consistent fashion. These tables are related to each other hierarchically, that is, there is one master table, and a number of dependent tables, The master table is called OP (operation). Most of the subordinant table names begin with either GN (gillnet), or TR (trawl). Another subordinate table is BT which contains temperature profile data.

All data stored in the tables is represented the same as in the ASCII (card image) data sets with the following exceptions:

Port is stored as the combination of lake code and port code. For example, Saugatuck (24) in Lake Michigan (2) is stored as 224. This convention will keep port codes unique throughout the system.

Likewise grid is stored as the combination of lake code and grid number. For example, grid 721 in Lake Ontario (6) is stored as 60721. This convention will keep grid codes unique throughout the system.

Depths are stored in meters rather than fathoms or feet. Precision is to the nearest decimeter. This is a consistent simple way of storing depth that will accomodate the needs of all five lakes. Although meters is the only accepted unit in the scientific literature, depth measurements can be displayed in any unit desired through a simple conversion factor.

The following is a description of each data base table starting with OP and working down the hierarchy.

OP

Table OP (operation) contains a log of Research Vessel operations. Each row represents a deployment of a sampling device by a research vessel. The primary key is composed of year, vessel, serial, and sample_type. Column op_id represents the primary key, is system (arbitrarily) assigned, and is a key to each operation throughout the system. Information includes time, location, conditions, and target organism(s). Examples of distinct operations are: trawl tow, gillnet set, gillnet lift, remote operated vehicle (ROV) transect, hydroacoustic transect, and plankton tow. A separate op row is created even when two operations are done simultaneously (Note: This does not necessarily imply more than one Vessel Operations Form.).

GN_OP

Table GN_OP (gillnet operation) contains information about each whole gillnet deployed by a research vessel. There will be one row in GN_OP for each gillnet set row in OP. The primary key is column op_id.

TR_OP

Table TR_OP (trawl operation) contains information about each trawl tow. There will be one row in TR_OP for each trawl-set row in OP. The primary key column is op_id.

GN_EFFORT

Table GN_EFFORT (gillnet effort) contains information about each panel of a whole gillnet. Each panel is represented as a row in GN_EFFORT. The primary key is composed of columns op_id, mesh-size, and net_material. Column gn_effort_id is system assigned, is representative of the primary key, and is used to relate rows in GN_CATCH, GN_LF, and GN_FISH to a panel of net. GN_EFFORT is in a many to one (M:1) relationship with OP. Notice that a particular gillnet-set row in OP will key directly to one row in GN_OP and many rows in GN_EFFORT. Information includes fishing depth, mesh size, length, and material composition of the panel.

GN_CATCH and TR_CATCH

These tables represent the gross catch of each unit of gillnet or trawl effort. They are identical in structure except for the system assigned key. GN_CATCH is subordinate to GN_EFFORT linked through gn_effort_id and TR_CATCH is subordinate to TR_OP linked through op_id. The primary key for GN_CATCH is composed of the columns gn_effort_id, species, and life_stage. The primary key for TR_CATCH is op_id, species, and life_stage. Information includes fish species, life stage, and total number and weight.

GN_LF and TR_LF

These tables will contain length frequency data and are keyed through gn_effort_id and op_id to related units of effort. Each row models a number of a species of fish at a particular length. The primary key for GN_LF is gn_effort_id, species, and length. The primary key for TR_LF is op_id, species, and length.

GN_FISH and TR_FISH

Individual fish are modeled in these tables. Rows are keyed through gn_effort_id or op_id to related units of effort. Information includes fish species, length, weight, sex, maturity, age, diameter at capture of age structure, fin clip, cwt number, scar and wound information. These tables are a combination of the historical Length Weight, Scale, and Predator Prey data. **There is no primary key for these tables!** TR_fish_id and gn_fish_id are system assigned and key to subordinate information which includes annulus and prey data.

GN_PREY and TR_PREY

These tables are identical in structure to GN_LF and TR_LF except that rows are subordinate to a predator in GN_FlSH or TR_FISH rather than a unit of effort. Rows are keyed to individual predators through gn_fish_id and tr_fish_id. The primary key is composed of columns gn_fish_id, species, and length for GN_FISH, and tr_fish_id, species, and length for TR_FISH.

GN_ANNULUS and TR_ANNULUS

The annulus tables model individual annulus measurements. Rows are keyed to individual fish through gn_fish_id and tr_fish_id. Each row includes the annulus number, age_struct, and size. The primary key is composed of gn_fish_id, age_struct, and annulus for GN_ANNULUS and tr_fish_id, age_struct, and annulus for TR_ANNULUS.

BT

Each row in BT represents a temperature at a depth for a particular operation and bt cast. The primary key is composed of op_id, bt, and depth. As many depths as desired may be stored for each profile.

