2007-08 Southern California Regional Mussel Survey Workplan

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INTRODUCTION

To characterize the spatial extent and temporal trends in contaminant levels in the coastal ocean and Great Lakes, NOAA's National Status and Trends (NS&T) Program has collected and analyzed bivalve species since 1986. Representative samples of locally abundant species are collected from fixed sites around the nation during the winter (Nov-Mar) season. To assess long-term temporal trends, samples are collected on a bi-annual schedule. Bivalve tissue samples are analyzed for trace metal and semi-volatile organic constituents and histopathology. Additional information on the NS&T "Mussel Watch" Program can be found at http://ccma.nos.noaa.gov/stressors/pollution/nsandt.

The Southern California coastal zone stretching from Pt. Conception to the Mexican border is currently home to ~16.5 million people inhabiting five counties (San Diego, Orange, Los Angeles, Ventura and Santa Barbara). Because the regional population is projected to exceed 20 million by 2020 (State of California 2001), land-based contaminant sources and loadings are expected to increase as well as change in terms of composition over the next decade and beyond. Prior to 2007, NS&T established 21 Mussel Watch sites in this region, with most located along the open coast (Fig. 1). These existing or "historical" sites were last sampled during the winter of 2005-06.

Assessment of coastal environmental quality in the Southern California region is of interest to decision makers and stakeholders at multiple levels of organization. Protecting resources via designation of marine protected areas (MPAs) and areas of biological significance (ASBS) requires data to define baseline environmental conditions, characterize the impacts of point and nonpoint sources of contamination and to establish time trends in environmental quality indicators, including chemical contaminants and bivalve health and condition. Development of alternative monitoring tools, e.g. passive sampling of waterborne chemical contaminants using solid phase microextraction (SPME), is another area of focus for regional scientists. Specific objectives of this effort include:

1. Increase spatial coverage of NS&T Program in the Southern California region
2. Provide Mussel Watch data at ASBS and MPAs
3. Utilize existing monitoring program frameworks to achieve objectives 1 and 2
4. Compare passive sampling methods (e.g. SPME) with bivalve accumulation

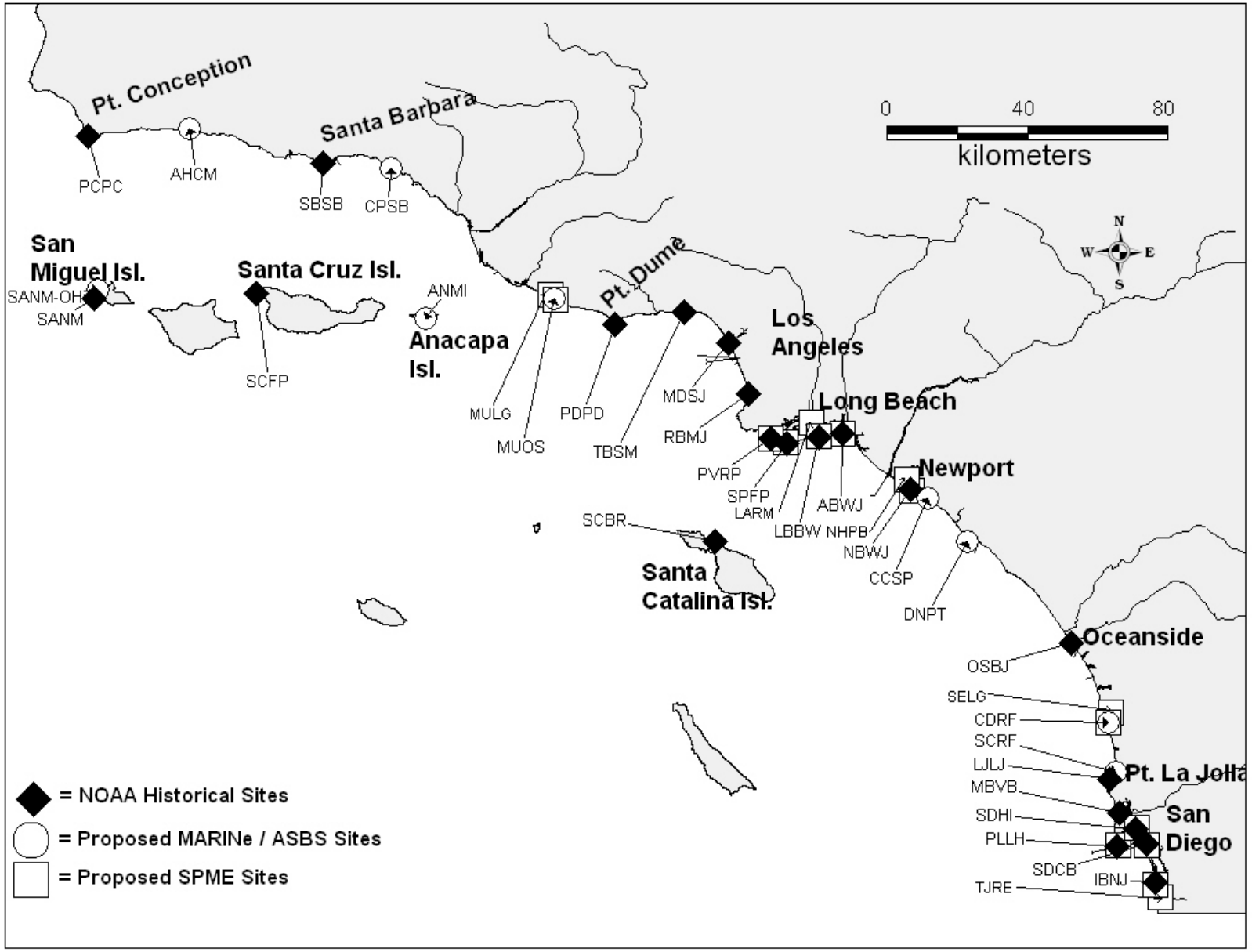


Figure 1. Existing and new (proposed) NOAA NS&T Mussel Watch sites in Southern California. Four letter site codes are given in Table 1.

To achieve these goals, a collaboration among NOAA, the Southern California Coastal Water Research Partnership (SCCWRP), the California State Water Resources Control Board (State Water Board), and the Multi-Agency Rocky Intertidal Network (MARINe) is being established. The first major task for this effort is the selection of new sites that complement existing NS&T sites. Among the criteria for selection of new sites are: non-proximity to existing NS&T sites; coincidence with existing MARINe monitoring sites; representation within ASBS; identification of additional embayment sites to allow for contaminant comparisons between inner and outer coastal waters and to monitor inputs from watersheds with different/changing land uses; and inclusion of National Estuarine Research Reserves (NERRs).

It is the goal of this collaborative effort to identify 34 total sites (21 existing; 13 new) for sampling during the winter of 2007-2008. NOAAs sampling effort in the past has been to split the Southern California sites into even and odd years. To simplify future sampling schedules, all 34 Southern California regional stations will be sampled during a single year time period. SPME samplers will also be deployed at selected sites during the 2007-08 sampling cycle.

APPROACH

Sampling Locations

Existing NS&T. NOAA has established 21 sites within Southern California (Fig. 1 and Table 1). Site descriptions (Appendix B) are found in Lauenstein et al. (1997). The historical site on San Miguel Island at Tyler Bight (site code SANM) has not been sampled regularly due to logistical difficulties. The Otter Harbor site on San Miguel Island at Otter Harbor is proposed as an alternative to Tyler Bight for this study.

New (proposed). A total of 13 new sites are proposed (Table 1). In collaboration with representatives from MARINe and the State Water Board, up to 15 sites were co-located at near existing MARINe sites and up to 10 sites were selected to represent ASBS locations (Table 1). The MARINe group members include local, State, and Federal agencies, universities and private organizations that monitor rocky intertidal sites along the California (and Oregon) coast, including the Channel Islands, on a long-term basis. Five new sites are located in embayments that are subject to discharge from watersheds with different overall and/or changing land use and are thus expected to represent a gradient of contaminant impacts. One of the new embayment sites will be located within the Tijuana River NERR). Individual site descriptions are given in Appendices C and D.

A summary description of all 34 study sites (21 existing; 13 new) is given in Table 1. For new sites, three sampling sub-locations within each site will be established in accordance with the SOP (Appendix A). A key restriction to minimize disturbance of ongoing studies is that no mussels will be collected from current MARINe monitoring sub-locations, as delineated by regional MARINe coordinators (see *Key Contacts).*

Sampling and Analytical Protocols

Sample collection and analysis for trace metal and organic constituents and mussel condition will follow protocols established by the NOAA NS&T (Mussel Watch) Program (Lauenstein and Cantillo 1998). An SOP based on the NOAA sampling protocol has been developed for standardizing mussel collections at all sites (Appendix A). Permission to collect samples in restricted access areas (e.g. MPAs, ASBS) will be solicited from the appropriate authorities prior to the scheduled collection date. Samples will be collected by hand from three sub-locations for each site and placed into individual bags on ice. Mussels will be shipped to NOAA's contract labs for analysis.

SPME Deployment, Retrieval and Analysis

SPME samplers will be submerged near selected mussel sampling locations for a minimum of 18 days. The sampling locations (Table 1) will represent matched embayment/ocean facing locations (e.g. Los Angeles Rivermouth and the Long Beach Harbor breakwall). SPME sampler design, and procedures for preparation, deployment, retrieval and data analysis will follow those described previously (Zeng et al. 2004; 2005) or modified for shallow water deployments.

Schedule

Each site will be sampled within a 3 week window around a pre-established target sampling date (Table 1). Existing site descriptions (Appendix B) contain historical observations that project the tidal height at which mussels emerge above the water surface. To maximize the number of mussels available for collection, sampling will be scheduled to occur at low tide (Fig. 2). Although crews will attempt to collect samples during the pre-established timeframe, sites may be abandoned or collection rescheduled because of safety concerns. Sites that require special access will be abandoned if permission cannot be obtained. Field sampling will be scheduled during spring tide (full or new moon) periods that offer collection opportunities during daylight minus MLLW levels. Neap tide periods will serve as backup collection time intervals (Fig. 2). The sampling schedule may be adjusted to accommodate weather conditions. Sites will be grouped into sampling time blocks according to proximity. Group 1 (Nov 22 to Dec 27, 2007) will target 10 existing NS&T sites; Group 2 (Jan 7 to Feb 9, 2008) will target 4 existing sites: and Group 3 (Feb 5 to Apr 2, 2008) will target 7 existing sites. The 13 new sites will be sampled during Group 2 and 3 time intervals. SPME samplers will be deployed and retrieved within ± 3 weeks of the corresponding site mussel collection date.

Table 1. Proposed sites for the 2007-08 Southern California Regional Mussel Survey.

