Technical Report 359
March 2002

Field Operations Manual for Marine Water-Column, Benthic, and Trawl Monitoring in Southern California

Southern California
Bight Field Methods
Committee

Southern California Coastal Water Research Project

FIELD OPERATIONS MANUAL FOR MARINE WATER-COLUMN, BENTHIC, AND TRAWL MONITORING IN SOUTHERN CALIFORNIA

Southern California Bight

Field Methods Committee

March 2002

TABLE OF CONTENTS

SECTION

ACKNOWLEDGMENTS

This first revision of the Field Manual for Marine Water-Column, Benthic and Trawl Monitoring in Southern California (SCBPP, FCT 1995), was accomplished by the members of the Southern California Bight Field Methods Committee. Mike Kelly (City of San Diego, Metropolitan Wastewater Department) was the lead editor and Chair of this team and Dr. M. James Allen (Southern California Coastal Water Research Project) was Co-Chair. Other members of the Southern California Bight Field Methods Committee who contributed to this effort included Elizabeth Caporelli (USC Wrigley Institute for Environmental Studies), Ann Dalkey (City of Los Angeles, Environmental Monitoring Division), Dario Diehl (Southern California Coastal Water Research Project), Sarah Fangman (Channel Islands National Marine Sanctuary), Jeff Grovhoug and Brad Davidson (U.S. Navy, SPAWAR SYS. CEN., San Diego), Michael Machuzak (Aquatic Bioassay and Consulting Laboratories), Mike Mengel and Fred O'Brien (Orange County Sanitation District), David E. Montagne (County Sanitation Districts of Los Angeles County). Other contributors to this effort included Dr. Stephen B. Weisberg (Southern California Coastal Water Research Project), Ross Duggan (City of San Diego, Metropolitan Wastewater Department), and the members of The Southern California CTD Users Group.

INTRODUCTION

The mainland shelf of the Southern California Bight (SCB) (defined here as extending from Point Conception, California, to the United States – Mexico international border) is an important ecological and economic area to the more than 17 million people that live in southern California and it is the home or is part of the migratory route of many species of marine organisms. The SCB is used extensively for recreational and commercial activities that include the discharge of waste from municipal wastewater treatment plants, power generating stations, industrial plants, and storm drains.

More than $31M is spent annually in monitoring the environmental quality and natural resources of the SCB, with about 70% of that expended by dischargers in accordance with requirements of their National Pollutant Discharge Elimination System (NPDES) permits. Although these compliance-monitoring programs provide useful information, they are focused on addressing local questions and not questions of regional interest. These programs are independently implemented and conducted in response to requirements issued by three different Regional Water Quality Boards in the SCB. Hence, these programs use similar, but not identical, methods. The differences are an impediment to data integration and inhibit the use of these data in characterizing the ecological conditions of the region.

One step that dischargers and regulators have taken to increase consistency in monitoring methods is to conduct periodic cooperative regional surveys. These cooperative surveys provide an opportunity for dialog about methods and a forum for conducting intercalibration exercises. The first of these regional studies, which was conducted in 1994 and referred to as the Southern California Bight Pilot Project (SCBPP) included participation of 12 regulatory, discharge, and environmental agencies of southern California (SCBPP 1998). Part of the SCBPP involved development of a standardized field methods manual for the survey. Following the survey, the participating organizations revised that document into a formal field operations manual that recommended protocols and field methods for inclusion in NPDES permits that have monitoring requirements (SCBPP, FTC 1995). This manual was approved in 1995 by the SCCWRP Commission, consisting of five regulatory agencies (U.S. Environmental Protection Agency, Region IX; State Water Resources Control Board; and Regional Water Quality Control Boards for Los Angeles, Santa Ana, and San Diego Regions) and four major wastewater dischargers (Cities of Los Angeles and San Diego, and County Sanitation Districts of Los Angeles County and Orange County) involved in environmental monitoring in southern California.

The success of the 1994 survey led to a larger cooperative regional survey that was conducted in 1998. Referred to as the Southern California Bight 1998 Regional Survey (Bight '98), this survey involved 62 organizations, including some from northern Mexico. The field methods used in the Bight '98 survey were similar to those used in the 1994 survey, but modifications were made to accommodate the addition of 1) a number of new participants 2) new habitats that would be sampled and 3) new measurements that would be taken.

This document is a revision of SCBPP, FTC (1995) with additions from the field manual used in the Bight '98 survey, and is intended to serve as a guidance document for groups conducting or requiring monitoring in the Southern California Bight. The document includes sections on navigation, as well as on water-column, benthos/sediment, and trawl sampling elements.

GENERAL CONSIDERATIONS

Safety

The generally hazardous nature of working at sea makes it imperative for each agency to have in place an adequate safety program that will ensure the safe return of all personnel at the end of each sampling day. While these programs will undoubtedly vary among organizations, topics that should be addressed in any safety program include (but are not limited to): periodic first aid/CPR training, hazardous materials training, the physical condition of the crew/field members and adequate training in the safe operation of equipment used in the field to complete the survey.

Navigation

Accurate location of sampling sites is important to the success of any monitoring survey. In order to effectively meet this objective, the minimum required navigational equipment that must be aboard all monitoring vessels is a Global Positioning System (GPS) and a fathometer. The GPS instrument should be capable of displaying Differential GPS (DGPS) positions since this improvement in navigation is now being provided by the U.S. Coast Guard.

Throughout a survey cruise, the captain will navigate to a sampling site using a set of nominal station coordinates. The coordinates of each station location must be based on North American Datum 1983 (NAD 83), and should be expressed in degrees, minutes, and thousandths of a minute. Fathometer readings should be recorded in meters and direction (e.g. course and heading) should be reported as degrees from magnetic North. Each agency is responsible for maintaining an accurate log of general cruise activities and specific site data sheets.

Cruise and Site Data

A specific set of cruise and site data should be recorded for every CTD, benthic, and trawl survey.

The following data should be recorded for each cruise:

1) Date
2) Vessel
3) Crew and scientific party
4) Check box indicating that the GPS system is functioning properly

The following standard data should be recorded at each sampling site regardless of the type of sampling:

1) Date
2) Station coordinates of the actual sampling location
3) Time
4) Depth for each sampling position
5) Weather observations; sky, wind speed, and wind direction
6) Sea conditions; swell height, period and direction
7) Tide height, and time of low and high tides bracketing the sampling event.
8) Comments section

Additional specific types of data should be recorded depending on the type of sampling being conducted. For water quality sampling these data might include:

1) Instrument identification if more than one CTD is used for sampling.
2) Specific depth information if any water samples are collected during a cast

For benthic sampling, additional data categories will include:

1) Time at which a replicate was sampled
2) Depth of sediment in grab
3) Sediment descriptions; to include color and type of sediment
4) Replicate identification; whether a sample was collected for community or chemical analysis
5) Checkboxes for each chemical constituents sampled

For trawl sampling, the additional data categories will include:

1) Trawl data log; trawl in water, trawl on bottom, trawl end, trawl on deck, length of trawl wire deployed and whether a trawl was damaged during the course of sampling
2) Tare bucket information

3) Species identification

4) Enumeration information

5) Biomass information

6) Checkbox for specimens saved for further identification

7) Checkbox to identify species measured using size class sheets

8) List of anomaly codes

9) Trawl debris

Chain of Custody

Ocean Monitoring Programs routinely collect samples that include water quality (ammonia and bacterial indicators), benthic (sediment chemistry and benthic invertebrate characterization), and fish and macroinvertebrate (trawl) monitoring. A critical aspect of sound sample collection and analysis protocols is the maintenance of strict chain of custody (COC) procedures. Sample custody procedures include inventorying and documentation during sample collection, shipment, and laboratory processing. A sample is considered to be in an individual's custody if the sample is (1) in the physical possession or view of the responsible party, (2) secured to prevent tampering, or (3) placed in a restricted area by the responsible party. Documentation of transfer of custody for all samples is required to insure integrity of the samples and any associated data. If the COC process is not an automated procedure then blank COC forms should be filled in by hand.

Sample custody is initiated with detailed record keeping by the field sampling personnel. COC establishes the documentation and control necessary to identify and trace a sample from sample collection to final analysis. It includes field sample labeling to prevent mix-up and ensure secure custody, and it provides the recorded support information for potential litigation.

Chain of Custody Record

COC forms are used to document the integrity of all samples. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, a COC form should be filled out for each sample set at the end of each sampling day. The COC form should contain the following information:

1) Sample number (for each sample in shipment)
2) Collection date (for each sample shipment)

3) Number of containers of each sample
4) Sample description (environmental matrix)
5) Analyses required for each sample

Samples of generic COC forms are located in Appendix 1.