LIFE_SIZE

Each row in LIFE_SIZE represents a range of cut off lengths for the life_stage of a species of fish for a lake and year. It documents this information within the database, and is used to segregate length frequency data during report generation. The primary key is composed of year, lake, species and life_stage.

```
SQL> describe op
 Name                                      Null?    Type
 ----------------------------------------- -------- ----
 OP_ID                                     NOT NULL NUMBER(6)
 YEAR                                      NOT NULL NUMBER(4)
 VESSEL                                    NOT NULL NUMBER(2)
 SEQUAL                                    NOT NULL NUMBER(4)
 SAMPLE_TYPE                               NOT NULL NUMBER(2)
 TARGET                                             NUMBER(3)
 LAKE                                      NOT NULL NUMBER(2)
 PORT                                      NOT NULL NUMBER(6)
 CRUISE                                    NOT NULL NUMBER(2)
 OP_DATE                                   NOT NULL DATE
 TIME                                      NOT NULL NUMBER(4)
 GRID                                               NUMBER(5)
 BEG_X                                              NUMBER(7,2)
 BEG_Y                                              NUMBER(7,2)
 END_X                                              NUMBER(7,2)
 END_Y                                              NUMBER(7,2)
 LATITUDE                                           NUMBER(4)
 LONGITUDE                                          NUMBER(5)
 AVE_DEPTH                                          NUMBER(5,1)
 BEG_DEPTH                                          NUMBER(5,1)
 END_DEPTH                                          NUMBER(5,1)
 BEG_BT                                             NUMBER(3)
 END_BT                                             NUMBER(3)
 TEMP_METHOD                                        NUMBER(1)
 SURF_TEMP                                          NUMBER(3,1)
 SECCHI                                             NUMBER(4,1)
 WEATHER                                            NUMBER(1)
 WIND_SPEED                                         NUMBER(2)
 SEA_CONDITION                                      NUMBER(1)
 BOTTOM                                             NUMBER(2)
 VESSEL_DIRECTION                                   NUMBER(3)
 WIND_DIRECTION                                     NUMBER(3)
 BEG_LORAN                                          NUMBER(7,1)
 END_LORAN                                          NUMBER(7,1)
 COMPLETE                                           NUMBER(1)
 REMARK                                             CHAR(80)
 SEG_BT_ID                                          NUMBER(6)
 END_BT_ID                                          NUMBER(6)

SQL> describe op_target
 Name                                      Null?    Type
 ----------------------------------------- -------- ----
 OP_ID                                     NOT NULL NUMBER(6)
 TARGET                                    NOT NULL NUMBER(3)

SQL> describe bt
 Name                                      Null?    Type
 ----------------------------------------- -------- ----
 OP_ID                                     NOT NULL NUMBER(6)
 BT                                        NOT NULL NUMBER(2)
 DEPTH                                     NOT NULL NUMBER(5,1)
 TEMP                                      NOT NULL NUMBER(3,1)

SQL> describe ebt
 Name                                      Null?    Type
 ----------------------------------------- -------- ----
 BT_ID                                     NOT NULL NUMBER(6)
 DEPTH                                     NOT NULL NUMBER(4,1)
 TEMP                                      NOT NULL NUMBER(3,1)
 LIGHT                                              NUMBER(6,2)

SQL> describe gn_op
 Name                                      Null?    Type
 ----------------------------------------- -------- ----
 OP_ID                                     NOT NULL NUMBER(6)
 SET_TIME                                           NUMBER(4)
 LIFT_TIME                                 NOT NULL NUMBER(4)
 WEIGHTS_OUT                               NOT NULL NUMBER(2)
 TYPE_SET                                  NOT NULL NUMBER(1)
```

```
FISHING_TEMP_SET                          NUMBER(5,1)
GAID                                      NUMBER(5)
FISHING_TEMP_LIST                         NUMBER(5,1)

SQL> describe gn_effort
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 GN_EFFORT_ID                             NOT NULL NUMBER(6)
 GP_ID                                    NOT NULL NUMBER(6)
 MESH_SIZE                                NOT NULL NUMBER(2)
 NET_MATERIAL                             NOT NULL NUMBER(1)
 BEG_DEPTH                                         NUMBER(5,1)
 END_DEPTH                                         NUMBER(5,1)
 NET_LENGTH                               NOT NULL NUMBER(4)

SQL> describe gn_catch
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 GN_EFFORT_ID                             NOT NULL NUMBER(6)
 SPECIES                                  NOT NULL NUMBER(3)
 LIFE_STAGE                                        NUMBER(1)
 N                                        NOT NULL NUMBER(6)
 WEIGHT                                            NUMBER(6)
 LF_N                                              NUMBER(3)

SQL> describe gn_l1
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 GN_EFFORT_ID                             NOT NULL NUMBER(6)
 SPECIES                                  NOT NULL NUMBER(3)
 LENGTH                                   NOT NULL NUMBER(4)
 N                                        NOT NULL NUMBER(4)
 LIFE_STAGE                                        NUMBER(1)

SQL> describe gn_fish
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 GN_FISH_ID                               NOT NULL NUMBER(6)
 GN_EFFORT_ID                             NOT NULL NUMBER(6)
 SAMPLE                                            NUMBER(4)
 SPECIES                                  NOT NULL NUMBER(3)
 LENGTH                                   NOT NULL NUMBER(4)
 WEIGHT                                            NUMBER(5)
 SEX                                               NUMBER(1)
 MATURITY                                          NUMBER(1)
 AGE                                               NUMBER(2)
 AGE_STRUCT                                        NUMBER(2)
 DC                                                NUMBER(4)
 FIN_CLIP                                          NUMBER(2)
 TAG                                               NUMBER(1)
 CWT                                               NUMBER(6)
 STOMACH                                           NUMBER(1)
 A1                                                NUMBER(1)
 A2                                                NUMBER(1)
 A3                                                NUMBER(1)
 A4                                                NUMBER(1)
 B1                                                NUMBER(1)
 B2                                                NUMBER(1)
 B3                                                NUMBER(1)
 B4                                                NUMBER(1)
 SCAR                                              NUMBER(1)
 WOUND                                             NUMBER(1)

SQL> describe gn_annulus
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 GN_FISH_ID                               NOT NULL NUMBER(6)
 AGE_STRUCT                               NOT NULL NUMBER(2)
 ANNULUS                                  NOT NULL NUMBER(2)
 DIAMETER                                 NOT NULL NUMBER(4)

SQL> describe gn_prey
```

```
Name                          Null?    Type
----------------------------- -------- ----
GN_FISH_ID                    NOT NULL NUMBER(6)
SPECIES                       NOT NULL NUMBER(3)
LENGTH                                 NUMBER(4)
N                                      NUMBER(3)

SQL> describe gn_grouped
Name                          Null?    Type
----------------------------- -------- ----
GN_FISH_ID                    NOT NULL NUMBER(6)
SPECIES                       NOT NULL NUMBER(3)
N                                      NUMBER(2)
AVE_LENGTH                             NUMBER(4)
WEIGHT                                 NUMBER(6,2)
VOLUME                                 NUMBER(4)

SQL> describe tr_op
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
SET_TIME                               NUMBER(4)
TOW_TIME                      NOT NULL NUMBER(3,1)
SPEED                         NOT NULL NUMBER(5,1)
SPEED_UNIT                    NOT NULL NUMBER(1)
TYPE_SET                      NOT NULL NUMBER(1)
FISHING_TEMP                           NUMBER(3,1)
FISHING_DEPTH                          NUMBER(5,1)
MESH_SIZE                     NOT NULL NUMBER(2)
TR_DESIGN                     NOT NULL NUMBER(2)
GRID                                   NUMBER(3)

SQL> describe tr_catch
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
LIFE_STAGE                             NUMBER(1)
SPECIES                       NOT NULL NUMBER(3)
N                             NOT NULL NUMBER(6)
WEIGHT                                 NUMBER(7)
LF_N                                   NUMBER(4)

SQL> describe butter
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
WEIGHT                        NOT NULL NUMBER(7)

SQL> describe tr_sub
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
LIFE_STAGE                             NUMBER(1)
SPECIES                       NOT NULL NUMBER(4)
NM_N                                   NUMBER(4)
LF_N                                   NUMBER(3)
SUB_WEIGHT                             NUMBER(6)

SQL> describe tr_lf
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
SPECIES                       NOT NULL NUMBER(3)
LENGTH                        NOT NULL NUMBER(4)
N                             NOT NULL NUMBER(4)
LIFE_STAGE                             NUMBER(1)

SQL> describe tr_l
Name                          Null?    Type
----------------------------- -------- ----
OP_ID                         NOT NULL NUMBER(6)
LIFE_STAGE                             NUMBER(1)
```

```
SPECIES                                   NUMBER(1)
LENGTH                                    NUMBER(1)

SQL> describe tr_fish
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 TR_FISH_ID                               NOT NULL NUMBER(6)
 OP_ID                                    NOT NULL NUMBER(6)
 SAMPLE                                            NUMBER(4)
 SPECIES                                  NOT NULL NUMBER(3)
 LENGTH                                   NOT NULL NUMBER(4)
 WEIGHT                                            NUMBER(5)
 SEX                                               NUMBER(1)
 MATURITY                                          NUMBER(1)
 AGE                                               NUMBER(2)
 AGE_STRUCT                                        NUMBER(2)