	Site (Location)	Category	Code	Mussel Collection Species	Date	Notes
1	Tijuana River NERR (TBD)	N	TJRE**	ME	TBD	NERR; SPME
2	Imperial Beach (North Jetty)	H	IBNJ	MC	12/10/07	SPME
3	Point Loma (Lighthouse)	H	PLLH	MC	01/26/08	MARe; MPA; SPME
4	San Diego Bay (Coronado Bridge)	H	SDCB	ME	12/12/07	SPME
5	San Diego Bay (Harbor Island)	H	SDHI	ME	12/09/07	SPME
6	Mission Bay (Ventura Bridge)	H	MBVB	ME	12/11/07	
7	La Jolla (Pt. La Jolla)	H	LJLJ	MC	01/28/08	ASBS (adj); MPA
8	Scripps Reef (TBD)	N	SCRF**	MC	TBD	ASBS; MARe; MPA
9	Cardiff Reef (TBD)	N	CDRF**	MC	TBD	MARe
10	Oceanside (Municipal Beach Jetty)	H	OSBJ	MC/ME	01/27/07	
11	Dana Point (TBD)	N	DNPT**	MC	TBD	MARe; MPA
12	Crystal Cove SP (TBD)	N	CCSP**	MC	TBD	ASBS; MARe; MPA
13	Newport Beach (West Jetty)	H	NBWJ	MC	1/25/08	SPME
14	Newport Harbor (PCH Bridge)	N	NHPB**	ME	TBD	SPME
15	Anaheim Bay (West Jetty)	H	ABWJ	MC	12/08/07	SPME
16	Long Beach (Breakwater)	H	LBBW	ME	03/07/08	SPME
17	Los Angeles Rivermouth (TBD)	N	LARM**	ME	TBD	SPME
18	San Pedro Harbor (Fishing Pier)	H	SPFP	ME	12/13/07	SPME
19	Palos Verdes (Royal Palms SP)	H	PVRP	MC	12/03/07	MARe (adj); SPME
20	Redondo Beach (Municipal Jetty)	H	RBMJ	MC	03/06/08	
21	Marina Del Rey (South Jetty)	H	MDSJ	ME	12/02/07	
22	Las Tunas Beach (Santa Monica Bay)	H	TBSM	MC	03/05/08	
23	Point Dume (Pt. Dume)	H	PDPD	MC	12/01/07	ASBS/MARe (adj)
24	Old Stairs (TBD)	N	MUOS**	MC	TBD	ASBS; MARe; SPME
25	Mugu Lagoon (TBD)	N	MULG**	ME	TBD	ASBS (adj); SPME
26	Carpinteria State Beach (TBD)	N	CPSB**	MC	TBD	MARe
27	Point Santa Barbara (Pt. Santa Barbara)	H	SBSB	MC	11/29/07	
28	Arroyo Hondo (Canyon Mouth)	N	AHCM	MC	TBD	MARe (adj)
29	Point Conception (Pt. Conception)	H	PCPC	MC	02/23/08	MARe,
30	South Catalina Island (Bird Rock)	H	SCBR	MC	03/09/08	ASBS; MARe, MPA (adj)
31	Anacapa Island (North Middle Island)	H	ANMI	MC	TBD	ASBS; MARe, MPA
32	Santa Cruz Island (Fraser Pt.)	H	SCFP	MC	02/22/08	ASBS; MARe (adj)
33	San Miguel Island (Otter Harbor*)	H*	SANM**	MC	03/14/08	ASBS; MARe
34	San Elijo Lagoon (TBD)	N	SELG**	ME	TBD	SPME

TBD - to be determined; N - new; H - historical; MC - *Mytilus californianus;* ME - *Mytilus "edulis" complex;*

ASBS - areas of biological significance; MARe – Multi-Agency Rocky Intertidal Network site; MPA – marine protected area
SPME - solid phase microextraction; adj – adjacent to existing site. *Historical location was Tyler Bight; **proposed code for new sites

Key Contacts

San Diego State Collector: Constance Gramlich (gramlich@sunstroke.sdsu.edu)
Orange County MARINe sites: Steve Murray (smurray@fullerton.edu) and Jayson Smith (jasmith@fullerton.edu) (714-278-4233).
LA, Ventura, Santa Barbara Co MARINe sites: Rich Ambrose (rambrose@ucla.edu) (310-825-6144)
Point Conception site: Pete Raimondi (raimondi@biology.ucsc.edu) (831-459-5674)

References

State of California. 2001. Interim County Population Projections. Demographic Research Unit. Sacramento, CA.

Lauenstein GG, Cantillo AY, Kokkinakis S, Frew S, Jobling HJ, Fay RR. 1997. Mussel Watch Project Site Descriptions, through 1997. NOAA Technical Memorandum NOS ORCA 112.

Lauenstein GG, Cantillo AY. 1998. Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project: 1993-1996 Update. NOAA Technical Memorandum NOS ORCA 130.

Zeng EY, Tsukada D, Diehl DW. 2004. Development of a solid-phase microextraction-based method for sampling of persistent chlorinated hydrocarbons in an urbanized coastal environment. *Environ Sci Technol* 38:5737-5743.

Zeng EY, Tsukada D, Diehl DW, Peng J, Schiff K, Noblet JA, Maruya KA. 2005. Distribution and mass inventory of total DDE in the water column of the Southern California Bight (USA). *Environ. Sci. Technol.* 39, 8170-8176.

Figure 2. Projected tide intervals for the 2007-08 winter sampling period. Lowest tide series occur during late month full moon periods. Additional low tides occur during early-month new moon periods.

Appendicies

Appendix A
Standard Operating Procedure (SOP)
NOAA NS&T Mussel Collection and shipment

A) Procedures

1.0 SCOPE AND APPLICATION

1.1 The following document describes SCCWRP's procedure for collection and shipment of NOAA NS&T mussel watch samples from Southern California.

2.0 SUMMARY OF METHOD

2.1 Arrive at the designated sample site during low (minus) tide and within 3 weeks of the target date. Collect 80 – 160 mussels from predetermined locations by hand. Collect ancillary data such as temperature and salinity at the site. Sort sample into two categories: histology (20 mussel minimum) and tissue analysis (remaining mussels). Prepare samples for shipment. Ship samples to designated labs.

3.0 DEFINITIONS

3.1 SCCWRP – Southern California Coastal Water Research Project.
3.2 NOAA – National Oceanic and Atmospheric Administration.
3.3 NS&T – National Status and Trends Program.
3.4 Site – An area identified by a 4 letter code and described in the work plan.
3.5 Station – An independent location within a site along a 100 m transect.

4.0 HEALTH AND SAFETY WARNING

4.1 Sample collections are done in winter. Storms producing high surf are prevalent during this time. Extreme caution must be observed during sampling to prevent injury or loss of life from high wave conditions. Safety first. Abandon site for another day if surf conditions look dangerous. Teams of at least two people are highly recommended.
4.2 Expect to get wet from wave splash and/or rain storms. Air temperatures will be cold so wear thermal protection. Rocks may be slippery so wear appropriate foot gear. Use extreme caution while jumping, landing, or climbing on (in-between) rocks.
4.3 Carry gear and collected mussels in a backpack to free your hands for balance and stability while traversing rocky habitats.
4.4 Mussel beds may have sharp edges and objects. Wear gloves to protect your hand when necessary.

5.0 CAUTIONS

5.1 Equipment used to collect and store mussels should be clean to avoid external contamination.
5.2 The animals (shells) should be thoroughly rinsed in water at the site to remove mud and debris which are sources of contamination to their tissue inside. In high energy

areas, collect site water in a container then move to a safe location before cleaning mussels.

5.3 Mussels should be immediately place in bags on ice or other cold media. Bivalves exposed to fresh water will open prematurely and degrade or contaminate their tissue. Keep mussels cold and well drained but avoid contact with freshwater.

5.4 Hold samples over weekend periods in cold location (not frozen) until shipments can arrive at the analysis laboratory by next day air (Monday – Thursday). Do not let shipping company hold samples.

6.0 INTERFERENCES

6.1 Mussels must be kept cold during the whole shipment process, from pickup to delivery.

6.2 The use of a metal pry bar is strongly discouraged. Samples will be analyzed for trace metal compounds such as iron, nickel, chromium, titanium, and others. These are common constituents of many types of metal tools (e.g., steel, stainless steel, titanium, cooper mixtures, aluminum). The byssal threads that the mussel uses for attachment to rocks are not that strong. If you encounter stubborn mussels, search for others easier to remove.

7.0 PERSONNEL QUALIFICATIONS

7.1 An individual with a California Department of Fish and Game scientific collectors permit.

7.2 Permission to access specific marine protected areas, state beaches, and private land.

7.3 Ability to identify different mussel species and target them for sample collection. A biologist is preferable.

8.0 EQUIPMENT AND SUPPLIES

8.1 Backpack
8.2 Ice chest
8.3 Ice
8.4 Plastic bags, zip lock style
8.5 Bucket
8.6 Gloves
8.7 Salinity sample container
8.8 Thermometer
8.9 Refractometer
8.10 Multi-sensor meter (includes temperature and salinity, optional)
8.11 NOAA datasheet
8.12 Pencil or pen with indelible ink
8.13 Field log (optional)
8.14 Chain of Custody forms

9.0 PROCEDURE

9.1 Select a day and time to arrive at a sampling location. The criterion for the date is +/- 3 weeks from the target date specified in Appendix 1. The time must correspond to a tidal stage at or lower than the water depth specified in Appendix 1. Mussels should be easy to access and could be considered as the height of earliest

access. Water depth reference is Mean Low Low Water (MLLW). Actual tidal heights will vary according to weather condition and time. Use a tide calendar to plan sample collection. Recommended sampling times are during the minus tide time series.

9.2 Clean and prepare sampling gear, back packs, ice chests, plastic bags, ice, temperature/salinity meters, backup thermometers, salinity sample containers, and datasheets. Prepare shipping containers and locate drop-off sites for the shipping company. Calibrate any sensors according to manufacturer's recommendation. If needed, gather any access permission letters for the sampling site.

9.3 Arrive at the specified sampling location within the site as described in Appendix 1 during low tide. Access problems may occur during storm and high surf conditions. Prepare to get wet. Use caution when traversing rocks and boulders because conditions may be wet and slippery. Remember that injuries can occur when humans fall on rocks or into the ocean. Boats can get damaged by swells pushing them onto rocks. Locate a bed of mussels and climb down to the location. This will have to be done at three locations within a site.

9.4 For new sites, establish 3 independent stations. Stations at intertidal sites are along a 100 m transect of shoreline. For instance, a rocky intertidal site has a transect along-shore while a rock jetty transect is on the exposed side perpendicular to shore. Though not pertinent to Southern California sites, NOAA has subtidal sites in other parts of the county that use an oyster dredge. Subtidal sites have 3 dredge transects within a 400 m (radius) area. Establish the center transect point as one location then radiate outward 20 – 40 m on either side to establish the two remaining locations. These subtidal stations are considered replicates, not independent locations as with intertidal sites.

9.5 Identify the target species and remove by hand. Use gloves to protect your hands animals. If you encounter stubborn mussels, search for others easier to remove. Place animals in a bucket or similar container. If available, pass animal container to another team member for handling and processing.

9.6 At each site, the optimal mussel size is 5 – 8 cm (2 – 3 ¼ inches) which targets 80 total mussels from a sampling site (20 for histology and 60 for tissue analysis). The 20 (minimum number needed) for histology is always fixed but the remaining animal quantities will vary with size. Tissue chemistry analysis needs mass versus quantity. When animal are small, malnourished, or sick, their tissue mass is small compared to health animals. The limits set for small animals are about 1 cm (< ½ inch) with a maximum number of 160 total mussels. Some animals may die during transport so include extra mussels for histological and chemical analysis. The chemistry lab estimates that it needs sixty healthy, live, optimal size mussels as a minimum number for analysis.