Sample Shipping

If the samples require shipment to an outside laboratory, then the following information should also be included on the chain of custody sheet:

1) Shipment number (i.e. Fed-Ex)
2) Shipping address of the laboratory
3) Date, time, and method of shipment
4) Spaces to be signed as custody is transferred.

The individual in charge of shipping the samples is responsible for completing the COC form and inspecting it for completeness and accuracy. If any changes are made to the COC form they should be written in ink and initialed by the person making the change.

Transfer of Custody and Shipment

When the possession of samples is transferred, the individual relinquishing them should record the date and time and then sign the COC document. The individual receiving the samples should repeat the procedure. This record represents the official documentation for all sample custody transfers until the samples have arrived at the laboratory.

Sample Receipt

A designated sample custodian should be in charge of receiving all samples transferred from the field. The sample custodian should remove the samples from the storage containers and compare the sample labels with the information provided on the COC form. If applicable, sample preservation, temperature etc., should be checked at the time of sample receipt.

The COC document should again be checked for consistency and transcription accuracy, and if any discrepancies in the information are discovered, they should be noted for corrective action. As the discrepancies are resolved, they will be noted directly on the COC form or on some other the login sheet. In general, samples will not be logged in until all discrepancies are resolved.

If all sample documentation matches the information on the chain of custody form, then the sample recipient will sign the chain of custody form and provide the sender with a copy of the form.

WATER-COLUMN PROFILING

Purpose

Water-column profiles are collected at discrete sampling sites to characterize depth-related gradients in temperature, salinity, hydrogen ion content (pH), transmissivity, dissolved oxygen (DO), and chlorophyll fluorescence. For example, water-column profiles can describe whether stratification (layering) is present and, if so, the depth of the thermocline or pycnocline. Variation in these parameters at the same depth among stations may indicate anthropogenic or natural perturbations of the environment: low salinity values at some stations may indicate the presence of an effluent plume whereas high pH and dissolved oxygen, and low transmissivity may indicate a phytoplankton bloom.

Equipment

A conductivity-temperature-depth profiler (CTD) with an expanded compliment of sensors will be used to provide a continuous water-column profile of the attributes described above. This instrument must meet the performance specifications for temperature, conductivity, salinity, DO, pH, transmissivity, chlorophyll (a) fluorescence and pressure listed below in Table 1.

Table 1. Required instrument program specifications for conductivity-temperature-depth profilers (CTD) and auxiliary sensors used in receiving-water monitoring programs for the major publicly owned treatment works in southern California.

Parameters	Resolution
Dissolved Oxygen (DO)	0.1 mg/L
Salinity	0.001 psu
Conductivity	0.00004 S/m
Transmissivity	0.05%
Temperature	0.0003 °C
Hydrogen Ion Content (pH)	0.1 pH units
Pressure	0.01 decibars
Chlorophyll (a)	0.03 :g/Liter

Training

Prior to performing maintenance, calibrations or operation of a CTD, an individual should obtain prior certification by the chief scientist. A trainee's proficiency should be evaluated on the basis of their successfully completing particular operations, following written procedures and demonstrating an understanding of the CTD system. Additionally, the individual should be evaluated on their ability to troubleshoot common problems they might encounter in the field. All training and the progression of an individual trainee's proficiency should be documented. An agency using and deploying a CTD should be an active participant in a regional CTD users group such as the Southern California CTD Users Group.

Factory Calibration and Maintenance

Maintenance, calibration and factory servicing of the CTD and its compliment of sensors should be documented thoroughly. If after a factory servicing any sensors have been repaired and adjusted, or replaced, the next calibration procedure should be updated to incorporate the most recent changes so that the instrument readings will continue to be as accurate and as precise as possible.

The temperature and conductivity sensor calibration should only be conducted at a National Oceanic and Atmospheric Administration/National Regional Calibration Center (NOAA/NRCC) laboratory and certified thereafter by the manufacturer of the CTD. A copy of the certification document should be provided when the sensor is returned.

Ctd Intercomparison Exercise

A CTD intercomparison exercise is recommended when it is deemed necessary to evaluate the precision, accuracy and, therefore, the intercomparability of those CTDs being used by agencies participating in regional monitoring. All CTD's participating in

the exercise must conform to the manufacturer specifications, and the calibration of each unit should be completed as close to the date of the exercise as possible.

Ctd Pre-Survey Calibration, Equipment Checkout and Post-Survey Calibration

Pre-survey Calibration

It is recognized that CTDs and sensors are produced by a variety of manufacturers and, therefore, that each will have specific recommendations for equipment checkout and calibration. You are encouraged to follow the respective manufacturer's recommendations. While the following discussions were developed from agencies using SeaBird CTDs, many of the concepts and procedures are applicable to other CTD models and can be modified accordingly. Regardless of any of the differences between various factory recommended procedures, the goal is to produce the most accurate and comparable data possible.

It is recommended that a pre-survey calibration of the pH, dissolved oxygen, transmissivity, chlorophyll (a) and pressure sensors be completed within 24 hr prior to starting a sampling survey.. A calibration log sheet will be prepared at that time so that all of the necessary calibration data can be recorded and archived for QA/QC purposes. There is no lab calibration for conductivity and temperature

Hydrogen Ion Content (pH)

The pH sensor is calibrated by employing commercially available buffer solutions as standards. When sampling in the ocean it is best to bracket the pH range by using the three buffers, pH 7, 8, and 9. The manufacturer's specifications should always be followed during calibration of the probe. It is important that the buffer is thermally equilibrated with the water bath; this is best accomplished by keeping the CTD in the water bath and by using a holding bracket for the buffer container. Depending on the CTD model, the appropriate readings for each of the three buffers (e.g. water temperature, pH, and voltage output) should be recorded on the calibration log. The pH probe should be adjusted according to the manufacturer's specifications using this information.

Agreement between the measured sensor output and the known buffer values should be within +/- 0.1 pH unit. If this range is exceeded, the buffer readings should be used to calculate the values necessary to properly adjust the pH sensor. When the calibration has been successfully completed, the pH electrode should be stored in a KCL-saturated, pH 4 buffer solution.

Dissolved Oxygen (DO)

Follow the manufacturer's recommended procedure for calibrating the DO sensor. Ensure that the pump being used to supply water to the sensor during the calibration is operating correctly and that it flows within the factory specifications. Compare the sensor-measured DO values with the saturation values taken from the most recent edition of Standard Methods; it should match to within 0.1 ml/L (0.143 mg/L). Sensor performance should be

monitored over time and it must either be repaired or replaced if the results do not meet the manufacturer's minimum specifications.

Transmissometer

The transmissometer should be calibrated prior to each sampling survey according to the manufacturer's recommended procedures.

Fluorometer

The fluorometer should be calibrated according to a manufacturer's recommended procedures. This calibration is performed using a 50 µg/L solution of Coproporphyrin as a substitute for chlorophyll (a) and distilled water for a blank. Coproporphyrin may be purchased from chemical distributors who can be located by contacting either the Bight'98 Water Quality Group or the Cooperative Regional Offshore Water Quality Monitoring Group via the SCCWRP website (www.sccwrp.org).

Pressure

The pressure sensor should be checked before each sampling survey. Again, follow the factory recommended adjustment procedures. The pressure reading in air at sea level should be a negative number between 0.00 and -0.60 decibars (db). If the correct pressure cannot be displayed by adjusting the offset, the manufacturer should service the sensor as soon as possible.

Pre Survey Equipment Checkout

A pre-survey equipment checkout should be conducted before calibrating the sensors and also within 24 hrs prior to starting the cruise. The inspection should include the following:

1) Visually inspect the CTD for any obvious defects.

2) Check all metal components for corrosion and clean or replace as necessary.

3) Inspect and clean all of the sub sea connections with contact cleaner as necessary.

4) Lubricate newly cleaned connectors with silicone grease and ensure they are securely reconnected.

5) Check all cables for nicks, cuts, abrasions, or other signs of physical damage.

6) Test the CTD to see if connections and software work properly.

7) Clean or replace all accessory tubing as necessary.

8) Check the battery status for all units using RAM data storage.

Post Survey Calibration

A post-survey calibration should be performed to observe any sensor drift that may have occurred between the pre-survey and the post-survey. The values in Table 2 can be used as a guide to determine if sensor drift is within an acceptable range following a cruise. The sensor testing follows the same basic procedures outlined in the pre-survey calibration section except that no new coefficients are added to the software. The chief scientist is responsible for deciding whether post-survey calibrations are within acceptable limits. Depending on the importance of the sensor to the survey, unacceptable limits could cause station re-sampling or for data to be flagged and removed. The recommended time between the last cast and the completion of the post-calibration should be not more than 24 hr.

Table 2. Acceptable range of values for CTD sensor drift during cruise post-calibration.