 DC                                                NUMBER(4)
 FIN_CLIP                                          NUMBER(2)
 TAG                                               NUMBER(1)
 CWT                                               NUMBER(6)
 STOMACH                                           NUMBER(1)
 A1                                                NUMBER(1)
 A2                                                NUMBER(1)
 A3                                                NUMBER(1)
 A4                                                NUMBER(1)
 B1                                                NUMBER(1)
 B2                                                NUMBER(1)
 B3                                                NUMBER(1)
 B4                                                NUMBER(1)
 SCAR                                              NUMBER(1)
 WOUND                                             NUMBER(1)
 LF                                                NUMBER(1)

SQL> describe tr_annulus
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 TR_FISH_ID                               NOT NULL NUMBER(6)
 AGE_STRUCT                               NOT NULL NUMBER(2)
 ANNULUS                                  NOT NULL NUMBER(2)
 DIAMETER                                 NOT NULL NUMBER(4)

SQL> describe tr_prey
 Name                                     Null?    Type
 ---------------------------------------- -------- ----
 TR_FISH_ID                               NOT NULL NUMBER(6)
 SPECIES                                  NOT NULL NUMBER(4)
 LENGTH                                            NUMBER(4)
 K                                                 NUMBER(3)

SQL> spool off
```

```
SQL>
SQL> select * from age_struct order by age_struct;

AGE_STRUCT AGE_STRUCT
---------- ----------
         1 Scale
         2 Otolith
         3 Operculum
         4 Gut
         5 Fin Clip
         6 Spine
         7 Fin Ray
         8 Vertebra

8 records selected.

SQL> select * from bottom order by bottom;

    BOTTOM BOTTOM_NAME
---------- --------------------
         1 Bedrock
         2 Rubble
         3 Course gravel
         4 Fine gravel
         5 Sand
         6 Silt
         7 Clay
         8 Marl
         9 Mud
        10 Organic debris
        11 Mud & Gravel
        12 Gravel & Clay
        13 Sand & Clay
        14 Sand & Silt
        15 Sand & Gravel
        16 Sand & Mud
        17 Silt & Clay
        18 Mud & Silt
        19 Mud & Clay
        20 Other (remarks)
        99 N/D

23 records selected.

SQL> select * from direction order by direction;

 DIRECTION DIREC
---------- -----
         0 V
         1 NE
         2 E
         3 SE
         4 S
         5 SW
         6 W
         7 NW
         8 N
         9 N/D

10 records selected.

SQL> select * from fin_clip order by fin_clip;

  FIN_CLIP FIN_CLIP_A FIN_CLIP_NAME
---------- ---------- ------------------------------------------
         0 NC         No clip
         1 AD         Adipose
         2 ADLV       Adipose-left ventral
         3 ADRV       Adipose-right ventral
         4 ADLVRV     Adipose-left ventral-right ventral
         5 ADLP       Adipose-left pectoral
         6 ADRP       Adipose-right pectoral
```

```
         7 ADLM         Adipose-left maxillary
         8 LPRM         Left pectoral-right maxillary
         9 RPRM         Right pectoral-right maxillary
        10 LV           Left ventral
        11 RV           Right ventral
        12 RV LVRV      Left ventral-right ventral
        13 LP           Left pectoral
        14 RP           Right pectoral
        15 RP LPRV      Left pectoral-right pectoral
        16 LPLV         Left pectoral-left ventral
        17 RVLP LPRV    Left pectoral-right ventral
        18 RPLV         Right pectoral-left ventral
        19 D            Dorsal
        20 D.V          Dorsal-left ventral
        21 DRV          Dorsal-right ventral
        22 DRV DRVLV    Dorsal-right ventral-left ventra
        23 DLP          Dorsal-left pectoral
        24 DRP          Dorsal-right pectoral
        25 UNK          Origin unknown
        26 RM           Right maxillary
        27 LM           Left maxillary
        28 RPRV         Right pectoral-right ventral
        29 ADRP
        30 DAD          Adipose-dorsal
        31 LPLM         Left pectoral-left maxillary
        99 No Code

43 records selected.

SQL> select * from food order by food;

      FOOD FOOD_NAME
---------- --------------------
         0 Nil
         1 Plant
         2 Hydra
         3 Clams
         4 Unk
         5 Leech
         6 Insects
         7 Fish Eggs
         8 Snails
         9 Vegetable
        10 Caddis
        11 Ella
        12 Terpods
        13 Ridge Larvae
        14 Microdrilles
        15 Crayfish
        16 Megadrilles
        17 Mythotrephes
        18 Spherids
        19 Zooplankton
       106 Alewife
       108 Gizzard shad
       109 Smelt
       127 Burbot
       129 Threespine Stickleba
       130 Ninespine Stickleback
       131 Trout Perch
       200 Coregonids
       204 Bloater
       216 chub
       301 Chinook
       307 Lake trout
       706 Johnny Darter
       801 yellow perch
       900 Sculpins
       902 Slimy Sculpin
       904 Deepwater Sculpin
      1001 Acroperus harp
      1002 Alona
```

```
1003 Bosmina longir
1004 Calanoid copep
1005 Ceriodaphnia
1006 Copepod naupli
1007 Chydorus sphaer
1008 Cyclopoid copep
1009 Diacyclops thom
1010 Cyclops varic
1011 Acanthocyclops v
1012 Daphnia
1013 Daphnia galeata
1014 Daphnia pulex
1015 Diaphanosoma
1016 Epischura lacus
1017 Eucyclops agil
1018 Eurycercus lam
1019 Graptoleberis
1020 Harpacticoida

FOOD FOOD_NAME
---------- --------------------
1021 Macrocyclops
1022 Mesocyclop edax
1023 Ophryoxus
1024 Pleuroxus
1025 Polyphemus
1026 Scapholeberis
1027 Simocephalus
1028 Skistodiaptomus
1029 Tropocycl pras
1030 Acarina
1031 Argulus
1032 Bryozoan statbl
1033 Cenarium (prot.)
1034 Ceratopogonid
1035 Chaoborus punct
1036 Chiron. larvae
1037 Collembola
1038 Ergasilus
1039 Hydra
1040 Nematoda
1041 Oligochaeta
1042 Ostracoda
1043 Diaporeia affin
1044 Tardigrada
1045 Kellicottia
1046 All Other Rotifers
1047 Mayfly
1048 Cyclopoid adult
1049 Alonella
1050 Terr. insect
1051 Diptera (larv.)
1052 Ectocyclops
1053 Trichoptera
1054 Odonata nymph
1055 Chiron. pupae
1056 Corixidae
1057 Paracyclops
1058 Holopedium
1059 Turbellaria
1060 Leptodiap. sicilis
1061 Limnocalanus
1062 Ilyocryptus
1063 Asplanchna
1064 Macrothrix
1065 Chiron. eggs
1066 Sida
1067 Leptodiap. ash
1068 Leptodiap. min
1069 Mysis relicta
1070 Bythotrephes ce
1071 Ceratopog. pupa
```

```
      1072 Daphnia retrocu
      1073 Eurytemora affi
      1074 Eubosmina coreg
      1075 Leptodora kindt
      1076 Daphnia catawba
      1077 Daphnia parvula

      FOOD FOOD_NAME
---------- --------------------
      1078 Daphnia pulicaria
      1079 Daphnia schodleri
      1080 Latona setifera
      1081 Leptodiaptomous
      1082 Cyclopoida
      1083 Eucyclops
      1084 Diaptomidae
      1085 Adult calanoid
      1086 Senecella
      1087 Leptodiapt. siciloid

124 records selected.

SQL> select * from lake order by lake;

      LAKE LAKE_NAME
---------- ---------------
         1 Superior
         2 Michigan
         3 Huron
         4 St. Clair
         5 Erie
         6 Ontario
         7 Gone
         8 St. Clair River
         9 Detroit River
        10 St. Marys River
        11 Anchor Bay
        99 Other

12 records selected.

SQL> select * from life_stage order by life_stage;

LIFE_STAGE LIFE_STAGE_NAME
---------- ----------------------------------------
         0 Young of Year
         1 Yearling
         2 Beyond second year (age-group II and older)
         3 Subsample
         4 Subsample
         5 Subsample
         6 Life Stage Not Recorded
         7 Adult
         8 Less than 7 inches
         9 Greater than 7 inches

10 records selected.

SQL> select * from maturity order by maturity;

  MATURITY MATURITY_NAME
---------- ---------------
         0 Unknown
         1 Immature
         2 Mature
         3 Gravid
         4 Ripe
         5 Partly spent
         6 Spent
         7 Abnormal
         8 Unrecorded
```

```
71 records selected.

SQL> select * from mesh_size order by mesh_size;

 MESH_SIZE MESH_SIZE_NAME
---------- ---------------
         0 0 0
         1 0 1/8
         2 0 2/8
         3 0 3/8
         4 0 4/8
         5 0 5/8
         6 0 6/8
         7 0 7/8
        10 1 0
        11 1 1/8
        12 1 2/8
        13 1 3/8
        14 1 4/8
        15 1 5/8
        16 1 6/8
        17 1 7/8
        20 2 0
        21 2 1/8
        22 2 2/8
        23 2 3/8
        24 2 4/8
        25 2 5/8
        26 2 6/8
        27 2 7/8
        30 3 0
        31 3 1/8
        32 3 2/8
        33 3 3/8
        34 3 4/8
        35 3 5/8
        36 3 6/8
        37 3 7/8
        40 4 0
        41 4 1/8
        42 4 2/8
        43 4 3/8
        44 4 4/8
        45 4 5/8
        46 4 6/8
        47 4 7/8
        50 5 0
        51 5 1/8
        52 5 2/8
        53 5 3/8
        54 5 4/8
        55 5 5/8
        56 5 6/8
        57 5 7/8
        60 6 0
        61 6 1/8
        62 6 2/8
        63 6 3/8
        64 6 4/8
        65 6 5/8
        66 6 6/8
        67 6 7/8
        70 7 0

 MESH_SIZE MESH_SIZE_NAME
---------- ---------------
        71 7 1/8
        72 7 2/8
        73 7 3/8
        74 7 4/8
        75 7 5/8
        76 7 6/8
```

```
       77 7 7/8

n4 records selected.

SQL> select * from net_material order by net_material;

NET_MATERIAL NET_MATERIAL_NA
------------ ---------------
           1 Nylon
           2 Cotton
           3 Linen
           4 Monofilament

SQL> select * from port order by port;

      PORT PORT_NAME
---------- ------------------------
       102 Sault Ste. Marie Mich.
       104 Whitefish Bay
       106 Grand Marais
       108 Munising
       110 Shelter Bay
       112 Marquette
       114 Stannard Rock
       116 Big Bay
       118 Huron Bay
       120 L'Anse
       122 Portage Entry
       124 Grand Traverse Bay
       126 Gete Gris Bay
       128 Copper Hr.-Eagle Hr.
       130 Upper Entry
       132 Portage Lake
       134 Ontonagon
       136 Black River
       138 Chequamegon Bay
       140 Apostle Islands
       142 Cornucopia-Port Wing
       144 Superior-Duluth
       146 Two Harbors
       148 Taconite Harbor
       150 Grand Marais (Minn.)
       152 Pigeon Bay
       154 Washington Harbor
       156 Sisikwit Bay
       158 Rock Harbor
       160 North Channel
       162 Thunder Bay
       164 Black Bay
       166 Nipigon Bay
       168 Rossport
       170 Jackfish
       172 Heron Bay-Marathon
       174 Superior Shoal
       176 Otter Head
       178 Michipicoten Is.
       180 Caribou Is.
       182 Michipicoten Hr.
       184 Gargantua Hr.
       186 Montreal R.
       188 Batchewana Bay
       202 St. James
       203 Cross Village
       204 Charlevoix
       205 Little Traverse Bay
       206 Grand Traverse Bay
       207 Northern Refuge
       208 Leland
       209 Fox Islands and reef area
       210 Frankfort
       211 Point Betsie
       212 Manfrere
```