9.7 At each station within a site collect anywhere from 30 to 60 mussels depending on size. Separate stations into separate plastic bags and label accordingly (i.e., A, B, C). Note GPS coordinates for each station. If unable to get enough animals from 3 stations, try to separate the "pickings" spatially, note the "picking" midpoint with a GPS position, and comment on the distance covered for each "picking" bag.

9.8 The specimens' shells should be thoroughly rinsed in water at the site to remove mud and debris which are sources of contamination of the tissues inside. In high energy areas, collect site water in a container then move to a safe location before cleaning mussels. Place animals in appropriately labeled bags on ice, whenever possible. NOAA recommends you carry an ice chest with ice to the sampling site.

9.9 Samples from different stations (in different bags) within a site can be placed side by side in an ice chest. Mixing between bags must be avoided. If field teams are

sampling multiple sites within a day, sites cannot be co-mingled. Sites must be in separate containers (e.g., ice chest) or other barrier separated system.

9.10 Repeated sites are treated as separate collections in time so sites cannot be co-mingled before shipment. They must be packaged separately.

9.11 Measure surface water temperature, salinity, and take a discrete surface water sample for salinity (10 ml minimum). If a multi-sensor meter is unavailable, other acceptable measures are an outdoor thermometer placed in water or into a bucket of water for temperature and a refractometer for salinity. Salinity will also be measured by the analytical lab so it can be termed an optional field measure. Fill a small plastic vial with seawater and tape the lid securely. Place the vial in the ice chest with the mussels. The water sample will be sent, with the mussels, to the chemistry lab. The datasheet has additional water column measures (e.g., dissolve oxygen) but those are optional.

9.12 During and after bivalve collection, record information on waterproof site datasheet such as name, site code, date, time, water temperature, salinity, and check box that salinity sample was taken. Estimate the "height of collection" as being the height above the water level at which mussels were collected (e.g., samples at water level are given a value of 0 ft). Estimate the "height of highest access" as being the height above the water level at which mussels are available for collection (e.g., mussels available at the high water mark are given a value of 6 ft). Record the GPS coordinate (NAD 83 datum) at the midpoint of each station that has a bagged mussel sample. On the back of the sheet record relevant information that might influence contaminant levels, future collections or the health of the mussels. Typical observations might include notices of shellfish closures or prohibitions on fishing posted nearby, oil sheen on water, weathered oil on rocks, smell, known discharges into the area (nearby outfalls, recent oil spills, runoff from rain storms, etc.), depauperate or declining populations, and/or limitations to accessibility. Use a pencil, preferable, or pen with indelible ink on datasheet. Place datasheet or card in one of the bags going back to the laboratory.

9.13 Upon completing site requirements (mussel collection, measuring water temperature, salinity sample, and datasheet), gather equipment and travel back to your vehicle. Stowing gear in backpacks allows arm/hands to maintain body balance while traversing over rocks.

9.14 At your vehicle, place samples in coolers and fill out chain of custody forms. Either return to lab or prepare samples for shipment.

10.0 SAMPLE HANDLING, HOLDING, PACKING, and SHIPPING

10.1 Two principles guide the transport process. First, keep the transit time (collection until delivery at the labs) to a minimum, especially the time the samples are with the courier. It is preferable that samples be held by the field team rather than by the courier. For example, if samples are collected on a Saturday, keep samples until Monday and monitor their holding condition rather than dropping them off at courier location on Saturday for a Monday delivery. Similarly, do not leave samples with a courier after the last scheduled shipment for that day. Keep the samples until the next day. Second, keep the samples cold on ice but not frozen, and well drained (no standing water, either fresh or seawater). Ice should be package in separate bags and is discussed below.

10.2 The ideal scenario would be to collect the samples in the early afternoon, pack them for shipping and deliver them (or have them picked up by) to an overnight courier

by the cut off time (same day as collection) for next day delivery. However, this is not always possible for all tidal scenarios and sample locations.

10.3 Prior to shipping. Keep samples on ice until ready for shipping. Samples kept directly on ice (not in bag) is OK while collecting samples but melt water must be drained continually from the container. Note that contact with water will invariably cause the mussels to open and introduce possible contamination or depuration. If the water is fresh, it will kill the mussels or oysters, rendering them useless for the study. The preferred method is to place the mussels in a zip lock bag and place this on top or beneath another zip lock bag filled with ice. It is also OK to store the mussels in a refrigerator if an extended hold (overnight) is required. All sample bags should have the appropriate site and date marked on them with a water proof pen. Don't put ice in the bags with the specimens. Don't allow them to freeze (this is a caution peculiar to the Alaska and few east coast sites almost exclusively, in winter). Mussels can be held for days on ice this way if the sample bags are not sealed and are kept free of (drained) fresh water. Periodically examine the bags of mussels to ensure that any entrained water has not leaked into the mussels' container. If standing water is observed, drain it from the mussels.

10.4 Packaging. When it comes time to ship the samples divide the number of mussels for contaminant analyses (60 to 160) into 2 to 3 zip lock bags destined for one (larger) ice chest and the histopathology mussels (20 regardless of size) in another zip lock bag and into the smaller ice chest. Up until now mussels for contaminant and histopatholgy analyses can all be chilled and held together. Put ice into separate zip lock bags, not into the chest directly. Or use "blue ice". “Blue ice” use for histopathology samples is discouraged without some sort of barrier because they can be frozen to well below the freezing temperature of water and damage tissue. Drained mussels are placed in their own bag(s), ice is in its own bag(s). Thus, water is contained as it melts and the mussels are segregated from any leaks or contamination by their sample bags. Also, as the ice melts, it will not leak from the ice chest. If the samples are chilled well before shipping (overnight or days) it will not require a lot of ice to keep them cold as they will have stored a lot of cold already but it better to error on the side of caution and add extra ice. Bagged ice is placed beneath the samples, and bagged ice added on top of the samples. Samples should be packaged and iced in such a way that the specimens will not be compromised if there is a day or two delay in transit.

10.5 Shipping. The best method is to take the ice chests to a overnight courier office or authorized agent. Another acceptable method is to call a courier company in the morning or day before sampling and arrange for a Pick Up by their driver. It is also acceptable, and has been done in the past, to flag down a courier delivery truck and turn it over to the driver. DO NOT leave the ice chest unattended at a drop box or a location which is not an authorized agent. One ice chest (with 20 mussels in a single zip lock bag) goes to the laboratory performing the gonadal index and histopathlogy analyses. The other ice chest containing two or three zip lock bags of mussels (with approximately 30 large or 80 small mussels each), the data card, and the vial of seawater goes to laboratory (ies) performing the contaminant analyses.

10.6 Sealing and Labeling. Use at least 3 separate bands of multiple wraps of fiber tape to close the container. Put your data sheet in a zip lock bag and send it back with the samples. Keep a copy of the collection information for yourself. There is a sheet of address labels for both labs. Put three or four address labels on the respective ice chests in addition to the air bill. Cover these address labels with the wide clear tape.

10.7 Precautions. 1) The samples must arrive for histopathology and gonadal index determinations alive. If there is a substantial unavoidable delay of several days between collection and shipping of samples, the contaminant mussels can be frozen solid and held in that condition for quite some time if they are not allowed to thaw. In this case samples must be kept frozen solid when shipped, which requires the use of dry ice. Such a delay and sample treatment will invalidate the histopathology and gonadal index samples. 2) None of the samples should be allowed to freeze (with the exception above) or to warm up. 3) Keep specimens out of water (don't let them stand in salt water or in ice water melt). This will cause them to open up and introduce possible contamination or specimen death. 4) The samples will be analyzed for trace metal and organic contaminants. Avoid situations where these can be introduced (oil, fuel, pesticide, PCBs, exhaust fumes, flaking or rusty metal). 5) Avoid collection of samples on other than natural substrates. Untreated concrete and nature rock used for breakwaters is acceptable. 6) The specimens' shells should be thoroughly rinsed in water at the site to remove mud and debris which are sources of contamination of the tissues inside.

10.8 Laboratory Contact Information:

For organic and trace element samples,

Juan Ramirez
TDI Brooks International, Inc.
1902 Pinon
College Station, TX 77845
(979) 693-3446
juanramirez@tdi-bi.com

For histopathology samples

Younger Kim
Haskins Shellfish Research laboratory
Ruters University
6959 Miller Avenue
Port Norris, NJ 08349
(856) 785-0074 x 141
ykim@hsrl.rutgers.edu

11.0 DATA AND RECORDS MANAGEMENT

Data and sample management records are presented in three forms of written documentation sent with the sample or mailed separately to a designated person.

11.1 An activities log documenting the days sampling activities with times and comments. The datasheet may substitute for log.

11.2 Sampling event datasheet either made by the NOAA NS&T mussel watch program or something equivalent with required data fields.

11.3 Chain of custody sheet for the shipped sample.

B) QUALITY CONTROL AND QUALITY ASSURANCE

1.0 Correctly identify the target species. *Mytilus trossulus spp. complex* is the correct reference to any pacific coast mussel identified as *Mytilus edulis*. See Appendix 2 for keys and additional information.

2.0 Clean gear which may cause contamination (soap/water then methanol rinse) followed by ambient seawater rinse before use.

3.0 Maintain animals in good condition from collection to analytical lab. Steps include monitoring sample bags for standing water (drain if necessary) and ensuring samples are cold.

4.0 Ensure shipping company gets packages before end-of-day cut-off time for proper overnight shipments. Hold samples for the following day if necessary. Ship samples Monday – Friday. Hold samples over the weekend for Monday shipments if necessary.

5.0 Notify appropriate laboratory that samples have been shipped and supply laboratory with air bill number.

C) REFERENCES

1.1 Lauenstein, G.G., A.Y. Cantillo, S. Kokkinakis, S. Frew, H.J. Jobling and R.R. Fay. 1997. Mussel watch project site descriptions, through 1997. NOAA Technical Memorandum NOS ORCA 112. pp. 354.

1.2 Gunnar Lauenstein. 2007. Personal communication on collection, preservation, and shipping instructions for mussel watch samples.

D) APPENDICIES

1.0 Packaging NS&T Samples for Shipment

2.0 Mussel Identification

3.0 Data sheet

Appendix 1. Packaging NS&T Samples for Shipment

Packaging and Labeling is illustrated in the figures that follow.

Packaging NS&T Samples for Shipment

1. Bagged ice on bottom

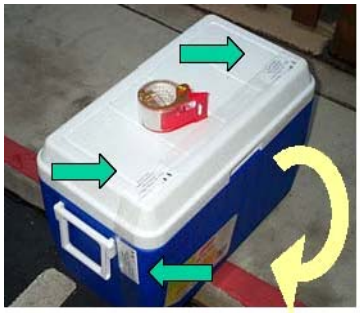
2-Drained, bagged samples with label laid on ice. Site label and salinity vial with samples

3. Bagged samples layered between bags of ice

4- Bagged ice on top. Fill void with more ice

.

5- Three address labels



6- Sealed with at least two bands encircled completely by (3 wraps each) fiber tape, and 1 band wide clear tape wide clear tape. Airbill and tag affixed to chest with fiber tape, not handle.