Parameters	Acceptable Deviation
Dissolved Oxygen (DO)	0.30 mg/L
Salinity	0.009 psu
Transmissivity	0.50 %
Temperature	0.03 °C
Hydrogen Ion Content (pH)	0.1 pH units
Pressure	1.3 decibars
Chlorophyll (a)	1.0 µg/Liter

Station Occupation

While other specific survey designs may impose more stringent station occupation requirements, the general recommendation for the Model Monitoring Program is that CTD casts should be initiated and completed within 0.05 nm of the nominal station coordinates.

CTD Deployment

The objective of water-column profiling is to collect data for every meter of depth while lowering the CTD. Ideally a scan-rate of eight scans per second or greater should be used. The absolute minimum scan-rate is two scans per second and should be reserved for use in small bodies of water, where deploying smaller units is more practical. In larger bodies of water, where larger units are easier to deploy, it is strongly recommended that the scan-rate be eight scans per second. Some manufacturers' software allow the descent rate to be monitored digitally when the CTD is deployed using a real-time means of data collection by displaying and viewing lowering rate variable. If RAM is used during deployment, the rate should be monitored with a meter wheel and timer. Descent rates should always be greater than the upward acceleration of the instrument caused by the swell to minimize shed wake spiking of the data.

Use of an onboard water bath for the CTD is recommended to prevent excessive heating of the sensors while traveling between stations. However, if a water bath is not practical, a wet towel should be wrapped around the instrument's sensors to prevent them from overheating. Rinse the lenses of the transmissometer with deionized water to remove any crystallized salt prior to each cast.

Before beginning a cast where dissolved oxygen is being measured, it is recommended that the sensor be brought to thermal equilibration with the ambient sea-water by soaking the CTD for a minimum of three minutes at the first station of the day and for 90 seconds at every station thereafter. Surface equilibration time is performed for two reasons; DO sensor re-polarization and thermal equilibration. Additionally, air bubbles may become trapped in the CTD's tubing that can adversely affect the performance of the DO sensor unless they are removed. The air bubbles can be purged from the tubing simply by lowering the unit five meters below the surface for a short time, then raising it back to the surface so that the top of the CTD is just below the surface prior to starting the cast. The recommended optimal descent rate while lowering the CTD is 1 m/s.

CTD Cast Acceptability

As a means of reducing field-related data errors and, therefore, preventing needless resampling, station occupation criteria and cast acceptability should be evaluated as often as possible during a sampling day. Checking the data at the first station of the day will ensure that the CTD is operating properly. To ensure cast acceptability, it is recommended that the data be checked at every station thereafter when using a real-time means of data collection. The data should be checked at every other station or so when using a RAM method of data collection. Cast acceptability can be evaluated by using one, or all of the following three methods:

1) All parameters can be displayed graphically to determine if any grossly anomalous readings occurred. The graphics can be scaled to illustrate any obviously anomalous values that lie outside the control limit range for each parameter (Table 3).

2) A range-checking computer program can be used to evaluate the presence of anomalous values on the basis of predetermined criteria (i.e. range acceptability checks).

3) Casts can also be evaluated by comparing values collected at a particular station with those obtained at previous or nearby stations.

Table 3. Reasonable ranges of measurements from waters of the mainland shelf of southern California.

Parameter	Typical Range
Dissolved Oxygen (DO)	3 – 12 mg/L
Salinity	32 – 34 psu
Transmissivity	20 – 90 %
Temperature	8 – 24 ℃
Hydrogen Ion Content (pH)	7.5 – 8.5 pH units
Chlorophyll	0 – 50 µg/Liter

If anomalous values in the data are discovered, the cause should be investigated and remedied if possible before proceeding. If damage to the CTD (due to striking the bottom or some other mechanical event) is suspected, review the cast as described above to ensure the data are acceptable. Further review of the subsequent casts will ensure that all of the sensors continue to function properly through the remainder of the sampling day. If a sensor has been damaged and needs to be replaced, the CTD should be configured according to the factory recommended specifications and another cast should be performed at the sampling station. All activities relating to the occurrence of these types of events (e.g., repeated casts, damaged equipment and remedies, replaced sensors, etc.) should be noted on the field data sheet.

CTD Quality Assurance/Quality Control

No field QC of any of the parameters is required beyond the cast acceptability check described above. When the data from a particular sampling site have been evaluated for cast acceptability, ensure that the data file and any CTD-specific files have been correctly named and stored. If the data indicate that the CTD, or one of it's components, are not operating correctly, the defect will be documented, sampling will be halted and the unit will either be repaired in the field and reevaluated, or it will be returned to the laboratory.

Quality assurance and quality control (QA/QC) of the water quality data will be determined by closely monitoring and documenting the performance of the CTD and by adhering to the manufacturer's recommended calibration procedures and maintenance schedules.

CTD Data

CTD data may be shared between two or more agencies. As a means of facilitating data comparability, the format of the data will be determined by mutual agreement before any actual sampling takes place. An example of such a format is as follows:

1) Agency
2) Station
3) Date
4) Depth (m)
5) Temperature, IPTS-90 (°C)
6) Conductivity (Siemens/m)
7) Oxygen (mg/L)
8) Light Transmission (%)
9) Salinity, PSS-78 (psu)
10) pH
11) Density (sigma-theta), (kg/m3)
12) Chlorophyll Flourescense

Records of all sensor and equipment factory maintenance, calibration logs, and CTD field data sheets should be maintained and made available upon request. Additionally, all raw CTD files, configuration files, header and mark files should be archived.

SECTION 4

BENTHIC SAMPLING

BENTHIC SAMPLING

Purpose

The purpose of benthic sampling is to obtain at each site one or more samples of the seafloor sediment having no less than a minimum fixed surface area and volume. The sediment samples are used to describe the biological physical and chemical

characteristics of the site. This information is particularly useful in characterizing the extent and impact of the discharge from an outfall, or various other anthropogenic influences relative to the prevailing natural conditions.

Equipment

A 0.1 m^2 modified Van Veen grab will be used to collect sediment samples for physical, chemical, and infaunal analysis (Figure 1) (Stubbs, et al. 1987). (Currently Kahl Scientific Instrument Corporation, El Cajon, CA, manufactures these grabs). The grab may be galvanized, stainless steel, or Teflon-coated. All surfaces of the grab must be clean and free of rust. Either single or tandem-rigged Van Veen grabs may be used. Tandem-rigged Van Veen grabs are two grabs mounted on a shared hinge pin (Figure 2).

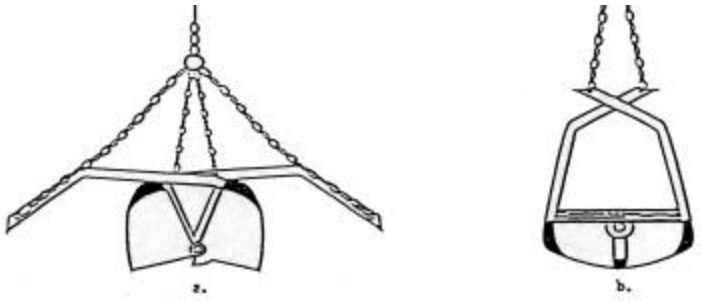

Figure 1. Modified Van Veen grab sampler recommended for marine receiving-water monitoring programs in southern California: a) cocked position; b) tripped position (modified from Stubbs, et al. 1987).

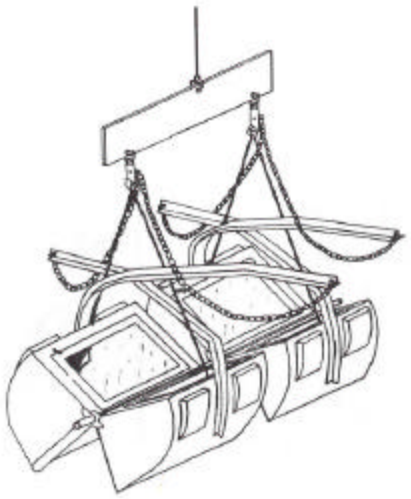

Figure 2. Tandem-rigged Modified Van Veen Grabs.

Station Occupation

Typically, multiple grabs are required at a site to collect sufficient material to assess biota, habitat variables (such as grain size, total organic carbon (TOC), toxicity) and sediment contaminant levels. It is important that the successive grabs are collected as close together as is practicable to help ensure that all grabs are from sediments of similar character. The standard is for all grabs collected at a site to be within 0.025 nm (50m) of the nominal site coordinates and within 10% of the nominal station depth. Greater precision than this minimum is typically achievable with DGPS navigation aids.