214 Ludington
216 Pentwater

PORT	PORT_NAME
218	White Lake
220	Muskegon
222	Grand Haven
223	Port Sheldon
224	Saugatuck-Holland
226	South Haven, Palisades
228	Benton Hr.-St. Joe, Cook
229	New Buffalo
230	Michigan City
231	Gary, Indiana
232	Chicago
234	Waukegan
235	Highland Park
236	Racine-Kenosha
238	Milwaukee
240	Port Washington
241	Milwaukee Reef
242	Sheboygan
244	Manitowoc-Two Rivers
246	Kewaunee-Algoma
248	Sturgeon Bay
249	Bailey's Harbor
250	Washington Island
252	Fairport
254	Manistique
256	Naubinway, Epoufette
257	North Shore
258	Simmons Reef
259	White Shoals
270	Washington Isles
272	Gitts Rock
274	Sturgeon Bay
276	Sunnico
278	Oconto
280	Marinette, Menominee
282	Cedar River
284	Escanaba
286	Little Bay De Noc
288	Big Bay De Noc
290	Fairport
302	Mackinac-St. Ignace
303	Six-Fathom Bank
304	Cheboygan
305	Hammond Bay
306	Rogers City
307	Presque Isle, Rockport
308	Alpena-Thunder Bay
309	Yankee Reef
310	Harrisville, Oscoda
311	Au Sable Point
312	Tawas City
314	Bay City
316	Bay Port
318	Port Austin
320	Harbor Beach
322	Port Sanilac
324	Lexington, Port Huron

PORT	PORT_NAME
325	St. Clair River
326	Goderich
328	Kincardine
330	Southampton
332	Pike Bay
334	Tobermory
336	South Baymouth