Appendix 2. Mussel Identification

MYTILIDAE

Taken primarily from Kozloff, 1987, 1996

1a. Shell decidedly longer than high; umbones usually at or close to the anterior end (in Adula, near the end of the first quarter)……..…….2

1b. Shell about as high or higher than long; umbones near the middle of the dorsal margin……13

2a. Umbones essentially terminal; anterior ends of valves acute……...3

2b. Umbones not quite terminal; anterior ends of valves rounded…….4

3a. Valves with course radial ribs as well as irregular growth lines; periostracum of larger specimens often partly or completely worn off; length frequently exceeding 10 cm; in relatively exposed situations, mostly on the open coast…….*Mytilus californianus*

3b. Valves without coarse radial ribs, and with rather regular growth lines; periostracum usually shiny black (brown in small specimens) and generally persistent; length rarely exceeding 7 cm; common in protected situations but also found on the open coast…….……..*Mytilus trossulus, Mytilus galloprovincialus, Mytilus edulis*

4a. Greatest height of shell usually only slightly greater than the height at the level of the umbones (except in Adula diegensis); width sometimes greater than the height; mostly burrowing in shale (except Adula diegensis, which is attached to rocks, pilings, etc.)…...5

4b. Greatest height of shell usually about 1.5 times the height at the level of the umbones; width not greater than the height; attached to firm substrata but not boring…...8

5a. Posterodorsal slopes of valves hairy (photo), and generally with an accumulation of clay particles; boring in shale or attached to rocks, pilings, etc …….…..……..6

5b. Posterodorsal slopes of valves with rough, chalky encrustations and transverse wrinkles, but not hairy; boring in limestone, sometimes other rocks (not likely to be found north of California)……..*Lithophaga plumula*

6a. Valves with filelike vertical striations; length sometimes exceeding 6 cm; boring in shale (not likely to be found north of Oregon)…….*Adula falcata*

6b. Valves smooth or with fine radiating striations on their anterior portions; length not (usually) attaining 5 cm……...7

7a . Valves generally tapering posteriorly (the height at the level of the umbones is not usually exceeded behind the middle, but there are exceptions); genrerally boring in shale but sometimes attached to rocks, other mussels, etc ……*Adula californiensis*

7b. Valves generally higher posteriorly than near the middle (the greatest height is usually about 1.5 times the height at the level of the umbones); attached to rocks or pilings……..*Adula diegensis*

8a. Length from about 2 to about 3 times the height (if slightly less than 2 times the height, then relatively large--up to more than 10 cm long)…….9

8b. Length about 1.5 to 1.75 times the height……...11

9a. Maximum length about 3 cm; periostracum greenish, often with wavy, brownish markings; periostracum not elaborated into soft bristles (introduced, along with oysters, into estuarine situations)……..*Musculista senhousia*

9b. Length commonly greater than 5 cm; periostracum usually brown or blackish brown, periostracum of young speciment elaborated into soft bristles……..10

10a. Length about twice (or slightly less than twice) the height and width……...…*Modiolus modiolus*

10b. Length about 3 times the height and width (not likely to be found north of California) (*M. flabellatus* is here considered to be a synonym)…….*Modiolus rectus*

Another good reference is:

The Light and Smith Manual. Intertidal Invertebrates form Central California to Oregon. 2007. 4rd edition. James T. Carlton editor. University of California Press, Berkeley, CA.

Additional Information from Web Searches

Mytilus edulis and *Mytilus galloprovincialis* often occur in the same location in the northern range of *Mytilus galloprovincialis*. As they both show great variation in shell shape due to environmental conditions (Seed, 1968, 1992), they are often difficult to distinguish. In addition, they may hybridize. However, in *Mytilus galloprovincialis*:

* the umbones turn down, giving the basal line of the shell a concave appearance;
* the valves are higher and less angular;
* the mantle edges are darker, becoming blue or purple, and
* *Mytilus galloprovincialis* tends to grow larger (Tebble, 1976).

Note no single morphological characteristic can be used to separate *Mytilus* species (Gosling, 1992c; Seed, 1992, 1995). Recent evidence suggests that there are only three lineages of the genus, *Mytilus edulis*, *Mytilus galloprovincialis* and *Mytilus trossulus*, although some authorities suggest that all of the smooth shelled mussels belong to the same species (for discussion see Seed, 1992).

Seed, R., 1968. Factors influencing shell shape in the mussel *Mytilus edulis*. Journal of the Marine Biological Association of the United Kingdom, 48, 561-584.

Seed, R., 1992. Systematics evolution and distribution of mussels belonging to the genus *Mytilus*: an overview. American Malacological Bulletin, 9, 123-137.

Seed, R., 1995. Speciation and geographical distribution within the genus *Mytilus*. Bulletin of the Malacological Society of London, 24, 4.

Mytilus edulis

The taxonomy of the genus *Mytilus* has been the subject of some debate in recent years, and there is often confusion between three 'species' in particular: *Mytilus edulis*, *M. trossulus* and *M. galloprovincialis*. The status of the latter has been particularly debated; it was once widely thought to be a separate species but is now regarded by many as a form of *M. edulis* (see e.g. McDonald et al., 1991; Gosling, 1992a; Seed, 1992 for summaries). Nevertheless, *M. edulis* seems to have a broad distribution; it is circumpolar, and reported as far south as Japan and China in the Pacific and to North Carolina in the Atlantic, while in Europe the northern limit is within the Arctic circle, and it is found as far south as the Mediterranean (Clay, 1967). It forms dense aggregations which might fit the definition of biogenic reefs over much of this geographical range. In the south west of England it frequently forms hybrids with the more southerly distributed *Mytilus galloprovincialis*, but in more sheltered and lower salinity areas, where true reefs tend to occur, *M. edulis* is much the more dominant form (Gardner, 1994; Gardner, 1996). Hybridisation also occurs on Scottish and Irish coasts, but here there is less intermixing of genes between populations of the two forms than in the south west of England (Gosling, 1992a). Populations show extensive hybridisation worldwide and are a well studied example of a marine hybrid zone. There are multiple sites of hybridisation between the species *Mytilus edulis*, *M. trossulus* and *M. galloprovincialis* across the Atlantic, Scandinavian and the Mediterranean Seas. These hybrid zones vary considerably. Some hybrid zones, such as the one in Newfoundland in Canada show remarkably few hybrids, while in Scandinavia most individuals are hybrids to some

degree. Morphological and genetic differences are clear between these populations and it is believed that they are close to full speciation. They are probably maintained through a combination of hybrid unfitness, positive assortative mating and habitat segregation.

Based on the fossil record and genetic marker studies the following chronology is used to explain the Mussel hybrid zone:

* The genus *Mytilus* is at one point restricted to the North Pacific but spreads to the Atlantic through the Bering Straight around 3.5 million years ago (Vermeij 1991).
* *M. trossulus* evolves in the North Pacific and *M. edulis* in the Atlantic in near allopatry as migration across the Bering Straight is very low.
* Subsequently *M. galloprovincialis* undergoes cladogenesis from *M. edulis* in the Mediterranean Sea after it is temporarily isolated from the Atlantic.
* Recently *M. trossulus* from the Pacific enters the Atlantic and colonises shores on both sides. It spreads and forms secondary contact hybrid zones with *M. edulis* populations on coasts across Scandinavia and the eastern Atlantic.
* Riginos and Cunningham (2005) includes a suggested pattern of migration of *M. trossulus* across the ocean based on a review of genetic marker studies.

Toro et al (2002) investigated whether different reproductive patterns and behaviour were the cause of this prezygotic isolation and discovered that *M. edulis* spawned over a 2-3 week period in July, while *M. trossulus* spawned over a more extensive period between late spring to early autumn. It was also found that hybrids were not infertile and exhibited normal reproductive development, allowing them to introgress with pure species. It was concluded that "differences in reproductive traits may partially explain the maintenance of the mussel hybrid zone in Newfoundland."

The other likely candidate for hybrid zones stability is species segregation by habitat which has been investigated but not conclusively. Several studies have suggested that *M. edulis* are found in areas of lower salinity and less wave exposure at the heads of bays more than *M. trossulus*. *M. trossulus* appears to be favoured in habitats with higher wave exposure (Bates and Innes, 1995). The one subtidal (low wave action) site sampled by Bates and Innes had just 8% *M. trossulus* individuals. A similar segregation has been found in the Mediterranean hybrid zone with *M. edulis* also favouring more sheltered habitats compared to *M. galloprovincialis* (Bierne et al. 2003). If this is the case, this would provide partial habitat separation and reduce the probability of gametes of two species encountering one another and cross-fertilising. This would increase genetic distinctiveness despite the populations living in sympatry. However, conflicting results have been identified to this trend of habitat segregation and so these results are not conclusive (Riginos and Cunningham, 2005). It is suggested that differences in habitat are what has led to the very different type of hybrid zones in Scandinavia and Canada. Hybrid mussel fitness has not been properly investigated, so it is not possible to judge its effects on postzygotic isolation and whether it could cause reinforcement (Riginos and Cunningham, 2005).

Barton NH. (1979) The dynamics of hybrid zones. Heredity 43:341-359

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Toro et al.(2002) Reproductive isolation and reproductive output in two sympatric mussel species (Mytilus edulis, M. trossulus) and their hybrids from Newfoundland. Marine Biology 141:897-909

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Mytilus californianus – From the Multi-Agency Rocky Intertidal Network (MARINe) group web site (www.marine.gov)
General Description, Habitat, and Range (from Morris et al. 1980):
Black and bluish color, often eroded white valves, darker at margins; radial ribbing but also concentric growth lines present; shell to about 130 mm long. Abundant, on surf-exposed rocks and pier pilings; mainly in upper-middle intertidal zone on outer coast; subtidal and offshore to 24 m (depth); Aleutian Is., Alaska to southern Baja California

Biology: The California sea mussel forms extensive beds, which may be multi-layered (usually in the north). These beds create habitat for many species of invertebrates and algae (Paine 1966; MacGinitie & MacGinitie 1968; Suchanek 1979; Kanter 1980). Mussels are attached to hard substrate by secreting byssal threads at the base of the foot (Morris et al. 1980). Mussel beds are damaged by large swells, and are more susceptible to damage after heavy predation by sea stars (Morris et al. 1980). Beds that are already patchy or thinned by human disturbance (fishers who use mussels as bait) can also be susceptible to wave damage. An area completely cleared of mussels may take from 1 to 10 years to reestablish the diverse community (Morris et al. 1980; Vesco and Gillard 1980). Mussels have been found to be adversely affected by oil spills (Chan 1973; Foster et al. 1971). *Mytilus galloprovincialis/trossulus*, the bay mussel, can be interspersed with *M. californianus*, but generally occurs in calmer waters because of its weaker byssal threads

(Morris et al. 1980). In California, sea mussels are quarantined from late spring to early autumn because the toxin from a dinoflagellate accumulates in the tissue (Kozloff 1983). This toxin can cause paralysis and death.

Can be confused with: *M. galloprovincialis/trossulus*, which are more common in sheltered habitats; have smooth valves, lacking radiating ridges, with strong elbow-curve at umbo; less eroded than *M. californianus*

Mytilus galloprovincialis/trosullus (top) and *Mytilus californianus* (bottom)

Both the native *Mytilus trossulus* and the introduced *Mytilus galloprovincialis* have previously been collected in outer coast rocky intertidal habitat in California (Braby and Somero, 2006). These 2 species along with a third, *Mytilus edulis*, form a complex that can be morphologically indistinguishable at the species level. In addition, Braby and Somero (2006) confirmed a zone along the California coastline between Monterey and Cape Mendocino where *M. trossulus* and *M. galloprovinicialis* hybrids are found. In the current survey, *Mytilus* specimens morphologically identified to be part of this complex, but not identified down to species level, were collected from fourteen outer coast survey sites, spanning from northern to southern California. Since the complex includes both a native and an introduced species, this complex was given the introduction status 'unresolved' for this study. Even though the current study lacks genetic confirmation that *M. galloprovincialis* was collected, data from these previous studies suggest that some if not all of the current survey's sites harbor this introduced species. *M. galloprovincialis* is listed by the World Conservation Union as one of the world's 100 worst invaders (1000 of the World's Worst Invasive Alien Species. Retrieved October 23, 2006, from http://www.issg.org/booklet.pdf).