Grab Sampling Procedures

Prior to deployment, the grab should be cocked and then the safety key should be put in place. The grab is next hoisted over the side; the safety key is removed and then lowered at a rate of approximately 2 m/sec until it is about 5 m above the bottom. From this point, it is lowered at 1 m/sec to minimize the effects of bow wave disturbance. After bottom contact has been made (indicated by slack in the hydrowire), the tension on the wire is slowly increased which causes the lever arms to close the grab. The grab is then brought back to the surface and retrieved back on deck as quickly and as safely as possible to avoid any "washing" at the surface caused by the boat rolling in the sea. Once the grab is back onboard, the top doors are opened so that the sample can be inspected.

Criteria for Acceptable Grab Samples

Before the grab can be processed, the acceptability of the sample must be determined. This determination is based upon sample condition and depth of penetration. Sample condition is judged using criteria for surface disturbance, leakage, canting, and washing (Figure 3). An acceptable sample condition is characterized by an even surface, with minimal surface disturbance, and little or no leakage of the overlying water. Heavily canted samples are unacceptable. A sample with a large amount of humping along the midline of the grab, an indication the sample was "washed" during retrieval, is also unacceptable. While some humping might be evident in samples taken from firmer substrates, this is primarily due to the closing action of the grab and is not evidence of unacceptable washing.

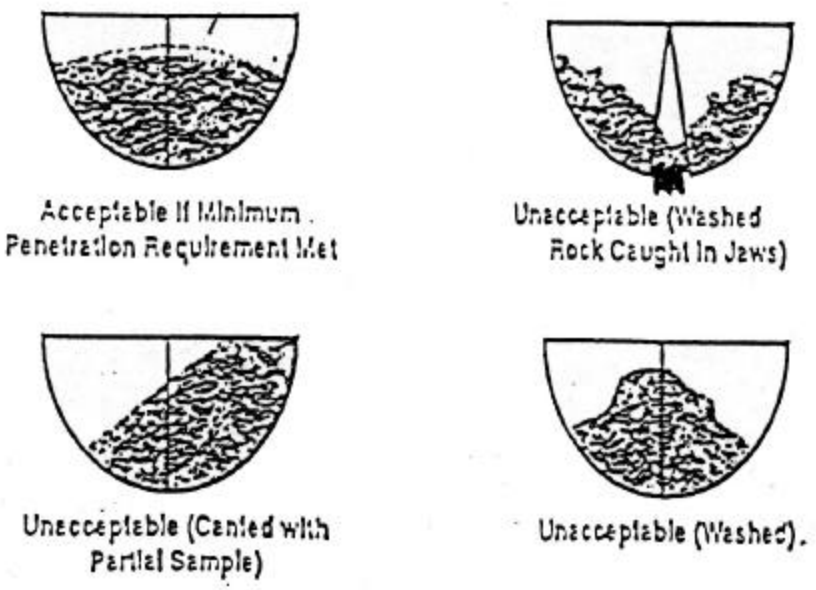

Figure 3. Examples of acceptable and unacceptable grab sample condition (modified from Tetra Tech, 1986).

If the sample condition is deemed acceptable, the overlying water is drained into an underlying container by slightly opening the jaws of the grab. This water must be retained for later screening with the sediments (see Sample Processing below). Extra caution should be taken to drain the overlying water from the grabs for chemistry and toxicity samples so as to avoid disturbance and loss of the surface sediments. The method described above for removing water is acceptable, but siphoning or decanting the water is highly recommended

The next step in processing the grab is measuring the depth of penetration. For infaunal samples, sediment penetration depth must be at least 5 cm; however, penetration depths of at least 7-10 cm should be obtainable in silt (fine sand to clay). Inserting a plastic ruler vertically along the grab midline and measuring the depth of the sediment to the nearest 0.5 cm determines the depth of penetration.

Sediment Description

Sediment characteristics should be described following the measurement of penetration depth. The general sediment type should be characterized (e.g., clay, silt, sand, gravel, or any combination of these) and if the sample contains large quantities of shell hash, this should also be noted on the data sheet. The presence of petroleum tar should be recorded, as well as any obvious odors such as sulfides (the odor of H_2S or rotten eggs), oil (the odor of petroleum tar), or humic smells (a musty, organic odor). Sediments will usually have no particular odor. General sediment color (e.g., black, green, brown, red, yellow) should also be recorded.

Sample Processing

Benthic Infaunal Samples

After the sample description has been completed, the sediment sample intended for infaunal analysis is washed completely from the sampler, saving sediment, overlying seawater, and wash water for subsequent screening. All raw wash waters used on the sample are to be filtered in some fashion to preclude the accidental introduction of surface-water organisms. Two methods that may be used are an in-line filter in the boat's seawater pumping system, or the fitting of all wash hoses with fan nozzles having small apertures (<0.5 mm diameter).

A sediment-washing table is recommended for benthic sample processing. The table provides a flat, smooth surface over which to spread and wash the sample. This provides a means of gently breaking up the sediment before it runs off the end of the table into the screen box. The screen box must be equipped with a stainless steel mesh with 1.0-mm openings. Wire diameter should be similar to that found in the U.S. Standard 1.00 mm Sieve (0.58 mm). The surface area of screen should be adequate to easily accept the sample without build up. Typical screens have surface areas ranging from 1500 to 2100 cm^2. Water pressure should be controlled while washing the sample to avoid damaging the organisms. Minimize direct application of water from the hose to the material and organisms collecting on the screen.

Once the sample has been washed through the screen, the material (debris, coarse sediment, and organisms) retained on the screen should be transferred to a sample container. The sample container should be labeled with an external, water resistant adhesive label naming the station , depth, date, replicate and "split number" (i.e. 1 of 2, 2 of 2, etc.), if applicable. It is recommended that a duplicate label be placed inside the container. This label should be waterproof and marked using a pencil or indelible ink.

The sample container must have an adequate watertight closure and be sufficiently large to accommodate the sample material, relaxant and fixative. If necessary, a sample may be split between two or more containers, however, each container must have the appropriate labels (described above) with the corresponding split number clearly marked. Splitting samples should be avoided if possible. Splitting samples is usually unnecessary if the field crews have a broad range of sample container sizes available.

The material retained on the screen should be gently removed in order to avoid damaging the organisms. The sample container should be filled to approximately 40% (no more than 50%) of capacity with screened material. After the sample material has been transferred to the container, the screen should be closely examined for any remaining organisms caught in the mesh. Those organisms should be removed with forceps and added to the sample container. The screen box should be thoroughly washed and the mesh scrubbed with a stiff brush before the next sample is screened.

It is recommended that all infaunal samples be treated with a relaxant solution for approximately 30 minutes prior to fixation. Either an Epsom salts ($MgSO_4$) solution or a propylene phenoxytol solution (formulations below) may be used for this purpose. The relaxant solution may be used as the diluent water for the fixative, or may be decanted after exposure and replaced with diluted fixative.

If the relaxant is used as diluent water, fill the sample container to 80% of its volume, close the container and invert it several times to distribute the solution. Leave the sample in the relaxant for 30 minutes. After 30 minutes top off the container with enough sodium borate buffered formalin to achieve a 10% formalin solution. Close the container once again and invert it several times to assure mixing. Store the sample for return to the laboratory.

If the relaxant solution is not used as the diluent water, the relaxant must be removed from the sample container and replaced with 10% formalin. After the 30-minute treatment, decant the relaxant from the sample through a screen with a mesh size of less than 1.0 mm. Make sure that all of the material and animals have been removed from the screen and placed in the sample container. Fill the sample container with a 10% solution of sodium borate buffered formalin rather than with undiluted formalin. Close the container, invert it several times to assure mixing and then store it for return to the laboratory.

Relaxant and fixative stock solutions are as follows:

1)	Epsom salts relaxant solution:	1.5 kg Epsom salts ($MgSO_4 \bullet 7H_2O$) per 20 L of freshwater.
2)	Propylene phenoxytol solution:	30 ml propylene phenoxytol to 20 L of seawater.
3)	Buffered formalin solution:	50 g sodium borate ($NA_2B_4O_7$) per liter of formalin.

4) Buffered 10% formalin solution: 1 part buffered formalin solution to 9 parts fresh or salt water.

Sediment Chemistry Samples

Sediment grain-size and chemistry (e.g., TOC, trace metals, trace organics) samples will be collected from the top 2 cm by randomly subsampling undisturbed surface material with a stainless steel, Teflon-coated, or plastic scoop. A metallic scoop should be replaced if any signs of rust are visible. Sediment in contact with, or within 1 cm of the metal sides of the grab should be avoided to reduce the chance of sample contamination (e.g. metals, organics, etc.). Care should be taken not to touch any surfaces of the grab sampler with the scoop. At a minimum, the scoop will be thoroughly rinsed to remove any traces of sediment form the previous station then stored to avoid being contaminated between stations.

Chemistry samples should always be placed in precleaned containers. Sediment grain-size and some sediment chemistry (e.g., TOC and trace metals) samples can be collected in glass or plastic containers, but trace organics samples should always be made of glass. Sediment chemistry sample containers should have Teflon-lined lids, although this is not a requirement for sediment grain-size samples. An air space should be left at the top of each sample.