PORT	POINT_NAME
338	South Bay
340	Burnt Island
342	Detour
344	Cedarville
346	Refuge
350	Tobermory
352	Lionhead
354	Owen Sound
356	Meaford, Collingwood
358	Victoria Harbor
360	Parry Sound
362	Britt
364	Killarney
380	Manitowaning Bay
382	Little Current
384	Spanish
386	Blind River
388	Thessalon
390	St. Marys River
401	Clinton River
402	United States
403	Anchor Bay
404	Canada
406	Thames River
415	Pine Creek
502	Pts.-Maulitee-Amherstburg
504	Monroe
506	Toledo
508	Bono_East Bay
510	Port Clinton
512	Bass Island
513	Sash Harbor
514	Sandusky
515	Cedar Point
516	Sandusky-Huron
518	Vermilion-Lorain
520	Cleveland
522	Fairport
524	Ashtabula
526	Conneaut
528	Erie
530	Barcelona
532	Dunkirk
534	Buffalo
536	Port Colborne
538	Port Maitland
539	Nanticoke
540	Port Dover
542	Long Point
544	Port Burwell
545	Lakeview
546	Port Stanley-Pt. Talbot
548	Erieau
550	Wheatley
552	Pt. Pelee-Pelee Island
554	Leamington-Kingsville
556	Colchester
602	Youngstown
603	Wilson
604	Olcott
605	Thirty Mile Pt.
606	Oak Orchard
607	Hamlin
608	Rochester
609	Sodus Pt.
610	Pulaskyville
611	Sodus
612	Fairhaven
613	Oswego

```
       614 Mexico Bay
       615 Southwick
       616 Galls-Stoney Islands
       618 Henderson Bay
       620 Black River Bay
       622 Chaumont Bay
       623 Cape Vincent
       624 St. Lawrence River
       626 Amherst
       628 North Channel
       630 Adolphus Reach
       632 Bay of Quinte
       634 Prince Edward Bay
       635 Prince Edward Point
       636 Wellington
       638 Lakeport
       640 Port Hope-Cobourg
       642 Oshawa-Pt. Whitney
       644 Toronto
       645 Port Credit
       646 Hamilton
       648 Jordan Harbor
       650 Niagara-on-the-Lake
       844 Marine City
      9980 unknown source
      9981 non-Great Lakes samples
      9982 round robin samples
      9984 reference material sample
      9990 laboratory samples
      9994 Great Lake sample no port
      9996 matrix sample unspiked
      9997 matrix sample spiked
      9998 check samples

223 records selected.

SQL> select * from sample_type order by sample_type;

SAMPLE_TYPE SAMPLE_TYPE_NAME
----------- --------------------
          1 Trawl
          2 Gillnet Set
          3 Gillnet Lift
          4 Gillnet Set and Lift
          5 Hydroacoustics
          6 ROV
          7 Zooplankton
          8 Bongo Net Fry Tow
          9 Ponar Dredge
         10 Water Chemistry
         11 Trap Net
         12 Temperature Only
         13 Light Trap Set
         14 Light Trap Lift

14 records selected.

SQL> select * from sea_condition order by sea_condition;

SEA_CONDITION SEA_CONDIT
------------- ----------
            0 0 ft.
            1 < 1 ft.
            2 1 - 2 ft.
            3 2 - 4 ft.
            4 4 - 6 ft.
            5 6 - 8 ft.
            6 8+ ft.
            9 N/O

8 records selected.
```

```
SQL> select * from sex order by sex;

       SEX SEX_NAME
---------- ----------
         0 Unknown
         1 Male
         2 Female
         3 Hermaphrodite

SQL> select * from sop order by sop;

       SOP SOP_NAME
---------- ----------
         0 Standard Operating Procedures

SQL> select * from species order by species;

   SPECIES COMMON_NAME                                    SCI_NAME
---------- ---------------------------------------------- ----------
         0 No fish caught
         1 Chestnut lamprey                               Ichthyomyzon castaneus
         2 Northern brook lamprey                         Ichthyomyzon fossor
         3 Silver lamprey                                 Ichthyomyzon unicuspis
         4 American brook lamprey                         Lampetra lamottei
         5 Sea lamprey                                    Petromyzon marinus
       101 Lake sturgeon                                  Acipenser fulvescens
       102 Paddlefish                                     Polyodon spathula
       103 Spotted gar                                    Lepisosteus oculatus
       104 Longnose gar                                   Lepisosteus osseus
       105 Bowfin                                         Amia calva
       106 Alewife                                        Alosa pseudoharengus
       107 American shad                                  Alosa sapidissima
       108 Gizzard shad                                   Dorosoma cepedianum
       109 Rainbow smelt                                  Osmerus mordax
       110 Mooneye                                        Hiodon tergisus
       111 Central mudminnow                              Umbra limi
       112 Grass pickerel                                 Esox americanus vermiculatus
       113 Northern pike                                  Esox lucius
       114 Muskellunge                                    Esox masquinongy
       115 White catfish                                  Ictalurus catus
       116 Black bullhead                                 Ictalurus melas
       117 Yellow bullhead                                Ictalurus natalis
       118 Brown bullhead                                 Ictalurus nebulosus
       119 Channel catfish                                Ictalurus punctatus
       120 Stonecat                                       Noturus flavus
       121 Tadpole madtom                                 Noturus gyrinus
       122 Brindled madtom                                Noturus miurus
       123 Flathead catfish                               Pylodictus olivaris
       124 American eel                                   Anguilla rostrata
       125 Banded killifish                               Fundulus diaphanus
       126 Mosquitofish                                   Gambusia affinis
       127 Burbot                                         Lota lota
       128 Brook stickleback                              Eucalia inconstans
       129 Threespine stickleback                         Gasterosteus aculeatus
       130 Ninespine stickleback                          Pungitius pungitius
       131 Trout-perch                                    Percopsis omiscomaycus
       132 White perch                                    Morone americana
       133 White bass                                     Morone chrysops
       134 Freshwater drum                                Aplodinotus grunniens
       135 Shortnose sturgeon                             Acipenser brevirostrum
       136 Pallid sturgeon                                Scaphirhynchus
       137 Shovelnose sturgeon                            Scaphirhynchus platorynchus
       138 Gar
       139 Alligator gar                                  Lepisosteus spatula
       140 Shortnose gar                                  Lepisosteus platostomus
       142 Ohio shad                                      Alosa ohiensis
       143 Skipjack herring                               Alosa chrysochloris
       146 Goldeye                                        Hiodon alosoides
       150 Blue catfish                                   Ictalurus furcatus
       151 Bullheads
       160 Muskellunge x Northern Pike Hybrid
       170 Brook silverside                               Labidesthes sicculus
```

190	White perch/White bass (hybrid)	
200	Whitefishes	
201	Longjaw cisco (rare)	Coregonus (Leucichthys) alpenae
202	Cisco (lake herring)	Coregonus (Leucichthys) artedi