**Mytilus trossulus* is the dominant protected water mussel of the Pacific northwest, but it is probably identified as *Mytilus edulis* in most manuals. The systematics of *M. edulis* and its very close relatives is in a state of flux right now, and the name *Mytilus edulis* does not apply at all to any of the populations on the west coast of the United States. In California, it is not clear as yet

which species is present, but it may be the Mediterranean *Mytilus galloprovincialis*, although how it got there is anybody's guess.

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Kozloff EN (1983) Seashore life of the northern Pacific coast. University of Washington Press, Seattle

MacGinitie GE and MacGinitie N (1968) Natural history of marine animals. McGraw Hill, New York

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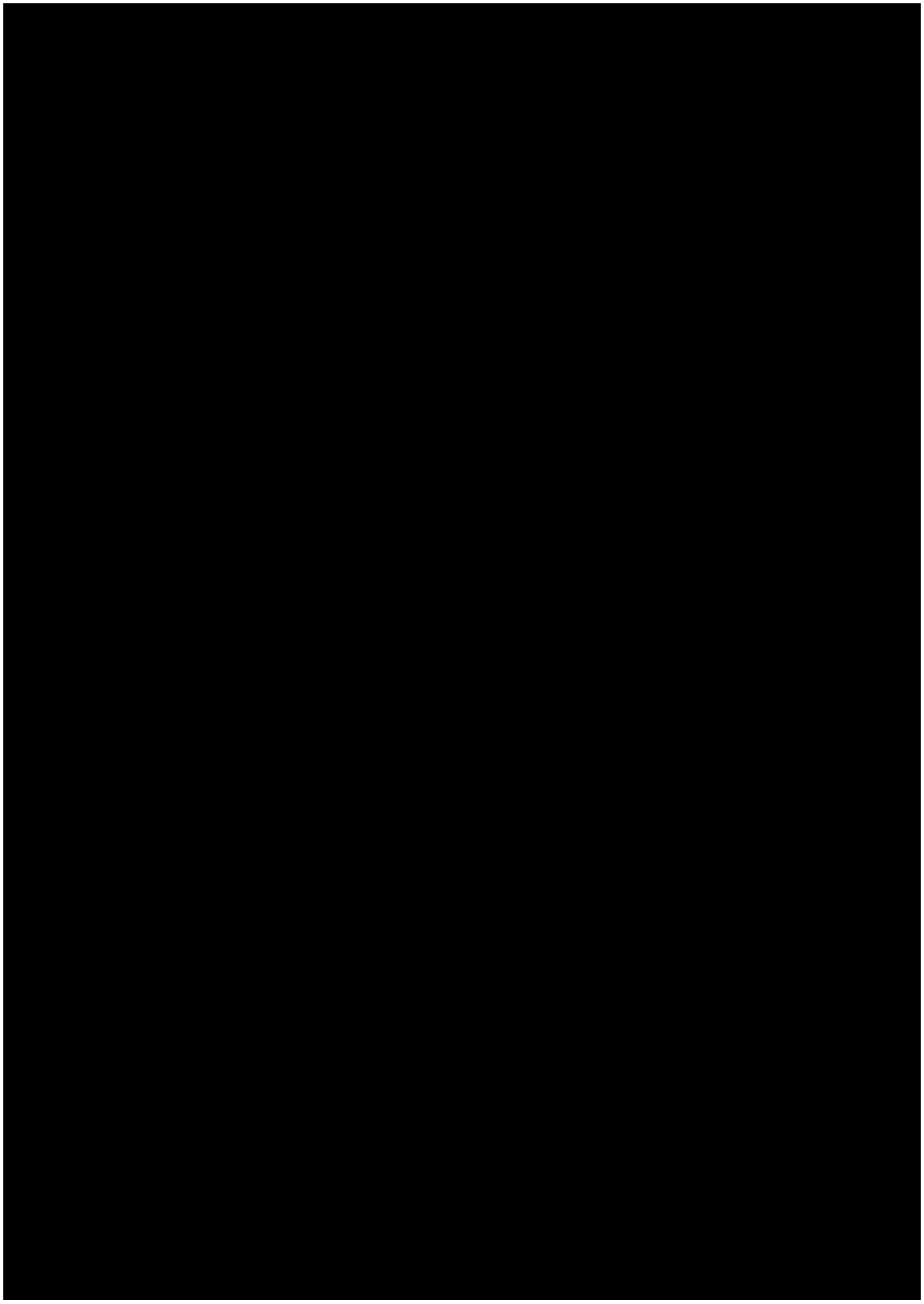
Vesco LL and Gillard R (1980) Recovery of benthic marine populations along the Pacific Coast of the United States following man-made and natural disturbances including pertinent life history information. U.S. Department of the Interior, Bureau of Land Management Service, POCS Reference Paper No. 53-4.

Appendix 3. Data sheet.



APPENDIX B – EXISTING (NOAA NS&T) SITE LOCATIONS

1	Sites arranged by target sampling date:		
Site Code:	SBSB	Latitude:	34° 23.74' N
Site Name:	Point Santa Barbara	Longitude:	119° 43.65' W
Site Location:	Point Santa Barbara	GIS Latitude:	34.39566667
County:	Santa Barbara	GIS Longitude:	-119.7275
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	11/29/2007
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		

Access Directions: Follow Hwy. 101 into Santa Barbara and take the Route 225 exit (Las Positas Rd.) going south. At the "T" intersection, turn left onto Cliff Drive. At the next set of lights, turn right onto Mesa Lane. Proceed to the intersection of Mesa Lane and Edgewater Drive and park the vehicle. Follow the pathway at the end of Mesa Lane and hike down the wooden stairs to the beach. The site is located about 1/3 of a mile to the west of the Santa Barbara Lighthouse, some 150 m to the east of the wooden stairs below Mesa Lane.

Site Description: The nominal site center is on the beach, some 150 m to the east of the base of the stairs. A good landmark is a 6" diameter black plastic drainage pipe, on the cliff above the site. There are 12" diameter steel drainage pipes on either side of the black pipe. The three stations are about 25 m apart along the beach, Station 2 being in the middle and below the black pipe.

2			
Site Code:	Point Dume	Latitude:	34° 00.06' N
Site Name:	Point Dume	Longitude:	118° 48.53' W
Site Location:	Los Angeles	GIS Latitude:	34.001
County:	CA	GIS Longitude:	-118.8088333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	12/1/2007
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		

Access Directions: From Hwy. 1 (Pacific Coast Hwy.) west of Malibu, take Westward Beach Rd. south to Zuma Beach. Proceed to the last parking area at the end of the road past the life guard station. The site is below the sheer cliff at the southeast end of the beach. This site is located on Point Dume, Malibu.

Site Description: The site center is a 1-ft high steel pipe projecting vertically from a rock at the base of the cliff, above a pile of large boulders that extend down to the waterline. The pipe is about 10 m above the waterline. Station 2 is directly below the site center in the splash zone. The other two discrete collection stations are approximately 15 m northwest and southeast of the middle station. This is a rugged, exposed site that should be sampled with great caution. Minus tides will be required for collections made during periods of large swells.

3	Sites arranged by target sampling date:		
Site Code:	MDSJ	Latitude:	33° 57.71' N
Site Name:	Marina Del Rey	Longitude:	118° 27.48' W
Site Location:	South Jetty	GIS Latitude:	33.96183333
County:	Los Angeles	GIS Longitude:	-118.458
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1996	Target Date:	12/2/2007
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		

Access Directions: From interstate 405 in Los Angeles, take the Marina Freeway (Hwy. 90) west. Turn left onto Culver Blvd at the first signal and proceed approximately 2 mi to Pacific Ave. Turn right onto Pacific Ave. and proceed until the road ends at the pedestrian bridge spanning Ballona Creek, adjacent to 62nd Ave. Park and cross the bridge to the south jetty, This site is located on the south jetty at the mouth of Marina Del Rey Harbor.

Site Description: The site center is the end of the paved path towards the west (seaward) end of the jetty. The middle discrete collection station was directly below the end of the path on the south side of the jetty. The other two stations were approximately 25 m east and west of the middle station, also on the south side of the jetty.

4			
Site Code:	PVRP	Latitude:	33° 43.02' N
Site Name:	Palos Verdes	Longitude:	118° 19.36' W
Site Location:	Royal Palms State Park	GIS Latitude:	33.717
County:	Los Angeles	GIS Longitude:	-118.3226667
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	12/3/2007
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 110 south in San Pedro, take the Gaffey St. exit south approximately 2.5 mi to Paseo Del Mar. Turn right (west) and proceed to the State Park entrance (approximately 1.7 mi), just before the intersection of Western Ave. Drive down the park entrance road and park near the life guard tower. The site is on a large rock outcrop from the life guard tower, and accessible across the beach at low tide. This site is located at Royal Palms State Park on the Palos Verdes peninsula.

Site Description: The site center is the highest rock peak on the outcrop. Discrete collection stations were on the northwest side of the outcrop. The middle station was directly below the site center and the other two stations were 25 m inshore and offshore of the northwest side of the outcrop. This site is very exposed and would be hazardous in heavy seas. Moreover, the rock outcrop is an island at all but the lowest tides.

5	Sites arranged by target sampling date:		
Site Code:	ABWJ	Latitude:	33° 44.01' N
Site Name:	Anaheim Bay	Longitude:	118° 06.06' W
Site Location:	West Jetty	GIS Latitude:	33.7335
County:	Los Angeles	GIS Longitude:	-118.101
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	12/8/2007
Access Mode:	Car	Water Depth:	intertidal, +0.25 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 405 just south of its intersection with Interstate 605, take the seal Beach Boulevard exit. Turn left (west) onto Seal Beach Boulevard. At the traffic lights, turn west onto 12th Ave. (Balboa Ave. goes to the east) and then left onto Ocean Ave. Then right (southwest) onto Neptune St. Park the car on Neptune St. and walk across the beach to the jetty that projects southwards from the beach. The site is on a jetty adjacent to Anaheim Bay in Seal Beach.

Site Description: The nominal site center is a large round timber wedged into the boulders of the jetty, whose top projects barely above the boulders. The site center is approximately 75 m from the end of the chain-link fence. The three discrete sampling stations are on the west side of the jetty, approximately 25 m apart. Station 1 is 40 m past the end of the fence, Station 2 is about 75 m past the end of the fence at the timber post and Station 3 is a further 25 m past Station 2. This site is very exposed and would be hazardous in heavy seas.