Sediment grain-size samples should not be frozen; rather they should be stored at approximately 4 ^{o}C by packing them in wet ice, or in a refrigerator. Sediment chemistry samples may be stored at <4 ^{o}C (wet ice / refrigerator), but must be frozen at -20 ^{o}C within 24 hrs..

Quality Assurance

The quality of benthic sediment samples is dependent on following the field procedures described in this manual with special attention to the following:

1) Prior to each deployment the interior of the grab must be thoroughly washed with seawater to remove any sediment from the previous sample.

2) Once the grab is returned to the surface, it should be recovered as quickly as safe handling permits as a means of avoiding sample washing as the boat rolls in the sea.

3) The grab sample should be visually inspected to ensure the overall condition is acceptable and it should be measured to guarantee the minimum depth of penetration.

4) Gentle water pressure should be employed when washing and screening the infaunal samples to avoid damaging any of the organisms.

5) The screen must be thoroughly washed and scrubbed between samples.

6) A relaxant is recommended for use on all infaunal samples to minimize fragmentation of the organisms during fixation.

7) The infaunal sample container should be filled no more than 40% full of screening material. After adding relaxant and fixative solutions, the container needs to be inverted several times to assure a thorough mixing and exposure to relaxant and fixative.

8) Timers should be used to ensure that fixation of the samples takes place 30 minutes after being exposed to the relaxant solution A distinctive sticker may be affixed to the lid of the sample container to visually distinguish between the samples being treated with relaxant and those having been fixed.

9) Extra care should be taken when draining the overlying water from grabs intended for chemistry samples. This minimizes disturbance and loss of surficial sediments. Use of a tygon tubing siphon is highly recommended.

10) Field personnel must be thoroughly trained to recognize and avoid potential sources of contamination of chemistry samples (e.g., engine exhaust, winch wires, deck surfaces, ice used for cooling).

11) Grabs for sediment chemistry samples must be of similar sediment type and have similar penetration as the grab used for the infaunal sample. This is to ensure an adequate volume of surface sediments for subsampling, and that the chemistry samples come from sediments of similar character as the infaunal sample. Tandem-rigged Van Veen grabs can facilitate this by simultaneously collecting sediment samples from the same site for chemistry and benthic analyses.

12) Sample devices that come in direct contact with the chemistry sample sediment should be made of non-contaminating materials (e.g. plastic, glass, high quality stainless steel, and/or Teflon) and should be thoroughly cleaned between sampling stations.

13) Chemistry sample containers must be of the recommended type of material and must be carefully precleaned.

14) Sample holding conditions and holding times specified for chemistry samples must be followed explicitly.

TRAWL SAMPLING

Purpose

The purpose of trawl sampling is to obtain data on the abundance, biomass, diversity, and disease prevalence of demersal fish and invertebrate assemblages. It is also used to collect fish and invertebrates for tissue contaminant analysis. This information is useful in characterizing the extent and impact of the discharge from an outfall, or for describing the influence of other anthropogenic activities on demersal fish and invertebrate populations relative to natural conditions. Mearns and Allen (1978) provides a comprehensive description of how small otter trawls should be designed and used for conducting biological surveys in coastal waters.

Collection Permits

Scientific Collecting Permits are mandatory for collecting specimens in the field and can be obtained from the California Department of Fish and Game (CDFG). Both the permit and the permit holder must be onboard during sampling and it must be presented to any CDFG warden or personnel who request to see it. The local office of the CDFG (San Diego, (619) 237-7311; Los Angeles/Orange County area, (562) 342-7100) must be contacted prior to collecting fish and invertebrates. The caller will be asked for his or her name, scientific collector's permit number, date, time, and area of sampling, type of gear to be used, vessel size, color, CF numbers (or documentation), number of persons in party and what organisms will be collected.

Otter-Trawl Specifications

A semiballoon otter trawl (otter trawl) will be used to collect epibenthic invertebrates and demersal fish (Figure 4). Net dimensions are the following: 7.6-m head rope (25 ft); 8.8-m foot rope (29 ft); 3.8-cm (1.5 in) body mesh; and a 1.3-cm cod-end mesh (0.5 in). This net will have 22.9-m (75 ft.) long bridles made of 1.0-1.6 cm (3/8 to 5/8 in.) diameter rope (e.g., Samson braid). Typical otter boards (doors) for this size net will have a width of approximately 76 cm (30 in.), height of 50 cm (20 in.), and a suggested weight of 16 kg (35 lb) (Figure 5). The actual specifications of how any trawl door is set up may depend of the manufacturer of the otter trawl, but the user of the equipment should be sure to follow all the factory recommended set-up procedures to ensure that the net fishes appropriately in the field.

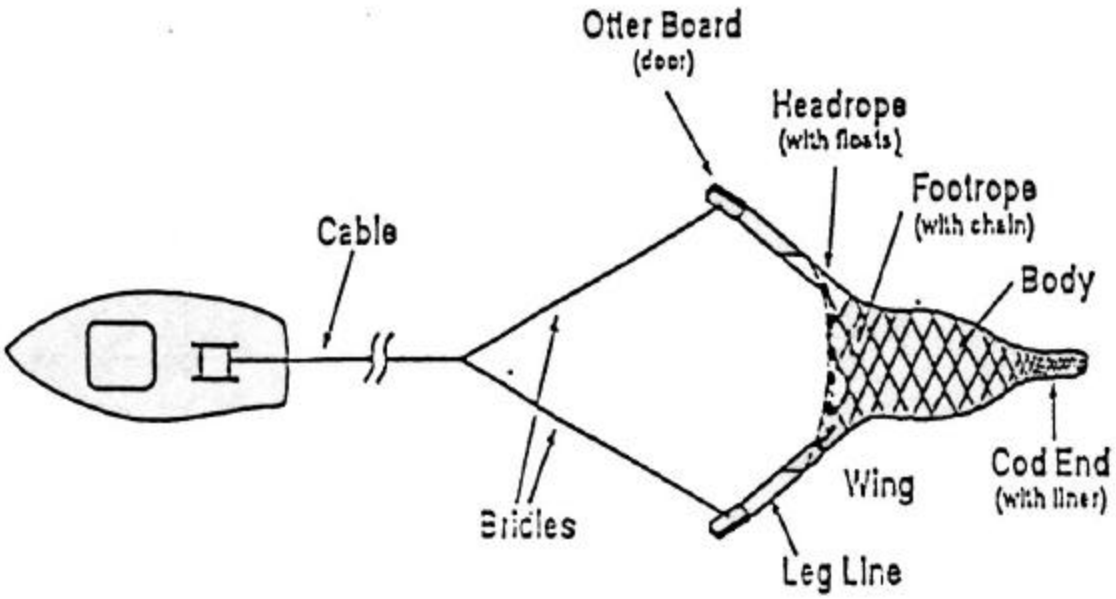

Figure 4. Semiballoon otter trawl recommended for marine receiving-water monitoring programs in southern California (modified from Mearns and Allen, 1978)

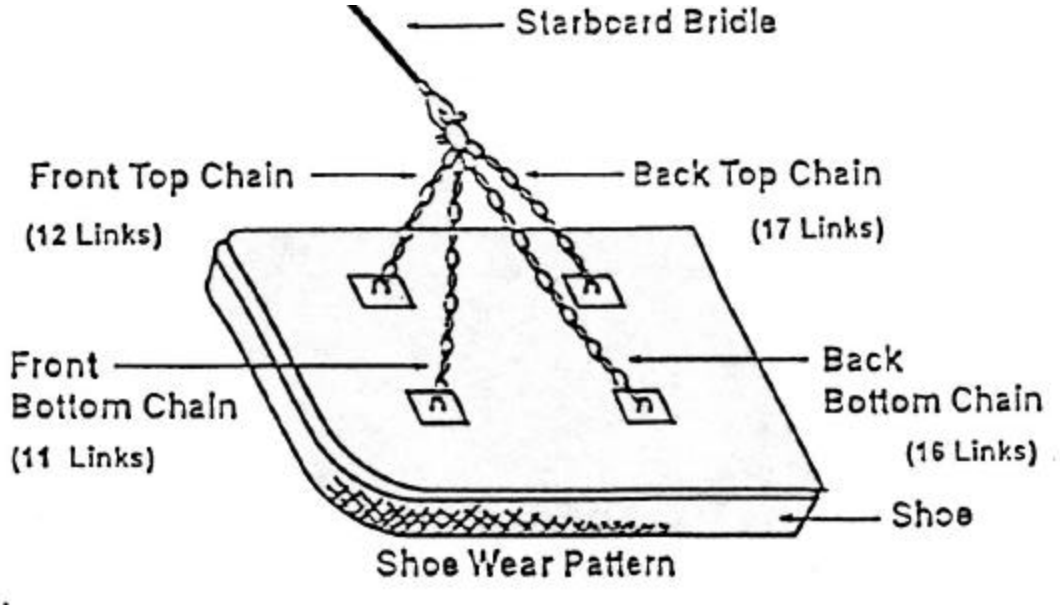

Figure 5. View of an otter board of a semiballoon otter trawl with recommended numbers of chain (5-mm or 3/16 in. diameter) links (modified from Mearns and Allen, 1978)

Pretrawl Survey

Trawl gear is likely to be lost or damaged if they become snagged on bottom obstructions. Evaluate the trawl course at a previously unsampled station by using a fathometer. This "pretrawl" survey can enable the navigator to avoid uncharted reefs and other obstacles. If obstacles are encountered, resurvey a new trawl course. The chief scientist alone has the authority to decide whether to trawl or abandon an unknown station.