SPECIES	COMMON_NAME	SCI_NAME
203	Lake whitefish	Coregonus clupeaformis
204	Blogger	Coregonus (Leucichthys) hoyi
205	Deepwater cisco (extinct)	Coregonus (Leucichthys) johannae
206	Kiyi	Coregonus (Leucichthys) kiyi
207	Blackfin cisco (rare or extinct)	Coregonus (Leucichthys) nigripinnis
208	Shortnose cisco	Coregonus (Leucichthys) reighardi
209	L. Superior shortnose	Coregonus (Leucichthys) reighardi dymondi
210	Shortjaw cisco (rare)	Coregonus (Leucichthys) zenithicus
211	Pygmy whitefish	Prosopium coulteri
212	Round whitefish	Prosopium cylindraceum
213	Unidentified chubs	
214	Chubs (large)	
215	Chubs (small)	
216	Chubs	
217	Unidentified coregonid	
300	Trouts and graylings	
301	Chinook salmon	Oncorhynchus tshawytscha
302	Cutthroat trout	Salmo clarki
303	Rainbow trout (Steelhead)	Salmo gairdneri
304	Atlantic salmon	Salmo salar
305	Brown trout	Salmo trutta
306	Brook trout	Salvelinus fontinalis
307	Lake trout	Salvelinus namaycush
308	Siscowet (fat trout)	Salvelinus namaycush siscowet
309	Arctic grayling	Thymallus arcticus
310	Coho salmon	Oncorhynchus kisutch
311	Kokanee	Oncorhynchus nerka
312	Humper lake trout	
313	Halfbreed lake trout	
314	Splake (brook trout x lake trout)	
315	Released lake trout (commercial) MDNR use	
316	Pink salmon	Oncorhynchus gorbuscha
317	Native lake trout	
400	Suckers	
401	Goldfish	Carassius auratus
402	Carp	Cyprinus carpio
403	Quillback	Carpiodes cyprinus
404	Longnose sucker	Catostomus catostomus
405	White sucker	Catostomus commersoni
406	Lake chubsucker	Erimyzon sucetta
407	Northern hogsucker	Hypentelium nigricans
408	Bigmouth buffalo	Ictiobus cyprinellus
409	Spotted sucker	Minytrema melanops
410	Silver redhorse	Moxostoma anisurum
411	Black redhorse	Moxostoma duquesnei
412	Golden redhorse	Moxostoma erythrurum
413	Northern redhorse	Moxostoma macrolepidotum
414	Greater redhorse	Moxostoma valenciennesi
415	Unidentified redhorse	
416	Goldfish x carp hybrid	
417	River redhorse	Moxostoma carinatum
418	Shorthead Redhorse	Moxostoma breviceps
423	River carpsucker	Carpiodes carpio
424	Highfin carpsucker	Carpiodes velifer
425	Plains carpsucker	Carpiodes forbesi
429	River sucker	Cycleptus elongatus
435	Smallmouth buffalo	Ictiobus bubalus

SPECIES	COMMON_NAME	SCI_NAME
436	Black buffalo	Ictiobus niger
500	Minnows	
501	Silver chub	Hybopsis storeriana
502	Golden shiner	Notemigonus crysoleucas
503	Pugnose shiner	Notropis anogenus

```
       504 Emerald shiner                          Notropis atherinoides
       505 Common shiner                           Notropis cornutus
       506 Blackchin shiner                        Notropis heterodon
       507 Bigmouth shiner                         Notropis heterolepis
       508 Spottail shiner                         Notropis hudsonius
       509 Sporfin shiner                          Notropis spilopterus
       510 Sand shiner                             Notropis stramineus
       511 Mimic shiner                            Notropis volucellus
       512 Pugnose minnow                          Opsopoeodus emiliae
       513 Bluntnose minnow                        Pimephales notatus
       514 Fathead minnow                          Pimephales promelas
       515 Longnose dace                           Rhinichthys cataractae
       516 Unidentified minnows
       517 Stoneroller                             Campostoma anomalum
       518 Creek chub                              Semotilus atromaculatus
       519 Lake chub                               Hybopsis plumbea
       520 Sturgeon chub                           Hybopsis gelida
       521 Fallfish                                Semotilus corporalis
       522 Silver minnow                           Hybognathus nuchalis
       525 Cutlips minnow                          Exoglossum maxillingua
       524 Bridle shiner                           Notropis bifrenatus
       525 Striped shiner
       526 Bonneyhead chub
       527 Redfin shiner                           Notropis umbratilis cyanocephalus
       528 Silver shiner
       600 Sunfish and bass
       601 Rockbass                                Ambloplites rupestris
       602 Warmouth                                Chaenobryttus gulosus
       603 Green sunfish                           Lepomis cyanellus
       604 Pumpkinseed                             Lepomis gibbosus
       605 Bluegill                                Lepomis macrochirus
       606 Longear sunfish                         Lepomis megalotis
       607 Smallmouth bass                         Micropterus dolomieui
       608 Largemouth bass                         Micropterus salmoides
       609 White crappie                           Pomoxis annularis
       610 Black crappie                           Pomoxis nigromaculatus
       611 Crappies                                Pomoxis spp.
       612 Orange spotted sunfish                  Lepomis humilis
       700 Darters
       701 Eastern sand darter                     Ammocrypta pellucida
       702 Greenside darter                        Etheostoma blennioides
       703 Iowa darter                             Etheostoma exile
       704 Fantail darter                          Etheostoma flabellare
       705 Least darter                            Etheostoma microperca
       706 Johnny darter                           Etheostoma nigrum
       707 Logperch                                Percina caprodes
       708 Channel darter                          Percina copelandi
       709 Blackside darter                        Percina maculata
       710 River darter                            Percina shumardi
       711 Unidentified darters
       800 Yellow perch and pikeperch
       801 Yellow perch                            Perca flavescens

   SPECIES COMMON_NAME                             SCI_NAME
---------- ------------------------------------- ----------------------------------------
       802 Sauger                                  Stizostedion canadense
       803 Walleye                                 Stizostedion vitreum vitreum
       804 Blue pike (rare or extinct)             Stizostedion vitreum glaucum
       805 Ruffe                                   Gymnocephalus cernuus
       900 Sculpin
       901 Mottled sculpin                         Cottus bairdi
       902 Slimy sculpin                           Cottus cognatus
       903 Spoonhead sculpin                       Cottus ricei
       904 Deepwater sculpin                       Myoxocephalus thompsoni
       950 zebra_mussel                            dreissena_polymorpha
       999 Miscellaneous or unidentified species

182 records selected.

SQL> select * from speed_unit order by speed_unit;

SPEED_UNIT SPE
```