6			
Site Code:	SDHI	Latitude:	32° 43.48' N
Site Name:	San Diego Bay	Longitude:	117° 11.68' W
Site Location:	Harbor Island	GIS Latitude:	32.72466667
County:	San Diego	GIS Longitude:	-117.1946667
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1995	Target Date:	12/9/2007
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 5 south in San Diego, take the Sassafras St. exit and follow the signs toward San Diego Airport. On Harbor Drive near the airport, take the Harbor Island exit. When the road ends at the water, take Harbor Island Drive to the left (east). Park in the first pull-out, just the first palm tree east of the intersection. The site is on the south shore of Harbor Island at the north end of San Diego Bay.

Site Description: The site center is a pyramid-shaped rock at 0 m MLLW on the steep boulder-covered bank between the palm tree and the first sidewalk bench west of the palm tree. The middle discrete collection station was the pyramid-shaped rock, with the other two stations being approximately 20 m on either side.

7	Sites arranged by target sampling date:		
Site Code:	IBNJ	Latitude:	32° 35.26' N
Site Name:	Imperial Beach	Longitude:	117° 08.01' W
Site Location:	North Jetty	GIS Latitude:	32.58766667
County:	San Diego	GIS Longitude:	-117.1335
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1995	Target Date:	12/10/2007
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 5 south to imperial Beach, take the Palm Ave. exit west to Seacoast Drive. Turn right (north) onto Seacoast Drive and park near Carnation Ave. Walk to the end of Carnation Ave. and around the vehicle gate. The jetty is to the right (north) approximately 150 m. This site is located on a jetty at the north end of imperial Beach.

Site Description: The site center is below the tallest rock on the jetty, approximately 2/3 of the way out to the seaward end of the jetty. The three discrete collection stations are on the south side of the jetty, with the middle station located below the site center, and the other two stations approximately 15 m inshore and offshore of the center station.

8			
Site Code:	MBVB	Latitude:	32° 46.05' N
Site Name:	Mission Bay	Longitude:	117° 14.52' W
Site Location:	Ventura Bridge	GIS Latitude:	32.7675
County:	San Diego	GIS Longitude:	-117.242
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1995	Target Date:	12/11/2007
Access Mode:	Boat	Water Depth:	intertidal, +0.75 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 5 south in San Diego, take the Sea World Drive exit. Proceed west past Sea World to Ingraham St. Go north on Ingraham St. and turn left (west) at the first signal onto Dana Landing Rd. After Dana Landing Rd. curves to the left, the boat launch ramp is on the right. Take a boat and proceed out of the harbor to the left (west) and go to the Ventura Bridge, less the 0.5 mi away. This site is located at the Ventura Bridge Over Mission Bay in San Diego.

Site Description: The Ventura Bridge is supported by paired concrete pillars. The site center is the fourth pair of pillars from the east end of the bridge. Mussels were collected from the seaward sides of the bayward pillar in pairs 3, 4, and 5, counting from the east end of the bridge.

9	Sites arranged by target sampling date:		
Site Code:	SDCB	Latitude:	32° 41.19' N
Site Name:	San Diego Bay	Longitude:	117° 09.55' W
Site Location:	Coronado Bridge	GIS Latitude:	32.6865
County:	San Diego	GIS Longitude:	-117.1591667
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1995	Target Date:	12/12/2007
Access Mode:	Boat	Water Depth:	intertidal, +0.75 m MLLW
Collection Method:	Hand		

Access Directions: From Interstate 5 south in San Diego, take the Rosecrans (Hwy. 209) exit and proceed south approximately 3 mi to shelter Island Drive. Turn left (east) onto Shelter Island Drive (note that a right turn at the intersection puts you onto Byron St.) and proceed east to the rotary. The launch ramp is just to the right of the rotary. Take a boat east from the launch ramp, around the north end of North Island and then south to the Coronado Bridge (about a 20 minute ride). This site is located on the concrete supports for the Coronado Bridge across San Diego Bay.

Site Description: The concrete supports are numbered consecutively, with the lowest numbers on the western side of the channel. The site center is bridge support 10, with samples being collected from the west side of supports 9, 11, and 12.

10			
Site Code:	SPFP	Latitude:	33° 42.40' N
Site Name:	San Pedro Harbor	Longitude:	118° 16.45' W
Site Location:	Fishing Pier	GIS Latitude:	33.70666667
County:	Los Angeles	GIS Longitude:	-118.2741667
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1996	Target Date:	12/13/2007
Access Mode:	Boat	Water Depth:	intertidal, 0-0.25 m MLLW
Collection Method:	Hand		

Access Directions: Head south along I-110 to where it ends and turn left onto Gaffey St. Follow Gaffey St. south, then turn left onto 27th St. and right onto Pacific Ave. At the lights, turn left onto Stephan M. White Drive (Cabrillo Beach sign) and left again onto Oliver Vickery Circle Way at the statue. Drive into the Park and follow the signs to the boat ramp, which is located in the northeastern corner. The Fishing Pier is located just to the east of the ramp and small boat basin. This site can only be accessed by boat and is located at the western end of the Long Beach Harbor.

Site Description: The site is located under the eastern end of the San Pedro Harbor Fishing Pier, and can only be sampled from a small boat. Station 1 is located on the 5th set of pilings from the east end of the pier, Station 2 is on the 6th set and Station 3 is on the 9th set of pilings. Care should be taken to avoid all the fishing lines, this is a popular weekend fishing spot.

11	Sites arranged by target sampling date:		
Site Code:	NBWJ	Latitude:	33° 35.46' N
Site Name:	Newport Beach	Longitude:	117° 52.83' W ***
Site Location:	West Jetty	GIS Latitude:	33.591
County:	Los Angeles	GIS Longitude:	-117.89
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	1/25/2008
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	Follow Hwy. 1 south into Newport Beach, and take the Route 55 exit south onto Newport Blvd. Continue on down the Boulevard and out onto Balboa Island, where it runs into Balboa Blvd. Take a right onto Ocean Blvd. And proceed along the shoreline to the intersection of Channel Blvd. Park in the vicinity of the Channel Blvd. Park, and walk out to the jetty. This site is a walk-up, and is easily accessed by automobile. The site originally had the acronym - NBBC (1986-88).		
Site Description:	The site is located on the west jetty at the Balboa Channel Entrance to Newport Bay, in Newport Beach. The discrete stations are located along the west side of the west jetty, and are located about 25 m apart. Station 2 is the nominal site center, with Station 1 being inshore and Station 3 farther out.		

*** The original longitude (117° 53.40' W) in NOAA TM 112 was incorrect and should be 117° 52.83' W

12			
Site Code:	PLLH	Latitude:	32° 40.83' N
Site Name:	Point Loma	Longitude:	117° 14.93' W
Site Location:	Lighthouse	GIS Latitude:	32.6805
County:	San Diego	GIS Longitude:	-117.2488333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1995	Target Date:	1/26/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		
Access Directions:	From Interstate 5 in San Diego, take the Hwy. 209 (Rosecrans) exit south. Follow Hwy. 209 to Cabrillo National Monument. Hwy. 209 follows, in sequence, Rosecrans St., Canon St., Catalina Boulevard, and Cabrillo Memorial Drive. Just prior to the gate into Cabrillo National Monument, take the road to the right past the lighthouse to the Point Loma Wastewater Treatment Plant. At the lighthouse, follow the road as it doubles back toward the north to the treatment plant. Check in at the Administration Building. At the Administration Building, take the left fork and head down toward the water. Proceed to where the road ends, adjacent to a concrete spillway that directs storm runoff from the street down toward the ocean. Climb down the boulders below the spillway to a series of rock benches 10-15 m south.		
Site Description:	The site center is the highest bluff above the cliff, 10 m south of the end of the road. Collection stations are on the rocky benches at the base of the cliff below the bluff. The site is to small and the mussels were too sparse to support designation of discrete collection stations.		

13	Sites arranged by target sampling date:		
Site Code:	OSBJ	Latitude:	33° 35.46' N
Site Name:	Oceanside	Longitude:	117° 53.40' W
Site Location:	Municipal Beach Jetty	GIS Latitude:	33.591
County:	San Diego	GIS Longitude:	-117.89
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus **
Year Start:	1995	Target Date:	1/27/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		
Access Directions:	From Interstate 5 just north of Oceanside, take the Oceanside Harbor exit and go west to Harbor Drive. At Harbor Drive, take the left fork to the south. After the road curves to the right (west), park in the parking lot where Pacific St. ends at Harbor Drive. The jetty projects offshore from the parking lot, adjacent to the mouth of the San Luis Rey River. This site is located on the jetty at the mouth of the San Luis Rey River in Oceanside.		
Site Description:	The site center is a large boulder next to a peace symbol carved into the concrete matrix atop the jetty, approximately 20 m from the seaward end of the jetty. Discrete collection stations were approximately 30 m apart on the north side of the jetty, with the outermost station being directly below the site center.		

** This site had both species sampled in the past. M. californianus is the primary target.

14			
Site Code:	LJLJ	Latitude:	32° 51.09' N
Site Name:	La Jolla	Longitude:	117° 16.43' W
Site Location:	Point La Jolla	GIS Latitude:	32.8515
County:	San Diego	GIS Longitude:	-117.2738333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1995	Target Date:	1/28/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		
Access Directions:	From Interstate 5 in San Diego, take Ardath Rd. from the south, or La Jolla Village Drive from the north and go west to Torrey Pines Rd. Turn left onto Torrey Pines Rd. and proceed to Prospect St. Turn right onto Prospect St. and proceed to Coast Boulevard. Turn onto Coast Boulevard and park as near as possible to the water in the vicinity to Ellen B. Scripps Park. At the life guard station near the north end of the park and the south end of La Jolla Cove, check in with the duty life guard, notifying them of the collection (La Jolla Cove is within a marine reserve). Go west from the lifeguard station on the walkway along the top of the shoreline and take the stairs down to the rock platform adjacent to the western-most rocky point. This site is located on Point La Jolla, in La Jolla.		
Site Description:	The site is approximately 150-200 m west of the lifeguard station. There is no landmark that distinguishes the site center. The discrete collection stations were spaced approximately 20 m apart along the upper edge of the mussel beds nearest the tip of Point La Jolla. This site is approximately 0.25 mi west of the target site in La Jolla Cove, which could not be reached due to large swells that broke nearly continuously over the site.		

15	Sites arranged by target sampling date:		
Site Code:	SCFP	Latitude:	34° 03.48' N
Site Name:	Santa Cruz Island	Longitude:	119° 55.22' W
Site Location:	Fraser Point	GIS Latitude:	34.058
County:	Santa Barbara	GIS Longitude:	-119.9203333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	2/22/2008
Access Mode:	Air/boat	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	A sampling permit is required from the island owners (The Nature Conservancy) before access is granted. The site is most accessible by plane. Channel Islands Aviation (Camarillo) has access to the small dirt runway at Forney Cove, about 1/2 mile to the east of the sampling site. This site is located at the western end of Santa Cruz Island, which is about 25 mi offshore.		
Site Description:	The sampling site is located in a small cove on the northeast corner of Frazer Point, on Santa Cruz Island. There three stations are located some 25 m apart along the beach, the nominal site center being the middle Station (#2).		