Trawl Data Log

The field crew is responsible for keeping a trawl data log. The information recorded in the log includes water depth, length of tow wire used, times and coordinates (latitude and longitude) for net on the bottom and end of trawl (= beginning of trawl retrieval). The coordinates for when the net was deployed (net over) and when the net was retrieved (on deck) may also be recorded. Any anomalous conditions such as rocky bottom, rocks in the catch, and torn net should also be recorded in the log.

Net Preparation

The trawl components should be properly prepared prior to sampling so that the trawl can be deployed in an orderly and safe manner upon arrival at a sampling station. The net should be laid out and stacked on the stern of the vessel in the same configuration that it will be deployed: cod-end to the stern, floats up, and foot rope down . The trawl net should be checked to make sure that the cod-end is tied correctly, the trawl doors should be connected properly to the leg lines, and the bridles should be securely fastened to the doors and to the tow wire.

Station Occupation

Every effort should be taken to ensure that any particular trawl track passes the nominal station coordinates at a distance of no greater than 100 m, and that the trawl course varies no more than ± 10% of the target depth. The trawl track can be plotted prior to sampling so that a successive series of waypoint locations along the track can be obtained. These coordinates can then be entered into the DGPS and then retrieved at the time of sampling to ensure that the vessel maintains its course along the trawl track.

Trawling

Trawls should be towed along, rather than across, isobaths. While the vessel is underway, the net and doors are placed in the water. It is important that the floats skim the surface and that the net is not entangled (i.e., crossed leg lines, bunched or hooked portions of the net) prior to paying out the bridles. This small step could mean the difference between a successful or unsuccessful trawl. The bridles should be paid out by a person(s) on each side of the net, being careful to stand on the outside of the bridle lines to avoid becoming entangled in the rigging during deployment.

Use of the proper scope (i.e., length of hydrowire deployed out versus the water depth) is very important for successful catches. After the net touches the bottom, a sufficient length of hydrowire (towing wire) should be deployed to ensure that the net is pulled from a horizontal rather than a vertical position. Insufficient scope will prevent the net from consistently fishing the bottom and will result in a no-catch, or a short-catch situation. In general, the required scope declines with increasing depth because the additional weight of the hydrowire enhances the horizontal component of the towing forces (Table 3).

Table 3. Recommended scope and length of hydrowire for trawling at different depths in the Southern California Bight.

Water Depth (m)	Hydrowire Length (m)[1]	Approximate Scope (m)[1]
<5	50	10.0:1
10	80	8.0:1
30	180	6.0:1
60	300	5.0:1
100	400	4.0:1
150	550	3.6:1
175	625	3.5:1
200	700	3.5:1

[1] Bridle length is included in this scope.

These scopes are for 0.6 cm (0.25 in), 0.8 cm (0.31 in), and 1.0 cm (0.38 in) hydrowire. Larger diameter wire and greater depths require less scope.

Once on the bottom, the net is towed to cover a distance of about 600 m, which under normal circumstances is roughly equivalent to 10 min of trawl time at a speed-over-ground of 1.0 m/sec (3.3 ft/sec or 2.0 kt). Trawl speed and distance can be determined by DGPS. In confined areas the trawl duration should be reduced to 5 min, and a distance of 300 m. At the end of the prescribed trawl time, the net is retrieved and brought on board the vessel. The cod-end is opened and the catch is deposited into a tub or holding tank. The catch is subsequently released to the scientific crew for work-up.

Criteria for Accepting a Trawl

If after conducting a trawl the cod-end contains little or no catch, its acceptability will be evaluated according to whether the net was fishing properly. This evaluation is based on whether the proper depth, scope, speed, and distance (or duration) were maintained, whether the net was fouled (net tangled), and whether the sample shows evidence that it was on the bottom (e.g., rocks, benthic invertebrates, benthic fish). If any of the trawl procedures were not followed, if the net was fouled or torn (the tear must be sufficient to allow escapement), or if there was evidence of no contact with the bottom, the trawl will be considered unacceptable and another will be conducted at the site (if feasible).

Sample Processing

Sorting

The trawl catch should be sorted on deck into containers. The catch should initially be rough sorted into major categories (e.g., urchins, shrimp, other invertebrates, flatfish,

rockfishes, other fishes). The categories used are not important, but it is more efficient to sort into rough categories before identifying organisms to species. Debris may also be categorized and the amount (abundance and weight) noted.

Trawl Debris

Debris collected during any trawl should be quantified by recording the specific types of material and their quantities: present (1); low (2-10); moderate (11-100); and abundant (>100). The approximate weight of each type of material should also be estimated: trace <0.1 kg); low (0.1-1.0 kg); moderate (1.1-10.0 kg); and high (>10.0 kg).

Identification

The goal is to provide species-level identifications for all fish and invertebrates captured in the trawl. Most, if not all, of the trawl caught organisms should be identifiable to species in the field using taxonomic keys and field guides as needed. Species of fish and invertebrates that cannot be reliably identified to species in the field should be returned to the laboratory for further identification. In these instances, the field personnel should recognize their taxonomic limitations and record "FID" (further identification) on the field sheet along with the level of identification for which they can be certain. Under no circumstances should an organism be discarded if the identity is in question. When the unknown organisms have been identified in the laboratory or the field, the correct identity of the species should be recorded on the original data sheet. If the laboratory identity differs from that recorded in the field, the original name should be crossed out with a line. Do not erase the original name.

Although identifications will be made on all fish (either in the field or in the laboratory), only invertebrates meeting specific criteria will need to be identified. There are likely to be many small infaunal and pelagic species that are incidental to the trawl catch. These need not be processed. Only organisms that are greater than 1 cm in any dimension are to be included in the data. Colonial and pelagic organisms will be noted but do not have to be enumerated. Infaunal organisms do not need to be documented either. The presence of obvious fish parasites, such as leeches or cymothoid isopods, should be noted.

Pertinent field guides and taxonomic aids should be used for identifying fish and invertebrates. The most basic and comprehensive guides for fish are Miller and Lea (1972) and Eschmeyer, et al. (1983). Allen (1977) provides information for identifying juvenile rockfishes (*Sebastes* spp.), Orr et al. (2000) on adult *Sebastes* and *Sebastolobus*, and Kramer, et al. (1995) provides information for identifying flatfishes. Generally, there are no widely comprehensive guides to the epibenthic invertebrates.

Either common or scientific names of fish may be used in the field, but they should reflect the most up-to-date, scientifically valid nomenclature available (e.g., Robins et al. 1991, SCAMIT 1998, or updated versions of these or other lists).

Each organization should have a kit containing a variety of tools that will aid in field identification. This kit should include forceps (small with sharp points and large with blunt points); a hand lens; dividers or calipers; dissecting needles; scalpel with scalpel blades; probe; and plastic ruler in millimeters.

Length Measurement

All fish species will be measured on measuring boards or, for very large specimens, by a meter stick or tape measure. A measuring board typically consists of either a flat or trough shaped board with a part of a meter stick running down the middle. A smaller board (cross board) is attached across the zero-end of the meter stick. Trough-shaped boards facilitate keeping groups of fish on the board during measurement. Centimeter size-classes are marked along the side of the measuring board with the number of the size class marked next to the appropriate centimeter.

When measuring a fish, the head of the individual should be pushed against the crossboard at the zero-end of the measuring board. Board standard length in bony fishes is obtained by measuring from the anterior tip of head to the posterior end of the caudal peduncle, which is located slightly anterior of the externally visible origin of the caudal fin rays. Bending the tail laterally upwards and noting the point of sharp flexure can most closely approximate the position where board standard length is measured. It is recommended that the length of all fish specimens be reported in size classes of 1.0 cm intervals (Mearns and Allen, 1978). The first centimeter size class (size class number 1) would extend from >0 to 1.0 cm, size class 2 would extend from >1.0 to 2.0 cm, and so forth (Figure 6).