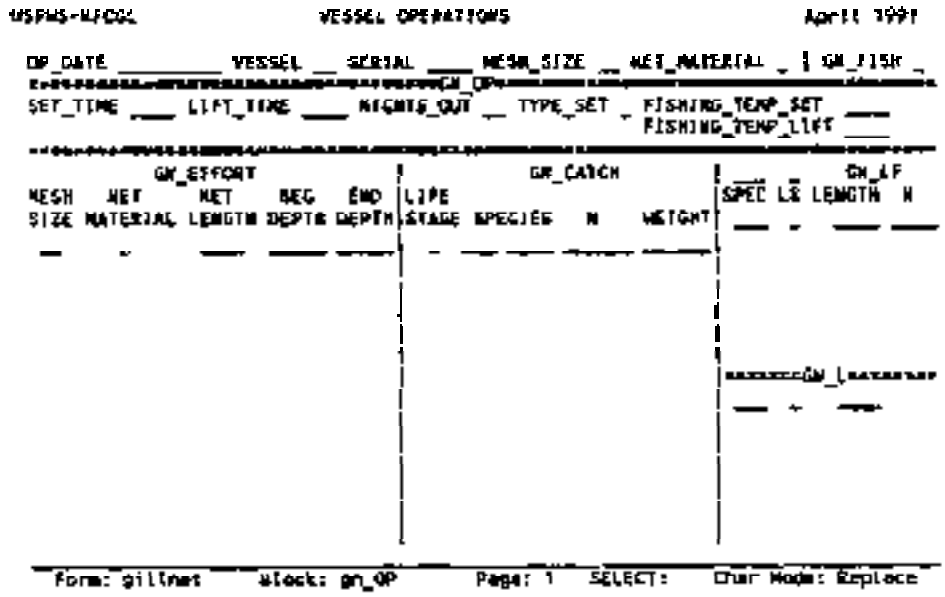
```
---------- ---
         1 MPh
         2 GPH

SQL> select * from stomach order by stomach;

   STOMACH STOMACH_NA
---------- ----------
           Not Taken
         0 Empty
         1 LF
         2 Volume

SQL> select * from target order by target;

    TARGET TARGET_NAME
---------- ------------------------------
         0 System Wide Targets
         1 Fall Forage Assessment
         2 Spring Forage Assessment
         3 Yellow Perch Assessment
         4 Lake Whitefish Assessment
         5 Ciscoes Assessment
         6 Lake Trout Assessment
         7 Lake Trout - Refuge
        20 Gear Manipulation
        99 Operation Aborted
       100 Lake Superior Specific Targets
       200 Lake Michigan Specific Targets
       201 Burbot Refuge
       202 Chinook - 10mR
       205 Bythotrephes - Lehman
       210 Fall Acoustic/Midwater Trawl Sidy
       211 Spring Acoustic/Midwater Trawl Study
       212 Summer Acoustic/Midwater Trawl Survey
       300 Lake Huron Specific Targets
       301 Down Bank Trawling,AuSable Pt.,'78
       302 21M WTR, Fall
       303 21M WTR, Spring
       304 National Pesticide Monitoring Prog.
       305 FF - 42' MTR
       306 Lake Trout CWT, Outside Sources
       307 Juv. LT, Down Bank, '83 thru '86
       308 FF - 54' MTR
       309 Lake Whitefish Recruitment
       310 Cisco Lamprey Wounding
       311 IJC Lake Trout & Smelt Collections
       315 Summer Forage Assessment
       326 FF - Goderich, Ontario
       327 SF - Goderich, Ontario
       399 Replicate Tows
       500 Lake Erie Specific Targets
       600 Lake Ontario Specific Targets

36 records selected.

SQL> select * from temp_method order by temp_method;

TEMP_METHOD TEMP_METHOD
----------- ----------
          0 Other
          1 Bucket
          2 Injection
          3 Rev. Therm.
          4 Thermograph
          5 BT
          6 Electronic-YSI
          9 Unknown

8 records selected.

SQL> select * from tr_design order by tr_design;
```

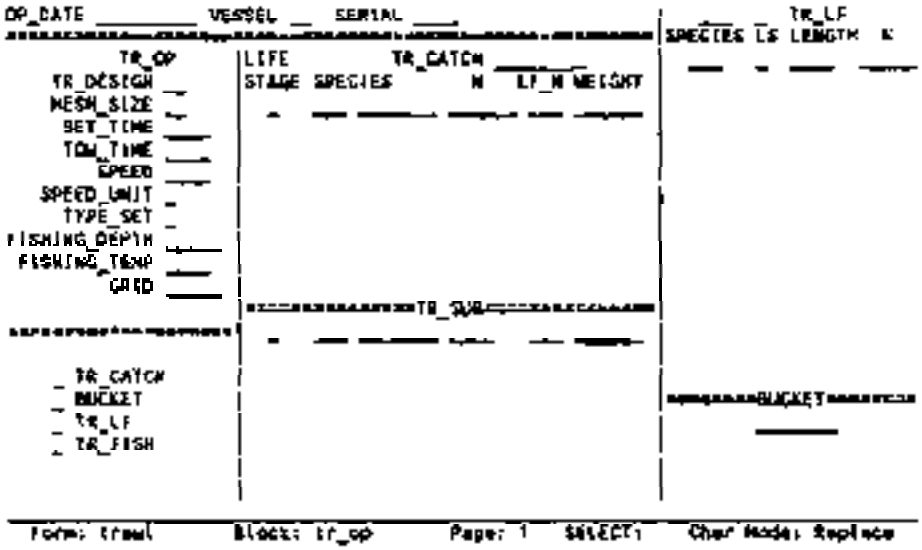
```
TR_DESIGN TR_DESIGN_NAME
--------- ------------------------
        1 K-3a; 52' balloon 7' wing
        4 39' Trawl
       16 K-1; 52' (Cod end: 1/2 in
       21 47' Midwater
       22 54' Headrope midwater
       23 70' Wing trawl
       24 60' Highrise Bottom trawl
       25 39' Roller Trawl
       26 16' Bottom trawl
       27 3 meter marmaliet trawl
       28 4' Beam trawl
       29 8' Tucker trawl
       30 20' WR Trawl (Steelhead)
       31 89' WB Midwater
       32 20' HR Midwater old
       33 25' WR Midwater new
       34 16' Rockhopper
       35 26' SB Bottom
       36 20'HR Long (Steelhead)

19 records selected.

SQL> select * from type_set order by type_set;

  TYPE_SET TYPE_SET_NAME
---------- ------------------------
         1 Bottom across contour
         2 Bottom along contour
         3 Oblique
         4 Surface
         5 Midwater

SQL> select * from vessel order by vessel;

    VESSEL VESSEL_NAME
---------- ------------------------------------------------
         1 Siscowet
         2 Cisco
         3 Munky II
         4 Kaho
         5 Buffalo
         6 Hiodon
         7 Judy
         8 Mooneye
         9 Daphnia
        10 Madtom and little Boston Whaler (Hammond Bay)
        11 Grayling
        12 21 ft. Boston Whaler 'Outrage' (Ann Arbor)
        14 17 ft. outboard at Saug.
        15 Seth Green
        16 Bowfin
        17 Steelhead (State Owned)
        18 22' Boston Whaler 'Outrage (Pike) (Sandusky)
        20 Togue
        31 Chambers Bros.
        45 A. E. Clifford
        90 Lady Nilus
        99 Coaster

22 records selected.

SQL> select * from weather order by weather;

   WEATHER WEATHER_NAME
---------- ------------------------------------------------
         0 Clear (no clouds at any level)
         1 Partly cloudy (scattered or broken)
         2 Continuous layer(s) of cloud(s)
         3 Rainstorm, duststorm or blowing snow
```

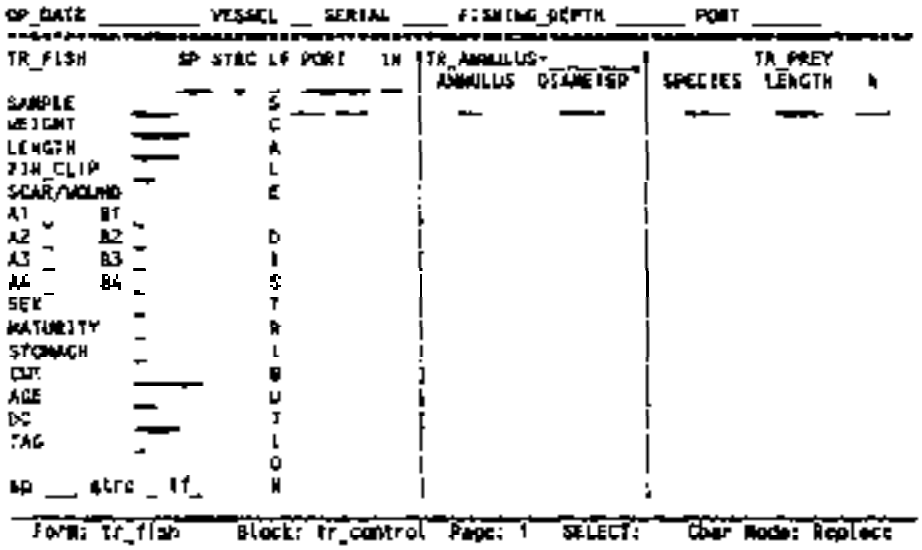
```
          4 Fog, thick dust, or haze
          5 Drizzle
          6 Rain
          7 Snow, sleet, hail
          8 Storm
          9 N/D

10 records selected.

SQL> spool off
```

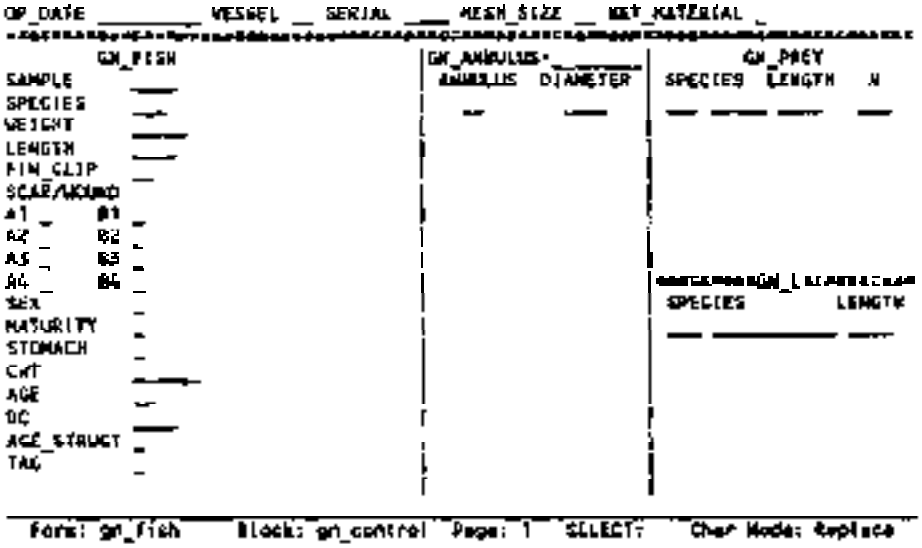
Appendix 5.

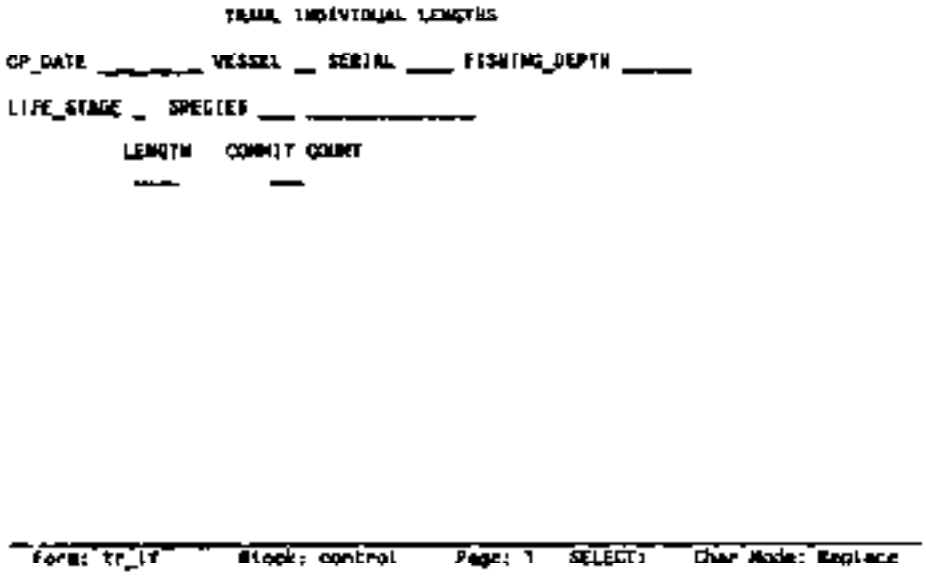
Research Vessel Data Entry Screens Used Under RVCAT




OP_DATE
VESSEL
SERIAL
TR_OP
TR_DESIGN
MESH_SIZE
SET_TIME
TOW_TIME
SPEED
SPEED_UNIT
TYPE_SET
FISHING_DEPTH
FISHING_TEMP
GRID
TR_CATCH
BUCKET
TR_LF
TR_FISH
LIFE STAGE
SPECIES
TR_CATCH N
LF_N
WEIGHT
TR_SUB
TR_LF
SPECIES
LS
LENGTH
N
BUCKET
Form: trawl
Block: tr_op
Page: 1
SELECT:
Char Mode: Replace


SP_DATE
VESSEL
SERIAL
FISHING_DEPTH
PORT
TR_FISH
SP
STOC
LF
PORT
IN
TR_ANNULUS
ANNULUS
DIAMETER
TR_PREY
SPECIES
LENGTH
N
SAMPLE
WEIGHT
LENGTH
FIN_CLIP
SCAR/WOUND
A1
B1
A2
B2
A3
B3
A4
B4
SEX
MATURITY
STOMACH
CWT
AGE
DC
TAG
SCALE
DISSECTOR
sp
stoc
lf
Form: tr_fish
Block: tr_control
Page: 1
SELECT:
Char Mode: Replace


OP_DATE
VESSEL
SERIAL
MESH_SIZE
NET_MATERIAL
GN_FISH
SAMPLE
SPECIES
WEIGHT
LENGTH
FIN_CLIP
SCAR/WOUND
SEX
MATURITY
STOMACH
CWT
AGE
DC
AGE_STRUCT
TAG
GN_ANNULUS
ANNULUS
DIAMETER
GN_PREY
SPECIES
LENGTH
N
SPECIES
LENGTH
Form: gn_fish
Block: gn_control
Page: 1
SELECT
Char Mode: Replace


TRAWL INDIVIDUAL LENGTHS
CP_DATE _____ VESSEL __ SERIAL ____ FISHING_DEPTH _____
LIFE_STAGE _ SPECIES ___ _____
LENGTH COMMIT COUNT
Form: tr_lf Block: control Page: 1 SELECT: Char Mode: Replace

Appendix 6.

Label Information Recorded on Fish Sample Tags
Sample Label

NATIONAL BIOLOGICAL SURVEY
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105-2899

Sample Description and Objective_____

_____

Date_____

Lake_____

Location_____

Serial No._____

Species_____

Sample No._____

Age/Size Group_____
__

Appendix 7.
Chain of Custody Record Form