16			
Site Code:	PCPC	Latitude:	34° 26.63' N
Site Name:	Point Conception	Longitude:	120° 27.42' W
Site Location:	Point Conception	GIS Latitude:	34.44383333
County:	Santa Barbara	GIS Longitude:	-120.457
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	2/23/2008
Access Mode:	Car	Water Depth:	intertidal, +0.5-1.0 m MLLW
Collection Method:	Hand		
Access Directions:	This site is located on private property, previously owned by the Bixby Ranch Company. Permission to gain access to the site is required. From Santa Barbara, follow Hwy. 101 west to Las Cruces (Gaviota Pass), turn west onto Hwy. 1 towards Lompoc. Travel ~15 mi along Hwy. 1, turn left (west) onto Jalama Rd and proceed for ~13 mi to the Bixby Ranch gate, which is located on the left before the railroad tracks and the Jalama Beach County Park. The white gate has a large Spanish "C" on it. From the gate, follow the ranch road for ~5 mi to the first house, turn right at the signpost and head towards Point Conception. Cross the railroad tracks, turn left towards Government Point and the old Union Oil Tanks. Park the vehicle and walk to the small knoll that lies to the southeast. There is a small iron pipe with a rope attached to it located at the top of the cliff. This is the only safe way down to the site. The site is located on Government Point, which is ~3/4 of a mile to the east-southeast of the old U.S. Coast Guard Station and Point Conception Lighthouse.		

Site Description:	The nominal site center is located on a flat rock bench below the cliff on Government Point. Station 1 is at the site center, Station 2 is some 20 m to the southeast and Station 3 is about 20 m to the northwest of Station 1. Avoid sampling within the stainless steel markers placed by other researchers on the rocks. This site can only be sampled at low tide and in calm weather, as it is very exposed to the elements.

17	**Sites arranged by target sampling date:**		
Site Code:	TBSM	Latitude:	34° 02.34' N
Site Name:	Las Tunas Beach	Longitude:	118° 35.83' W
Site Location:	Santa Monica Bay	GIS Latitude:	34.039
County:	Los Angeles	GIS Longitude:	-118.5971667
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	3/5/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		
Access Directions:	From Santa Monica, follow Hwy 1 going west towards Topanga and Las Tunas. The site is located on the west end of the beach, next to a white house (#19324) on the Pacific Coast Hwy., to the west of the Tunas Canyon Rd. intersection. Park on the unpaved area above the beach.		
Site Description:	The nominal site center is at the remains of a 1.5 meter high concrete wall that runs perpendicularly down the beach. Station 1 is located at the concrete wall, Station 2 is 25 m to the west and Station 3 is 25 m to the east of Station 1.		

18			
Site Code:	RBMJ	Latitude:	33° 49.92' N
Site Name:	Redondo Beach	Longitude:	118° 23.57' W
Site Location:	Municipal Jetty	GIS Latitude:	33.832
County:	Los Angeles	GIS Longitude:	-118.3928333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	3/6/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Hand		
Access Directions:	Follow Hwy.1 (Pacific Coast Hwy.) into Redondo Beach, and turn west onto Topaz St. Continue down Topaz to the end, where it intersects Esplanade St., and park in the vicinity. Walk down the alley, next to 703 Esplanade St., and across the beach to the jetty next to the lifeguard station. The site is located on the Municipal Jetty in Redondo Beach.		
Site Description:	The nominal site center is on the jetty. The original stations were located on the south side, but can be moved to the north side to facilitate sampling in rough weather. The three stations are 25 m apart, with Station 1 being at eh beach end of the jetty.		

19	Sites arranged by target sampling date:		
Site Code:	LBBW	Latitude:	33° 43.39' N
Site Name:	Long Beach	Longitude:	118° 10.41' W
Site Location:	Breakwater	GIS Latitude:	33.72316667
County:	Los Angeles	GIS Longitude:	-118.1735
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus edulis
Year Start:	1996	Target Date:	3/7/2008
Access Mode:	Boat	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	Head south along I-110 to where it ends and turn left onto Gaffey St. Follow Gaffey St. south, turn left onto 27th St. and right onto Pacific Ave. Turn left onto Stephan M. White Drive (Cabrillo Beach sign) and left onto Oliver Vickery Circle Way at the statue. Follow the signs to the boat ramp, which is located in the northeastern corner. From the boat ramp, head east 5.5 mi across the harbor to the site. This site can only be accessed by boat. It is located towards the western end of the eastern section of the Long Beach Harbor Breakwater.		
Site Description:	The bivalve sampling site is located on the north side (inside portion) of the Long Beach outer breakwater. Station 1 is located at the nominal site center, Station 2 is 25 m to the east and Station 3 is 25 m to the west of Station 1.		

20			
Site Code:	SCBR	Latitude:	33° 27.10' N
Site Name:	South Catalina Island	Longitude:	118° 29.24' W
Site Location:	Bird Rock	GIS Latitude:	33.45166667
County:	Los Angeles	GIS Longitude:	-118.4873333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	3/9/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Boat		
Access Directions:	This site can only be accessed by small boat. Take the ferry from Long Beach to Avalon. Permits from the Santa Catalina Island Conservancy and the California State Dept. of Fish and Game are required. The Santa Catalina Island Conservancy staff will provide transport on request between Avalon and Two Harbors, as no private vehicles are allowed to drive around the island. A small boat and operator are available at the Wrigley Marine Science Center in Two Harbors, which is necessary to cover the short distance out to Bird Rock.		
Site Description:	The site is located at the northwestern corner of Bird rock, on a small rock platform 1.5 m above MLLW. Landing is tricky, as one has to jump (with sampling supplies) from the boat onto a small rock ledge. There are a number of stainless steel survey grids in the intertidal area that should be avoided. Station 1 is located at the northwestern corner of the island, on the rock bench above the small cove (2nd landing site). Station 2 is on the rock bench at the extreme western end of the island, ~5 m west of Station 1. Station 3 is on the rock bench 5 m away from both stations 1 and 2.		

21	Sites arranged by target sampling date:		
Site Code:	SANM	Latitude:	34° 01.68' N
Site Name:	San Miguel Island	Longitude:	120° 25.16' W
Site Location:	Tyler Bight	GIS Latitude:	34.028
County:	Santa Barbara	GIS Longitude:	-120.4193333
State:	CA	Matrix:	Mussel - whole animals
Biannual:	Yes *	Species:	Mytilus californianus
Year Start:	1996	Target Date:	3/14/2008
Access Mode:	Car	Water Depth:	intertidal, +1.0 m MLLW
Collection Method:	Air/boat		

Access Directions: San Miguel Island is the westernmost of the four Santa Barbara Channel Islands. The island is part of the Santa Barbara Channel Islands National Marine Sanctuary. Two-thirds of the island is used by the U.S. Navy as a missile test center. Transportation to the island is possible by charter plane.

Site Description: The sampling site is located on the southwest side of the island at the western edge of Tyler Bight. Tyler Bight is approximately 1.5 nautical miles west of the missile-danger boundary. The site is a 30 minute hike from the air strip. The site center is the north head of the rocks on the eastern side of the beach between Tyler Bight and Judith Rock. The sampling stations are on the southern portions of these rocks.

APPENDIX C – MARINe/ASBS SITE LOCATIONS

1	Sites arranged from north to south:		
Site Code:	SANM**	Latitude:	34° 03.122' N
Site Name:	Otter Harbor	Longitude:	120° 24.455' W
Site Location:	San Miguel Island	GIS Latitude:	34.05203
County:	Santa Barbara	GIS Longitude:	-120.40758
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Airplane/Boat	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW

Access Directions: San Miguel Island is the westernmost of the four northern Channel Islands. The island is part of Channel Islands National Marine Sanctuary and Channel Island National Park. Permits to land, camp, or collect must be approved by Channel Islands National Park (CINP). Transportation to the island is by CINP or chartered planes/vessel from airports or Santa Barbara, Ventura, or Channel Islands Harbor. The drop-off point is at the San Miguel Island airstrip or in Cuyler Harbor. The site is a major hike from Cuyler Harbor.

Site Description: Specific mussel collecting site TBD. Current coordinates are for MARINe monitoring site. The sampling site is located on the inshore portion of a prominant reef off the northwest side of the island, approximately 0.5 mi east of the cove at Otter Harbor, and 1 mi north of the Dry Lake airstrip. Harford Canyon is just west of the site, and there is a tiny sand beach at the end of a surge channel on the eastern site boundary. Less than 100 m east is a small pocket beach that usually attracts elephant seals. From the airstrip, walk north over the bluff staying on the east side of Harford Canyon. If making a loop along the shore to Simonton, the easiest connection is through Range Pole Canyon meeting the trail to the Caliche Forest. The site is approximately 2-2.5 hrs walk from the Ranger Station. This locations is an ASBS and a MARINe monitoring site. Mussels should not be collected in the vicinity of survey plot marker bolts or epoxy blobs. If possible, mussel collection spots should be located just outside the MARINe site boundary. Ideally mussel collection should correspond with MARINe monitoring in the spring.

2	Sites arranged from north to south:		
Site Code:	ANMI**	Latitude:	34° 00.348' N
Site Name:	North middle-island	Longitude:	119° 23.746' W
Site Location:	Anacapa Island	GIS Latitude:	34.0058
County:	Ventura	GIS Longitude:	-119.39577
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Airplane/Boat	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	Anacapa Island is the easternmost of the four northern Channel Islands. The island is part of Channel Islands National Marine Sanctuary and Channel Island National Park. Permits to collect must be approved by Channel Islands National Park (CINP). Transportation to the island is by CINP or chartered vessel from Santa Barbara, Ventura, or Channel Islands Harbor. The drop-off point is at the Landing Cove Ranger Station at East Anacapa Island.		
Site Description:	Specific mussel collecting site TBD. Current coordinates are for MARINe monitoring site. The site must be accessed by skiff from East Anacapa Ranger Station at Landing Cove. Landing is best at the east side of the reef on the shelf at low tide. This location is an ASBS, a MPA, and a MARINe monitoring site. Mussels should not be collected in the vicinity of survey plot marker bolts or epoxy blobs; collection spots should be located just outside the MARINe site boundary. Mussel collection should correspond with MARINe monitoring in the spring.		

3	Sites arranged from north to south:		
Site Code:	AHCM**	Latitude:	34° 28.4064' N
Site Name:	Canyon Mouth	Longitude:	120° 8.724' W
Site Location:	Arroyo Hondo	GIS Latitude:	34.47344
County:	Santa Barbara	GIS Longitude:	-120.1454
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	The Arroyo Hondo site is ~25 min. drive from UCSB. Walking time from parking lot to site is 15 min. Drive north on Hwy 101 from Storke Rd exit ~11.5 miles passed the Refugio State Beach exit. Travel 0.6 miles and pass Arroyo Hondo canyon; oil platform offshore. In 0.4 miles, move into abrupt left turn lane; make U-turn; return south-bound for 300 m back over canyon. Exit at "Vista Point"; park along curb to the right, in off-highway parking area.		

Site Description: Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. Take the trail, beginning on ocean side of railroad tracks just before trestle bridge down to site. Follow path under bridge, down concrete stairs and out to beach. The MARINe site is ~500 m upcoast, but collection site can be located at the closest reef to the canyon mouth. Ideally, mussel collection should correspond with MARINe monitoring in the spring. The MARINe monitoring site is at third low-lying rocky reef. Look for bolts marking barnacle plots in upper intertidal.