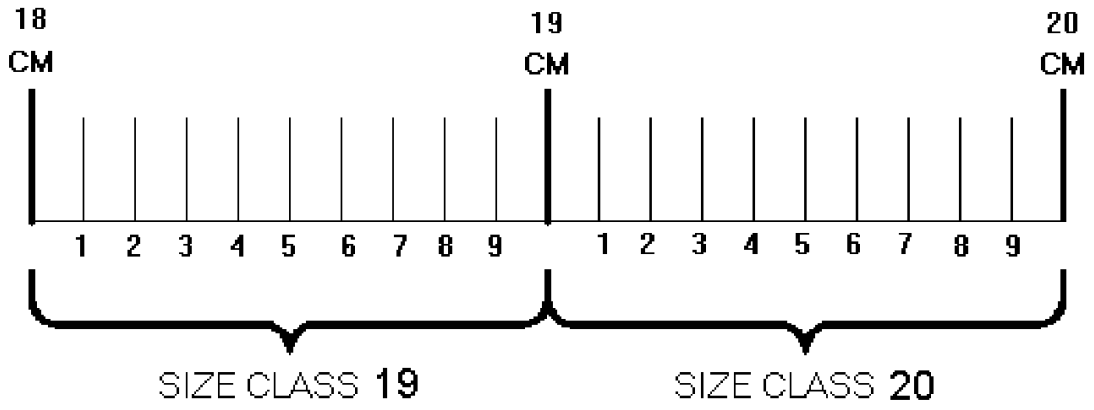

Figure 6. Relationship of cm size classes to mm values using cm and mm marks on a meter stick where size class 20 is defined as greater than 19.0 to 20.0 mm. Total length will be measured on cartilaginous fishes (Figure 7). Wingspan will also be measured for those rays with whip-like tails as the tips of their tails are frequently broken off.

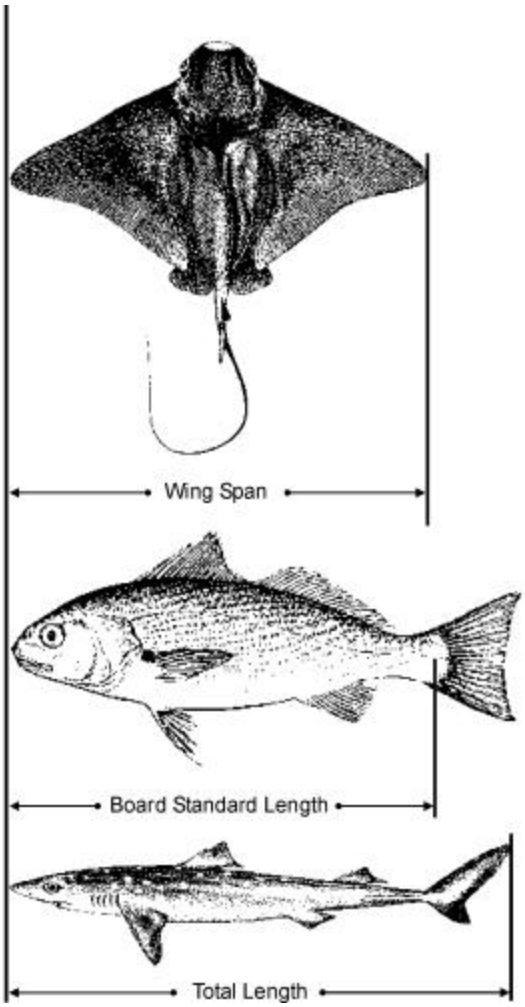

Figure 7. Endpoints for Wingspan (WS), Board Standard Length (SL), and Total Length for measuring the length of bony and cartilaginous fishes.

All species will be listed on trawl fish and invertebrate species data sheets. For fish species with 10 or fewer individuals, each size measurement (e.g., size-class 8) may be recorded on the trawl fish species data sheet. Record the size-class number for each fish on a line, separated by commas. For species with more than 10 individuals, the species identification and the total number are listed on the data sheet, but the sizes are tallied on a separate size-class sheet. An example of a fish size-class recording sheet is located in Appendix 2.

Attempt to size-class all fish, but for those rare occasions when size classing is not practical (e.g., a huge catch of a single species), a subsample of several hundred fish should be measured. When this occurs, the reason should be noted on the data sheet.

Lengths of invertebrate species will not be measured.

Weighing

Weight data collected from fish and invertebrate species will be used to estimate the total biomass of the catch and for each species where practical. Each agency should have a range of spring scales that are capable of weighing to the nearest 0.1 kg. The scales should be calibrated at the start of each trawling day using a standard set of weights. Weighing will be done using a pre-weighed tare bucket or another suitable container (e.g., plastic net bags). If a tare bucket is used, the bottom should have many holes drilled through it to allow any excess liquid to drain off before the weight is recorded. Tare buckets should be washed periodically to remove slime.

The total biomass of each species will be measured to the nearest 0.1 kg. The tare container weight will be subtracted from the gross weight (species + tare container) to yield the species, or net weight. Small species weighing less than 0.1 kg will be recorded as < 0.1 kg.

Large organisms may be weighed individually. Individual weights of smaller specimens may be collected optionally, using a range of scales capable of weighing to the nearest 0.1 g.

Enumeration

Fish are enumerated while measuring them. The total number of each species (including size-classed species) should be recorded on not only the fish species data sheet, but also the size-class data sheets.

Most invertebrates will be enumerated following their identification. However, the number of individuals in particularly abundant species may be estimated from the biomass of the species at a later time. First, the number of individuals that comprise a minimal weight can be used to provide a "number of individuals per kilogram" coefficient. The total biomass of a species divided by the number of individuals/kg yields the total number of individuals in the sample. The weight-aliquot should be sufficiently large (e.g., several kilograms) that it falls within the mid to upper range of the spring scale being used in order to prevent the inherent inaccuracy of the spring scale at the low end from being multiplied throughout the entire biomass calculation.

Examination for Gross Pathology

During the identification and measurement procedures, fish and invertebrates will be examined for gross pathology. This entails a scan of the individual organism for anomalies and noting the type of pathology (by abbreviation) next to the length of the organisms during measurement (for fish). The following anomalies will be noted for fish:

1) Fin (and tail) erosion
2) Tumors
3) External parasites (e.g., copepods, isopods, leeches)
4) Color anomalies (ambicoloration, albinism) (Mearns and Haaker 1973)
5) Skeletal anomalies (Valentine 1975)
6) Lesions

7) Other anomalies

Burnspots and other anomalies will be noted for invertebrates.

Fin erosion can be found on the dorsal, anal, and caudal fins of flatfishes, and on the lower caudal fin and pelvic fins of bilaterally symmetrical fishes. Tail erosion occurs on the top and bottom of the caudal fins of bilaterally symmetrical fishes. Tumors can be smooth and rounded (angioepithelial nodules) or furrowed (epidermal papillomas). Externally obvious copepod parasites occur on the eye, the fins, or on the body of fish. Cymothoid isopods occur in the gill cavities of fish or on the body; they can often fall off. Leeches occur on the body of some flatfishes. Skeletal deformities that might be encountered include crooked backs, snub noses, or bent fin rays. Lesions include sores that do not appear to be due to net damage. Burnspot disease, which is found on crabs and some shrimps, resemble cigarette burns. Any fish or invertebrate specimens exhibiting unknown diseases should be retained and vouchered.

Safe Handling of Trawl-Caught Specimens

Several trawl-caught organisms can harm field personnel if they are not handled carefully. The California scorpionfish (*Scorpaena guttata*) has venomous fin spines, which can cause severe pain. This species should be handled with either leather gloves or pliers. Hot water, meat tenderizer, or ammonia should be applied to any puncture wound inflicted by this animal; heat helps to break down the protein in the venom. Several other species of rockfishes and the spotted ratfish (*Hydrolagus colliei*) also have mildly venomous spines. Round sting rays (*Urolophus halleri*), California butterfly rays (*Gymnura marmorata*), and bat rays (*Myliobatis californica*) all have venomous spines on their tails.

Pacific electric rays (*Torpedo californica*) are capable of emitting a very strong electric shock. If you must handle this species, wear rubber gloves and hold it by the tail- do not grasp the disk with both hands!

Pacific angel sharks (*Squatina californica*), spiny dogfish (*Squalus acanthias*), spotted ratfish, Pacific electric rays, and California halibut (*Paralichthys californicus*) all have sharp teeth that can result in painful bites if they are not handled properly.
Care must also be taken in handling blueleg mantis shrimp (*Hemisquilla ensigera californiensis*). This species is capable of severely cutting a person with its raptorial appendages. Care should also be taken in handling crabs and octopus.