4	**Sites arranged from north to south:**		
Site Code:	CPSB**	Latitude:	34° 23.2218' N
Site Name:	Barnacle Reef	Longitude:	119° 30.8442' W
Site Location:	Carpinteria State Beach	GIS Latitude:	34.38703
County:	Santa Barbara	GIS Longitude:	-119.51407
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW

Access Directions: The Carpinteria site is approx. 25 - 35 minute drive from UCSB. Estimated walking time from parking lot to site is <5 min. Drive south on Hwy 101 about 21.5 miles. Exit onto Casitas Pass Rd. (marked "Carpinteria State Beach"); proceed toward ocean. Travel 0.25 miles and turn right at Carpinteria Ave. (Rt 224). Travel 0.1 miles and turn left at Palm Ave., just past swimming pool. Travel 0.18 miles and stop at State Park entrance kiosk for parking permit. Double back around kiosk and follow road downcoast past camping area. Travel 0.18 miles and park in farthest parking lot near stairs down to beach.

Site Description: This site is a California State Beach. A permit is needed to waive entry fees and collect mussels. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. Barnacle Reef is directly below parking lot. Main Reef is approximately 300 m upcoast, out from main lifeguard tower. Mussels should not be collected in the vicinity of survey marker plots or epoxy blobs. If possible, mussel collection spots should be located just outside the MARINe site boundary. Ideally, mussel collection should correspond with MARINe monitoring in the spring.

5	Sites arranged from north to south:		
Site Code:	MUOS**	Latitude:	34° 3.9672' N
Site Name:	Old Stairs	Longitude:	118° 59.8674' W
Site Location:	Point Magu	GIS Latitude:	34.06612
County:	Ventura	GIS Longitude:	-118.99779
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	From Santa Monica, take Hwy 1 (Pacific Coast Highway). Travel north, 32 miles, past Leo Carrillo State Beach. Continue on, past the LA/Ventura County Line and Yerba Buena Rd. (1.81 miles). Old Stairs intertidal site is located off Hwy 1 about 2.4 miles past Yerba Buena Road. There is a highway cleaning sign on the north side of the road across from the site. The study site is about 3 utility poles north of call box #1-35, and just south of the VEN-1 PM 3.5 mile marker.		
Site Description:	This site is an ASBS and MARINe monitoring location. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. Mussels should not be collected in the vicinity of survey marker plots or epoxy blobs. If possible, mussel collection spots should be located just outside the MARINe site boundary. Ideally, mussel collection should correspond with MARINe monitoring in the spring.		

6	Sites arranged from north to south:		
Site Code:	CCSP**	Latitude:	33° 34.2468' N
Site Name:	Crystal Cove	Longitude:	117° 50.2638' W
Site Location:	Laguna Beach	GIS Latitude:	33.57078
County:	Orange	GIS Longitude:	-117.83773
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	From Los Angeles, take the San Diego Freeway (405) south to the Corona Del Mar Freeway (SR73). Take the MacArthur exit off of SR 73. Turn right onto MacArthur and drive 2.7 miles until the road ends at Pacific Coast Highway (SR 1). Turn left onto SR 1 and drive south 3.7 miles to the Reef Point Area at the Crystal Cove State Park. Turn right into the Reef Point parking lot, and pay parking fee. Turn right at the stop sign to park in the northern portion of the lot.		

Site Description: This site is a California State Park, an ASBS, and a MARINe monitoring location. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. Follow signs to enter the trail on the north side and walk down the cement path which leads down an incline towards the shoreline. This site is located about 200-300m north of the base of the cement path, which is the first of three rocky intertidal benches. Mussels should not be collected in the vicinity of survey plot markers or epoxy blobs. If possible, mussel collection spots should be located just outside the MARINe site boundary. Ideally, mussel collection should correspond with MARINe monitoring in the spring.

7	**Sites arranged from north to south:**		
Site Code:	DNPT**	Latitude:	33° 27.594' N
Site Name:	Dana Point	Longitude:	117° 42.885' W
Site Location:	Dana Point	GIS Latitude:	33.4599
County:	Orange	GIS Longitude:	-117.71475
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW

Access Directions: From Los Angeles, take the San Diego Freeway (405) south, merge onto Interstate 5 south, then exit onto Pacific Coast Highway (1) in Dana Point. You will be heading west. Turn left at the signal for Dana Point Harbor Drive. Follow the road until it ends and you see the sign for the Orange County Marine Institute. Park in parking lot (no fee).

Site Description: This site is a State Marine Conservation Area and a MARINe monitoring site. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. A permit is needed to collect mussels within this MPA. Proceed to the entrance to the Dana Point Marine Life Refuge. Mussels should not be collected from the vicinity of survey marker bolts or epoxy blobs. If possible, mussel collection spots should be located just outside the MARINe site boundary. Ideally, mussel collection should correspond with MARINe monitoring in the spring.

8	Sites arranged from north to south:		
Site Code:	CDRF**	Latitude:	32° 59.9904' N
Site Name:	Cardiff Reef	Longitude:	117° 16.7202' W
Site Location:	South of San Elijo Lagoon	GIS Latitude:	32.99984
County:	San Diego	GIS Longitude:	-117.27867
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	From Interstate 5 head south towards San Diego. Exit Freeway 5 at Lomas Santa Fe Drive. Head west on Lomas Santa Fe Drive for 0.9 mi. Just past railroad tracks, turn right onto Pacific Coast Highway (Rt. 1). Go north on Pacific Coast Highway for 1.0 mi. Turn left into southernmost parking lot for Cardiff State Beach. Park in southernmost corner of lot nearest the beach.		
Site Description:	Walk south from the parking lot around the corner to the rocky reef extending out from the seawall. This site is a State Beach and a MARINe monitoring site. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. A permit is needed to collect mussels within this MPA. Mussels should not be collected from the vicinity of survey marker bolts or epoxy blobs. Ideally, mussel collection should correspond with MARINe monitoring in the spring.		

9	Sites arranged from north to south:		
Site Code:	SCRF**	Latitude:	32° 52.299' N
Site Name:	Scripps Reef	Longitude:	117° 15.1968' W
Site Location:	Scripps Reef	GIS Latitude:	32.87165
County:	San Diego	GIS Longitude:	-117.25328
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus californianus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	Heading north from San Diego, exit Freeway 5 at Ardath Road. Head northwest on Ardath Road (toward La Jolla) for about 1.5 mi. Turn right onto La Jolla Shores Drive. Go north for about 1.0 mi. and park on street above Scripps Institution of Oceanography.		
Site Description:	Walk down to the Scripps Pier and follow a ramp (on the right) down to the beach. Walk north along the sand beach about one-third mi to the prominant reef. This site is a State Marine Conservation Area, a University of California Reserve, an ASBS, and a MARINe monitoring site. Specific mussel collecting spot TBD. Current coordinates are for MARINe monitoring site. Permits are needed to collect mussels within this MPA. Mussels should not be collected from the vicinity of survey marker bolts or epoxy blobs. Ideally, mussel collection should correspond with MARINe monitoring in the spring.		

APPENDIX D – SPME SITE LOCATIONS

1	Sites arranged from north to south:		
Site Code:	MULG**	Latitude:	
Site Name:	Mugu Estuary	Longitude:	
Site Location:	Point Magu	GIS Latitude:	
County:	Ventura	GIS Longitude:	
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus edulus
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW
Access Directions:	From Santa Monica, take Hwy 1 (Pacific Coast Highway). Travel north, past Leo Carrillo State Beach, the LA/Ventura County Line, Yerba Buena and Deer Ck. Rds. until you round Pt. Mugu. Exit Las Posas Rd. and head west toward the military base. Go to the visitor information building, located outside the base gates. Obtain permission to enter the base. Make prior arrangements with U.S. Fish and Wildlife Service personnel. They will need to escort you while on military property.		
Site Description:	Under escort, travel to Laguna Rd. It crosses the lagoon and has culverts to allow water passage between wetland sections. Bay mussels should be around the culverts on Laguna Road.		

2	Sites arranged from north to south:		
Site Code:	LARM**	Latitude:	
Site Name:	Los Angeles River	Longitude:	
Site Location:	Queen Mary	GIS Latitude:	
County:	Los Angeles	GIS Longitude:	
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus edulis
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	Head south along I-710 toward Long Beach. The freeway splits near the end, take the highway (Harbor Scenic Drive) towards the Queen Mary. Where the highway turns to streets, Harbor Plaza Rd. crosses, turn left towards the Queen Mary. The road turns into Queensway Drive. Do not turn right into the Queen Mary parking lot. Straight ahead you will see Events Park on the right-side of the road. As the road turns to the north, you will see restroom buildings. Park on the road near the building.		
Site Description:	Walk past the restroom building toward the point that extends out into the water. Use that as your center point. An alternative site will be across the water at the Shoreline Village marina parking.		

3	Sites arranged from north to south:		
Site Code:	NHPB**	Latitude:	33° 37.020' N
Site Name:	Newport Beach	Longitude:	117° 54.249' W
Site Location:	PCH Bridge	GIS Latitude:	33.617
County:	Los Angeles	GIS Longitude:	-117.90415
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus edulis
Year Start:	2008	Target Date:	
Access Mode:	Car/Boat	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	Follow Hwy. 1 (Pacific Coast Highway) south into Newport Beach, pass Route 55 (Newport Blvd), and continue until it crosses Newport Bay. Turn left onto Bayside Dr. Turn left again at the first driveway. The sign says marina and Pearson's Port parking. Follow paved roads back toward the Hwy. 1 overpass. You should be able to park near or under the overpass, Pearson's Port should be on the right side. Another access point is on the south side of Hwy 1 in the marina parking lot. A public boat launch ramp is located near there in Newport Dunes Resort. Take Hwy 1 to Jamboree Rd., head north (bottom of hill) to backbay Drive. Turn left, then left again into the Dunes Resort. Pay parking and launch fees.		
Site Description:	The site is located under the Pacific Coast Highway overpass. There should be low relief rocks along the edge. You may need to get (by boat) to the concrete pilings in the center of the channel to obtain mussels.		

4	Sites arranged from north to south:		
Site Code:	TJRE**	Latitude:	
Site Name:	Tijuana River	Longitude:	
Site Location:	Tijuana National Estuary	GIS Latitude:	
County:	San Diego	GIS Longitude:	
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus edulis
Year Start:	2008	Target Date:	
Access Mode:	Car	Water Depth:	intertidal, +0.5 m MLLW
Collection Method:	Hand		
Access Directions:	From Interstate 5 south to imperial Beach, take the Coronado Ave. exit, head west. The road turns into Imperial Beach Blvd. Turn south (Left) on 3rd St. and left on Caspian Way. Park at the Tijuana Estuary National Preserve Visitor Center. Check in. You should have made arrangements with estuary staff before arriving.		
Site Description:	Site reconnaissance has not been made at the site. Depend on director and staff for available mussel locations.		

5	Sites arranged from north to south:		
Site Code:	SELG**	Latitude:	
Site Name:	San Elijo Lagoon	Longitude:	
Site Location:	San Elijo Lagoon	GIS Latitude:	
County:	San Diego	GIS Longitude:	
State:	CA	Matrix:	Mussel - whole animals
Biannual:	NA	Species:	Mytilus edulis
Year Start:	2008	Target Date:	
Access Mode:	Car/Boat?	Water Depth:	guestimate: intertidal,
Collection Method:	Hand		+0.5 m MLLW

Access Directions: From Interstate 5 south to Encinitas, take the Birminghsm Dr. exit, head west. Turn Left (South) on San Elijo Ave. The road runs along the railroad tracks. Find parking on the road after the lagoon's ocean channel appears on the west side.

Site Description: The location is at the railroad trestles. It is accessible buy a short trail off the road.