Preservation of Samples

Incompletely identified fish and invertebrate specimens and those with diseases that require further examination should be returned to the laboratory. Fish and invertebrate specimens may be preserved or documented for QC, or for identification purposes in one of three ways:

1) Fixing in buffered formalin-seawater
2) Freezing

3) Photographing.

The preferred method for preserving small specimens is to fix them in 10% buffered formalin-seawater. Specimens with tumors, fin erosions, or lesions should also be fixed in this manner. The body cavities of fish greater than 60 mm in length should be slit with a scalpel on either the right side (for most bilaterally symmetrical fish), the blind side (for flatfish), or the ventral (side for dorsoventrally flattened fish, such as rays) before the specimen is placed in the formalin. The slit allows preservative to enter the body cavity and preserve the internal organs. Note that by convention, bilaterally symmetrical fish are photographed or drawn with their heads facing left and dissections are only conducted on the right side of preserved specimens.

Fish and invertebrates can be placed in either plastic bags or plastic jars and fixed in 10% buffered formalin-seawater. Fish should be inserted tail-first into jars so that they can be removed easily without destroying the fin rays or spines.

Fish should remain in the formalin solution for up to a week before being transferred to a freshwater bath. It is recommended that fish specimens soak in the fresh water for at least two days. The water should be changed at least once during that period. The fish should then be transferred to a solution of 50% isopropanol (isopropyl alcohol) or 70% ethanol for preservation. Trawl-caught invertebrates will also be fixed in 10% buffered formalin-seawater and preserved in 70% ethanol.

Larger specimens can be placed in plastic bags and frozen on dry ice if excessively large quantities of formalin would be required to fix the specimen in the field. These can then be thawed and fixed in the laboratory with 10% buffered-formalin solution. Any large specimens with tumors, fin erosion, or lesions should be fixed in the field with formalin rather than frozen if possible.

Small invertebrates (e.g., nudibranchs) may be kept cold in seawater and returned alive to the lab for identification.

Photographing large specimens (and colorful species) of fish and invertebrates in the field is permissible, but it is not considered an acceptable method to voucher specimens for which important taxonomic characteristics cannot be clearly recorded in the photograph. Photographs of unidentified rockfishes should be taken in the field since their color, which is an important taxonomic character, fades during preservation. When photographing a fish specimen, bilaterally symmetrical species should be photographed facing left (unless an anomaly occurs on the right side). Flatfishes should be photographed on the eyed side, facing the appropriate direction depending on whether it is a right- or left-eyed species. The blind side can also be photographed if important characteristics, or anomalies occur there. Dorsoventrally flattened fishes, such as skates and rays, should be photographed from the top, with the fish facing left. All specimens should be photographed on a light background with a meter stick along side and a label giving date, station number, and species in large bold letters. Photographs should show the overall appearance of the specimen, plus important identifying features if possible. Notes of any important morphological characteristics that could aid in the identification

of the specimen (e.g., counts of fin rays, gill rakers, and scales) should be made on the data sheet.

Specimens preserved for further identification should be noted on the field data sheet. A note should be made whether the organism is fixed, frozen, or photographed. A log of all the organisms that have been photographed should be kept during the survey, recording the frame number, date, location, station, and subject of each photograph.

Quality Assurance/Quality Control Procedures

Trawling Procedures

Demersal fish and invertebrate assemblage data are significantly influenced by the collection methodology. Gear type and deployment, tow duration, and towing speed can affect the composition of the catch. Therefore, strict adherence to prescribed sampling protocols is critical. Standard nets must be used and field crews must follow the standard trawling procedures described above to ensure that comparable samples are collected within a sampling program and between sampling organizations.

Data Collection on Species

Fish species identification, enumeration, biomass, and individual lengths must be determined in the field following protocols presented in this manual. Field personnel will also be expected to have appropriate identification aids. All species that are difficult to identify in the field should be returned to the laboratory for identification. It is very important that the final identity of any specimens returned to the laboratory for identification is noted on the original data sheet.

Voucher Collection

Each group conducting trawl surveys should develop and maintain a voucher collection of all fish and invertebrate species reported in their trawls. Voucher specimens should also be collected for all anomalies or diseases reported. Voucher specimens should be preserved in a manner appropriate to the material and clearly labeled as to identity, collection date, site name, site location, and depth. For very large fishes, photographs can serve as vouchers, but preserved specimens are preferred in almost all cases and are required for small species or specimens.

LITERATURE CITED

Allen, M. J. 1977. Southern California trawl-caught juvenile rockfishes (Preliminary). S. Calif. Coastal Water Res. Proj., El Segundo, CA. Proc. Taxonomic Standardization Program 5 (4): 25-32.

Eschmeyer, W. N., E. S. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Houghton Mifflin Co., Boston, MA. 336 p

Kramer, D.E., W.H. Barss, B.C. Paust, and B.E. Bracken. 1995 Guide to northeast Pacific flatfishes. University Alaska, Fairbanks, Alaska Sea Grant College Prog., Fairbanks,AK.104 p.

Mearns, A. J., and M. J. Allen. 1978. Use of small otter trawls in coastal biological surveys. U. S. Environ. Prot. Agcy., Environ. Res. Lab., Corvallis, OR. EPA-600/3-78-083. 33 p.

Mearns, A. J., and P. L. Haaker. 1973. Identifying and coding color anomalies in flatfishes. S. Calif. Coastal Water Res. Proj., El Segundo, CA. TM 200. 6 p.

Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game, Fish. Bull. 157. 249 (addendum in 1976).

Orr, J., M. A. Brown, and D. C. Baker. 2000. Guide to rockfishes (Scorpaenidae) of the genera *Sebastes* and *Sebastolobus*, and *Adelosebastes* of the Northeast Pacific Ocean, second edition. NOAA Tech. Memo., NMFS-AFSC-117. 47 p.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. 5th edition. Am. Fish. Soc., Spec. Publ. 20. 183 p.

SCAMIT (Southern California Association of Marine Invertebrate Taxonomists). 1998. A taxonomic listing of soft bottom macroinvertebrates from infaunal monitoring programs in the Southern California Bight. Edition 3. S. Calif. Assoc. Mar. Invert. Tax., San Pedro, CA. 167 p.

SCBPP (Southern California Bight Pilot Project). 1998. Southern California Bight 1994 Pilot Project: I. Executive summary. Southern California Coastal Water Research Project, Westminster, CA. 20 p.

SCBPP, FCT (Southern California Bight Pilot Project, Field Coordination Team). 1995. Field operations manual for marine water-column, benthic, and trawl monitoring in southern California. So. Calif Coastal Water Res. Proj., Westminster, CA. 63 p.

Southern California Bight Pilot Project Field Coordination Team. 1995. Field operations manual for marine water-column, benthic, and trawl monitoring in southern California. So. Calif Coastal ater Res. Proj., Westminister, CA. 63 p.Stubbs, H. H., D. W. Diehl, and G. P. Hershelman. 1987. A Van Veen grab sampling method. S. Calif. Coastal Water Res. Proj., Long Beach, CA. Tech. Rep. 276. 4 p.

Tetra Tech. 1986. Quality Assurance and Quality Control for 301(h) Monitoring Programs: Guidance on field and laboratory methods. Final report prepared for U. S. Environ. Prot. Agency, MOD/OMEP. Contract No. 68-01-6938.

Valentine, D. W. 1975. Skeletal anomalies in marine teleosts. Pages 695-718 in W. E. Ribelin and G. Migaki (eds.), The pathology of fishes. Univ. Wis. Press, Madison, WI.

APPENDIX 1

CHAIN OF CUSTODY FORMS

Agency Address Phone: Contact							Report Attention: Project: Analysis Required:					
Date Sampled	Time Sampled	Station	Total # Samples	INFAUNA			TOC	Grain Size	Metals	Pesticides/ PCBs/PAH's	AVS	LABs
				Rep 1	Rep 2	Rep 3						

	Signature	Print Name	Agency	Date and Time
Relinquished By:				
Received By:				
Relinquished By:				
Received By:				

Agency Address Phone:	Report Attn. Project: Analysis Required:

Date Sampled	Time Sampled	Station	Total # Samples	Depth																		

	Signature	Print Name	Date	Time
Relinquished by:				
Received by Lab				
Analyzed by:				
Data entered into WQ Database				
Data accepted by:				

APENDIX 2

FISH SIZE-CLASS DATA SHEET

TRAWL FISH SIZE-CLASS

Station:_____

SPECIES NAME:_____ Date:_____

WEIGHT (Kg): Gross:_____ Tare:_____ Net:_____ Page:___ of ___

Class	Tally	Total
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
	Total:	

Anomaly Abbreviations: A = ambicoloration D = skeletal deformity F = fin erosion
B = albinism G = diffuse pigmentation L = lesion
P = parasite T = tumor

Comments:

Completed By: