INTRODUCED AQUATIC SPECIES IN CALIFORNIA OPEN COASTAL WATERS -2007

Final Report

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Moss Landing Marine Laboratories
Marine Pollution Studies Laboratory

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INTRODUCTION

The Marine Invasive Species Act of 2003, as specified in Chapter 491, Statutes of 2003, stipulates that the California Department of Fish and Game (CDFG) will conduct several studies, including a supplemental survey, developed under the Ballast Water Management Act of 1999, to augment the baseline data of non-indigenous species (NIS) in coastal bays and estuaries. The supplemental survey, conducted in 2004, focused on the intertidal and subtidal habitats of the open coast and served as a baseline survey for the open coast habitat. The Act of 2003 further required that these baseline surveys be followed by on-going monitoring to determine the presence of any newly introduced species. This monitoring effort is required in order to determine the effectiveness of the ship vector control measures put in place by the Act. The current study was the first of the monitoring surveys for the outer coast locations. The field and laboratory studies for both the outer coast baseline study in 2004 and the current outer coast monitoring study focused on locations near prominent headlands that are proximate to shipping lanes such as Point Saint George, Cape Mendocino, Point Arena, Diablo Canyon, Pillar Point, Pigeon Point, Dana Point and Point Loma as well as other locations where ballast water exchange or other ship-related vectors could likely result in NIS invasions (Figure 1).

The CDFG's Office of Spill Prevention and Response (OSPR) provided the lead role for the NIS investigations. Literature and data reviews were complimented by field and laboratory studies jointly conducted by CDFG/OSPR and San Jose State University Foundation's Moss Landing Marine Laboratories (MLML). Additional universities and specialized laboratories provided taxonomic expertise in identification of marine species.

The vast majority of known marine introductions in California have occurred in bays and harbors, probably because several of the major introduction vectors (ballast exchange, aquaculture, and ship hull fouling) have historically concentrated there. Relatively few NIS were detected from the open coast during the baseline survey conducted by MLML/CDFG in 2004; a total of 6 species identified in the 2004 survey from the above locations are currently considered to be NIS in California (CANOD, 2008). It may be likely that the open coastal environment is both more resistant to invasions and less exposed to them. As studies of marine species invasions continue, it is apparent that knowledge of the natural histories of both native and non-native species is vital to understanding and predicting sustainable invasions (Carlton, 1996). The survey presented here should aid our knowledge of the extent of invasions and subsequent ecological adaptations, as well as prevalent trends in recruitment and succession caused by bioinvasions.

This study aimed at collecting monitoring information on the presence, distribution, and abundance of NIS along California's open coast. Taxonomic experts for each phylum were relied upon heavily for comments and direction in determining the status of species as introduced, cryptogenic, or native. Taxonomist's comments were supplemented with literature reviews in many cases to address questionable or problematic species status determinations. This process led to several updates to the introduction statuses previously reported by MLML/CDFG (CDFG, 2002; Maloney et al., 2006; CDFG, In Prep; Maloney et al., 2007; Maloney et al., 2008), and these updates are described in text and tables below. The process also highlighted the need for additional basic taxonomic, ecological, and genetic studies before many species' status determinations can be finalized. The sampling design was adapted from the design used in previous MLML/CDFG NIS surveys conducted in California bays and harbors (CDFG, 2002), and California's open coast (Maloney et al., 2006), and focused on whole community structure rather than singling out any one "invasive" species or habitat. Site selection and general descriptions are detailed below.

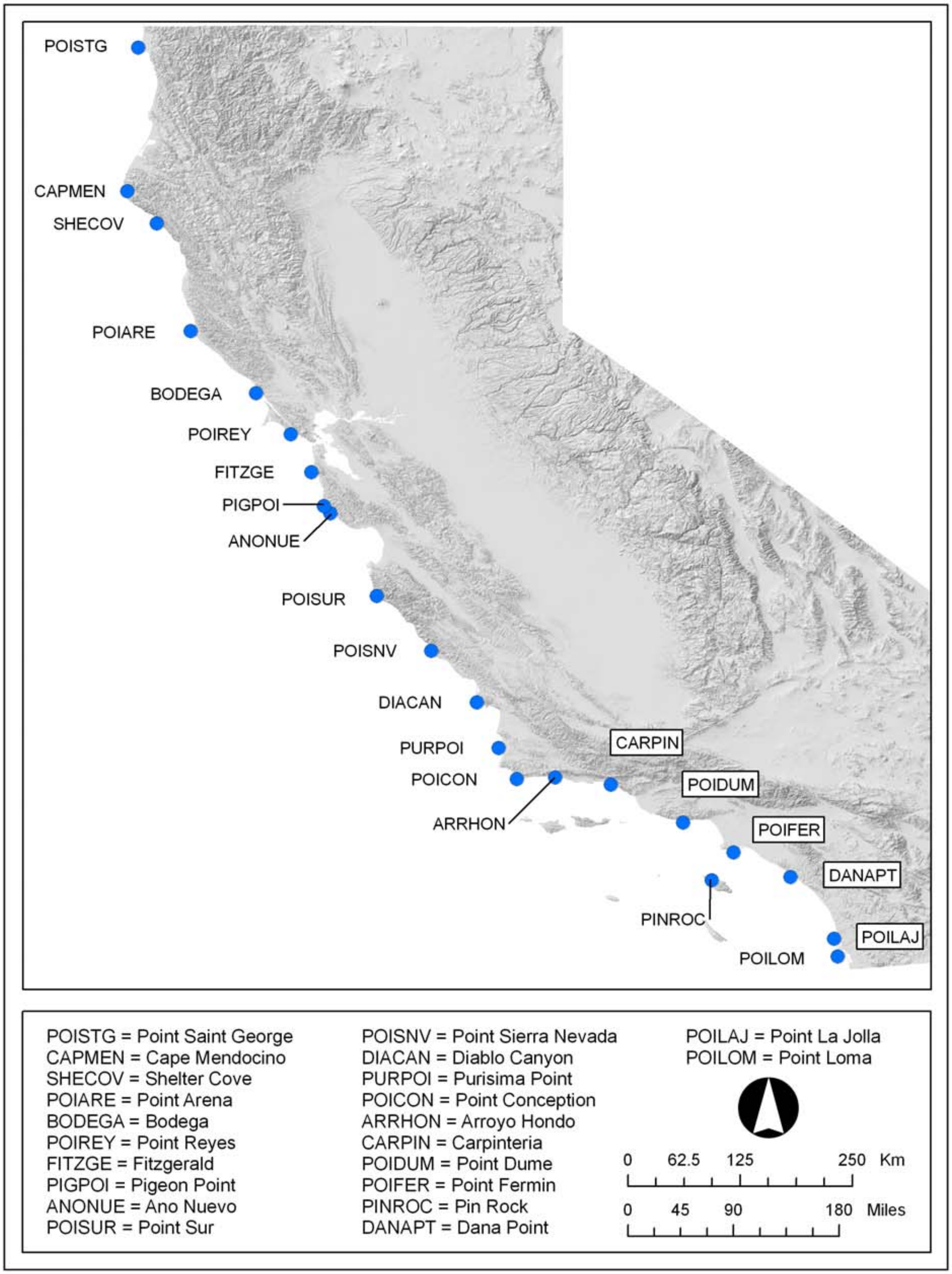

POISTG
CAPMEN
SHECOV
POIARE
BODEGA
POIREY
FITZGE
PIGPOI
ANONUE
POISUR
POISNV
DIACAN
PURPOI
POICON
ARRHON
CARPIN
POIDUM
POIFER
DANAPT
PINROC
POILAJ
POILOM
POISTG = Point Saint George
CAPMEN = Cape Mendocino
SHECOV = Shelter Cove
POIARE = Point Arena
BODEGA = Bodega
POIREY = Point Reyes
FITZGE = Fitzgerald
PIGPOI = Pigeon Point
ANONUE = Ano Nuevo
POISUR = Point Sur
POISNV = Point Sierra Nevada
DIACAN = Diablo Canyon
PURPOI = Purisima Point
POICON = Point Conception
ARRHON = Arroyo Hondo
CARPIN = Carpinteria
POIDUM = Point Dume
POIFER = Point Fermin
PINROC = Pin Rock
DANAPT = Dana Point
POILAJ = Point La Jolla
POILOM = Point Loma
0 62.5 125 250 Km
0 45 90 180 Miles

Figure 1. California outer coast sites sampled during the 2007 survey.

Outer Coast Survey Sites

Site Selection

The OSPR originally developed a list of 22 geographic areas spanning California's outer coast, targeting prominent headlands in proximity to shipping lanes and potential entrainment areas that may have increased larval settlement. For the 2004 open coast survey, MLML further refined these areas to 22 specific sampling sites to 1) find accessible intertidal and subtidal habitats near the areas identified by OSPR, and 2) whenever possible, overlap locations with historic or current species datasets that could be used to monitor change in species composition over time. These same locations were re-sampled for the current survey.

Point Saint George

This site was chosen as the northern-most prominent headland to sample for the current survey. Point Saint George lies approximately 15 miles south of the Oregon-California border. The point itself is composed mostly of rugged, rocky reef, whereas the nearby coastline is composed of mainly large boulder fields with some rocky outcrops and few small sandy patches. The subtidal terrain is equally as rugged as the intertidal coastline. As one of the few accessible rocky intertidal reefs along the extreme northern California coastline, this site is also a current study site for other intertidal ecological research and monitoring (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). Intertidal sampling for the 2004 survey occurred on the downcoast-facing side of the rocky point that jets out from the coastline and is exposed only at low tide (Figure 2). Note that subtidal sample locations shown on figure 2 indicate the target locations, but subtidal sampling did not occur at this survey site due to logistical constraints.

Cape Mendocino

Sampling occurred approximately five miles south of Cape Mendocino, in an area thought to be a larval entrainment area (Ebert and Russell, 1988). The survey site lies approximately 30 miles south of Humboldt Bay, between the mouth of the Bear River to the north and the Mattole River to the south (Figure 2). This site is very remote as well as subject to winter storms and strong surf. There is a large, easily accessible intertidal rocky reef where other ecological experimental and monitoring historically and currently occur (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). Note that subtidal sample locations shown on figure 2 indicate the target locations, but subtidal sampling did not occur at this survey site due to logistical constraints.

Shelter Cove

Shelter Cove was chosen as one of the major geographical points along the northern California coastline (Point Delgada). Although remote and difficult to get to by boat or car, this area is a small hub for fishing boat traffic. The specific sampling locations were all adjacent to the bulk of boating activities in the area, which included a small boat launch, permanent moorings, and transient anchorages. Intertidal sampling took place at the reef just north of the Shelter Cove boat launch area and extended upcoast and around the point a few hundred meters. The intertidal sandy sampling occurred on the beach that extended downcoast from the boat launch area.

Subtidal rocky sampling occurred on a rocky reef off of Point Delgada and the subtidal sandy sampling occurred offshore from the launch ramp (Figure 2). This area's rocky intertidal reefs have also been studied and are currently monitored by marine ecological researchers and monitoring groups (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/).

Point Arena

This site was selected because it is one of the most prominent headlands along the Mendocino/Sonoma coastline. Point Arena itself consists of steep cliffs and rugged rocky coastline and was deemed inaccessible by MLML field crew. Moss Landing Marine Laboratory staff sampled approximately 1.5 miles to the south of Point Arena at an accessible rocky reef (Figure 2) which has previously been a site for ecological studies conducted by various researchers (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). There were no sandy beaches with fine enough sand in the immediate vicinity of the rocky reef sampled, so sandy intertidal samples were collected at Schooner Gulch. This sandy intertidal location is approximately 8 miles downcoast from where samples were collected during the 2004 survey.

Bodega

This site was chosen by CDFG as a prominent headland in this area of the coastline. Sampling occurred approximately one mile North of Bodega Harbor, at Bodega Marine Lab, within the Bodega Marine Reserve. Researchers from Bodega Marina Lab and other ecological research and monitoring groups constantly study this shoreline (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/), which could provide historical species datasets for comparison. The rugged but accessible rocky reef adjacent to a sandy cove also made this an ideal sampling site (Figure 2).

Point Reyes

CDFG originally selected Point Reyes as a sample location because of its prominence as a headland in the area. However, the headland itself consists of steep cliffs and is virtually inaccessible for intertidal sampling. After researching possibilities in the area, and based on the recommendation of Point Reyes National Seashore park researchers, MLML chose the rocky intertidal reef at Bolinas Point as the alternate intertidal sampling site. Bolinas Point is another fairly prominent point on the southern portion of Point Reyes National Seashore, and still within national park protection. In addition, it is difficult to find a subtidal sampling site considered safe for SCUBA divers, as this area is known to have an abundance of great white sharks. Bodega Marine Lab scientific collectors experienced in sampling this area directed MLML to a subtidal site at the north end of Drakes Bay near Chimney Rock. This was accepted as the only site in the area safe enough for sampling via SCUBA, and even then the sampling event was timed to occur after the vast majority of sharks were thought to have left the area. Although technically inside Drakes Bay, the bay is very large, open and exposed like the outer coast (Figure 2).

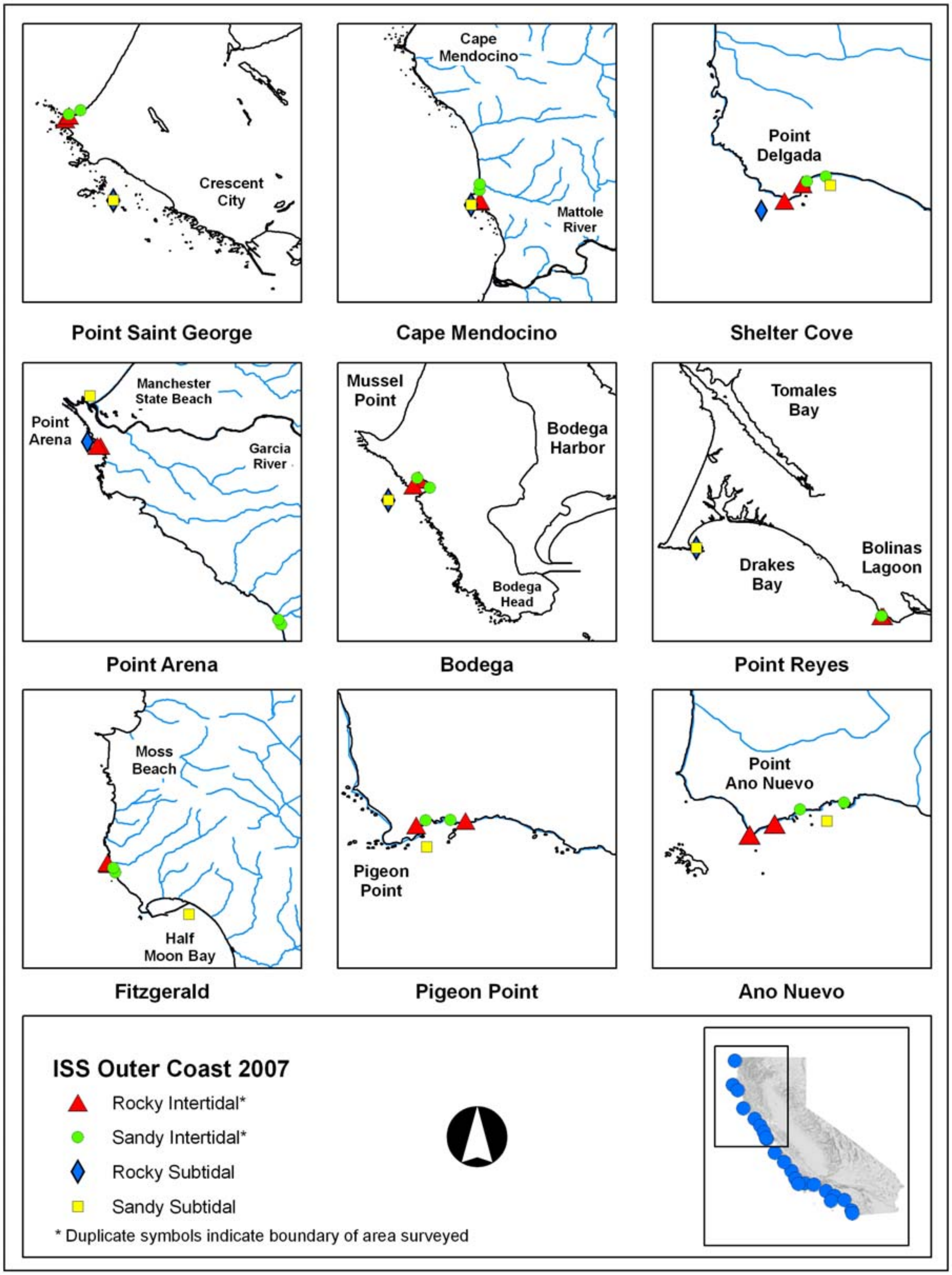


Figure 2. Northern California sites sampled during the 2007 surveys.

Fitzgerald
Fitzgerald State Park was selected as a sampling site due to its large, accessible rocky intertidal reef with an adjacent sandy beach (Figure 2), and since other rocky reef research occurs at the site there may be historical species datasets available for comparison (SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). Fitzgerald State Park is less than five miles north of the world-famous big wave surf spot, Maverick's reef, and is within state park boundaries. This intertidal area is not far from San Francisco and is regularly visited by locals and tourists; the trampling disturbance may make it more susceptible to species introductions than other nearby areas. An additional local disturbance comes from harbor seals who regularly haul out in certain areas of the rocky intertidal reef sampled. This area is known to have a high abundance of great white sharks, so subtidal sampling at this site was limited to sandy habitat sampled using a surface-deployed benthic grab from the boat. No diving was planned or attempted for rocky subtidal samples.

Pigeon Point
This sampling site was selected because it is a prominent headland in the area, and it has been studied by other marine ecological researchers (PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org). Intertidal sampling occurred south of the point, along a sandy beach and adjacent rocky outcrops that are somewhat protected by the point. Subtidal sampling occurred just offshore from the intertidal sampling, and did not include SCUBA diving as this area is known to be frequented by great white sharks (Figure 2).

Ano Nuevo
Point Ano Nuevo was selected as a sampling site for several reasons. It is a prominent headland in the region, historical datasets reported introduced species found in the rocky intertidal up to 30 years ago, and it is a site researched by other groups both historically and currently (J. Pearse, personal communication, July 14, 2004). There is a rocky intertidal reef, an adjacent low-lying boulder field, and adjacent beaches, all somewhat protected by Ano Nuevo Island just offshore (Figure 2). Elephant seals regularly haul out at this site, creating a disturbance that may increase this site's susceptibility to introductions. White sharks attracted to the elephant seals are abundant in this area, so subtidal samples were not collected using SCUBA divers. The rocky reef surveyed is also currently a study site for other intertidal ecological monitoring research (SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/).

Point Sur
CDFG selected Point Sur as a prominent headline along the Big Sur coastline in southern Monterey County. The point itself is a rugged, steep headland, so sampling occurred approximately 0.5 miles to the south, in between Point Sur and Andrew Molera State Park (Figure 3). Accessible intertidal rocky reef is adjacent to a long sandy beach, and just offshore lays a large rocky reef and kelp forest. Since this area is directly in the lee of Point Sur, it may be an area of larval entrainment. This intertidal and subtidal rocky reef area is also being studied and monitored by PISCO (Retrieved July 21, 2008, from http://www.piscoweb.org).

Point Sierra Nevada
Point Sierra Nevada lies just south of the Big Sur coastline, in between Ragged Point to the north and Point Piedras Blancas to the south. Point Sierra Nevada is an historical rocky intertidal study/monitoring site for other research groups, including monitoring funded by the Minerals

Management Service (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org); SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). Since no sandy beaches are adjacent to the intertidal rocky reef sampled, sandy samples were collected at the next accessible beach south on Highway One. This area is approximately 5 miles north of a recovering Elephant Seal rookery at Piedras Blancas and thus is presumably white shark habitat, so using SCUBA divers was deemed unsafe at this site. All subtidal samples were collected from a boat by retrieving kelp holdfasts and using a sediment grab at the nearest possible location to Point Sierra Nevada (Figure 3).

Diablo Cove
Considered a potential recruitment area for introduced species due to the warm water output from the nuclear power plant, Diablo Cove was selected as a sampling site for the current survey. Species assemblages at Diablo Cove are known to be unusual for that area as a result of the warm water. Although Diablo Cove has been highly studied and species lists date back decades, MLML does not know of any other surveys conducted at this site that focused on introduced species detection. This site is situated between Point Buchon to the north and San Luis Obispo Bay to the south (Figure 3).

Purisima Point
Purisima Point lies approximately 10 miles north of Point Arguello, and is this survey's southernmost sampling site within the cold waters of the California Current north of Point Conception. At Purisima Point, an accessible, flat, intertidal reef jets out to sea and is exposed only at low tide, while a subtidal reef and kelp bed lie just offshore in the lee of the point (Figure 3). The rocky intertidal habitat on the point is a long-term monitoring site, and researchers report observations of large amounts of kelp and debris washing up to shore, leading us to suspect that it is an area of larval retention (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; P. Raimondi, personal communication, May 27, 2004). Researchers have also observed higher species richness in attached marine algae at this site than at other nearby rocky intertidal sampling sites (P. Raimondi, personal communication, May 27, 2004). There is an intertidal beach on the north side of the point, but the sand is typically very coarse there and not suitable for collecting infaunal samples for this survey. However, suitable beaches can be found slightly downcoast of the rocky reef.

Point Conception
Point Conception is both a major headland within the region and known as a biogeographic boundary along the California coastline and the northern or southern range limit for many marine species. Cojo Anchorage lies just to the south of the point and is an accessible dive site with kelp forests (Figure 3). Rocky intertidal benches line parts of the coastline around Point Conception, but are not easily accessible by land or by boat, making the coastline well protected from human trampling. Both the intertidal and subtidal rocky reef habitats have been studied and monitored historically at this site (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; M. Readdie, personal communication, October 23, 2006).

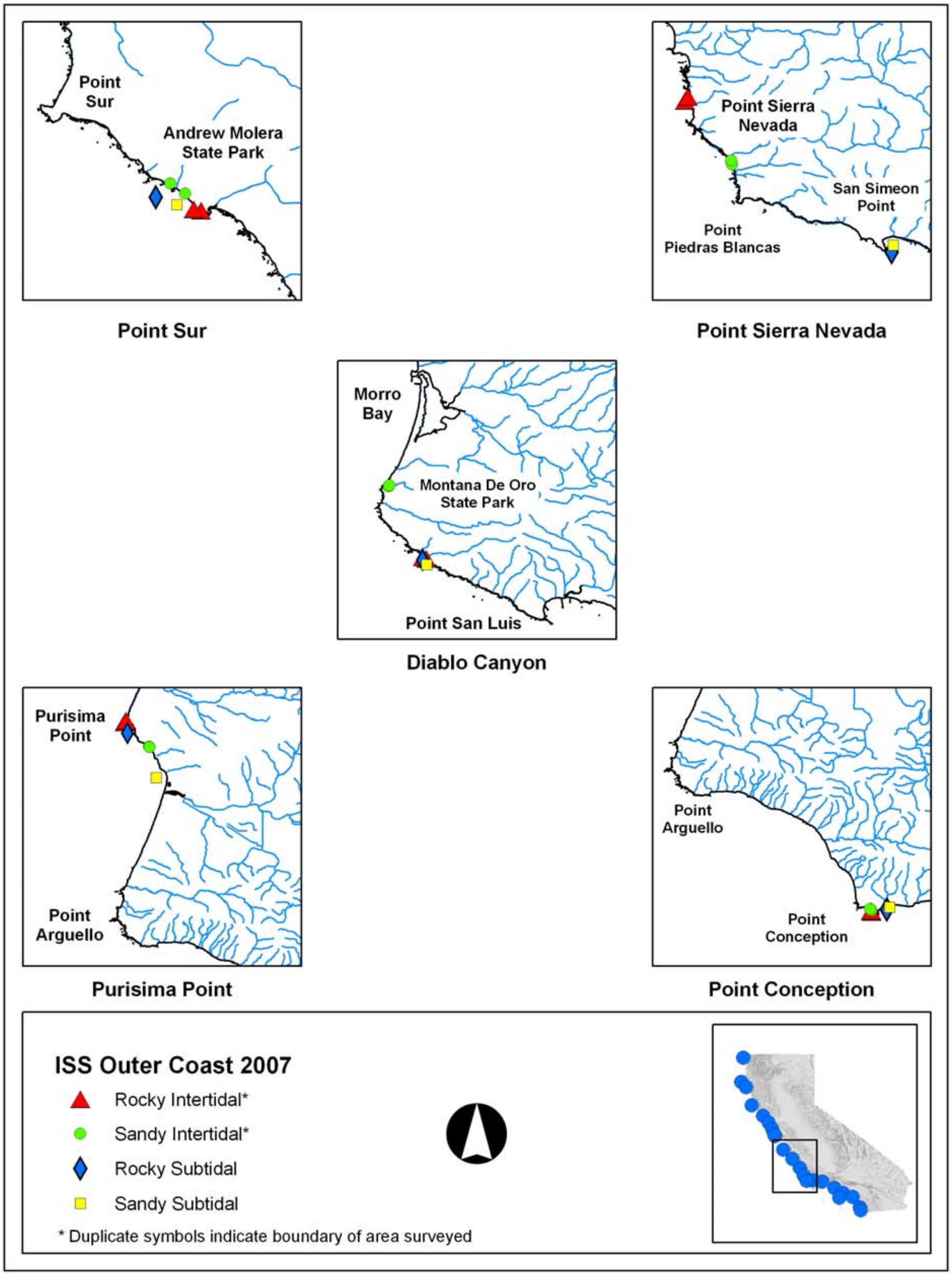


Figure 3. Central California sites surveyed during the 2007 surveys.

Arroyo Hondo
This fairly remote site is between Gaviota and Goleta, towards the northern end of the Santa Barbara Channel (Figure 4). The majority of the surrounding coastline is dominated by sandy beaches and low-lying rocky reefs. Arroyo Hondo's rocky intertidal reef was recommended as the most extensive rocky intertidal reef in the area, is a site of long-term monitoring and ecological experiments, and was also a known and studied location of the introduced marine algae *Sargassum muticum* (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). The reef also extends offshore to kelp forest habitat and is an accessible dive site.

Carpinteria
South of the city of Santa Barbara, Carpinteria State Beach lies in the lee of Sand Point, and near a small estero. One of the only rocky intertidal reefs along this area of coastline is in the middle of Carpinteria State Beach, and there is a subtidal reef and kelp forest habitat offshore (Figure 4). Both the rocky intertidal and subtidal reefs sampled for this project are also study locations for biological monitoring and ecological experiments (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/; C. Nelson, personal communication, October 23, 2006).

Point Dume
Point Dume is a major headland on the north end of Santa Monica Bay. The point is very exposed, with large boulders and rocky outcrops, so the area just downcoast of the point and stretching along the beach to Paradise Cove was selected as the site for the current survey (Figure 4). Rocky intertidal habitat included cobble and boulder fields as well as a small but prominent intertidal rocky reef. This intertidal rocky reef is a study site for various long-term monitoring studies and ecological experiments (MARINe. Retrieved July 21, 2008, from http://www.marine.gov/; SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). This area is a popular beach and experiences high human traffic. Both sandy and rocky reef habitat are found offshore in this area.

Point Fermin
Located just upcoast of San Pedro Bay, and adjacent to the major shipping centers of Los Angeles and Long Beach Harbors (Figure 4), this sampling site was selected as a prime candidate for marine species introductions that may spread out from the harbors. Samplers also observed the container ships sitting offshore waiting for their turn to enter the harbor and offload their cargo. In addition, this rocky intertidal site has historically been studied by various groups both for long-term biological monitoring as well as ecological experimentation (SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/; PISCO. Retrieved July 21, 2008, from http://www.piscoweb.org). Although part of a Marine Life Refuge, this site is centered in an area of high human population and is subject to human visitors and trampling disturbances.

Dana Point
Dana Point was recommended as a sampling site because all target habitats are present, and historical and current ecological and monitoring datasets exist for this area (SWAT. Retrieved July 21, 2008, from http://cbsurveys.ucsc.edu/). The sampling site is also just downcoast from

Dana Point itself, which is quite prominent for this area and currents may create an eddy or retention area on its south side (Figure 4). Dana Point Harbor is also less than one mile away from the sampling site, potentially making this site a likely candidate for introduced species either spreading from within the harbor or in the water column from all of the small boat traffic in the vicinity. Dana Point is also within a Marine Life Refuge.

Pin Rock, Catalina Island
Pin Rock was selected as an outer coast sampling location on Catalina Island for several reasons. This is one of the few sites on the south-west facing side of the island with a rocky bench rather than sheer cliffs. The survey site at Pin Rock is on the ‘back side’, or seaward side of the island, and due to the angle of Catalina Island, the sample site is somewhat protected from north and west swells. Also, the survey site extends along the shore towards the mouth of one of the few small boat harbors on the island, Catalina Harbor (Figure 4). This proximity to the harbor could increase the vulnerability of the outer coast habitats to introductions, because non-native marine species had previously been reported from within Catalina Harbor (K. Miller, personal communication, October 23, 2006). All of the target habitats for the survey occur at or near Pin Rock, which is uncommon along the shoreline of Catalina Island. However, the only sandy intertidal habitat found in the vicinity of the site is within Catalina Harbor, so is not true open coast habitat.

Point La Jolla
After careful reconnaissance and consideration, the Point La Jolla area was selected as a sampling site for this survey primarily because all of the target habitats are available and fairly close together. Intertidal sampling actually occurred south of Point La Jolla, near Bird Rock, while subtidal sampling occurred closer to the point (Figure 4). During reconnaissance, samplers discovered that this site harbored a significant band of *Mytilus californianus* in the rocky intertidal, which is currently uncommon this far south, and is also one of the habitats targeted in this survey at other sites.

Point Loma
Point Loma was selected as the southernmost survey site along the California coastline. The sampling site is within the jurisdiction of Cabrillo National Monument, which maintains rocky intertidal zones that are protected from daily human visitor traffic and disturbance as well as zones that are not protected. Samples collected at this site are from areas of varying human disturbances, but still within a fairly condensed overall area. Point Loma is also in close proximity to two bays with known introductions, as it is adjacent to the mouth of San Diego Bay, and approximately 6 miles south of Mission Bay (Figure 4). Since mussel beds are rare in the rocky intertidal habitat in this area, one of the rocky intertidal quadrat clearings was collected to the north of the main survey site where mussels could be found and collected, but qualitative searches were not conducted at this more northern sampling location, and this collection location is not shown in Figure 4.

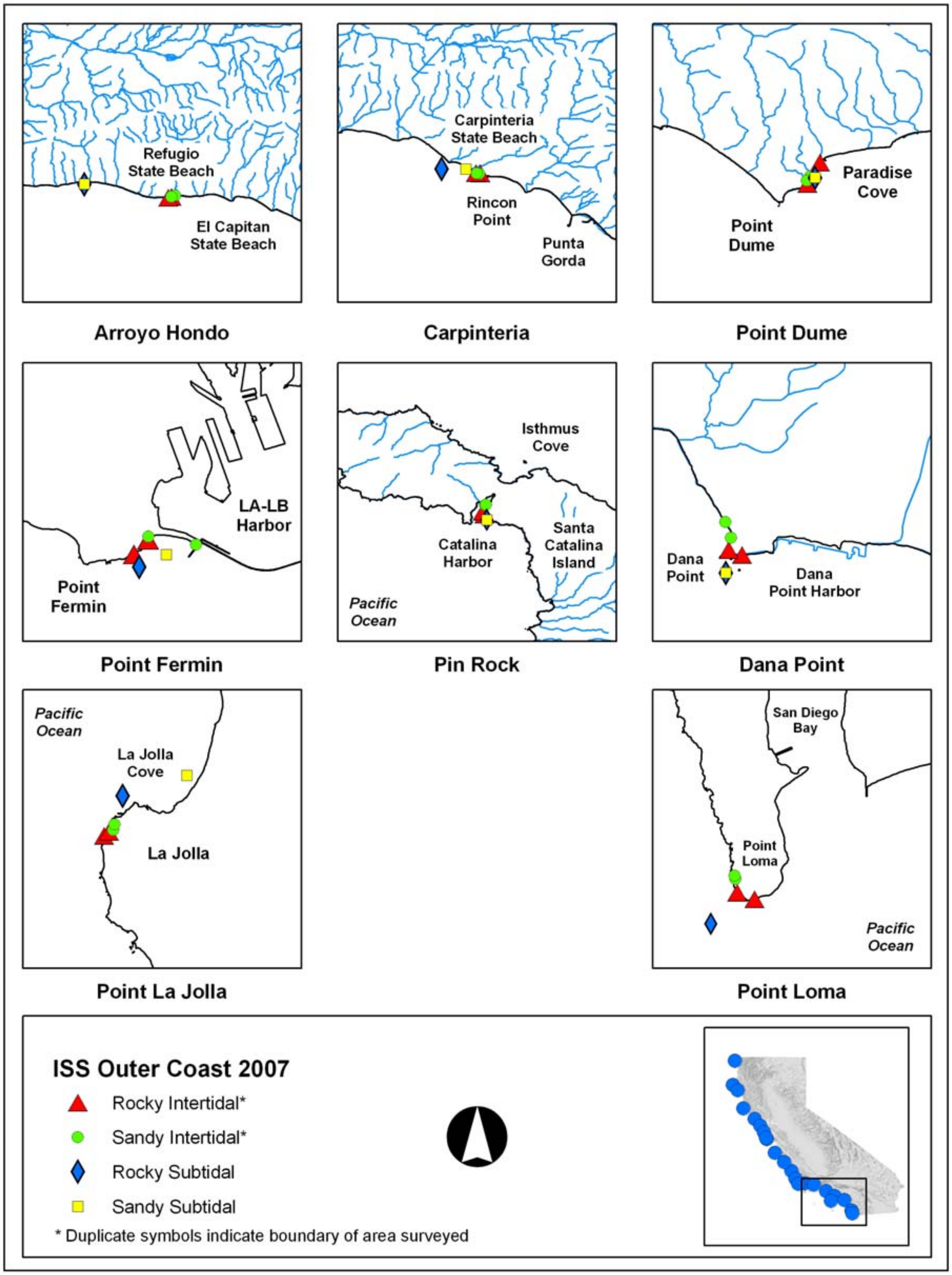


Figure 4. Southern California sites sampled during the 2007 surveys.

METHODS

Summary of Introduction Status Determinations

As experts on the respective taxa, taxonomists are familiar with the most updated and informative sources, current literature, and occasionally even unpublished records of specimen collections. For this reason, taxonomists identifying samples for the current survey were asked to provide an assessment on the introduction status for species they identified. Status determinations made by taxonomists were used to establish a master taxa list for the current survey. The master taxa list was compared to and then combined with the taxa list stored in MLML/CDFG's California Aquatic Non-native Organism Database (CANOD), which is available to the public through the CDFG website (CDFG, 2008). See references section for current full web address.

When introduction status discrepancies were found between what taxonomists reported for the current survey and what had been previously listed in CANOD or other sources, further reviews were conducted by MLML in an attempt to resolve those status discrepancies. These reviews targeted multiple sources of information including peer reviewed scientific publications, web sites, agency literature, field surveys and personal communications, and information was gathered regarding the species' native range, current known distribution and reported introductions. Final species status determinations were made to the best of our knowledge based on all available sources, and after both careful consideration and consultation with taxonomists. Sources used in making status determinations were documented, and the master taxa list was used to identify introduced and cryptogenic species collected from the field surveys of this study.

It should be noted that this survey did not attempt to determine the population status of the introduced species identified from the survey sites. Rather, this survey reports the presence of these species at the survey sites at the time of the survey. Since most survey sites were visited just once during the course of this survey, and often times the introduced species could not be identified without being collected and observed under a microscope, further efforts would be necessary to make a reliable determination of the status of these populations as established and reproducing or not.

Summary of Sampling Design

Field Protocol Design

While the basic sampling regime used in the MLML/CDFG 2002 NIS survey was retained (CDFG, 2002), protocol details were adjusted for the MLML/CDFG 2004 outer coast NIS survey to accommodate for the more natural substrates found at outer coast habitats (Maloney et al., 2006) and those protocols were maintained for the current survey. Depending on sampling location and the collection method, sampling can potentially underestimate the true populations if not all habitat types are represented, as seen in studies of ships' ballast (Carlton and Geller, 1993). It must be acknowledged that not all possible subtidal and intertidal habitats and communities were sampled in this broad statewide survey, but an attempt was made to be as representative as possible within the logistical and budgetary constraints of the project.

At each of the 22 outer coast sites, 4 main habitat types were targeted: rocky intertidal, rocky subtidal (kelp forests if possible), sandy intertidal, and sandy subtidal. The overriding principle was to collect samples from as many different habitats as possible, and within each of those habitats to target the most diverse appearing areas, rather than randomly selecting locations for sample collections. Sampling included the use of qualitative and quantitative sampling protocols to survey representative communities for the presence of NIS. Methods employed included the use of sediment cores and grabs, quadrat clearings and qualitative taxonomic surveys. Samples were preserved and transported to the appropriate laboratories and taxonomists for identification and enumeration. Taxonomists familiar with local marine flora and fauna participated in qualitative visual searches for introduced species at the majority of intertidal habitats. Taxonomists also provided information about historical or ongoing ecological or monitoring research conducted at or near survey sites.

Outer coast subtidal sampling focused on average depths less than 30 feet, and rocky subtidal sampling in particular focused on kelp forest habitat whenever possible to target high diversity communities. Due to habitat differences that could influence larval recruitment and subsequent colonization, the sampling strategy encompassed multiple depths, intertidal zones, substrates and light exposure conditions.

Summary of Field Sampling Methods

Sampling Vessel

Whenever possible, collections were made using 19 ft Boston Whalers (*Ms. B1* and *Ms. B2*) with Johnson 100 hp and135 hp commercial outboard engines and 15 hp spare outboard engines. *Ms. B1* was outfitted with a 5.5 hp Honda motor that powers a hydraulic winch, used for sediment grabs at sites where diving was not possible or prudent. Since many sampling locations were remote and required larger seagoing vessels or local knowledge for safety purposes, several research vessels from other institutions were used, including CDFG, Moss Landing Marine Labs, PG&E, University of California-Davis, University of California-Santa Barbara, University of California-Santa Cruz and University of Southern California. All sampling events were recorded as latitude and longitude (decimal minutes, NAD83) using a Garmin GPS Map76S Global Positioning System. All station information pertinent to the sampling effort was recorded in a field logbook.

Epifaunal Sample Collection

<u>Quantitative quadrat clearings</u>

At each of the 22 outer coast sites, epifaunal samples were collected quantitatively from rocky intertidal and subtidal substrate, by scraping clear and collecting the biological contents from quadrats of known areas (0.05 m^2). In order to increase the chances of detecting a non-native species, field samplers selectively placed quadrats in areas that appeared to have the most diversity or were likely to harbor non-native species, including but not limited to overhangs, big cracks in the rock, mussel beds and turf communities. Decisions made on quadrat placement were primarily based on background research on the natural history of known non-native algae and invertebrates on the outer coast. Digital photographs were taken of both the plot and its surrounding community before the plot was cleared. Samplers carefully and completely collected everything found within each quadrat clearing.

At rocky intertidal habitat, 4 quadrats were cleared for a total area of $0.2m^2$. Whenever possible, the 4 intertidal quadrat clearings were distributed in the intertidal as follows: 1) one clearing from the mid-zone mussel bed; 2) one clearing from the mid zone, non-mussel bed, in what appeared to be the most diverse habitat, (note: in Southern California, sites with turf habitat covering much of the intertidal area were often encountered. At many of these sites this mid zone quadrat was placed in mid to high zone turf habitat); 3) one clearing from the low zone, oriented horizontally, in the most seemingly diverse habitat; 4) one clearing from the low zone on a vertical surface or under an overhanging rock.

Subtidal surveys were conducted via SCUBA at all sites unless white shark presence prohibited diving. In rocky subtidal habitat, the total area of $0.2m^2$ was modified into 3 quadrats ($0.05m^2$ each), and one kelp holdfast when kelp was present. All subtidal sample collections were taken from a target depth of 30 feet or less if possible. At least one subtidal quadrat clearing was taken from a vertical surface or overhang, while the other two clearings were taken from the most seemingly diverse habitat types observed at each site. *Macrocystis pyrifera* and *Nereocystis leutkeana* plants with a holdfast diameter of at least 20cm were targeted for the holdfast collection whether found dead or alive. Holdfasts collected which were 60-100cm in diameter were cut into smaller, more manageable pieces before being put into containers. For larger holdfasts (~100cm), a representative subsample was taken. At sites where shark presence prohibited diving, attempts were made to collect four holdfasts of either *M. pyrifera* or *N. leutkeana* from a boat by tying off to the kelp stipes at the surface and pulling on them. Quadrat clearings could not be collected without SCUBA divers, so the contents of the holdfasts were the only rocky subtidal samples collected from non-dive sites.

Quadrat and holdfast samples collected underwater were placed in mesh bags (0.5mm mesh), which were closed tight and transferred to the surface. On the boat, the entire contents within the mesh bags for each sample were carefully sieved through a 0.5mm screen and then transferred into separate containers and labeled. Intertidal collections were placed into separate containers and labeled in the field. All quantitative clearing samples were fixed in 10% formalin in the field and later preserved in 80% ethanol.

Visual Searches

To the extent that they were available, taxonomists and/or natural historians familiar with the local flora and fauna conducted qualitative visual searches for introduced species at each site, collecting algae and invertebrates that they either recognized as non-native species or did not recognize at all. The goal was to have at least one invertebrate expert and one phycologist conduct visual surveys at each intertidal site, and to dive at subtidal sites if possible. Due to budgetary and logistical constraints related to SCUBA diving, taxonomists were not actively sought out for all subtidal surveys. Full-time MLML staff assisted taxonomists, or conducted the visual searches when local taxonomists were unavailable. At intertidal habitats, taxonomists and/or MLML staff spent one low tide (approximately 3 hours) conducting each survey. At subtidal habitats, MLML staff (and sometimes taxonomists) conducted the swimming visual searches for approximately 30 minutes (or the duration of one SCUBA dive) and focused on depths of 30 feet or less. Since the priority of this project was to detect any NIS, as opposed to making a comparison between sites, there was no attempt to standardize search time, expertise, or search effort between sites. However, the total time searched and personnel involved were recorded for each site. During swimming surveys, unidentified species and small rocks or large algal blades that could potentially house a variety of species such as bryozoans were collected.

Specimens collected during the visual searches were sorted into rough groups and fixed in a manner that best preserved identification characteristics, as recommended by taxonomists for each phylum. A 10% formalin fixative was used with all specimens, with the exception of bryozoans, hydroids and echinoderms which were fixed in 70% isopropanol, and poriferans, *Crepidula* and *Mytilus* which were fixed directly in 85-95% ethanol. *Diadumene spp*. were divided and fixed in both formalin and ethanol when enough specimens were present. Ascidians were also relaxed in a mixture of freshwater and magnesium chloride, until unresponsive to touch, before being fixed in the formalin. Algal collections were pressed on herbarium paper. Pre-preservation photographs were taken of many organisms to record live color and appearances.

Infaunal Sample Collection

In order to target as many habitats as possible at each site, five quantitative benthic infaunal cores were collected from sandy beaches for community analyses from the high intertidal zone (targeting substrate underneath beach wrack and sampling through beach wrack whenever possible), 5 cores were collected from the low intertidal zone (targeting -1.0 ft tide height, below the sand crab zone), and 5 cores were collected in subtidal sand from a target depth of approximately 30 feet underwater. Cores were taken using large (15 cm diameter) coffee cans and lowering them to a maximum depth of 10 cm where possible, making sure to capture the surface layer. The multiple core samples collected resulted in a total surface area of $0.1m^2$ collected from each of the three zones. Subtidal infaunal samples were collected by SCUBA divers whenever possible, and at sites where no dives were conducted, subtidal cores were collected using a Young-modified Van Veen sediment grab ($0.05m^2$ per grab for a total area of $0.25m^2$ per subtidal site). The five cores in each zone were spread out over approximately 10-20 meters. Contents from high zone core samples were sieved through a 1.0 mm mesh screen, and contents from low zone and subtidal core samples were sieved through a 0.5 mm screen. Residues (e.g., organisms and remaining sediments) were rinsed into unique, pre-labeled storage containers, fixed in 10% formalin, and preserved in 80% ethanol.

Grain Size Sample Collection

At each of the 22 outer coast sites, three representative grain size samples were collected within the general area of the infaunal core sample collections (one from the intertidal high zone, one from the intertidal low zone, and one from the subtidal sandy area). For each grain size collection, a tube was lowered approximately 5-10 cm into the sand, and the entire sample placed in a bag and kept cool. Samples were then archived at MLML for further analysis if necessary.

Field Abundance Measurements of NIS Algae

Since marine algal species were not identified in the quadrat clearing samples, extra efforts were made to assess the abundance of *Sargassum muticum*, an introduced algal species found in rocky intertidal habitats at several of the survey sites. *S. muticum* generally grows in patches, and is often limited to tidepools. Whenever *S. muticum* was common within a sampling site (as per CDFG (2002): “a common species would be relatively easy to find, and often would occur in significant numbers”), MLML field samplers conducted a timed count of individual *S. muticum* plants over a known area of rocky intertidal reef. At each site, two samplers roamed and counted *S. muticum* plants for 15-20 minutes each, making sure to not count the same plant twice. The duration of the count depended on how widespread *S. muticum* was at a site, and count time was set to allow samplers to cover the entire area or the majority of the area where *S. muticum* was found. Latitude and longitude coordinates were recorded to mark the boundary of the area counted, and not all plants within the boundary were necessarily counted. Timed counts may be repeated during future surveys to crudely detect changes in the density or expansion of *S. muticum* plants in the areas sampled over time.

Documentation of Sample Sites

Latitude and longitude coordinates were documented for the upcoast and downcoast borders of the rocky intertidal area searched, upcoast and downcoast borders of sandy intertidal beaches sampled, and from the boat at subtidal sampling events. A crude map was drawn for each site and notes were taken on anything unique about the area searched, the geology of the intertidal bench, and the specific reason for choosing the sample area. Digital overview photos were also taken of the site.

Summary of Laboratory Processing Methods for Quantitative Samples

Preserved quadrat, holdfast and infaunal quantitative field samples were sent to MLML’s Benthic Laboratory for processing and sorting as described below and were then sent to taxonomists for identification and enumeration. Quantitative field samples were fixed in 10% buffered formalin in the field. Formaldehyde penetrates tissue at about 5 mm per day and, after a few days, acidity can begin breaking down small calcareous structures. Because almost all organisms were very small, complete penetration through all tissue was easily completed in 3-4 days and samples were transferred from formalin to a preserving solution of 70% isopropyl or 80 % ethyl alcohol. All quantitative samples were stained with rose Bengal, a vital stain that colors animal tissue red. The red color allows animals, particularly small ones, to be more easily recognized and separated from detritus and sediment during sorting. Staining was necessary because of the very large size of samples, great quantity of detritus, and great disparity in animal sizes.

Subsampling

Subsampling of each of the quantitative samples was accomplished by placing the entire sample contents into a large, flat photographic tray marked into 4 equal-sized quadrats for subsampling, a procedure modified from Harrington and Born (Lazorchak et al., 1999). The sample was gently agitated until equally distributed across the tray. Most of the alcohol was then drawn off the sample by suctioning with a turkey baster from the center of the tray until the sample was immobile within the tray. Animals that were drawn up with the alcohol were caught on a screen guard and returned to the center to the tray. When subsampling occurred, a flat plastic blade was used to draw the sample in from the sides of a randomly selected quadrat until the sample was concentrated into the corner of the selected quadrat, away from the other three quadrats. This isolated portion of the entire sample was the one-quarter quantitative subsample. Depending on the size of the sample, contents were subsampled to 1/2, 1/4, 1/8, and occasionally 1/16, 1/32, and 1/64. The volume of the subsampled portion ranged from 500ml to 1L. The fractional sample was then sorted by standard sorting procedure described below. The portion of the original sample that was not subsampled (i.e. fully sorted as described below) was redistributed in the tray and inspected with a magnifying glass or magnifying lamp. Any taxa that were not represented in the sorted fraction were removed for a qualitative subsample (called a “scan” sample) of the remaining sample. The remaining unsorted fractions were archived. A subsampling log was maintained, and entries were made for each sample, including those which were not subsampled. Some samples were not subsampled if the volume was small enough that the entire sample could be sorted.

Sorting

High-resolution dissecting microscopes (Wild, Nikon and Olympus) with high intensity (fiber optic) light sources were used to sort the sample materials. Samples were sorted into 1 dm or 2 dm shell vials with airtight plastic stoppers or Wheaton snap-cap vials, also with airtight lids. Some samples needed to be retained in quart or gallon plastic or glass jars. Labels were prepared with underwater paper (which is not affected by water or preservatives) and pencil (which does not break down, fade, or run as some ink does). The embossing affect of pencil is further assurance of permanence. Each label contained the unique sample identifier (IDORG), collection date, station code, sample type (sandy or rocky, intertidal or subtidal) and replicate. All samples were always maintained within secondary containers. This was a mandated human safety procedure, due to alcohol flammability, and also ensured greater protection for the samples in case of a spill.

Animals were sorted in water or alcohol with fine forceps from residue into appropriate size container, mostly 1 dm glass shell vials. They were separated into phylogenetic groups: Arthropoda, Cirripedia, Bryozoa, Cnidaria, Crustacea, Echinodermata, Gastropoda, Hydrozoa, Insecta, Kamptozoa, Mollusca, Mytilus, Nemertea, Oligochaeta, Ophiuroidea, Platyhelminthes, Polychaeta, Porifera, Sipuncula, Urochordata, and Other. Some duplication of taxa (Arthropoda and Crustacea, for example) allowed the sorters to place large numbers of a particular taxon into a separate container, to assist the taxonomists with sample handling. A label was placed into each vial and the animals stored in fresh alcohol. Exceptionally large or entangling organisms were separated into a large container. Each vial or jar was assigned a code called a subIDORG, which included the IDORG and a four character qualifier that designated whether the sample was quantitative or scan, the method of subsampling, and what the phylogenetic group was. If there were two containers for a particular taxon, the subIDORG was followed by a decimal and a number. For example, subIDORG 0050QX06.1 represents a sample from IDORG 0050, which is quantitative (Q), subsampled without density fractionating (X), contains crustaceans (06), and is one of multiple containers for that IDORG (.1). The subIDORG was written on the back of the pre-printed sample label in pencil, and if there was space, the phylogenetic group was also written.

Infaunal samples were processed similarly to epifaunal samples with the major exception that the whole sample was processed in most cases. The samples were swirled as above. The supernatant fraction was sorted and then the residue was sorted. Most sorted samples fit within 1 dm or 2 dm vials.

Laboratory QA/QC

Laboratory quality assurance/quality control (QA/QC) procedures have been described in Stephenson et al. (1994). The most pertinent procedures are summarized here along with applications specific to this project. The prime quality assurance rests with competent personnel. All workers on this project are associated with academic institutions, experienced laboratory and microscope workers, and familiar with sample management and care. In addition, all were trained on the job to refine their skills specifically to this project. A senior biologist was present and supervised sorting technicians.

Chain of custody was maintained in the sorting lab where samples were delivered and logged into the master ledger where each individual sample was recorded. Sample labels in the jars were verified and checked against the master ledger. Each sorter logged out the replicate to be sorted and recorded it in the master ledger with their initials and date opposite the sample replicate. Many samples were very large and often required several days to complete sorting of a given sample. When completed, samples were logged back into the master ledger and the number and taxa of each vial or jar was recorded. Weekly the senior sorter conducted a sample inventory to ensure that each sample was accounted for. The senior sorter maintained a database of sorted samples and an entry was made for each subIDORG which was used to generate a Chain of Custody (COC) to transfer sorted samples back to the personnel responsible for sending samples to taxonomists. As each batch of samples was transferred, two people checked the subIDORG of each vial or container against the COC. At the same time the COC was generated, the subsampling data were also entered into the same spreadsheet. Every time a batch of samples was transferred, electronic copies of the COC and subsampling data were sent to the database managers.

Following is a summary of laboratory QA/QC principles:

1. Adherence to Chain of Custody procedure with written documentation to sample condition, location, and status.
2. Instructions to sorters on project objectives, sample handling, sorting procedures, and taxonomic procedures.
3. Check points of sample fidelity to schedule of progress.
4. Instrument maintenance.
5. Proper supply availability.
6. Competent and experienced laboratory personnel.
7. Efficiency checks and verification of sample progress. Includes checks on sorting technique, efficiency, accuracy, productivity, taxonomic determination, and compliance with established protocols such as labeling, sample storage, supply use and equipment functioning.

The most vulnerable point in the sample processing was during sorting, when the sample was open and exposed. Samples were processed over safeguard trays, large photographic trays that could contain spills so contents of jars, dishes, and other containers subject to spilling were always protected by an underlying tray. Transfer of organisms to vials always took place over the trays. No spills occurred. All samples were stored in glass or plastic containers, grouped by station or taxon and placed within secondary containment vessels of plastic.

Summary of Specimen Identification

Specialized taxonomists received both qualitative (preserved according to taxonomic group in the field and sent directly to taxonomists) and quantitative (fixed in formalin in the field and sorted as per the above protocols) field samples for identification. Taxonomists were selected according to qualifications, experience and specialty. Appendix A lists taxonomists involved with identifying specimens for this study.

In a standardized Excel file provided by MLML, taxonomists were requested to provide a list of species identified from each sample, to count non-native species in the quadrat clearing, holdfast and infaunal samples, to maintain a list of all species reported for this survey, and to create vouchers of introduced, cryptogenic, and provisional species identified in the current survey. Instructions sent to taxonomists can be viewed in Appendix B. On the list of species they identify, taxonomists were asked to fill in details pertinent to each particular species, including but not limited to higher taxonomic classifications, taxonomic authority/date, primary identification source, and up-to-date assessments and information about each species' introduction status with regards to the boundaries of California (as per the terminology outlined below). Taxonomists were urged to identify specimens to the lowest taxonomic level possible in order to make status determinations; however, emphasis was placed on careful and accurate identification and taxonomists were encouraged to seek the help of other experts whenever necessary.

Summary of Grain Size Analysis

Grain size analyses were not conducted for the current survey. All grain size samples collected have been archived.

Summary of Sample Tracking Methods

A Chain of Custody (COC) form accompanied each batch of samples during transportation from MLML to any taxonomist or external source, as well as upon return to MLML. Upon receipt of a batch of samples, the recipient was required to check that the contents of the package matched the sample list on the COC, then sign one COC copy and send it back to MLML. A COC was also required when samples were returned to MLML, at which point MLML was responsible for double checking the contents against the list.

Summary of Data QA/QC Methods

Extensive measures were taken to assure the quality and accuracy of reported data in this survey. All data was scrutinized and made to undergo rigorous quality control checks, both manual and computer-based, before any analyses were performed.

Field Data
Datasheets from the field were hand-entered into an Access database form designed specifically with a similar layout as the field datasheets for easier transfer of data. To further reduce the risk of data entry error, whenever possible, data entry fields were designed as drop-down boxes to force the person entering the data to select from a set of choices rather than type them in each time, eliminating the possibility of typing errors. This included, but was not limited to, choices for location details, sample method and profile, sampling equipment used, GPS model and datum used, station name and project ID code. Further quality control measures included manual visual checks of the entered datasheet data. MS Access queries were designed to check for missing or inaccurate data. Latitudes and longitudes of all reported coordinates were also checked by being plotted onto a GIS program to allow for visual inspection.

Data Handling
Samples were mailed to taxonomists along with a data CD which included, among other files, a blank formatted datasheet and species list in Excel for taxonomists to fill out as they identified the samples. When sample identifications were completed, taxonomists emailed their completed datasheets back to MLML to be uploaded into the MS Access database. Before being uploaded, datasheets were manually checked and then re-checked by two different personnel for missing, inaccurate, or unclear data. Once questions were communicated to the appropriate taxonomist and resolved, the datasheet could begin the uploading process which involved a series of queries designed to identify missing or duplicate data. Once taxonomist data was uploaded into the MLML database, additional queries were run prior to data analysis to ensure that no errors were introduced during or after the uploading process. Again, these queries were designed to identify missing, inaccurate or duplicate data. Spreadsheets of missing data were generated from these queries and sent to the appropriate taxonomist to be completed (e.g. missing counts for non-native species, missing or conflicting introduction status assessments, missing authority and dates).

Summary of Voucher and Archiving Methods

Voucher Collection
Representative examples of introduced, cryptogenic, and provisional species have been vouchered by taxonomists during the identification process and will be stored in a collection at MLML. Arrangements are also currently being made for many of the non-native voucher specimens to be deposited and stored in California natural history museums. Taxonomists were also required to submit informal descriptions of unpublished provisional species reported in this survey to be stored in conjunction with the voucher collection. These voucher specimens will be made available to interested taxonomists for purposes of species verification or appropriate related research.

Archiving
All samples collected in the current survey have been archived, with the exception of native species identified from the qualitative visual searches and some taxa of interest that have been sent to natural history museums or herbariums. In addition, unsorted sample portions will be stored by CDFG. The storage location of all samples is recorded in the CANOD database so that samples and specimens may be relocated in the future.

RESULTS AND DISCUSSION

Terminology

Standardization of terms used in this study is crucial because many descriptors were encountered that describe species' biogeography as being either native, including pre-historical invasions (Carlton, 1996), introduced, invasive, or cryptogenic (Cohen and Carlton, 1995). Because most literature does not use a standard definition in describing the analogous terms "introduced", "exotic", and "non-indigenous" species, some assumptions must be made. With one exception, this report used the definition of Boudouresque and Verlaque (2002), as they categorize an introduced species with these four succinct points:

> "1) It colonizes a new area where it was not previously.
> 2) The extension of range is linked, directly or indirectly, to human activity.
> 3) There is a geographic discontinuity between native area and new area (remote dispersal).
> 4) Finally, new generations of the non-native species are born in situ without human assistance, thus constituting self-sustaining populations: the species is established."

The only exception to the above is that without more long term monitoring efforts at these survey sites, the sampling protocol used for this survey does not gather sufficient data to determine whether species identified in this survey have established populations at the locations sampled, as explained number 4 above. Therefore, we report collections of species considered introduced and do not attempt to evaluate whether the population is self-sustaining.

In order to address the stipulations of the legislation, and for the purposes of this report, any species that is not considered native to California waters and whose native range is known to be outside of the California borders is considered an introduced species. In some cases, this includes species whose native range is elsewhere along the northeast Pacific coastline, not including California. These criteria may result in a non-intuitive definition of "introduction" based on geopolitical boundaries rather than biological range or habitats, which can add difficulty to the task of assigning an accurate introduction status to some species. However, the inclusion of the California borders in the criteria for determining the introduction status of a species is necessary to meet the legislative intent of the Marine Invasive Species Act of 2003 in collecting baseline information on the presence, distribution and abundance of NIS in California waters. As this program has evolved over the past five years, and experts in the field of marine invasions and/or taxonomy have provided compelling input regarding the natural history of these more difficult to classify species, some cases have come up where the decision was made to classify a species as native even if it had not previously been reported from California. In each of these cases, the species in question had been considered native to the Northeast Pacific and was identified in previously under sampled habitat in California, so California was included in the presumable native range of that species. In addition, the classification of "introduced" species used in this study will refer to both innocuous and invasive introductions without specificity to either.

A cryptogenic species is defined as "a species that is not demonstrably native or introduced" (Carlton, 1996). Cryptogenic is used as a catchall category for species with insufficiently documented life histories or native ranges to allow characterization as either native or introduced. In addition, when status discrepancies are found in the literature, that species is labeled here as cryptogenic until the discrepancy is resolved. As has been suggested by Carlton (1996), cryptogenic species are quite common, but have been underestimated to such an extent as to misshape our understanding of the true effects that invasions have on the eco-system.

Unless compelling evidence was present that a species is either native or introduced to California, it was designated as cryptogenic. For instance, species were classified as cryptogenic if records of collections from outside of California were found in the literature and native ranges were unclear. Many of the species listed as cryptogenic may be native to the California coastline but have gone previously undescribed. Occasionally, evidence suggests that a cryptogenic species is either more likely to be native or more likely to be introduced, even though not enough solid evidence is present to make the full determination of introduced or native. These cryptogenic species have been flagged in the MS Access database, and may be referred to in this report, as “Likely Native” or “Likely Introduced” accordingly.

After careful consideration, the above terms “introduced”, “cryptogenic” or “native” were assigned to each species identified in the current survey, based on recommendations from taxonomists and all available documentation. The native designation is surprisingly troublesome to use because species that have been historically reported as native in southern California may not have been historically native in northern California, and vice versa. In the current survey, native California species were identified in areas where they have not been previously reported. For example, the native gastropod *Eulithidium comptum* is reported by McLean (1978) as being not found North of Ventura, but was identified in the current survey from rocky intertidal habitat at Purisima Point, which is north of Point Conception by approximately 20 miles. It remains undetermined whether the new identification is a result of this survey sampling previously unsampled habitats, whether it is a natural range extension, or whether it is from an anthropogenic introduction. Considering the physical impediments to major natural range expansions in California, it is possible that some of these new identifications are a result of recent intrastate vessel activity, but proof is lacking. MLML previously listed these species as “Native X” (CDFG, 2002), but the current survey and the CANOD database no longer use that term. Rather, these species are reported here as native, and to note this disparity, they have been flagged within the database as new records to a location or depth range to note that they are native to California, but that they have now been identified in areas where not previously reported. The body of this report focuses only on introduced and cryptogenic species, and does not focus on true native species within their historic range. These assigned terms of introduced and cryptogenic should not be considered as static, but instead should be modified as research continues and taxonomy, native ranges and vectors of introduction are better understood.

Specimens that could not be identified beyond the family, class, order, or genus level (e.g. *Ophiopholis sp*) could not be confidently classified as introduced, cryptogenic or native, and were assigned an introduction status of ‘unresolved’. Likewise, most specimens from the current survey which have been given temporary provisional names were assigned an introduction status of unresolved. Specimens given the introduction status of unresolved will require additional taxonomic resolution before their true status can be confidently assigned. Specimens that were identified to the level of species complex in this survey were assigned introduction statuses according to the present understanding of the entire species complex. Due to the design of the

CANOD database, and the long term goals for CANOD, it is not possible to record different introduction statuses (such as native and introduced) by location for the same species. Thus, the introduction status term, "unresolved complex," was used in order to flag some of the situations where indistinguishable members of the species complex would be considered native if collected from some locations or habitats in California (e.g. the outer coast) and introduced from other locations or habitats in California (e.g. bays and harbors). This report gives further explanations for several of the taxa given the introduction status of unresolved complex to reflect current understanding for each of these. It is, however, important to include these specimens in our reporting because they may include new species or represent significant range extensions.

An additional term used to describe some biota in the literature is "invasive". An invasive species is generally thought of as any introduced species that has caused a disruption to the ecosystem resulting in damage either environmentally or economically. Literature that uses the word "invasive" as a descriptor may refer to species with detrimental economic impacts on native populations, while others use the term to simply indicate weedy species that may or may not impact native communities. Our review found that the use of the term was so subjective in the literature that consistent application of the term was impossible. To avoid the mixing of poorly clarified uses of the subsequently ambiguous term "invasive", it was not used in this report.

Summary of Introduction Status Determination Updates

One on-going effort of this project is to update introduction status determinations as new information becomes available for species that have been identified during the previous surveys and listed in the CANOD database. Outside reviews of the California NIS listed in the CANOD database, as well as discussions with taxonomists sparked by the variety of perspectives and ideas regarding taxonomy and natural history of these species, have recently led to several species names and/or introduction status revisions in the CANOD database. Here, we report the most recent updates that have been made to the CANOD database regarding species identifications and/or introduction statuses.

Updates to 2004 Outer Coast Survey Results

Appendix C lists all of the identification and introduction status changes that have been made to species originally or currently listed as introduced from the 2004 MLML/CDFG survey for NIS on California's outer coast (Maloney et al., 2006). Twenty one species originally listed as introduced in the 2004 outer coast survey results have had status changes, and thus only 5 of the original 26 remain currently listed as introduced in the CANOD database. In addition, one species that was identified in the 2004 survey and originally listed as cryptogenic, *Branchiosyllis exilis*, has been relisted as introduced, bringing the total number of species identified in the 2004 survey and currently listed as introduced to 6 species.

Some of the changes to the original 2004 survey classifications were made because the identification of the specimen itself has been re-evaluated and changed, while other changes were due to a re-evaluation and reclassification of the introduction status. Of the status changes specific to the outer coast 2004 survey shown in Appendix C, 10 were changes to the identification of the specimen, and under the new identification, the status was not considered introduced. These specimen identifications were changed either because the specimens were reexamined and determined to be incorrectly identified originally, or because taxonomists and other experts reported that those species belong to a complex of species that cannot be accurately distinguished (in which case the identification was changed to the species complex level rather than a species level identification, and listed with a status of unresolved complex). Further research and personal communications helped to determine that the remaining 12 species identifications were correct, but due to expert advice and/or further research and improved understanding of each of these species, their classification as introduced or cryptogenic was corrected. In some of these cases, further research or genetics studies are needed to confidently determine native versus introduced status, while in other cases, the first report of a species for California in the 2004 surveys was determined to be a possible range extension rather than an introduction. Information shown in Appendix C may facilitate understanding of some of the differences between the 2004 outer coast survey results originally reported and the results from the current outer coast survey.

Updates to General CANOD Data

Table 1 lists the general status updates that have been made in the CANOD database since the most recent MLML/CDFG survey report on California Bays and Harbors (Maloney et al., 2008). Sixteen species have received a status change since the previous MLML/CDFG survey report. None of those revisions resulted in a status change to introduced. A total of 6 of the revisions resulted in a status change from native to cryptogenic, 2 resulted in a change from introduced to cryptogenic, and 1 from unresolved to cryptogenic. Two of the revisions resulted in a status change from cryptogenic to native, while 5 of the revisions resulted in a change from another status to a status of unresolved complex. Also of the status revisions, 5 were to species from phylum Annelida, 5 were from phylum Arthropoda, 3 were from phylum Ectoprocta, 2 were from phylum Nemertea, and 1 change was to a species from phylum Chordata.

Quality control and assurance efforts are made prior to reporting of survey results, and results reported here are accurate to the best of our knowledge and ability at this point in time. However, due to the time constraints of this project, not all of the status determinations made by taxonomists have been verified or checked against other sources for native and cryptogenic species new to the database as of the current survey. As new research is published and techniques such as molecular analysis provide more accurate methods for refining taxonomy and the native ranges of species, this new information will be incorporated in the CANOD database, and some species introduction statuses can be expected to change in the future. Therefore, an ongoing effort of constantly refining the introduction status information stored in the CANOD database is anticipated.

Table 1. Species names and introduction status updates made to CANOD database since the most recent MLML/CDFG survey report.

Species Name	Previous Introduction Status	Updated Introduction Status	Status Determination Sources
Phylum Annelida			
Aphelochaeta glandaria complex	Native	Unresolved Complex	L. Harris pers. comm. Feb. 11, 2008
**Chone sp.* SD1 (Name updated to *Chone eiffelturris*)	Unresolved	Cryptogenic	L. Harris pers. comm. Jan. 2008; Tovar-Hernandez, 2007
Limnodriloides monothecus	Native	Cryptogenic	C. Erseus pers. comm. Jun. 12, 2008; Blake, Hilbig and Scott, 1997
Lumbricillus lineatus	Native	Cryptogenic, Likely Introduced	C. Erseus pers. comm. Jun. 12, 2008
Tubificoides parapectinatus	Native	Cryptogenic, Likely Introduced	C. Erseus pers. comm. Jun. 12, 2008
Phylum Arthropoda			
**Caprella scaura* (Identifications changed to *Caprella scaura* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. May 12, 2008; Krapp et al., 2006
**Cerapus tubularis* (Identifications changed to *Cerapus tubularis* complex)	Native	Cryptogenic, Likely Native	D. Cadien pers. comm. Apr. 21, 2008; SCAMIT, 2008 (in press)
Ericthonius rubricornis	Introduced	Cryptogenic	P. Fofonoff pers. comm. Jan. 11, 2008; Light and Smith, 2007
Oithona similis	Cryptogenic	Cryptogenic, Likely Native	K. Choi pers. comm. May 23, 2008
**Stenothoe valida* (Identifications changed to *Stenothoe valida* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. May 15, 2008
Phylum Chordata			
Diplosoma listerianum	Introduced	Cryptogenic	G. Lambert pers. comm. May 21, 2008
Phylum Ectoprocta			
**Bugula neritina* (Identifications changed to *Bugula neritina* complex)	Cryptogenic, Likely Introduced	Unresolved Complex	P. Fofonoff pers. comm. Jan. 11, 2008; Davidson and Haygood, 1999; McGovern and Hellberg, 2003; Mackie et al., 2006
**Cryptosula pallasiana* (Identifications changed to *Cryptosula pallasiana* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. May 13, 2008
**Flustrellidra corniculata* (Name updated to *Flustrellidra spinifera*)	Cryptogenic, Likely Introduced	Native	J. Carlton pers. comm. May 23, 2008
Phylum Nemertea			
Emplectonema gracile	Native	Cryptogenic	J. Ljubenkov pers. comm. May 27, 2008; Crandall and Norenburg, 2001
Tetrastemma nigrifrons	Native	Cryptogenic, Likely Native	J. Ljubenkov pers. comm. May 27, 2008; Crandall and Norenburg, 2001; Light and Smith, 2007

* Status change was the result of a species name change or change of identification

Summary of Field Surveys
A total of 156 epifaunal samples (hard substrate scrapings) were collected from the outer coast between March 2007 and March 2008. In addition, a total of 172 qualitative samples were collected during the visual searches of the survey sites. Three hundred fifteen infaunal samples (220 intertidal cores and 95 subtidal cores) were collected from the outer coast, as well as 63 grain size samples.

Due to weather conditions, subtidal habitats at the two northernmost survey sites, Cape Mendocino and Point Saint George, were not surveyed for the current survey. Intertidal habitats at those two sites were surveyed and those results are included in the data below. Also, for safety reasons, subtidal rocky and sandy habitats at Point Reyes were not sampled as planned; instead, the rocky subtidal samples from Point Reyes included 4 holdfasts instead of 3 clearings and 1 holdfast, and the subtidal sandy cores were collected in approximately the same tidal elevation as the typical low intertidal sandy core collections for the other sites in the current survey. Results from all of the Point Reyes habitats surveyed are included in the current report. Also, at the Pin Rock sample site on Catalina Island, sandy intertidal habitat was not found at the outer coast location. Intertidal sandy cores were collected from within Catalina Harbor, which is near the outer coast site of Pin Rock, but is tucked into the harbor enough to be considered more of a bay/harbor habitat than outer coast. Therefore, data from the 'Pin Rock' sandy intertidal samples is not included in the summarized data, tables and figures below.

All of the epifaunal, qualitative and infaunal samples collected were sent to taxonomists for identifications of the specimens. Station (also known as 'site' throughout the report) position and sampling information for each location are given in Appendix D.

Summary of Taxonomic Identifications
From the samples collected during the current field surveys, a total of 952 species were identified, of which 10 were classified as introduced, 140 were classified as cryptogenic and 802 were classified as native to California. The samples collected during the field surveys also produced 467 different taxa which were not identified to species level and were classified as unresolved for this report. In addition, a total of 7 taxa identified to the species complex level were classified with an introduction status of unresolved complex, and may or may not be introduced to California's outer coast as explained above. All 10 of the introduced species identified in the current survey have previously been reported from California. The CANOD database, available through CDFG/OSPR, gives detailed information for all samples, sampling information and all species identified, including native species.

Table 2 lists each outer coast survey site, and the number and percentage of taxa identified within each introduction status classification. Introduced species across the state ranged from a low of 0 species at 12 of the survey sites, to a high of 4 species at Pin Rock. Introduced species represented 0% to 1.3% of the total taxa collected from each site along the coastline. Cryptogenic species ranged from 11 to 56 species collected, representing 9.7% to 15.1% of the total taxa at each site, while native species ranged from 40 to 201 species collected per site, and represented 46.6% to 59.9% of total taxa collected at each site.

Table 2. Number and percentage of total taxa identified for each classification for each site.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	171	-	21 (12.3%)	90 (52.6%)	-	60 (35.1%)
Cape Mendocino	80	-	11 (13.8%)	40 (50.0%)	-	29 (36.3%)
Shelter Cove	252	1 (0.4%)	30 (11.9%)	143 (56.7%)	2 (0.8%)	76 (30.2%)
Point Arena	231	-	28 (12.1%)	132 (57.1%)	2 (0.9%)	69 (29.9%)
Bodega	338	-	37 (10.9%)	173 (51.2%)	1 (0.3%)	127 (37.6%)
Point Reyes	189	-	27 (14.3%)	88 (46.6%)	2 (1.1%)	72 (38.1%)
Fitzgerald	211	-	29 (13.7%)	112 (53.1%)	1 (0.5%)	69 (32.7%)
Pigeon Point	150	-	18 (12.0%)	72 (48.0%)	1 (0.7%)	59 (39.3%)
Ano Nuevo	171	-	22 (12.9%)	101 (59.1%)	-	48 (28.1%)
Point Sur	219	-	24 (11.0%)	130 (59.4%)	1 (0.5%)	64 (29.2%)
Point Sierra Nevada	344	-	35 (10.2%)	193 (56.1%)	1 (0.3%)	115 (33.4%)
Diablo Canyon	372	1 (0.3%)	56 (15.1%)	186 (50.0%)	3 (0.8%)	126 (33.9%)
Purisima Point	223	-	26 (11.7%)	121 (54.3%)	-	76 (34.1%)
Point Conception	299	-	37 (12.4%)	179 (59.9%)	2 (0.7%)	81 (27.1%)
Arroyo Hondo	335	1 (0.3%)	40 (11.9%)	191 (57.0%)	3 (0.9%)	100 (29.9%)
Carpinteria	362	1 (0.3%)	49 (13.5%)	201 (55.5%)	3 (0.8%)	108 (29.8%)
Point Dume	315	1 (0.3%)	38 (12.1%)	176 (55.9%)	4 (1.3%)	96 (30.5%)
Point Fermin	358	3 (0.8%)	41 (11.5%)	193 (53.9%)	1 (0.3%)	120 (33.5%)
Dana Point	334	3 (0.9%)	41 (12.3%)	193 (57.8%)	2 (0.6%)	95 (28.4%)
Pin Rock	309	4 (1.3%)	30 (9.7%)	178 (57.6%)	2 (0.6%)	95 (30.7%)
Point La Jolla	313	3 (1.0%)	42 (13.4%)	170 (54.3%)	1 (0.3%)	97 (31.0%)
Point Loma	230	3 (1.3%)	27 (11.7%)	133 (57.8%)	-	67 (29.1%)

Dashes indicate that none of the taxa identified in the current survey were classified with given status.

On a state-wide level, introduced species were identified from less than half of the sites surveyed, and when averaged across all sites, introduced species represented less than 0.1% of the total taxa collected from each site. At least one introduced species was identified from each site surveyed that was south of Point Conception (8 sites), whereas introduced species were only identified from 2 of the 14 sites north of and including Point Conception (Figure 5). At all sites, more than 46% of taxa collected and resolved to species-level identifications were native.

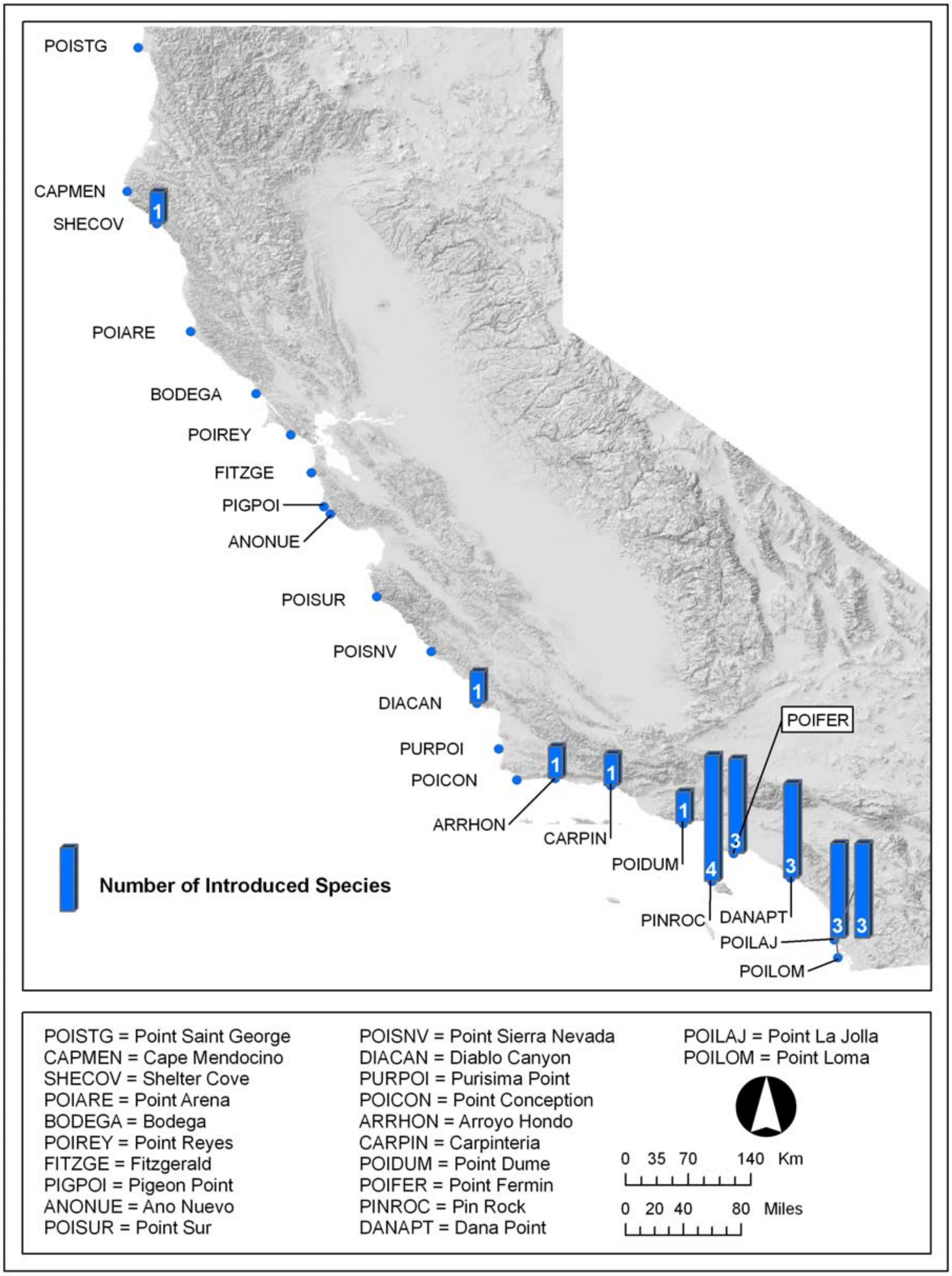


Figure 5. Number of introduced species identified from each of the 22 survey sites.

Four distinct habitats were sampled in the current survey, and the percentage of total taxa for each introduction status classification was quite similar between the four habitats (Table 3). The percentage of total taxa classified as introduced was low for all habitats, at less than 1%. Cryptogenic and unresolved complex percentages were also relatively low between habitats, whereas over 50% of the taxa identified from each habitat type were classified as native, and over 30% of the taxa identified from each habitat were unresolved. Appendix E depicts the number and percentages of taxa identified in each classification for the four habitat types sampled at each site.

Table 3. Number of species and percentage of total taxa within each classification for each habitat type sampled.

Habitat Type	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Rocky Intertidal	**729**	4 (0.5%)	64 (8.8%)	417 (57.2%)	4 (0.5%)	240 (32.9%)
Rocky Subtidal	**890**	6 (0.7%)	98 (11.0%)	490 (55.1%)	6 (0.7%)	290 (32.6%)
Sandy Intertidal	**187**	1 (0.5%)	21 (11.2%)	101 (54.0%)	2 (1.1%)	62 (33.2%)
Sandy Subtidal	**465**	-	63 (13.5%)	236 (50.8%)	2 (0.4%)	164 (35.3%)

Dash indicates that none of the taxa identified in the current survey were classified with given status.

When comparing the number of introduced species identified from each habitat, differences become more apparent. Among the four habitat types sampled, the highest number of introduced species were found in the rocky subtidal (6 species), followed by rocky intertidal (4 species). In contrast, only one introduced species was identified from sandy intertidal, and none from sandy subtidal habitat. Rocky habitats (including intertidal and subtidal) also produced much higher numbers of total taxa identified compared to sandy habitats, indicating that the high energy, low solid substrate conditions of average outer coast sandy beaches does not support the species richness supported by the rocky habitat surveyed. Physical conditions of the high energy outer coast beaches, including beach slope and large sand particle/grain size are likely a contributing factor to the relatively low numbers of total taxa identified in sandy habitats (McLachlan and Dorvlo, 2005). Based on grain size analyses conducted on samples collected in 2004, the survey sites averaged over 70% medium to very coarse sand. Additionally, greater effort was put forth in qualitatively sampling rocky habitats than in sandy habitats. However, even though the numbers of total taxa (and all introduction status categories) are less for sandy habitat than for rocky, sandy habitat still produced hundreds of taxa in the current survey, and only one introduced species.

The introduced species identified from rocky intertidal habitat in the current survey include: *Caulacanthus ustulatus*, *Lomentaria hakodatensis*, *Musculista senhousia*, and *Sargassum muticum*. *Niambia capensis* is the only introduced species identified in sandy intertidal. The introduced species identified from rocky subtidal habitat in the current survey include: *Botryllus schlosseri*, *Branchiosyllis exilis*, *Hydroides elegans*, *Monocorophium insidiosum*, *Sargassum filicinum* and *S. muticum*. Note that the only introduced species identified from more than one of the habitats sampled was *S. muticum*; all other species identifications were unique to one habitat type.

Table 4 details the number and percentage of species within each classification for the major phyla identified in the current survey. Introduced species were identified from 6 different phyla. Of the 10 introduced species identified in the current survey, 2 were annelids, 2 were arthropods, 1 was a chordate, 1 was a mollusc, and 4 were marine algae. Percents are not shown for marine algae (Chlorophyta, Heterokontophyta and Rhodophyta) because native species were rarely collected or recorded as per the sampling protocol, and so are underrepresented in the dataset.

Table 4. Number of species and percentage of total taxa of each classification for each phylum.

Phylum	**Total Taxa**	**Introduced**	**Cryptogenic**	**Native**	**Unresolved Complex**	**Unresolved**
Annelida	**397**	2 (0.5%)	68 (17.1%)	136 (34.3%)	1 (0.3%)	190 (47.9%)
Arthropoda	**471**	2 (0.5%)	46 (9.8%)	326 (69.2%)	3 (0.6%)	94 (19.9%)
Chlorophyta	**2**	-	-	2	-	-
Chordata	**38**	1 (2.6%)	2 (5.3%)	27 (71.1%)	-	8 (21.1%)
Cnidaria	**46**	-	2 (4.3%)	25 (54.3%)	-	19 (41.3%)
Echinodermata	**32**	-	3 (9.4%)	12 (37.5%)	-	17 (53.1%)
Ectoprocta	**40**	-	2 (5.0%)	33 (82.5%)	3 (7.5%)	2 (5.0%)
Entoprocta	**5**	-	-	3 (60.0%)	-	2 (40.0%)
Heterokontophyta	**4**	2	-	2	-	-
Mollusca	**262**	1 (0.4%)	1 (0.4%)	170 (64.9%)	-	90 (34.4%)
Nemata	**1**	-	-		-	1 (100.0%)
Nemertea	**46**	-	10 (21.7%)	20 (43.5%)	-	16 (34.8%)
Phoronida	**1**	-	-	-	-	1 (100.0%)
Platyhelminthes	**25**	-	1 (4.0%)	12 (48.0%)	-	12 (48.0%)
Porifera	**41**	-	3 (7.3%)	26 (63.4%)	-	12 (29.3%)
Rhodophyta	**9**	2	-	6	-	1
Sipuncula	**6**	-	2 (33.3%)	2 (33.3%)	-	2 (33.3%)

Dashes indicate that none of the taxa identified in the current survey were classified with given status.

Unresolved taxa numbered from 0 to 190 unique taxa collected within each phylum, and accounted for 0% to 100% of the total taxa collected within each phylum in the current survey. Specimens were classified as unresolved as a result of insufficient taxonomic resolution at the species level, which may have been due to a variety of reasons including damaged or juvenile specimens, undescribed species, and problems in the taxonomic literature for those taxa. An average of 34% of the total taxa collected within each phylum were classified as unresolved; this large percent of unresolved specimens points to the difficulty facing scientists when evaluating introductions throughout the world and the need for continued basic research on resolving taxonomy of marine species.

In order to determine the strongest factors causing the high number of unresolved taxa in this type of survey, MLML asked taxonomists to record the reason for each identification that is not resolved to species level. Table 5 lists the possible reasons for unresolved identifications and the number of specimens counted that were not identified to species level for each reason. Results from all habitat types sampled in the current survey are combined for table 5. The total number of specimens counted that were not resolved to species level identifications in the current survey was 158,974, while over 750,000 specimens in the current survey were identified to the species level. It should be noted that taxonomists were not required to count specimens classified as native (however most taxonomists counted everything out of habit), nor were specimens counted when identified from the qualitative search collections, so the above counts do not reflect exact numbers of specimens collected in the survey. However, the numbers and percentages shown in table 5 are still useful both for comparing the different reasons for unresolved identifications and for comparing the number of unresolved specimens versus specimens identified to species level.

Of the unresolved identifications for the current survey, approximately 65% were due to juvenile or non-reproductive specimens, approximately 4% were due to damaged specimens (presumably damaged during the collection or sorting process), approximately 15% were due to undescribed or unrecognized species, approximately 13% were due to other reasons which were not specified by the taxonomists, and approximately 3% were due to a combination of more than one of the above reasons.

Table 5. Number and percentage of total recorded unresolved identifications for each unresolved taxa category.

Unresolved Taxa Category	Unresolved
Juvenile or Non-reproductive Specimen	103,194 (65%)
Damaged Specimen	6436 (4%)
Undescribed or Unrecognized Species	23,484 (15%)
Other	20,982 (13%)
Combination of two or more of the above categories	4878 (3%)

*All counts are normalized from the subsample size to the actual area sampled and may not represent actual counts.

An additional 577 specimens in the current survey were not resolved to species level, and are not shown in table 5. They all fall into unresolved species complexes, and are given a status of “unresolved complex” which was explained in the above Terminology section of the report. The 577 specimens represent 7 different species complexes.

Table 6 depicts the number and percentage of unresolved identifications shown above by phylum. The majority of unresolved identifications came from molluscs (37%), annelids (34%), and arthropods (23%), which together comprised 94% of the recorded unresolved identifications from the current survey. For both molluscs and arthropods, the leading reason for the unresolved identifications was specimens that were juvenile or non-reproductive. In contrast, three reasons played fairly significant roles for the annelids: juvenile/non-reproductive specimens, undescribed species, and ‘other’ reasons not specified by the taxonomist. CDFG/OSPR and MLML related results similar to these from previous surveys to taxonomists, and asked for input as to whether these numbers of unresolved taxa seemed too high, as well as for ideas on how these numbers may be lowered in future surveys. The general consensus among the taxonomists was that these numbers are to be expected in any survey of this nature, and that the survey is being conducted during the best season for most phyla as far as reducing the number of juveniles (summer/fall). However, these data may still be useful when considering alternative sampling seasons or procedures.

Table 6. Number and percentage of total unresolved identifications for each phylum and unresolved taxa category.

Phylum	Total Number of Unresolved Identifications	Juvenile/Non-reproductive	Damaged	Undescribed	Other	Combination of Two or More Categories
Annelida	**54,898**	14,361 (26.2%)	3001 (5.5%)	13,676 (24.9%)	20,643 (37.6%)	3217 (5.9%)
Arthropoda	**37,451**	31,524 (84.2%)	1255 (3.4%)	4573 (12.2%)	67 (0.2%)	32 (0.1%)
Cnidaria	**1613**	0	2 (0.1%)	104 (6.4%)	0	1507 (93.4%)
Echinodermata	**2854**	2783 (97.5%)	29 (1.0%)	0	0	42 (1.5%)
Mollusca	**58,892**	51,046 (86.7%)	1995 (3.4%)	5515 (9.4%)	272 (0.5%)	64 (0.1%)
Nemata	**64**	64 (100%)	0	0	0	0
Nemertea	**2504**	2424 (96.8%)	24 (1.0%)	56 (2.2%)	0	0
Platyhelminthes	**981**	794 (80.9%)	130 (13.3%)	57 (5.8%)	0	0
Sipuncula	**244**	164 (67.2%)	0	64 (26.2%)	0	16 (6.6%)

*All counts are normalized from the subsample size to the actual area sampled and may not represent actual counts.

It should be noted that since Chordata (tunicates), Ectoprocta (bryozoans), Entoprocta (kamptozoans) and Porifera (sponges) include colonial organisms, counts of individual specimens for those phyla were not made for the survey, and those phyla are not represented in table 6. Algae are also not counted for this survey, so are not represented in table 6. Of the phyla not represented in table 6, the leading reasons for being unresolved are shown as follows: Chordata = Juvenile/ Non reproductive, Ectoprocta = Juvenile/ Non-reproductive, Entoprocta = Damaged, Porifera = Other.

Table 7 shows the survey sites, ordered from north to south, where each of the 11 introduced species identified in the current survey were found. Presence/absence data is listed for colonial organisms and for identifications made from qualitative visual searches of the site, where individual organisms were not counted. Numbers of individual organisms are shown for identifications made from quantitative samples which were counted. The area subsampled among sites has not been standardized, so counts of individuals should be used cautiously in a relative sense rather than an accurate, quantitative sense. If more accurate density estimates are needed, additional data analysis should be performed. Appendix F lists the taxa identified in the current survey that have been classified with an introduction status of cryptogenic or unresolved complex, and includes taxa classified as unresolved but noted to be likely native or likely introduced. Appendix F also shows the number of survey sites where each species was observed. Of the 146 cryptogenic, unresolved or unresolved complex taxa identified in the current survey, 6 have been considered to be “likely introduced”, 2 have been considered to be “likely cryptogenic” (applies to unresolved classifications), and 43 have been considered “likely native”.

Table 7. Number of individuals and presence/absence data for introduced species observed at each site in the current survey.

Species Name	Total Sites Observed	Maximum Number of Individuals Observed	Point Saint George	Cape Mendocino	Shelter Cove	Point Arena	Bodega	Point Reyes	Fitzgerald	Pigeon Point	Ano Nuevo	Point Sur	Point Sierra Nevada	Diablo Canyon	Purisima Point	Point Conception	Arroyo Hondo	Carpinteria	Point Dume	Point Fermin	Dana Point	Pin Rock	Point La Jolla	Point Loma
Phylum Annelida																								
Branchiosyllis exilis	**1**	**1**																				1		
Hydroides elegans	**1**	**16**															16							
Phylum Arthropoda																								
Monocorophium insidiosum	**2**	**80**			80															16				
Niambia capensis	**1**	**1**																1						
Phylum Chordata																								
Botryllus schlosseri	**1**	**4**																					4	
Phylum Mollusca																								
Musculista senhousia	**1**	**8**																						8
Phylum Heterokontophyta																								
Sargassum filicinum	**1**	**NA**																				P		
Sargassum muticum	**7**	**NA**												P					P	P	P	P	P	P
Phylum Rhodophyta																								
Caulacanthus ustulatus	**5**	**NA**																		P	P	P	P	P
Lomentaria hakodatensis	**1**	**NA**																			P			

*All counts are normalized from the subsample size from multiple habitats to the actual area sampled and may not represent actual individual counts made by taxonomists.
**Blank cells indicate that the species was not detected using the protocols of the current survey at the given site.

Summary of Annelid Taxonomy (Segmented Worms)


A


B

Branchyosyllis exilis (A) and *Hydroides elegans* (B), photos used with permission by Leslie Harris

A total of 397 different taxa from the phylum Annelida were identified in the current survey. Of those, 2 were classified as introduced, 68 were classified as cryptogenic, 136 were classified as native, one was classified as unresolved complex, and 190 were unresolved taxa (Table 8).

The two introduced annelid species identified in the current survey are both polychaetes (pictured above): *Branchiosyllis exilis* was identified from rocky subtidal habitat at Pin Rock (Catalina Island), and *Hydroides elegans* was identified from rocky subtidal habitat at Arroyo Hondo. Introduced annelids ranged from 0 to 1 species per site, and represented 0% to 1.4% of the total annelid taxa from each site. Cryptogenic annelids per site ranged from 7 to 29 species, representing 14% to 30.4% of total infaunal annelid taxa per site. Native species represented 21.7% to 41.7% of the annelid taxa identified from each site.

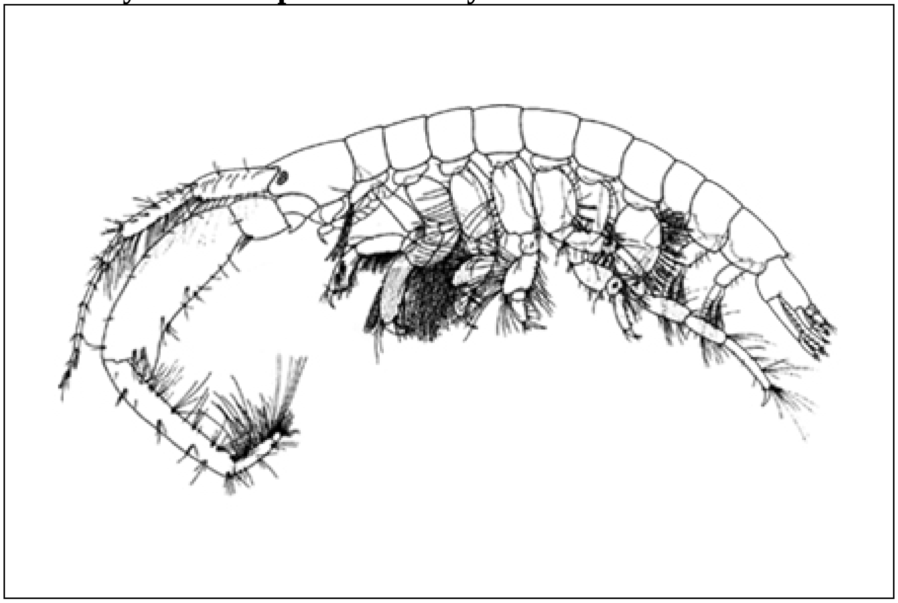
A large proportion of the annelid taxa (190 taxa out of 397 total unique taxa) collected in the current survey was not identified to the species level and thus was classified as unresolved. Unresolved taxa represented 33.9% to 53.1% of the total annelid taxa per site. A large number of identifications with provisional species names contributed to the high percentage of 'unresolved' annelids, which is consistent with findings from other similar surveys. In addition, one annelid taxa collected in the current survey was classified as unresolved complex, *Harmothoe imbricata* complex, and was found at 7 sites in the current survey, and it remains unclear whether the specimen here is native to California.

Table 8. Number of species and percentage of total annelid taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**49**	-	7 (14.3%)	19 (38.8%)	-	23 (46.9%)
Cape Mendocino	**23**	-	7 (30.4%)	5 (21.7%)	-	11 (47.8%)
Shelter Cove	**72**	-	13 (18.1%)	30 (41.7%)	1 (1.4%)	28 (38.9%)
Point Arena	**66**	-	10 (15.2%)	24 (36.4%)	1 (1.5%)	31 (47.0%)
Bodega	**98**	-	14 (14.3%)	31 (31.6%)	1 (1.0%)	52 (53.1%)
Point Reyes	**63**	-	15 (23.8%)	17 (27.0%)	1 (1.6%)	30 (47.6%)
Fitzgerald	**88**	-	20 (22.7%)	31 (35.2%)	-	37 (42.0%)
Pigeon Point	**53**	-	13 (24.5%)	19 (35.8%)	-	21 (39.6%)
Ano Nuevo	**59**	-	15 (25.4%)	24 (40.7%)	-	20 (33.9%)
Point Sur	**80**	-	15 (18.8%)	32 (40.0%)	-	33 (41.3%)
Point Sierra Nevada	**124**	-	18 (14.5%)	50 (40.3%)	1 (0.8%)	55 (44.4%)
Diablo Canyon	**146**	-	29 (19.9%)	50 (34.2%)	1 (0.7%)	66 (45.2%)
Purisima Point	**67**	-	13 (19.4%)	25 (37.3%)	-	29 (43.3%)
Point Conception	**82**	-	19 (23.2%)	33 (40.2%)	-	30 (36.6%)
Arroyo Hondo	**111**	1 (0.9%)	22 (19.8%)	39 (35.1%)	1 (0.9%)	48 (43.2%)
Carpinteria	**111**	-	26 (23.4%)	35 (31.5%)	-	50 (45.0%)
Point Dume	**95**	-	19 (20.0%)	33 (34.7%)	-	43 (45.3%)
Point Fermin	**118**	-	21 (17.8%)	43 (36.4%)	-	54 (45.8%)
Dana Point	**75**	-	18 (24.0%)	22 (29.3%)	-	35 (46.7%)
Pin Rock	**69**	1 (1.4%)	11 (15.9%)	24 (34.8%)	-	33 (47.8%)
Point La Jolla	**84**	-	17 (20.2%)	27 (32.1%)	-	40 (47.6%)
Point Loma	**57**	-	8 (14.0%)	21 (36.8%)	-	28 (49.1%)

Dashes indicate that none of the annelids identified at the indicated site in the current survey were classified with given status.

Summary of Arthropod Taxonomy



Monocorophium insidiosum (Crawford, 1937)

Arthropods represent the phylum with the highest number of introduced species in the current survey. A total of 471 different taxa from the phylum Arthropoda were identified in the current survey. Of those, 2 were classified as introduced, 46 were classified as cryptogenic, 326 were classified as native, 3 were classified as unresolved complex, and 94 were unresolved taxa (Table 9).

Of the introduced species identified, *Niambia capensis* was identified from a sandy intertidal sample collected at Carpinteria, and *Monocorophium insidiosum* (pictured above) was identified from rocky subtidal habitat at both Shelter Cove and Point Fermin. These introduced species represented 0% to 0.9% of total arthropod taxa per site. Cryptogenic arthropods numbered from 2 to 19 species, and represented 4.8% to 16.5% of total arthropod taxa per site.

The majority of arthropod taxa identified in the current survey were native species; native arthropod species ranged from 19 to 90 species per site, and represented 61.9% to 80.8% of the total arthropod taxa at each site. Unresolved arthropod taxa ranged from 6 to 24 per site, and represented 11.3% to 33.3% of the total arthropod taxa per site.

An additional introduced arthropod, *Monocorophium acherusicum*, was identified during the current survey, but was excluded from the data summaries because it was only collected from sandy intertidal habitat at the Pin Rock site. As explained above, the only sandy habitat available to sample at or near Pin Rock was tucked inside Catalina Harbor, and thus is not considered a true outer coast site. However, the report of *M. acherusicum* from sandy intertidal habitat at Catalina Harbor is noteworthy.

Table 9. Number of species and percentage of total arthropod taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**57**	-	6 (10.5%)	39 (68.4%)	-	12 (21.1%)
Cape Mendocino	**28**	-	3 (10.7%)	19 (67.9%)	-	6 (21.4%)
Shelter Cove	**109**	1 (0.9%)	13 (11.9%)	74 (67.9%)	1 (0.9%)	20 (18.3%)
Point Arena	**94**	-	13 (13.8%)	61 (64.9%)	-	20 (21.3%)
Bodega	**115**	-	12 (10.4%)	81 (70.4%)	-	22 (19.1%)
Point Reyes	**67**	-	8 (11.9%)	45 (67.2%)	1 (1.5%)	13 (19.4%)
Fitzgerald	**62**	-	6 (9.7%)	48 (77.4%)	1 (1.6%)	7 (11.3%)
Pigeon Point	**42**	-	2 (4.8%)	26 (61.9%)	-	14 (33.3%)
Ano Nuevo	**52**	-	3 (5.8%)	42 (80.8%)	-	7 (13.5%)
Point Sur	**63**	-	5 (7.9%)	44 (69.8%)	-	14 (22.2%)
Point Sierra Nevada	**109**	-	10 (9.2%)	79 (72.5%)	-	20 (18.3%)
Diablo Canyon	**100**	-	16 (16.0%)	65 (65.0%)	1 (1.0%)	18 (18.0%)
Purisima Point	**75**	-	10 (13.3%)	53 (70.7%)	-	12 (16.0%)
Point Conception	**116**	-	13 (11.2%)	86 (74.1%)	2 (1.7%)	15 (12.9%)
Arroyo Hondo	**106**	-	10 (9.4%)	83 (78.3%)	1 (0.9%)	12 (11.3%)
Carpinteria	**119**	1 (0.8%)	12 (10.1%)	87 (73.1%)	1 (0.8%)	18 (15.1%)
Point Dume	**106**	-	11 (10.4%)	70 (66.0%)	2 (1.9%)	23 (21.7%)
Point Fermin	**116**	1 (0.9%)	11 (9.5%)	79 (68.1%)	1 (0.9%)	24 (20.7%)
Dana Point	**112**	-	13 (11.6%)	83 (74.1%)	1 (0.9%)	15 (13.4%)
Pin Rock	**128**	-	15 (11.7%)	90 (70.3%)	1 (0.8%)	22 (17.2%)
Point La Jolla	**117**	-	19 (16.2%)	80 (68.4%)	1 (0.9%)	17 (14.5%)
Point Loma	**85**	-	14 (16.5%)	59 (69.4%)	-	12 (14.1%)

Dashes indicate that none of the arthropods identified at the indicated site in the current survey were classified with given status.

Summary of Chordata Taxonomy (Tunicates)

Botryllus schlosseri colony, growing on a bay mussel (*Mytilus galloprovincialis/trossolus complex*); photo used with permission by Luis Solarzano and SFEI

A total of 38 different taxa from the phylum Chordata were identified in the current survey. Of those, 1 was classified as introduced, 2 were classified as cryptogenic, 27 were classified as native, and 8 were unresolved taxa (Table 10).

The introduced chordate species identified in the current survey was *Botryllus schlosseri*, pictured above on a mussel. Introduced chordates represented 0% to 14.3% of the total chordate taxa per site, while cryptogenic chordates ranged from 0 to 1 species per site, and represented 0% to 9.1% of the total chordate taxa per site. Chordate taxa classified as unresolved numbered from 0 to 3 taxa per site, and represented 0% to 50% of the total chordate taxa per site, while none of the chordates identified in the current survey were classified as unresolved complex. The majority of chordate taxa identified from each site were classified as native; native chordate taxa ranged from 1 to 14 species per site, representing 50% to 100% of the total chordate taxa per site.

To our knowledge, *B. schlosseri* has not previously been reported from California's outer coast. Of the sites surveyed, this species was only identified from rocky subtidal habitat at Point La Jolla (Figure 6), which is in close proximity to two bays known to harbor fairly widespread populations of *B. schlosseri*, Mission Bay and San Diego Bay (CDFG, 2008). The collections made for the current survey could be individuals that have 'spilled out' from those bays, and more work would be required to quantitatively determine the abundance (or continued occurrence) of *B. schlosseri* in the rocky subtidal habitat at Point La Jolla. During the qualitative search portion of the rocky subtidal survey via SCUBA, divers only observed one small colony of this species.

A total of two cryptogenic chordates were identified in the current survey, *Aplidium sp. A* Lambert and *Diplosoma listerianum*. *D. listerianum* was previously listed by MLML/CDFG as introduced to California, and the possibility of a complex of several species that have been lumped as *D. listerianum*, each of which could potentially have a different native range, is currently under debate. Until that debate is resolved, which will likely require molecular analysis, the introduction status has been changed to cryptogenic in the CANOD database and this report. In the current survey, *D. listerianum* was identified from rocky subtidal habitat at Shelter Cove, Bodega, and Diablo Canyon. *Aplidium sp. A* Lambert was identified from rocky intertidal habitat at Point Dume.

Table 10. Number of species and percentage of total chordate taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**6**	-	-	6 (100.0%)	-	-
Shelter Cove	**11**	-	1 (9.1%)	10 (90.9%)	-	-
Point Arena	**9**	-	-	8 (88.9%)	-	1 (11.1%)
Bodega	**14**	-	1 (7.1%)	10 (71.4%)	-	3 (21.4%)
Fitzgerald	**1**	-	-	1 (100.0%)	-	-
Point Sur	**7**	-	-	7 (100.0%)	-	-
Point Sierra Nevada	**1**	-	-	1 (100.0%)	-	-
Diablo Canyon	**11**	-	1 (9.1%)	8 (72.7%)	-	2 (18.2%)
Purisima Point	**4**	-	-	2 (50.0%)	-	2 (50.0%)
Point Conception	**7**	-	-	6 (85.7%)	-	1 (14.3%)
Arroyo Hondo	**8**	-	-	7 (87.5%)	-	1 (12.5%)
Carpinteria	**11**	-	-	11 (100.0%)	-	-
Point Dume	**13**	-	1 (7.7%)	12 (92.3%)	-	-
Point Fermin	**8**	-	-	7 (87.5%)	-	1 (12.5%)
Dana Point	**16**	-	-	14 (87.5%)	-	2 (12.5%)
Pin Rock	**4**	-	-	3 (75.0%)	-	1 (25.0%)
Point La Jolla	**7**	1 (14.3%)	-	4 (57.1%)	-	2 (28.6%)

Dashes indicate that none of the chordates identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any chordate identifications are excluded from the table.

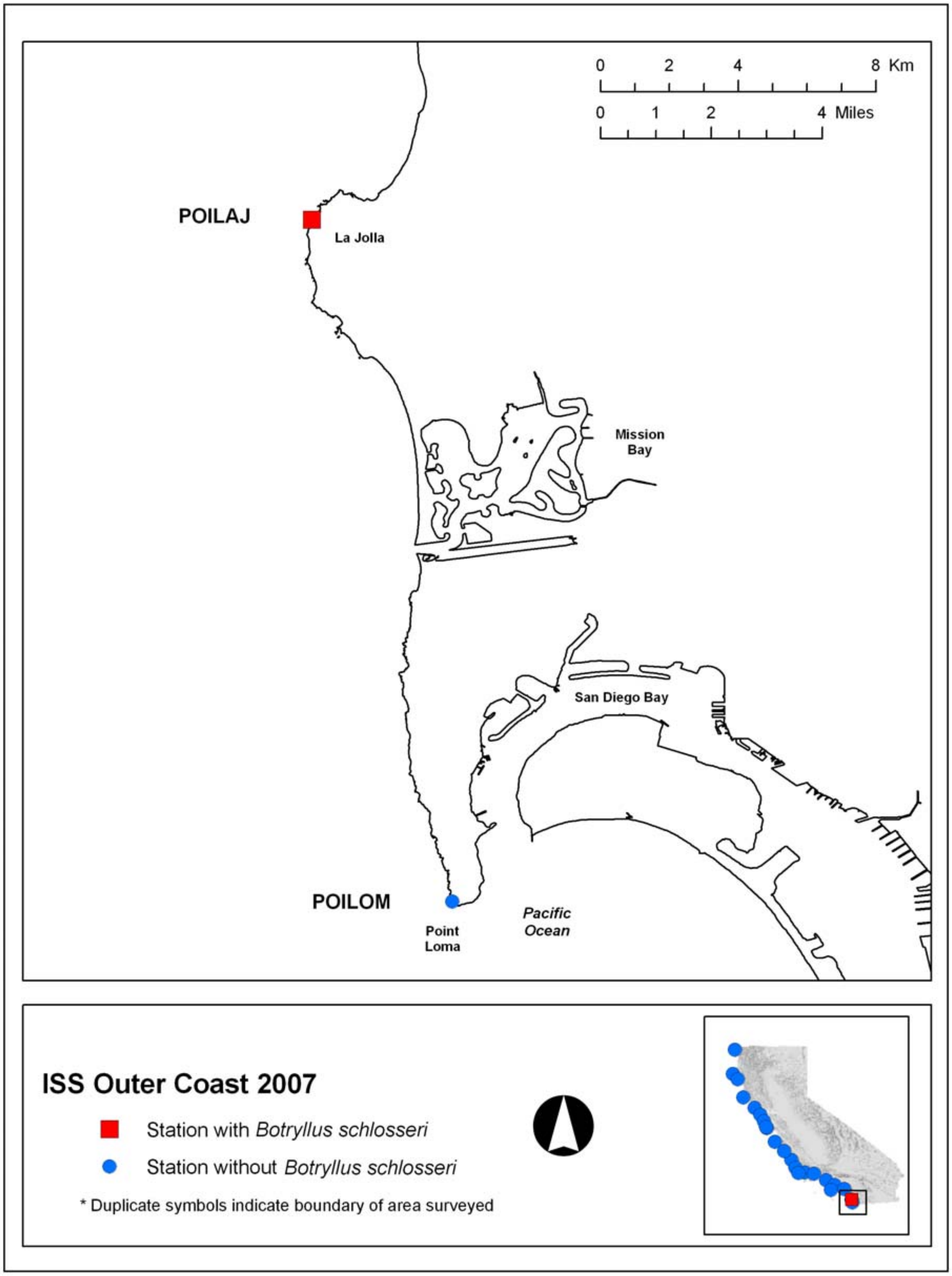


Figure 6. Location of *Botryllus schlosseri* collection for the current survey in relation to two major Bays.

Summary of Cnidarian Taxonomy

Metridium senile, photo by Robert Keen (published on the MarLIN website)

No introduced cnidarian species were identified in the current survey, while two cryptogenic cnidarians were identified, *Plumularia setacea* and *Metridium senile* (pictured above). Each of these cryptogenic species was found at only one survey site, and they represented 0% to 16.7% of the total taxa per site (Table 11). *M. senile* was identified from rocky subtidal habitat at Diablo Canyon, while *P. setacea* was identified from rocky subtidal habitat at Point Conception.

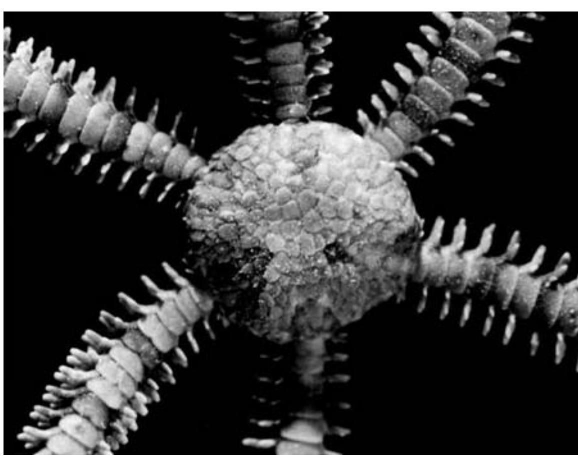
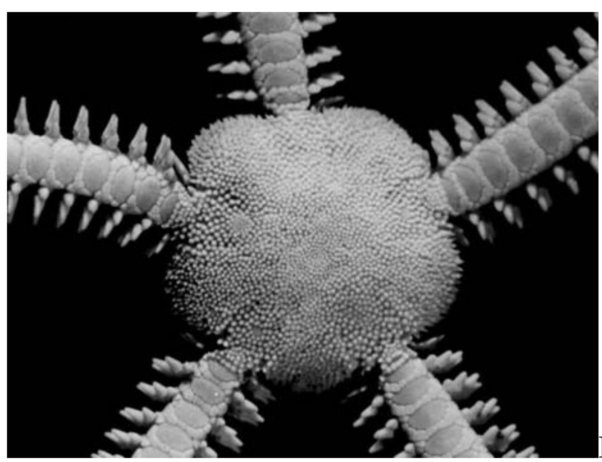
While not a large number of cnidarian taxa were identified in the current survey (46 total), native and unresolved taxa represented the majority of cnidarian taxa per site. Native species ranged from 0 to 7 per site, representing 0% to 100% of cnidarian taxa, while unresolved taxa ranged from 0 to 8 taxa per site and represented 0% to 100% of cnidarian taxa per site as well.

Table 11. Number of species and percentage of total cnidarian taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**6**	-	-	3 (50.0%)	-	3 (50.0%)
Shelter Cove	**1**	-	-	1 (100.0%)	-	-
Point Arena	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Bodega	**5**	-	-	2 (40.0%)	-	3 (60.0%)
Point Reyes	**6**	-	-	1 (16.7%)	-	5 (83.3%)
Fitzgerald	**1**	-	-	-	-	1 (100.0%)
Pigeon Point	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Ano Nuevo	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Point Sur	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Point Sierra Nevada	**4**	-	-	1 (25.0%)	-	3 (75.0%)
Diablo Canyon	**6**	-	1 (16.7%)	2 (33.3%)	-	3 (50.0%)
Purisima Point	**2**	-	-	2 (100.0%)	-	-
Point Conception	**9**	-	1 (11.1%)	6 (66.7%)	-	2 (22.2%)
Arroyo Hondo	**11**	-	-	3 (27.3%)	-	8 (72.7%)
Carpinteria	**11**	-	-	7 (63.6%)	-	4 (36.4%)
Point Dume	**4**	-	-	1 (25.0%)	-	3 (75.0%)
Point Fermin	**7**	-	-	4 (57.1%)	-	3 (42.9%)
Dana Point	**8**	-	-	3 (37.5%)	-	5 (62.5%)
Pin Rock	**5**	-	-	-	-	5 (100.0%)
Point La Jolla	**5**	-	-	3 (60.0%)	-	2 (40.0%)
Point Loma	**4**	-	-	1 (25.0%)	-	3 (75.0%)

Dashes indicate that none of the cnidarians identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any cnidarian identifications are excluded from the table.

Summary of Echinoderm Taxonomy


A

B

Ophiactis simplex (A) and *Ophiopholis kennerlyi* (B), photos used with permission by Gordon Hendler

Relative to some of the other phyla represented in the current survey, few total echinoderm taxa (32 taxa total) were identified. No introduced echinoderm species were identified in the current survey, and 3 cryptogenic echinoderms were identified: *Amphipholis squamata*, *Ophiactis simplex* (noted as likely native; pictured above) and *Ophiopholis kennerlyi* (pictured above). All 3 of these cryptogenic species are ophiuroids, or brittle stars. *A. squamata* was identified in rocky subtidal habitat at 7 survey sites, *O. simplex* was identified was identified from rocky intertidal and/or subtidal habitat at 10 survey sites, and *O. kennerlyi* was identified from rocky subtidal habitat at 3 sites and rocky intertidal habitat at 1 survey site. Cryptogenic echinoderm species numbered from 0 to 3 per survey site, representing 0% to 50% of the total echinoderm taxa per site (Table 12).

Native and unresolved taxa represented the majority of echinoderms. Native species ranged from 0 to 7 per site, representing 0% to 66.7% of total echinoderm taxa per site, while unresolved echinoderms numbered from 1 to 8 taxa per site, and represented 20% to 100% of total echinoderm taxa per site.

Table 12. Number of species and percentage of total echinoderm taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**2**	-	1 (50.0%)	-	-	1 (50.0%)
Shelter Cove	**6**	-	-	1 (16.7%)	-	5 (83.3%)
Point Arena	**4**	-	1 (25.0%)	1 (25.0%)	-	2 (50.0%)
Bodega	**11**	-	2 (18.2%)	1 (9.1%)	-	8 (72.7%)
Point Reyes	**1**	-	-	-	-	1 (100.0%)
Fitzgerald	**5**	-	-	1 (20.0%)	-	4 (80.0%)
Pigeon Point	**3**	-	-	1 (33.3%)	-	2 (66.7%)
Ano Nuevo	**3**	-	-	-	-	3 (100.0%)
Point Sur	**6**	-	-	4 (66.7%)	-	2 (33.3%)
Point Sierra Nevada	**11**	-	1 (9.1%)	4 (36.4%)	-	6 (54.5%)
Diablo Canyon	**14**	-	3 (21.4%)	5 (35.7%)	-	6 (42.9%)
Purisima Point	**3**	-	-	1 (33.3%)	-	2 (66.7%)
Point Conception	**9**	-	-	3 (33.3%)	-	6 (66.7%)
Arroyo Hondo	**12**	-	1 (8.3%)	7 (58.3%)	-	4 (33.3%)
Carpinteria	**9**	-	2 (22.2%)	3 (33.3%)	-	4 (44.4%)
Point Dume	**7**	-	1 (14.3%)	2 (28.6%)	-	4 (57.1%)
Point Fermin	**11**	-	2 (18.2%)	3 (27.3%)	-	6 (54.5%)
Dana Point	**9**	-	2 (22.2%)	4 (44.4%)	-	3 (33.3%)
Pin Rock	**6**	-	1 (16.7%)	2 (33.3%)	-	3 (50.0%)
Point La Jolla	**9**	-	2 (22.2%)	1 (11.1%)	-	6 (66.7%)
Point Loma	**5**	-	2 (40.0%)	2 (40.0%)	-	1 (20.0%)

Dashes indicate that none of the echinoderms identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any echinoderm identifications are excluded from the table.

Summary of Ectoproct Taxonomy (Bryozoans)

Membranipora tuberculata colony growing on algae blades, photo used with permission by Greg Schroeder

Only one introduced ectoproct species was identified in the current outer coast survey, *Watersipora arcuata*, but this species was excluded from the data summaries because it was only collected from sandy intertidal habitat at the Pin Rock site. As explained above, the only sandy habitat available to sample at or near Pin Rock was tucked inside Catalina Harbor, and thus is not representative of a true outer coast site. However, the report of *W. arcuata* from sandy intertidal habitat at Catalina Harbor is noteworthy. Also note that several of the ectoproct species identified in the MLML/CDFG 2004 outer coast survey and listed then as introduced were also identified in the current survey, but are no longer considered to be introduced species in California (see Appendix C for a list of changes to the 2004 introduced species list).

Two cryptogenic ectoproct species were identified in the current survey, *Membranipora tuberculata* (pictured above) and *Membranipora membranacea*. Cryptogenic species numbered from 0 to 2 per site, representing 0% to 16.7% of total ectoproct species per site (Table 13). Unresolved taxa numbers were relatively low for this phylum, numbering from 0 to 2 taxa per site, and representing 0% to 50% of the total ectoproct taxa per site. Native species, on the other hand, represented the majority of ectoproct taxa at all sites. Native ectoprocts numbered from 1 to 13 species per site, representing 50% to 100% of total ectoproct taxa per site.

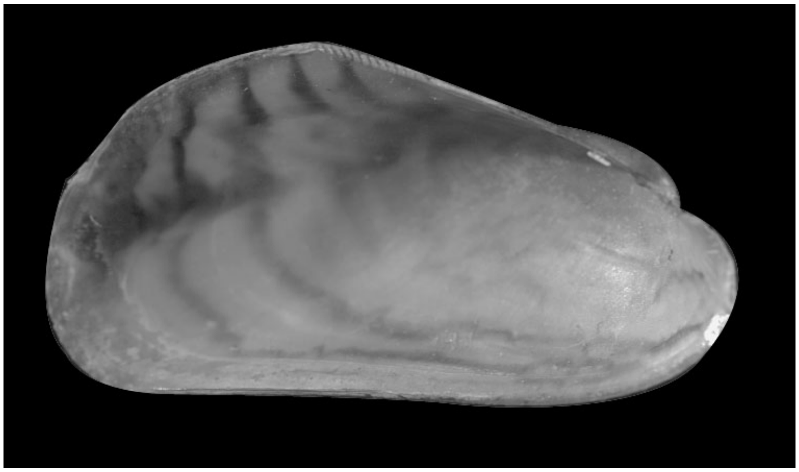
Table 13. Number of species and percentage of total ectoproct taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**3**	-	-	3 (100.0%)	-	-
Cape Mendocino	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Shelter Cove	**9**	-	-	9 (100.0%)	-	-
Point Arena	**5**	-	-	4 (80.0%)	1 (20.0%)	-
Bodega	**10**	-	-	10 (100.0%)	-	-
Point Reyes	**6**	-	1 (16.7%)	4 (66.7%)	-	1 (16.7%)
Fitzgerald	**3**	-	-	3 (100.0%)	-	-
Pigeon Point	**6**	-	-	4 (66.7%)	1 (16.7%)	1 (16.7%)
Ano Nuevo	**4**	-	-	4 (100.0%)	-	-
Point Sur	**9**	-	-	7 (77.8%)	1 (11.1%)	1 (11.1%)
Point Sierra Nevada	**7**	-	-	7 (100.0%)	-	-
Diablo Canyon	**11**	-	1 (9.1%)	9 (81.8%)	1 (9.1%)	-
Purisima Point	**6**	-	-	6 (100.0%)	-	-
Point Conception	**13**	-	1 (7.7%)	11 (84.6%)	-	1 (7.7%)
Arroyo Hondo	**12**	-	1 (8.3%)	10 (83.3%)	1 (8.3%)	-
Carpinteria	**13**	-	1 (7.7%)	8 (61.5%)	2 (15.4%)	2 (15.4%)
Point Dume	**10**	-	1 (10.0%)	7 (70.0%)	2 (20.0%)	-
Point Fermin	**12**	-	2 (16.7%)	9 (75.0%)	-	1 (8.3%)
Dana Point	**16**	-	2 (12.5%)	13 (81.3%)	1 (6.3%)	-
Pin Rock	**14**	-	-	12 (85.7%)	1 (7.1%)	1 (7.1%)
Point La Jolla	**10**	-	1 (10.0%)	9 (90.0%)	-	-
Point Loma	**7**	-	-	6 (85.7%)	-	1 (14.3%)

Dashes indicate that none of the ectoprocts identified at the indicated site in the current survey were classified with given status.

In addition, 3 ectoproct taxa were given the classification of unresolved complex: *Bowerbankia gracilis* complex, *Bugula neritina* complex, and *Cryptosula pallasiana* complex. Unresolved complex taxa numbered from 0 to 2 per site, representing 0% to 20% of the total ectoproct taxa per site. *Bowerbankia gracilis* (at the species level) has previously been reported by MLML/CDFG as introduced to California's outer coast (Maloney et al., 2006), but was determined to be a species complex, and introduction statuses of species within this complex are not resolvable at this time (J. Carlton, personal communication, October 20, 2007). *B. neritina* is a species complex as well; it is likely that the predominant species found in California harbors is introduced while the species found in the outer coast and deeper waters is native, but these species have not yet been described (P. Fofonoff, personal communication, January 11, 2008). Likewise, additional taxonomic work is needed to resolve the outer coast species of *Cryptosula pallasiana* complex.

Summary of Mollusc Taxonomy



Musculista senhousia, photo used with permission from the Santa Barbara Museum of Natural History

A total of 262 different taxa from the phylum Mollusca were identified in the current survey. Of those, 1 was classified as introduced, 1 was classified as cryptogenic, 170 were classified as native, and 90 were unresolved taxa (Table 14).

The introduced mollusc species identified from the current outer coast survey was *Musculista senhousia* (pictured above). This introduced mussel was only identified from the Point Loma survey site, and it represented 2.1% of the total mollusc taxa at that site. *Sphenia fragilis* is the only mollusc identified in the current survey and classified as cryptogenic. This cryptogenic species was identified at 4 sites, and represented 0% to 2.1% of the total mollusc taxa per site. Native and unresolved taxa represented the majority of molluscs identified at all survey sites. Native species numbered 15 to 41 per site, representing 47.1% to 76.5% of total mollusc taxa per site, while unresolved taxa numbered 7 to 29 taxa per site, and represented 23.5 to 52.9% of total mollusc taxa per site. None of the molluscs collected were classified as unresolved complex.

Another introduced mollusc that is known to be found in the rocky intertidal mussel community is the mussel *Mytilus galloprovincialis*, which was possibly collected but not yet identified for the current survey. Both the native *Mytilus trossulus* and the introduced *M. 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. Representative *Mytilus* specimens were collected from sites in the current survey and have been preserved in ethanol and archived, making future genetic analysis possible. 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.

Table 14. Number of species and percentage of total mollusc taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**31**	-	-	17 (54.8%)	-	14 (45.2%)
Cape Mendocino	**23**	-	-	15 (65.2%)	-	8 (34.8%)
Shelter Cove	**34**	-	-	16 (47.1%)	-	18 (52.9%)
Point Arena	**34**	-	-	26 (76.5%)	-	8 (23.5%)
Bodega	**63**	-	-	34 (54.0%)	-	29 (46.0%)
Point Reyes	**27**	-	-	18 (66.7%)	-	9 (33.3%)
Fitzgerald	**39**	-	-	25 (64.1%)	-	14 (35.9%)
Pigeon Point	**34**	-	-	18 (52.9%)	-	16 (47.1%)
Ano Nuevo	**38**	-	-	27 (71.1%)	-	11 (28.9%)
Point Sur	**27**	-	-	20 (74.1%)	-	7 (25.9%)
Point Sierra Nevada	**64**	-	-	41 (64.1%)	-	23 (35.9%)
Diablo Canyon	**55**	-	-	34 (61.8%)	-	21 (38.2%)
Purisima Point	**50**	-	-	27 (54.0%)	-	23 (46.0%)
Point Conception	**37**	-	-	19 (51.4%)	-	18 (48.6%)
Arroyo Hondo	**46**	-	-	29 (63.0%)	-	17 (37.0%)
Carpinteria	**52**	-	1 (1.9%)	28 (53.8%)	-	23 (44.2%)
Point Dume	**49**	-	-	35 (71.4%)	-	14 (28.6%)
Point Fermin	**52**	-	-	36 (69.2%)	-	16 (30.8%)
Dana Point	**59**	-	1 (1.7%)	36 (61.0%)	-	22 (37.3%)
Pin Rock	**61**	-	1 (1.6%)	37 (60.7%)	-	23 (37.7%)
Point La Jolla	**63**	-	-	39 (61.9%)	-	24 (38.1%)
Point Loma	**47**	1 (2.1%)	1 (2.1%)	29 (61.7%)	-	16 (34.0%)

Dashes indicate that none of the molluscs identified at the indicated site in the current survey were classified with given status.

The introduced mussel, *Musculista senhousia,* was identified from a rocky intertidal quadrat clearing collected at Point Loma. Relative to similar rocky intertidal sites farther north, few mussels can be found in the rocky intertidal area at or near Point Loma. As noted by Becker, there was a sharp decline of *Mytilus* species within the Cabrillo National Monument located at the Point Loma area (which is the same site sampled in the current survey) between 1990 and 1995, and the population has not recovered (Becker, 2005). For this reason, in order to get a representative mussel community collection for the survey, one rocky intertidal quadrat was collected approximately 1.3 miles north along the coastline north from the main intertidal survey area (Figure 7), and *M. senhousia* was identified from that quadrat clearing. Also note, as shown in figure 7, the collection location for this sample was in close proximity to San Diego Bay. *M. senhousia* is widespread within the Bay (Maloney et al., 2007), and much like the *Botryllus schlosseri* described in the chordata section above, it is possible, if not likely, that the *M. senhousia* specimens collected in the current survey had 'spilled out' from San Diego Bay. Further sampling would be necessary in order to quantitatively determine the abundance (or continued occurrence) of *M. senhousia* in the rocky intertidal mussel community at and near this outer coast survey site.

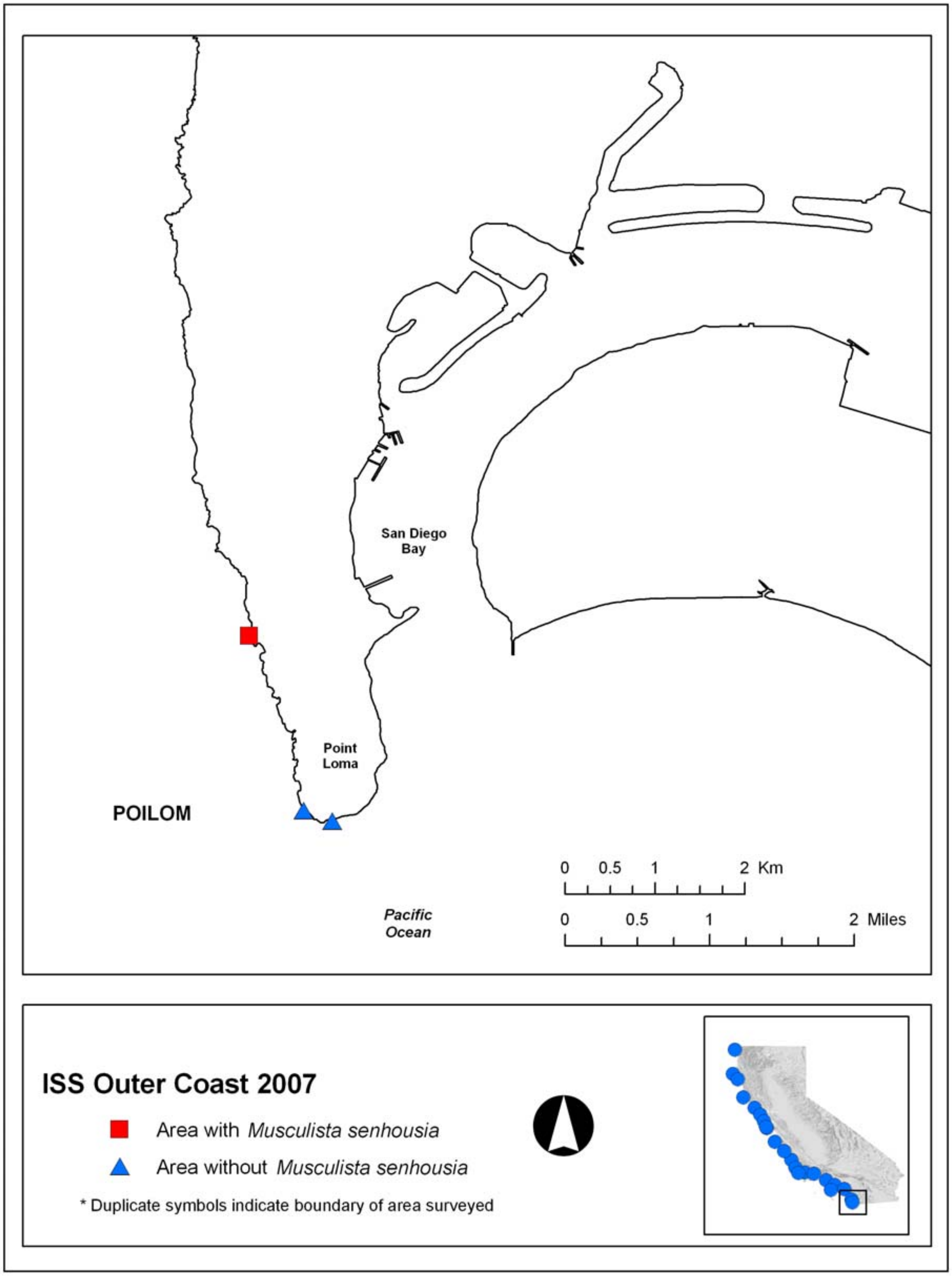


Figure 7. Location of *Musculista senhousia* collection for the current survey in relation to San Diego Bay.

Summary of Nemertean (Ribbon Worm) Taxonomy

No introduced nemertean species were identified in the current survey. Ten cryptogenic species were identified, including *Amphiporus angulatus, Amphiporus bimaculatus, Amphiporus cruentatus, Amphiporus imparispinosus, Cerebratulus marginatus, Emplectonema gracile, Micrura alaskensis, Tetrastemma candidum, Tetrastemma nigrifrons* and *Zygonemertes virescens.* Of those cryptogenic species, *A. angulatus, A. bimaculatus, A. imparispinosus* and *T. nigrifrons* were listed as likely native to California. Cryptogenic species represented 0% to 55.6% of the total nemertean taxa per site (Table 15). Native species ranged from 0 to 7 per site, and represented 0% to 46.2% of the total epifaunal nemertean taxa per site. Unresolved nemertean taxa were present at all sites sampled; they numbered from 1 to 7 taxa per site, and represented 15.4% to 100% of the total nemertean taxa per site. No nemertean taxa were classified as unresolved complex.

Table 15. Number of species and percentage of total nemertean taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**9**	-	5 (55.6%)	-	-	4 (44.4%)
Cape Mendocino	**1**	-	-	-	-	1 (100.0%)
Shelter Cove	**7**	-	1 (14.3%)	1 (14.3%)	-	5 (71.4%)
Point Arena	**8**	-	2 (25.0%)	1 (12.5%)	-	5 (62.5%)
Bodega	**13**	-	5 (38.5%)	1 (7.7%)	-	7 (53.8%)
Point Reyes	**10**	-	3 (30.0%)	-	-	7 (70.0%)
Fitzgerald	**8**	-	2 (25.0%)	1 (12.5%)	-	5 (62.5%)
Pigeon Point	**7**	-	2 (28.6%)	2 (28.6%)	-	3 (42.9%)
Ano Nuevo	**9**	-	3 (33.3%)	2 (22.2%)	-	4 (44.4%)
Point Sur	**10**	-	3 (30.0%)	3 (30.0%)	-	4 (40.0%)
Point Sierra Nevada	**16**	-	5 (31.3%)	6 (37.5%)	-	5 (31.3%)
Diablo Canyon	**12**	-	4 (33.3%)	4 (33.3%)	-	4 (33.3%)
Purisima Point	**10**	-	2 (20.0%)	4 (40.0%)	-	4 (40.0%)
Point Conception	**13**	-	2 (15.4%)	5 (38.5%)	-	6 (46.2%)
Arroyo Hondo	**17**	-	6 (35.3%)	6 (35.3%)	-	5 (29.4%)
Carpinteria	**13**	-	5 (38.5%)	6 (46.2%)	-	2 (15.4%)
Point Dume	**9**	-	3 (33.3%)	4 (44.4%)	-	2 (22.2%)
Point Fermin	**16**	-	4 (25.0%)	5 (31.3%)	-	7 (43.8%)
Dana Point	**17**	-	3 (17.6%)	7 (41.2%)	-	7 (41.2%)
Pin Rock	**6**	-	1 (16.7%)	2 (33.3%)	-	3 (50.0%)
Point La Jolla	**4**	-	1 (25.0%)	1 (25.0%)	-	2 (50.0%)
Point Loma	**8**	-	2 (25.0%)	3 (37.5%)	-	3 (37.5%)

Dashes indicate that none of the nemerteans identified at the indicated site in the current survey were classified with given status.

Summary of Platyhelminthes (Flatworm) Taxonomy

A total of 25 different taxa from the phylum Platyhelminthes were identified in the current survey. Of those, none were classified as introduced, 1 was classified as cryptogenic, 12 were classified as native and 12 were unresolved taxa. *Acerotisa californica*, the cryptogenic flatworm identified in the current survey, was only identified from rocky subtidal habitat at Point Dume, where it represented 16.7% of the total platyhelminthes taxa identified (Table 16). Native species numbered from 0 to 7 per site, representing 0% to 100% of the total platyhelminthes taxa per site, while unresolved taxa numbered 0 to 5 per site and represented 0% to 100% of the total platyhelminthes taxa.

Table 16. Number of species and percentage of total platyhelminthes taxa for each classification.

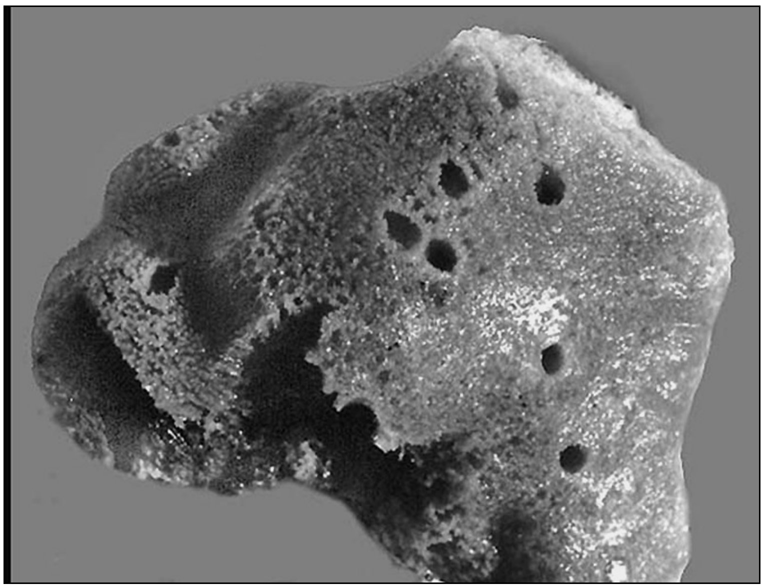
Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**3**	-	-	2 (66.7%)	-	1 (33.3%)
Cape Mendocino	**2**	-	-	-	-	2 (100.0%)
Shelter Cove	**1**	-	-	1 (100.0%)	-	-
Point Arena	**2**	-	-	2 (100.0%)	-	-
Bodega	**4**	-	-	2 (50.0%)	-	2 (50.0%)
Point Reyes	**6**	-	-	1 (16.7%)	-	5 (83.3%)
Fitzgerald	**3**	-	-	2 (66.7%)	-	1 (33.3%)
Pigeon Point	**1**	-	-	1 (100.0%)	-	-
Ano Nuevo	**3**	-	-	1 (33.3%)	-	2 (66.7%)
Point Sur	**2**	-	-	2 (100.0%)	-	-
Point Sierra Nevada	**4**	-	-	3 (75.0%)	-	1 (25.0%)
Diablo Canyon	**8**	-	-	4 (50.0%)	-	4 (50.0%)
Purisima Point	**4**	-	-	-	-	4 (100.0%)
Point Conception	**3**	-	-	1 (33.3%)	-	2 (66.7%)
Arroyo Hondo	**4**	-	-	1 (25.0%)	-	3 (75.0%)
Carpinteria	**9**	-	-	7 (77.8%)	-	2 (22.2%)
Point Dume	**6**	-	1 (16.7%)	3 (50.0%)	-	2 (33.3%)
Point Fermin	**7**	-	-	5 (71.4%)	-	2 (28.6%)
Dana Point	**10**	-	-	5 (50.0%)	-	5 (50.0%)
Pin Rock	**2**	-	-	1 (50.0%)	-	1 (50.0%)
Point La Jolla	**3**	-	-	1 (33.3%)	-	2 (66.7%)
Point Loma	**4**	-	-	3 (75.0%)	-	1 (25.0%)

Dashes indicate that none of the platyhelminthes identified at the indicated site in the current survey were classified with given status.

Summary of Entoproct (Goblet worms, or Kamptozoans), Nemata (Unsegmented Worm), and Phoronid (Horseshoe Worm) Taxonomy

No introduced or cryptogenic Entoproct, Nemata, or Phoronid species were identified in the current survey, and relatively few total taxa were identified from any of those 3 phyla. For Nemata and Phoronida, the only taxa that were identified were classified as unresolved. For the phylum Entoprocta, three native species were identified in addition to 2 unresolved taxa.

Summary of Porifera Taxonomy (Sponges)



Halichondria panicea, photo used with permission from Welton Lee

No introduced sponge species were identified in the current outer coast survey. Three of the sponge species identified in the current survey were classified as cryptogenic: *Clathrina coriacea, Dragmacidon sp. 1* Lee, and *Halichondria panicea* (pictured above). *C. coriacea* was identified in rocky subtidal habitat at Bodega and Carpinteria, and *D. sp. 1* Lee was identified in rocky subtidal habitat at Point La Jolla. *H. panicea* was only found in northern California, as it was identified from rocky intertidal habitat at Point Saint George and Point Arena as well as from rocky subtidal habitat at Shelter Cove and Bodega.

Cryptogenic poriferans numbered from 0 to 2 per site, and represented 0% to 100% of the total poriferan taxa per site (Table 17). Native sponge species comprised the majority of sponge taxa in the current survey (26 native species were identified), numbering from 0 to 10 per site and representing 0% to 100% of the total sponge taxa per site. Unresolved sponge taxa numbered from 0 to 4 per site and represented 0% to 66.7 of the total poriferan taxa per site.

Table 17. Number of species and percentage of total porifera taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**3**	-	1 (33.3%)	1 (33.3%)	-	1 (33.3%)
Shelter Cove	**1**	-	1 (100.0%)	-	-	-
Point Arena	**6**	-	1 (16.7%)	4 (66.7%)	-	1 (16.7%)
Bodega	**2**	-	2 (100.0%)	-	-	-
Point Reyes	**2**	-	-	2 (100.0%)	-	-
Point Sur	**12**	-	-	10 (83.3%)	-	2 (16.7%)
Diablo Canyon	**1**	-	-	1 (100.0%)	-	-
Purisima Point	**1**	-	-	1 (100.0%)	-	-
Point Conception	**5**	-	-	5 (100.0%)	-	-
Arroyo Hondo	**4**	-	-	4 (100.0%)	-	-
Carpinteria	**10**	-	1 (10.0%)	7 (70.0%)	-	2 (20.0%)
Point Dume	**6**	-	-	5 (83.3%)	-	1 (16.7%)
Point Fermin	**6**	-	-	2 (33.3%)	-	4 (66.7%)
Dana Point	**5**	-	-	4 (80.0%)	-	1 (20.0%)
Pin Rock	**3**	-	-	2 (66.7%)	-	1 (33.3%)
Point La Jolla	**6**	-	1 (16.7%)	3 (50.0%)	-	2 (33.3%)
Point Loma	**8**	-	-	7 (87.5%)	-	1 (12.5%)

Dashes indicate that none of the poriferans identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any Porifera identifications are excluded from the table.

Summary of Sipuncula Taxonomy (Peanut Worms)

Six species from the phylum Sipuncula were identified from the current survey. Of those, none were classified as introduced, and two were classified as cryptogenic (*Phascolosoma agassizii* and *Thysanocardia nigra*). All but 2 of the 22 survey sites had at least one of these cryptogenic species, and at 12 of the survey sites, these cryptogenic species represented 100% of the total sipunculid taxa (Table 18). In contrast, native species were only identified from 5 sites, numbered 0 to 2 species per site, and represented 0% to 50% of the total taxa per site. Unresolved taxa were found at less than half of the survey sites as well, numbered from 0 to 2 taxa per site, and represented 0% to 100% of the total sipunculid taxa per site.

Table 18. Number of species and percentage of total sipunculid taxa for each classification.

Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	**1**	-	1 (100.0%)	-	-	-
Cape Mendocino	**1**	-	1 (100.0%)	-	-	-
Shelter Cove	**1**	-	1 (100.0%)	-	-	-
Point Arena	**1**	-	1 (100.0%)	-	-	-
Bodega	**1**	-	1 (100.0%)	-	-	-
Fitzgerald	**1**	-	1 (100.0%)	-	-	-
Pigeon Point	**2**	-	1 (50.0%)	-	-	1 (50.0%)
Ano Nuevo	**1**	-	1 (100.0%)	-	-	-
Point Sur	**1**	-	1 (100.0%)	-	-	-
Point Sierra Nevada	**2**	-	1 (50.0%)	-	-	1 (50.0%)
Diablo Canyon	**2**	-	1 (50.0%)	1 (50.0%)	-	-
Purisima Point	**1**	-	1 (100.0%)	-	-	-
Point Conception	**1**	-	1 (100.0%)	-	-	-
Arroyo Hondo	**2**	-	-	-	-	2 (100.0%)
Carpinteria	**2**	-	1 (50.0%)	-	-	1 (50.0%)
Point Dume	**4**	-	1 (25.0%)	1 (25.0%)	-	2 (50.0%)
Point Fermin	**1**	-	1 (100.0%)	-	-	-
Dana Point	**3**	-	2 (66.7%)	1 (33.3%)	-	-
Pin Rock	**4**	-	1 (25.0%)	2 (50.0%)	-	1 (25.0%)
Point La Jolla	**1**	-	1 (100.0%)	-	-	-
Point Loma	**2**	-	-	1 (50.0%)	-	1 (50.0%)

Dashes indicate that none of the sipunculids identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any sipunculid identifications are excluded from the table.

Summary of Marine Algae Taxonomy (Seaweeds)


Lomentaria hakodatensis, photo used with permission from Kathy Ann Miller

Marine algae, when looking at the 3 phyla combined, represent the group with both the highest number of introduced species, as well as the most widespread distribution for introduced species detected in the current survey of the outer coast (Table 19). Four species of introduced marine algae were identified in the current survey: *Sargassum muticum*, *Sargassum filicinum* (phylum Heterokontophyta), *Caulacanthus ustulatus*, and *Lomentaria hakodatensis* (pictured above, phylum Rhodophyta). *L. hakodatensis* was identified in rocky intertidal habitat at Dana Point. *C. ustulatus* was identified in rocky intertidal habitat at 5 survey sites, including Point Fermin, Pin Rock, Dana Point, Point La Jolla and Point Loma (Figure 8). *C. ustulatus* was identified at all of the above sites except Pin Rock in the 2004 MLML/CDFG outer coast survey (Maloney et al., 2006), and has been reported from several other California rocky intertidal sites as well (Whiteside, K. and Murray, S., personal communication, September 2, 2008).

S. filicinum was only identified from the Pin Rock survey site, on Catalina Island. *S. filicinum* is a fairly new introduction in California, first found in LA/LB harbor in 2003, and then found at Catalina Island in 2006 (Miller et al., 2007). To our knowledge, this is the first report of *S. filicinum* from the Pin Rock/Catalina Harbor area of Catalina Island. *S. muticum* was the most widely distributed introduced species detected in the current outer coast survey. This species was identified from rocky intertidal habitat at 7 survey sites (Figure 9), as well as rocky subtidal habitat at Point Dume.

Unlike invertebrates collected in the current survey, algal species were not identified from the quadrat clearing samples, and seaweed identifications come only from the qualitative visual searches of each site. Because most known native species observed during the qualitative visual searches were not collected or recorded, native species are underrepresented in the dataset, and occurrence percentages have been left out of table 19.

Table 19. Number of marine algal taxa identified from visual searches for each classification.

Phylum	Site Name	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Chlorophyta	Diablo Canyon	**1**	-	-	1	-	-
Chlorophyta	Point Dume	**1**	-	-	1	-	-
Chlorophyta	Dana Point	**1**	-	-	1	-	-
Chlorophyta	Pin Rock	**2**	-	-	2	-	-
Chlorophyta	Point La Jolla	**1**	-	-	1	-	-
Chlorophyta	Point Loma	**1**	-	-	1	-	-
Heterokontophyta	Diablo Canyon	**1**	1	-	-	-	-
Heterokontophyta	Point Dume	**2**	1	-	1	-	-
Heterokontophyta	Point Fermin	**1**	1	-	-	-	-
Heterokontophyta	Dana Point	**1**	1	-	-	-	-
Heterokontophyta	Pin Rock	**3**	2	-	1	-	-
Heterokontophyta	Point La Jolla	**1**	1	-	-	-	-
Heterokontophyta	Point Loma	**1**	1	-	-	-	-
Rhodophyta	Point Conception	**3**	-	-	3	-	-
Rhodophyta	Arroyo Hondo	**1**	-	-	1	-	-
Rhodophyta	Carpinteria	**1**	-	-	1	-	-
Rhodophyta	Point Dume	**2**	-	-	1	-	1
Rhodophyta	Point Fermin	**1**	1	-	-	-	-
Rhodophyta	Dana Point	**2**	2	-	-	-	-
Rhodophyta	Pin Rock	**1**	1	-	-	-	-
Rhodophyta	Point La Jolla	**2**	1	-	1	-	-
Rhodophyta	Point Loma	**1**	1	-	-	-	-

Dashes indicate that none of the algae identified at the indicated site in the current survey were classified with given status. Sites which were sampled but did not produce any algae identifications are excluded from the table.

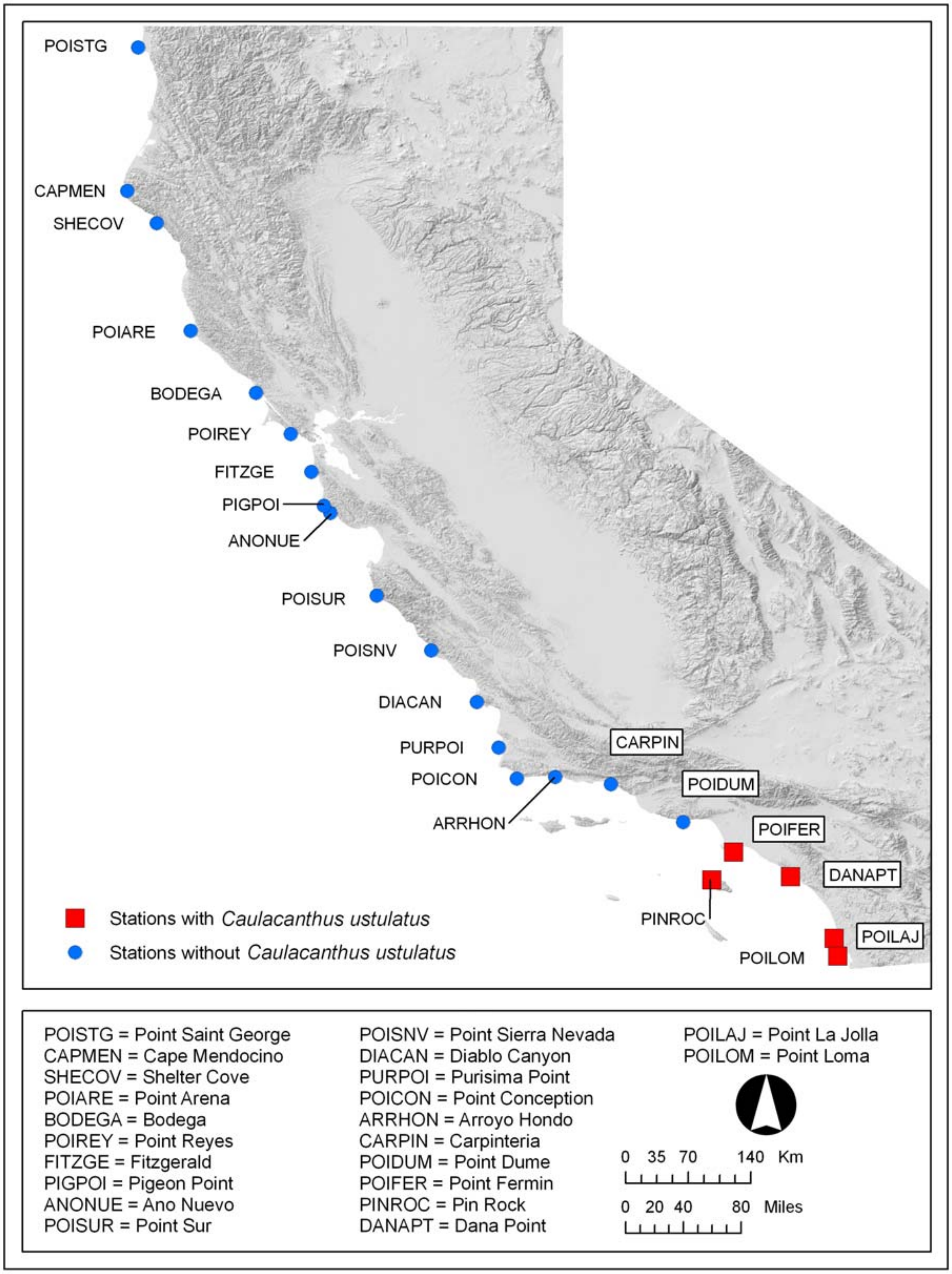


Figure 8. Location of *Caulacanthus ustulatus* identifications in the current survey.

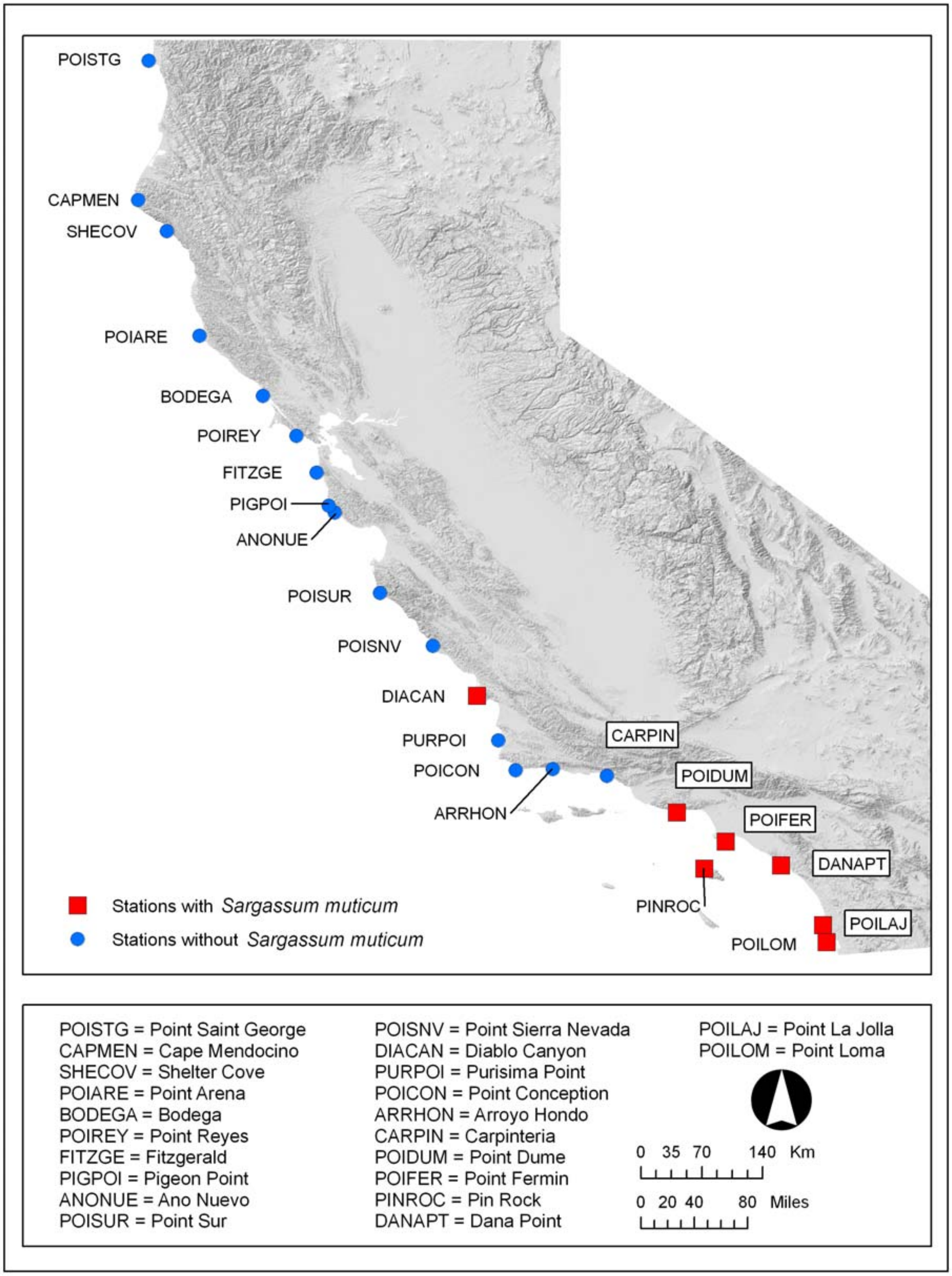


Figure 9. Distribution of *Sargassum muticum* in California as identified in the current survey.

SUMMARY

Summary of MS Access Database

To manage introduced species data from this survey as well as other sources, OSPR created a Microsoft (MS) Access 2000 relational database that includes field and analytical data as well as the name and location of every known non-native (or suspected non-native) species on the California coast. Called CANOD (California Aquatic Non-native Organism Database), the database is available to the public on the Department of Fish and Game's Office of Spill Prevention and Response (OSPR) web site at http://www.dfg.ca.gov/ospr/; link to Invasive Species. A copy of the database resides at Moss Landing Marine Laboratory's Marine Pollution Studies Lab.

CANOD serves as a baseline for addressing the following questions: 1. Which NIS have arrived in California via Ballast Water? 2. Is the rate of new introductions increasing or not? 3. Have ballast water regulations been successful in limiting introductions of new organisms? (a long-term question) 4. To what extent have humans redistributed plants and animals within California?

To answer these questions, the database includes information about the pathway of introduction (e.g. ballast water, intentional introduction), date of introduction, locations observed, and native region of each species. CANOD is updated with relevant results from the current literature and field surveys, and will also be refined in the future as more surveys for non-native aquatic species are completed.

Summary of Surveys

Nine hundred fifty two species were identified in the current survey of California's outer coast, of which 10 were classified as introduced, 140 as cryptogenic and 802 as native to California. In addition, 467 different taxa were not resolved to the species level, and have been classified as unresolved, while 7 taxa were identified to the species complex level and classified as unresolved complex. Several of the unresolved taxa are identified to the genus level and are listed with an unofficial, temporary provisional species name.

All 10 of the introduced species identified in the current survey have previously been reported from California. Introduced species were not identified from 12 of the 22 sites surveyed, while the highest number of introduced species found at any one survey site was 4. Introduced species represented from 0% to 1.3% of the total taxa collected from each survey site, and cryptogenic species represented 9.7% to 15.1% of the total taxa identified from those sites. The proportion of species identified at each site and classified as native was relatively high, at 46.6% to 59.9% of the total taxa collected per site.

The introduced species identified in the current survey were represented by 6 different phyla: Annelida (2 introduced species), Arthropoda (2 introduced species), Chordata (1 introduced species), Heterokontophyta (2 introduced species), Mollusca (1 introduced species), and Rhodophyta (2 introduced species). Some of the major phyla with no introduced species identified in the current survey included the Cnidaria (tunicates), Porifera (sponges), Ectoprocta (bryozoans), and Echinodermata. Of the 4 different habitat types sampled, rocky subtidal had the highest number of introduced species (6), followed by rocky intertidal (5), then sandy intertidal (1). No introduced species were identified from sandy subtidal habitat.

Unresolved taxa represented from 27.1% to 39.3% of the total taxa per site. The highest number of taxa not identified to species level and therefore classified as unresolved came from molluscs, annelids and arthropods. Juvenile or non-reproductive specimens caused the majority (65%) of identifications not resolved to species level in the current survey. Fifteen percent of the unresolved identifications were a result of undescribed species having been collected.

Based on the current status classifications used by MLML/CDFG and the CANOD database, 6 of the species identified in the 2004 outer coast MLML/CDFG survey are listed as introduced. Four introduced species were identified in both the 2004 survey and the current 2007 MLML/CDFG outer coast survey: *Branchiosyllis exilis, Caulacanthus ustulatus, Lomentaria hakodatensis,* and *Sargassum muticum*.

Further literature research for additional reports of NIS in California would help refine the dataset generated by the current outer coast survey. Species lists generated by other researchers conducting experimental and monitoring studies in the outer coast habitats should be perused for the presence of introduced or cryptogenic species along the coastline. Taxonomic uncertainties should also be addressed by researchers and taxonomists whenever possible in order to reduce the number of unresolved and cryptogenic identifications, and to determine whether those taxa are native or introduced to California.

Finally, it should be stated that there are undoubtedly species that were missed in the survey. Some species may have been in microscopic or otherwise undetectable life stages during the time of sampling, whereas other species could be rare in abundance or established in areas that were not surveyed. Repeated sampling and further investigations into other existing datasets will add to the understanding of introduced species on California's outer coast.

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APPENDICES

Appendix A – Name, specialty and affiliation of taxonomists identifying specimens in the current survey.

Taxonomist Name	Specialty	Affiliation
Kelvin Barwick	Mollusca - identification of collected specimens	City and County of San Francisco, SFPUC, Natural Resources and Lands Management Division, SCAMIT
Christopher Brown	Porifera – identification of collected specimens	Independent Consultant
Don Cadien	Arthropoda – identification of collected specimens	Los Angeles County Sanitation Districts Marine Biology Laboratory, SCAMIT
Jack Engle	Field Taxonomist	University of California-Santa Barbara, MARINe
Jeff Goddard	Nudibranchs - identification of collected specimens	Marine Science Institute, University of California-Santa Barbara
Constance Gramlich	Marine Algae - visual surveys at some field sites	San Diego State University
Nick Haring	Echinodermata - identification of collected specimens	City of San Diego, Environmental Monitoring & Technical Services Laboratory, SCAMIT
Leslie Harris	Polychaeta - identification of collected specimens	Natural History Museum of Los Angeles County, SCAMIT
Gordon Hendler	Ophiuroidea - identification of collected specimens	Natural History Museum of Los Angeles County
Gretchen Lambert	Urochordata - identification of collected specimens	University of Washington-Friday Harbor Labs, SCAMIT
Welton Lee	Porifera - identification of collected specimens	California Academy of Sciences
John Ljubenkov	Cnidaria - identification of collected specimens	Dancing Coyote Ranch, SCAMIT
Valerie Macdonald	Oligochaeta - identification of collected specimens	Biologica Environmental Services Ltd., SCAMIT
Kathy Ann Miller	Marine Algae - identification of collected specimens and visual surveys at some field sites	University of California-Berkeley

Taxonomist Name	Specialty	Affiliation
Dorothy Norris	Polychaeta - identification of collected specimens	City and County of San Francisco, SFPUC, Natural Resources and Lands Management Division, SCAMIT
John Pearse	Field Taxonomist	Long Marine Laboratory, University of California-Santa Cruz
Tony Phillips	Nemertea & Platyhelminthes - identification of collected specimens	City of Los Angeles, Environmental Monitoring Division, SCAMIT
Rick Rowe	Polychaeta - identification of collected specimens	Polychaete Identification Consulting Services, SCAMIT
Eugene Ruff	Polychaeta - identification of collected specimens	Ruff Systematics
Jared von Schell	Crustacea - identification of collected specimens	Moss Landing Marine Labs
Greg Schroeder	Bryozoa - identification of collected specimens	Moss Landing Marine Labs
Jayson Smith	Field Taxonomist	California State University-Fullerton, MARINe
Peter Slattery	Crustacea, Other - identification of collected specimens	Moss Landing Marine Labs, SCAMIT
Timothy Stebbins	Mollusca - identification of collected specimens	City of San Diego Marine Biology Laboratory

Appendix B – Instructions sent to taxonomists identifying specimens from the field collections.

Introduced Species Surveys
Season 4: Outer Coast
Protocols for Taxonomic Identifications of Samples

Dear Taxonomists,

The goal of this project is to compile a list and measure the abundance of Non-Native Aquatic Species (algae and invertebrates) found California's outer coast. At each of the 22 coastal sites, we will conduct field surveys and collect samples from four habitat types: Rocky Intertidal, Sandy Intertidal, Rocky Subtidal (~30' deep in or near kelp forests) and Sandy Subtidal (~30' deep). We have quantitative samples collected from a known area as well as qualitative samples collected during a swimming search of the site. All samples collected in the field have been preserved, sorted into taxa, and are being sent to specialized taxonomists for identification.

In general, we ask each taxonomist to provide a list of species identified from each sample, to count non-native species in the quantitative samples and separate them into vials by species, and to provide up to date information about each species' introduction status (i.e. native, cryptogenic, introduced or unresolved). We provide a standardized Excel file with multiple tabs, one for entering species identification data for each sample, and another, called the 'Species Table,' where each taxonomist will maintain a taxa list and fill in information about each species they identify. Please read the "ReadmeInfo" tab on the excel file provided for more detailed instructions on using the datasheet. We may also send you photos taken of specimens before they were fixed.

In addition, under the terms of our contract we must archive all quantitative samples and create a voucher collection for non-native species found over the duration of this project. We ask that each taxonomist set aside and voucher examples of non-native species found in both quantitative and qualitative samples (including introduced, cryptogenic species and provisional taxa). Please see the "Voucher Collection Protocols" for more details.
If you are interested in retaining all or parts of samples please contact us. Once the voucher collection requirements are fulfilled, some samples may be dispersed amongst museums, etc as long as they can be tracked down in the future.

Please keep in mind that in order to determine whether specimens are native or not we strive to have these samples accurately identified to the lowest taxonomic level possible. We also urge you to recognize when specimens don't fit the description for species known from the region, rather than forcing an identification that may not be accurate. We encourage and support reaching out to other taxonomists, even internationally, whenever necessary to help finalize or confirm an identification, so please let us know if we can be of assistance in that respect.

Below is a more detailed list of what we need from you for each type of sample you may receive. Please identify each sample as either qualitative or quantitative by referring to the "Sample Type Code" column on the Chain of Custody (COC) spreadsheet provided. Please use the datasheet provided for entering all data, and feel free to contact us with any questions.

Qualitative Samples (visual site search collections). We need:
-A list of all species identified, with corresponding entries on your master taxa list
-Only vouchers need to be returned for the qualitative portion
-At least 2 voucher specimens returned to us for each non-native species (see detailed voucher protocol below)
-No count is necessary for qualitative samples
-You may keep or discard all native species and non-natives not vouchered from these samples as we will not archive qualitative samples

Quantitative Samples (Clearing/Grab/Holdfast collection from hard substrate or sandy cores). We need:
-A list of all species identified, with corresponding entries on your master taxa list
-A count for all introduced, cryptogenic and native species. If you count a subsample of what was sent to you, please indicate the % of the sample that you counted in the column provided on the datasheet.
-At least 2 voucher specimens returned to us for each non-native species listed (see detailed voucher protocol below)
- Return the remaining native and non-native species combined in the original sample jar for archival of quantitative samples (let us know if you need additional jars/vials). Make sure the jar is labeled with the subIDORG.

ISS Voucher Collection

With your help, we will create a voucher collection for native and non-native species found in the four year duration of this survey. The main purpose of this voucher collection is to provide evidence of what was identified in this survey, and to keep examples to re-examine in the future. Vouchers will be kept at Moss Landing Marine Labs, and may also be used for our own education and field identification skills. The collection will include introduced and cryptogenic species, as well as examples of any new or provisional species identified during this study. This collection may also include species identified and known with certainty to be native. If you are listing provisional names for specimens you identify, (such as *Onchidella* sp. A Smith), please provide both a vouchered specimen and a short description of the specimen. One exception is that we do not need vouchers of unresolved taxa that were so distinguished because samples were juveniles, too damaged to identify, or too poorly preserved. At least two vouchers are needed for each species (non-native, cryptogenic, new species and provisionals); these two sets will be stored and used by MLML and CDFG. Taxonomists will provide the appropriate voucher specimens separated out into vials, and MLML staff will properly label and organize the voucher collection.

For each introduced, cryptogenic, provisional or new species, we need:
-At least two specimens vouchered, placed in separate vials or jars, labeled with subIDORG number and final taxonomic identification. (Labeling specimens by subIDORG allows us to link it to the appropriate sample information)
-If significant morphological variations are observed among samples, additional specimens should also be vouchered to show these variations.

Sample Tracking

A Chain of Custody (COC) form will accompany each 'batch' of samples you receive from us. When you receive a package, please check that the contents of the package match what's listed on the COC, sign and date one COC copy and mail it back to MLML.

After identifications are completed for each sampling season, taxonomists will return to MLML all quantitative samples for the archive collection. The voucher collection is on-going through each season of sampling, so the entire set will be returned at the end of the project. Taxonomists may arrange to keep or donate some of these samples, but only after first providing vouchers for the MLML collection. Please contact MLML staff to get approval before retaining any samples for personal use or for depositing to a museum; we will need a list of samples (by subIDORG) as well as contact information that will allow us to relocate the sample in the future if necessary.

When you are ready to return samples to us (for voucher or archive collection), please complete a Return COC. You can contact our staff to discuss logistics for shipping the samples.

Missorts

When missorts (specimens not within your specialty) are encountered in the samples, please send them back to MLML as soon as possible so that we may get them out to the appropriate taxonomist in a timely manner. This will help keep the process of identifying samples and entering data on track. Send missorts early and often!

Data Tracking

As mentioned above, we have a standardized Excel file for all taxonomists to use when entering species identification and count data. The file has multiple tabs, some with explanations and instructions, and others for data entry. Please familiarize yourself with this file (either included on a CD in your package of samples or emailed to you) and let us know if you have any questions. Your cooperation with using the datasheet provided greatly simplifies uploading data into the database, reducing errors and improving data management on our end and is much appreciated.

Appendix C – Identification and introduction status updates made to species originally or currently reported as introduced from the 2004 MLML/CDFG survey of California's outer coast.

Species Name	Previous Introduction Status (Outer Coast 2004 Survey)	Updated Introduction Status	Status Determination Sources	General Reason for Status/ Name Change
Phylum Annelida				
Branchiosyllis exilis	Cryptogenic, Likely Introduced	Introduced	Cohen et al., 2005	Further literature review
***Dipolydora barbilla*	Introduced	Cryptogenic	L. Harris pers. comm. Feb. 15, 2008	Genetics work needed
***Harmothoe praeclara*	Introduced	Cryptogenic	L. Harris pers. comm. Nov. 2007	Further research needed
***Pseudopolydora paucibranchiata*	Introduced	Cryptogenic	L. Harris pers. comm. Feb. 15, 2008; See Light and Smith, 2007	Genetics work needed
***Vermiliopsis infundibulum*	Introduced	Cryptogenic	L. Harris, pers. comm., Oct. 20, 2007	Genetics work needed
Phylum Arthropoda				
***Eobrolgus spinosus*	Introduced	Cryptogenic	D. Cadien pers. comm. Apr. 21, 2008	Genetics work needed
**Gibberosus myersi* (Identification changed to *Gibberosus myersi* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. Feb. 10, 2008	Species Complex
**Ianiropsis serricaudis* (Reexamined and Identification changed to genus *Ianiropsis*)	Introduced	Unresolved	Reexamined by P. Slattery	Reexamined- Specimens were misidentified as *Ianirospsis serricaudis* in the OC 04 surveys, and identifications were changed to the genus level *Ianiropsis*.
**Pleurocope floridensis* (Reexamined and Identification changed to genus *Pleurocope* pending description of new species)	Introduced	Cryptogenic	Reexamined by D. Cadien	Reexamined- New species
***Pontogeneia rostrata*	Introduced	Cryptogenic	J. Carlton pers. comm. Dec. 2007; See also Carlton, 1996	Genetics work needed
**Sinelobus stanfordi* (Identification changed to *Sinelobus stanfordi* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. Oct. 22, 2007	Species Complex

Species Name	Previous Introduction Status (Outer Coast 2004 Survey)	Updated Introduction Status	Status Determination Sources	General Reason for Status/ Name Change
Phylum Cnidaria				
**Dynamena disticha* (Identification changed to *Dynamena disticha* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. Oct. 10, 2007; See Light and Smith, 2007	Species Complex; Genetics work needed
**Obelia dichotoma* (Identification changed to *Obelia dichotoma* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. Oct. 22, 2007	Species Complex; Genetics work needed
Phylum Ectoprocta				
***Alcyonidium polyoum* (Identification changed to genus *Alcyoniduim*)	Introduced	Unresolved	J. Ryland pers. comm. Jan. 2008; See Ryland and Porter, 2006	Genetics work needed
**Bowerbankia gracilis* (Identification changed to *Bowerbankia gracilis* complex)	Introduced	Unresolved Complex	J. Carlton pers. comm. Oct. 20, 2007	Species Complex
***Conopeum commensale* (Identification changed to genus *Conopeum*)	Introduced	Unresolved	J. Carlton pers. comm. Oct. 2007	Needs reexamination
Heteropora alaskensis	Introduced	Native	J. Carlton pers. comm. Nov. 2007	Possible Range Extension
Rhamphostomella gigantea	Introduced	Native	J. Carlton pers. comm. Nov. 2007	Possible Range Extension
Rhynchozoon bispinosum	Introduced	Native	J. Carlton pers. comm. Nov. 2007	Possible Range Extension
Tricellaria erecta	Introduced	Native	J. Carlton pers. comm. Nov. 2007	Possible Range Extension
Tricellaria gracilis	Introduced	Native	J. Carlton pers. comm. Nov. 2007	Possible Range Extension
Phylum Mollusca				
**Urosalpinx cinerea* (Reexamined and identification changed for all specimens originally identified as *U. cinerea,* see General Reason)	Introduced	Native, Unresolved (see comments under General Reason)	Reexamined by P. Valentich- Scott and J. Carlton	Reexamined- Specimens were misidentified as *Urosalpinx cinerea* in the OC 04 survey, and identifications changed to *Ocinebrina interfossa* (native), *Ocinebrina* (juvenile, unresolved) and *Nassarius* (juvenile, unresolved)

* Status change was the result of a species name change or change of identification.
**Specimens which need to be reexamined or have genetic work done to confirm ID

Appendix D - Sampling Site Locations.

Site Name	Habitat Type	Sample Date	Latitude DD	Longitude DD	Datum
Point Saint George	Rocky Intertidal	16/Jun/2007	41.78535	-124.25446	NAD83
Point Saint George	Sandy Intertidal	16/Jun/2007	41.78706	-124.25080	NAD83
Cape Mendocino	Rocky Intertidal	17/Jun/2007	40.34334	-124.36320	NAD83
Cape Mendocino	Sandy Intertidal	17/Jun/2007	40.35345	-124.36308	NAD83
Shelter Cove	Rocky Intertidal	18/Jun/2007	40.02107	-124.06948	NAD83
Shelter Cove	Sandy Intertidal	18/Jun/2007	40.02418	-124.06594	NAD83
Shelter Cove	Rocky Subtidal	08/Aug/2007	40.01954	-124.07303	NAD83
Shelter Cove	Sandy Subtidal	08/Aug/2007	40.02350	-124.06233	NAD83
Point Arena	Rocky Intertidal	03/Jun/2007	38.93777	-123.72985	NAD83
Point Arena	Sandy Intertidal	03/Jun/2007	38.86651	-123.65560	NAD83
Point Arena	Rocky Subtidal	09/Aug/2007	38.93943	-123.73394	NAD83
Point Arena	Sandy Subtidal	09/Aug/2007	38.95818	-123.73299	NAD83
Bodega	Rocky Intertidal	05/Jun/2007	38.31623	-123.07128	NAD83
Bodega	Sandy Intertidal	05/Jun/2007	38.31721	-123.07071	NAD83
Bodega	Rocky Subtidal	10/Sep/2007	38.31430	-123.07460	NAD83
Bodega	Sandy Subtidal	10/Sep/2007	38.31430	-123.07460	NAD83
Point Reyes	Rocky Intertidal	04/Jun/2007	37.90218	-122.72514	NAD83
Point Reyes	Sandy Intertidal	04/Jun/2007	37.90280	-122.72495	NAD83
Point Reyes	Rocky Subtidal	06/Mar/2008	37.99408	-122.97325	NAD83
Point Reyes	Sandy Subtidal	06/Mar/2008	37.99408	-122.97325	NAD83
Fitzgerald	Rocky Intertidal	02/Jul/2007	37.52322	-122.51832	NAD83
Fitzgerald	Sandy Intertidal	02/Jul/2007	37.52053	-122.51506	NAD83
Fitzgerald	Sandy Subtidal	30/Oct/2007	37.49444	-122.47266	NAD83
Ano Nuevo	Rocky Intertidal	01/Jul/2007	37.11242	-122.32932	NAD83
Ano Nuevo	Sandy Intertidal	01/Jul/2007	37.11596	-122.32227	NAD83
Ano Nuevo	Sandy Subtidal	28/Oct/2007	37.11434	-122.31856	NAD83
Pigeon Point	Rocky Intertidal	04/Jul/2007	37.18271	-122.39252	NAD83
Pigeon Point	Sandy Intertidal	04/Jul/2007	37.18309	-122.39181	NAD83
Pigeon Point	Sandy Subtidal	28/Oct/2007	37.18116	-122.39175	NAD83
Point Sur	Rocky Intertidal	05/Feb/2008	36.28088	-121.86382	NAD83
Point Sur	Sandy Intertidal	05/Feb/2008	36.28754	-121.86975	NAD83
Point Sur	Rocky Subtidal	14/Dec/2007	36.28399	-121.87346	NAD83
Point Sur	Sandy Subtidal	14/Dec/2007	36.28208	-121.86808	NAD83
Diablo Canyon	Rocky Intertidal	20/Jan/2008	35.21286	-120.86003	NAD83
Diablo Canyon	Sandy Intertidal	17/Jan/2008	35.27461	-120.88843	NAD83
Diablo Canyon	Rocky Subtidal	02/Oct/2007	35.21034	-120.86041	NAD83
Diablo Canyon	Sandy Subtidal	02/Oct/2007	35.20666	-120.85676	NAD83
Point Sierra Nevada	Rocky Intertidal	03/Jul/2007	35.73009	-121.31677	NAD83
Point Sierra Nevada	Sandy Intertidal	03/Jul/2007	35.69064	-121.28957	NAD83
Point Sierra Nevada	Rocky Subtidal	07/Sep/2007	35.63362	-121.18989	NAD83
Point Sierra Nevada	Sandy Subtidal	07/Sep/2007	35.63784	-121.18878	NAD83
Purisima Point	Rocky Intertidal	19/Jan/2008	34.75669	-120.63787	NAD83
Purisima Point	Sandy Intertidal	19/Jan/2008	34.73322	-120.61648	NAD83
Purisima Point	Rocky Subtidal	06/Sep/2007	34.74535	-120.63651	NAD83
Purisima Point	Sandy Subtidal	06/Sep/2007	34.70550	-120.61055	NAD83
Point Conception	Rocky Intertidal	18/Jan/2008	34.44582	-120.45897	NAD83
Point Conception	Sandy Intertidal	18/Jan/2008	34.44750	-120.45998	NAD83
Point Conception	Rocky Subtidal	08/Oct/2007	34.44731	-120.44434	NAD83
Point Conception	Sandy Subtidal	08/Oct/2007	34.44923	-120.44198	NAD83

Site Name	Habitat Type	Sample Date	Latitude DD	Longitude DD	Datum
Arroyo Hondo	Rocky Intertidal	09/Dec/2007	34.46040	-120.07569	NAD83
Arroyo Hondo	Sandy Intertidal	09/Dec/2007	34.46124	-120.07320	NAD83
Arroyo Hondo	Rocky Subtidal	08/Oct/2007	34.47191	-120.14616	NAD83
Arroyo Hondo	Sandy Subtidal	08/Oct/2007	34.47191	-120.14616	NAD83
Carpinteria	Rocky Intertidal	15/Jul/2007	34.38769	-119.51668	NAD83
Carpinteria	Sandy Intertidal	15/Jul/2007	34.38773	-119.51590	NAD83
Carpinteria	Rocky Subtidal	16/Aug/2007	34.39106	-119.54315	NAD83
Carpinteria	Sandy Subtidal	16/Aug/2007	34.39079	-119.52448	NAD83
Point Dume	Rocky Intertidal	16/Jul/2007	34.00867	-118.79386	NAD83
Point Dume	Sandy Intertidal	16/Jul/2007	34.01022	-118.79409	NAD83
Point Dume	Rocky Subtidal	14/Aug/2007	34.01154	-118.79040	NAD83
Point Dume	Sandy Subtidal	14/Aug/2007	34.01154	-118.79040	NAD83
Point Fermin	Rocky Intertidal	17/Jul/2007	33.70613	-118.28712	NAD83
Point Fermin	Sandy Intertidal	17/Jul/2007	33.70880	-118.28497	NAD83
Point Fermin	Rocky Subtidal	15/Aug/2007	33.70429	-118.28632	NAD83
Point Fermin	Sandy Subtidal	15/Aug/2007	33.70608	-118.28233	NAD83
Pin Rock	Rocky Intertidal	10/Dec/2007	33.42772	-118.50694	NAD83
Pin Rock	Sandy Intertidal	11/Dec/2007	33.43119	-118.50538	NAD83
Pin Rock	Rocky Subtidal	11/Dec/2007	33.42398	-118.50495	NAD83
Pin Rock	Sandy Subtidal	11/Dec/2007	33.42398	-118.50495	NAD83
Dana Point	Rocky Intertidal	18/Jul/2007	33.46080	-117.71554	NAD83
Dana Point	Sandy Intertidal	18/Jul/2007	33.46618	-117.71616	NAD83
Dana Point	Rocky Subtidal	15/Aug/2007	33.45652	-117.71609	NAD27
Dana Point	Sandy Subtidal	15/Aug/2007	33.45652	-117.71609	NAD83
Point La Jolla	Rocky Intertidal	07/Nov/2007	32.84386	-117.28029	NAD83
Point La Jolla	Sandy Intertidal	07/Nov/2007	32.84583	-117.27886	NAD83
Point La Jolla	Rocky Subtidal	06/Nov/2007	32.85315	-117.27684	NAD83
Point La Jolla	Sandy Subtidal	06/Nov/2007	32.85834	-117.26036	NAD83
Point Loma	Rocky Intertidal	08/Nov/2007	32.66616	-117.24450	NAD83
Point Loma	Sandy Intertidal	08/Nov/2007	32.66896	-117.24486	NAD83
Point Loma	Rocky Subtidal	06/Nov/2007	32.66115	-117.24869	NAD83

Appendix E – Number of species and percentage of total taxa for each site and habitat type sampled.

Site Name	Habitat Type	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Point Saint George	Rocky Intertidal	**155**		20 (12.9%)	80 (51.6%)		55 (35.5%)
Point Saint George	Sandy Intertidal	**21**		2 (9.5%)	12 (57.1%)		7 (33.3%)
Cape Mendocino	Rocky Intertidal	**77**		11 (14.3%)	39 (50.6%)		27 (35.1%)
Cape Mendocino	Sandy Intertidal	**7**			3 (42.9%)		4 (57.1%)
Shelter Cove	Rocky Intertidal	**94**		13 (13.8%)	57 (60.6%)	1 (1.1%)	23 (24.5%)
Shelter Cove	Sandy Intertidal	**25**		1 (4.0%)	18 (72.0%)	1 (4.0%)	5 (20.0%)
Shelter Cove	Rocky Subtidal	**163**	1 (0.6%)	25 (15.3%)	86 (52.8%)		51 (31.3%)
Shelter Cove	Sandy Subtidal	**30**		3 (10.0%)	13 (43.3%)		14 (46.7%)
Point Arena	Rocky Intertidal	**92**		11 (12.0%)	49 (53.3%)	1 (1.1%)	31 (33.7%)
Point Arena	Sandy Intertidal	**11**			9 (81.8%)		2 (18.2%)
Point Arena	Rocky Subtidal	**143**		23 (16.1%)	76 (53.1%)	1 (0.7%)	43 (30.1%)
Point Arena	Sandy Subtidal	**13**		1 (7.7%)	10 (76.9%)		2 (15.4%)
Bodega	Rocky Intertidal	**99**		11 (11.1%)	54 (54.5%)		34 (34.3%)
Bodega	Sandy Intertidal	**34**		3 (8.8%)	18 (52.9%)		13 (38.2%)
Bodega	Rocky Subtidal	**194**		25 (12.9%)	106 (54.6%)	1 (0.5%)	62 (32.0%)
Bodega	Sandy Subtidal	**83**		10 (12.0%)	27 (32.5%)		46 (55.4%)
Point Reyes	Rocky Intertidal	**84**		13 (15.5%)	46 (54.8%)		25 (29.8%)
Point Reyes	Sandy Intertidal	**32**		5 (15.6%)	15 (46.9%)		12 (37.5%)
Point Reyes	Rocky Subtidal	**77**		15 (19.5%)	35 (45.5%)	2 (2.6%)	25 (32.5%)
Point Reyes	Sandy Subtidal	**41**		5 (12.2%)	12 (29.3%)		24 (58.5%)
Fitzgerald	Rocky Intertidal	**124**		16 (12.9%)	70 (56.5%)		38 (30.6%)
Fitzgerald	Sandy Intertidal	**55**		7 (12.7%)	30 (54.5%)	1 (1.8%)	17 (30.9%)
Fitzgerald	Sandy Subtidal	**55**		9 (16.4%)	27 (49.1%)	1 (1.8%)	18 (32.7%)
Ano Nuevo	Rocky Intertidal	**122**		16 (13.1%)	68 (55.7%)		38 (31.1%)
Ano Nuevo	Sandy Intertidal	**19**			16 (84.2%)		3 (15.8%)
Ano Nuevo	Sandy Subtidal	**39**		6 (15.4%)	23 (59.0%)		10 (25.6%)
Pigeon Point	Rocky Intertidal	**87**		10 (11.5%)	42 (48.3%)		35 (40.2%)
Pigeon Point	Sandy Intertidal	**29**		3 (10.3%)	17 (58.6%)	1 (3.4%)	8 (27.6%)
Pigeon Point	Sandy Subtidal	**48**		6 (12.5%)	21 (43.8%)		21 (43.8%)
Point Sur	Rocky Intertidal	**98**		12 (12.2%)	61 (62.2%)		25 (25.5%)
Point Sur	Sandy Intertidal	**10**			6 (60.0%)		4 (40.0%)
Point Sur	Rocky Subtidal	**97**		12 (12.4%)	50 (51.5%)		35 (36.1%)
Point Sur	Sandy Subtidal	**42**		6 (14.3%)	26 (61.9%)	1 (2.4%)	9 (21.4%)
Diablo Canyon	Rocky Intertidal	**110**	1 (0.9%)	18 (16.4%)	56 (50.9%)		35 (31.8%)
Diablo Canyon	Sandy Intertidal	**11**			4 (36.4%)		7 (63.6%)
Diablo Canyon	Rocky Subtidal	**228**		34 (14.9%)	113 (49.6%)	3 (1.3%)	78 (34.2%)
Diablo Canyon	Sandy Subtidal	**95**		22 (23.2%)	41 (43.2%)		32 (33.7%)
Point Sierra Nevada	Rocky Intertidal	**130**		15 (11.5%)	67 (51.5%)		48 (36.9%)
Point Sierra Nevada	Sandy Intertidal	**18**		1 (5.6%)	8 (44.4%)		9 (50.0%)
Point Sierra Nevada	Rocky Subtidal	**163**		20 (12.3%)	88 (54.0%)	1 (0.6%)	54 (33.1%)
Point Sierra Nevada	Sandy Subtidal	**73**		6 (8.2%)	44 (60.3%)		23 (31.5%)
Purisima Point	Rocky Intertidal	**139**		17 (12.2%)	71 (51.1%)		51 (36.7%)
Purisima Point	Sandy Intertidal	**5**			2 (40.0%)		3 (60.0%)
Purisima Point	Rocky Subtidal	**75**		11 (14.7%)	38 (50.7%)		26 (34.7%)
Purisima Point	Sandy Subtidal	**54**		8 (14.8%)	31 (57.4%)		15 (27.8%)

Site Name	Habitat Type	Total Taxa	Introduced	Cryptogenic	Native	Unresolved Complex	Unresolved
Arroyo Hondo	Rocky Intertidal	**77**		11 (14.3%)	32 (41.6%)	1 (1.3%)	33 (42.9%)
Arroyo Hondo	Sandy Intertidal	**12**		1 (8.3%)	8 (66.7%)		3 (25.0%)
Arroyo Hondo	Rocky Subtidal	**223**	1 (0.4%)	26 (11.7%)	125 (56.1%)	2 (0.9%)	69 (30.9%)
Arroyo Hondo	Sandy Subtidal	**82**		13 (15.9%)	49 (59.8%)	1 (1.2%)	19 (23.2%)
Carpinteria	Rocky Intertidal	**162**		21 (13.0%)	84 (51.9%)	2 (1.2%)	55 (34.0%)
Carpinteria	Sandy Intertidal	**24**	1 (4.2%)	5 (20.8%)	13 (54.2%)		5 (20.8%)
Carpinteria	Rocky Subtidal	**164**		22 (13.4%)	95 (57.9%)		47 (28.7%)
Carpinteria	Sandy Subtidal	**73**		8 (11.0%)	42 (57.5%)	1 (1.4%)	22 (30.1%)
Point Conception	Rocky Intertidal	**81**		12 (14.8%)	44 (54.3%)		25 (30.9%)
Point Conception	Sandy Intertidal	**8**			6 (75.0%)		2 (25.0%)
Point Conception	Rocky Subtidal	**197**		24 (12.2%)	112 (56.9%)	2 (1.0%)	59 (29.9%)
Point Conception	Sandy Subtidal	**58**		9 (15.5%)	39 (67.2%)	1 (1.7%)	9 (15.5%)
Point Dume	Rocky Intertidal	**154**	1 (0.6%)	18 (11.7%)	89 (57.8%)	1 (0.6%)	45 (29.2%)
Point Dume	Sandy Intertidal	**20**		1 (5.0%)	11 (55.0%)	1 (5.0%)	7 (35.0%)
Point Dume	Rocky Subtidal	**181**		24 (13.3%)	93 (51.4%)	3 (1.7%)	61 (33.7%)
Point Dume	Sandy Subtidal	**47**		7 (14.9%)	29 (61.7%)	1 (2.1%)	10 (21.3%)
Point Fermin	Rocky Intertidal	**146**	2 (1.4%)	14 (9.6%)	71 (48.6%)		59 (40.4%)
Point Fermin	Sandy Intertidal	**27**		3 (11.1%)	14 (51.9%)	1 (3.7%)	9 (33.3%)
Point Fermin	Rocky Subtidal	**169**	1 (0.6%)	25 (14.8%)	89 (52.7%)		54 (32.0%)
Point Fermin	Sandy Subtidal	**98**		13 (13.3%)	56 (57.1%)	1 (1.0%)	28 (28.6%)
Pin Rock	Rocky Intertidal	**106**	2 (1.9%)	12 (11.3%)	54 (50.9%)		38 (35.8%)
Pin Rock	Rocky Subtidal	**204**	3 (1.5%)	17 (8.3%)	118 (57.8%)	1 (0.5%)	65 (31.9%)
Pin Rock	Sandy Subtidal	**59**		9 (15.3%)	33 (55.9%)	1 (1.7%)	16 (27.1%)
Dana Point	Rocky Intertidal	**154**	3 (2.0%)	14 (9.0%)	87 (56.5%)		50 (32.5%)
Dana Point	Sandy Intertidal	**16**		2 (12.5%)	11 (68.8%)	1 (6.3%)	2 (12.5%)
Dana Point	Rocky Subtidal	**166**		28 (16.9%)	95 (57.2%)	2 (1.2%)	41 (24.7%)
Dana Point	Sandy Subtidal	**64**		7 (10.9%)	40 (62.5%)	1 (1.6%)	16 (25.0%)
Point La Jolla	Rocky Intertidal	**105**	2 (1.9%)	8 (7.6%)	60 (57.1%)		35 (33.3%)
Point La Jolla	Sandy Intertidal	**9**			4 (44.4%)		5 (55.6%)
Point La Jolla	Rocky Subtidal	**196**	1 (0.5%)	31 (15.8%)	102 (52.0%)		62 (31.6%)
Point La Jolla	Sandy Subtidal	**38**		6 (15.8%)	22 (57.9%)	1 (2.6%)	9 (23.7%)
Point Loma	Rocky Intertidal	**119**	3 (2.5%)	15 (12.6%)	58 (48.7%)		43 (36.1%)
Point Loma	Sandy Intertidal	**21**		2 (9.5%)	10 (47.6%)		9 (42.9%)
Point Loma	Rocky Subtidal	**109**		12 (11.0%)	76 (69.7%)		21 (19.3%)

Appendix F – Cryptogenic species and unresolved taxa with 'likely' statuses that were identified in the current survey.

Species Name	Introduction Status	Cryptogenic	Likely Introduced or Likely Native
Phylum Annelida			
Apoprionospio pygmaea	Cryptogenic	13	
Arabella iricolor complex	Cryptogenic	6	
Arenicola cristata	Cryptogenic	2	
Aricidea (Acmira) catherinae	Cryptogenic	2	
Boccardia proboscidea	Cryptogenic	5	Native
Boccardia tricuspa	Cryptogenic	3	
Boccardiella hamata	Cryptogenic	5	Introduced
Branchiomaldane simplex	Cryptogenic	13	
Chaetozone bansei	Cryptogenic	5	Native
Chone eiffelturris	Cryptogenic	2	
Chone minuta	Cryptogenic	21	
Chone mollis sensu stricto	Cryptogenic	1	
Chrysopetalum occidentale	Cryptogenic	6	
Circeis armoricana	Cryptogenic	1	
Dipolydora bidentata	Cryptogenic	1	
Dipolydora giardi	Cryptogenic	2	
Dipolydora socialis	Cryptogenic	4	
Dispio uncinata	Cryptogenic	6	
Dodecaceria concharum	Cryptogenic	4	
Dodecaceria fewkesi	Cryptogenic	3	Native
Apoprionospio pygmaea	Cryptogenic	13	
Arabella iricolor complex	Cryptogenic	6	
Eteone dilatae	Cryptogenic	1	
Exogone lourei	Cryptogenic	19	Native
Glycera americana	Cryptogenic	5	Native
Glycera macrobranchia	Cryptogenic	13	Native
Glycera oxycephala	Cryptogenic	2	
Glycinde picta	Cryptogenic	7	Native
Goniada littorea	Cryptogenic	3	Native
Goniada maculata	Cryptogenic	3	
Harmothoe hirsuta	Cryptogenic	1	
Hemipodia simplex	Cryptogenic	8	
Heteropodarke heteromorpha	Cryptogenic	7	
Limnodriloides monothecus	Cryptogenic	1	
Lumbricillus lineatus	Cryptogenic	13	Introduced
Lumbrineris japonica	Cryptogenic	4	Native
Lumbrineris latreilli	Cryptogenic	1	Native
Mediomastus ambiseta	Cryptogenic	1	
Monticellina siblina	Cryptogenic	1	
Nereis mediator	Cryptogenic	14	
Nicomache personata	Cryptogenic	3	
Notomastus lineatus	Cryptogenic	2	
Notomastus tenuis	Cryptogenic	10	
Ophiodromus pugettensis	Cryptogenic	9	
Pettiboneia sanmatiensis	Cryptogenic	1	
Phyllodoce longipes	Cryptogenic	3	
Pista brevibranchiata	Cryptogenic	5	
Platynereis bicanaliculata	Cryptogenic	20	
Polydora websteri	Cryptogenic	2	

Species Name	Introduction Status	Cryptogenic	Likely Introduced or Likely Native
Prionospio heterobranchia	Cryptogenic	1	Introduced
Proceraea okadai	Cryptogenic	5	
Protolaeospira eximia	Cryptogenic	1	
Protolaeospira triflabellis	Cryptogenic	2	
Pterocirrus sp. A Harris	Unresolved	2	Native
Pygospio elegans	Cryptogenic	1	
Questa caudicirra	Cryptogenic	1	
Saccocirrus eroticus	Cryptogenic	3	Native
Salmacina tribranchiata	Cryptogenic	4	
Schistocomus hiltoni	Cryptogenic	13	
Scoletoma zonata	Cryptogenic	1	
Scoloplos armiger complex	Unresolved	12	Native
Simplaria pseudomilitaris	Cryptogenic	2	
Sphaerodoropsis biserialis	Cryptogenic	1	Native
Sphaerosyllis californiensis	Cryptogenic	16	
Spiophanes duplex	Cryptogenic	5	
Sthenelais verruculosa	Cryptogenic	2	
Syllis adamanteus	Cryptogenic	6	
Syllis elongata	Cryptogenic	14	
Thelepus setosus	Cryptogenic	1	
Thormora johnstoni	Cryptogenic	1	
Trypanosyllis sp. C Harris	Cryptogenic	1	
Tubificoides parapectinatus	Cryptogenic	5	Introduced
Phylum Arthropoda			
Aciconula acanthosoma	Cryptogenic	1	Native
Amathimysis trigibba	Cryptogenic	1	Introduced
Ammothea hilgendorfi	Cryptogenic	2	
Ammothella menziesi	Cryptogenic	6	
Ampithoe lacertosa	Cryptogenic	1	
Argissa hamatipes	Cryptogenic	3	
Aruga holmesi	Cryptogenic	3	Native
Boreosignum sp. IS 1 Cadien	Cryptogenic	2	Native
Caprella californica	Cryptogenic	13	Native
Caprella equilibra	Cryptogenic	2	
Caprella natalensis	Cryptogenic	4	Native
Caprella penantis	Cryptogenic	11	
Cerapus tubularis complex	Cryptogenic	3	Native
Cumella vulgaris	Cryptogenic	14	Native
Colomastix sp. A Cadien	Unresolved	1	Cryptogenic
Ericthonius brasiliensis	Cryptogenic	14	
Ericthonius rubricornis	Cryptogenic	1	
Ericthonius sp. IS 1 Cadien	Cryptogenic	1	Native
Eusiroides sp. A Cadien	Cryptogenic	3	Native
Foxiphalus	Unresolved	3	Native
Hemioniscus balani	Cryptogenic	1	
Heterophoxus	Unresolved	1	Native
Ianiropsis tridens	Cryptogenic	10	
Ischyrocerus anguipes	Cryptogenic	11	
Ischyrocerus pelagops	Cryptogenic	3	Native
Jassa carltoni	Cryptogenic	2	
Jassa morinoi	Cryptogenic	4	Native
Jassa slatteryi	Cryptogenic	9	
Laticorophium baconi	Cryptogenic	9	

Species Name	Introduction Status	Cryptogenic	Likely Introduced or Likely Native
Lepidepecreum magdalenensis	Cryptogenic	7	Native
Leptochelia dubia	Cryptogenic	18	
Leucothoe alata	Cryptogenic	2	
Macronassa macromera	Cryptogenic	12	
Macronassa pariter	Cryptogenic	2	Native
Melita sp. A Cadien	Cryptogenic	1	Native
Metatiron tropakis	Cryptogenic	1	
Microjassa litotes	Cryptogenic	3	Native
Munna chromatocephala	Cryptogenic	1	Native
Orchomenella pinguis	Cryptogenic	1	Native
Paraconcavus pacificus	Cryptogenic	1	Native
Paradella dianae	Cryptogenic	3	Native
Paratanais sp. IS 1 Cadien	Cryptogenic	2	Native
Podocerus brasiliensis	Cryptogenic	5	Native
Podocerus cristatus	Cryptogenic	9	
Pontogeneia rostrata	Cryptogenic	10	
Ptilohyale plumulosa	Cryptogenic	1	
Sarsiella sp. IS 1 Cadien	Cryptogenic	3	Native
Sphaeromatidae sp. IS 1 Cadien	Unresolved	1	Cryptogenic
Zeuxo maledivensis	Cryptogenic	2	Introduced
Zeuxo normani	Cryptogenic	7	
Phylum Chordata			
Aplidium sp. A Lambert	Cryptogenic	1	
Diplosoma listerianum	Cryptogenic	3	
Phylum Cnidaria			
Metridium senile	Cryptogenic	1	
Plumularia setacea	Cryptogenic	1	
Phylum Echinodermata			
Amphipholis squamata	Cryptogenic	7	
Ophiactis simplex	Cryptogenic	10	Native
Ophiopholis kennerlyi	Cryptogenic	4	
Phylum Ectoprocta			
Membranipora membranacea	Cryptogenic	5	
Membranipora tuberculata	Cryptogenic	6	
Phylum Mollusca			
Sphenia fragilis	Cryptogenic	4	
Phylum Nemertea			
Amphiporus angulatus	Cryptogenic	1	Native
Amphiporus bimaculatus	Cryptogenic	2	Native
Amphiporus cruentatus	Cryptogenic	1	
Amphiporus imparispinosus	Cryptogenic	11	Native
Cerebratulus marginatus	Cryptogenic	1	
Emplectonema gracile	Cryptogenic	6	
Micrura alaskensis	Cryptogenic	12	
Tetrastemma candidum	Cryptogenic	9	
Tetrastemma nigrifrons	Cryptogenic	9	Native
Zygonemertes virescens	Cryptogenic	12	
Phylum Platyhelminthes			
Acerotisa californica	Cryptogenic	1	
Phylum Porifera			
Clathrina coriacea	Cryptogenic	2	
Dragmacidon sp. 1 Lee	Cryptogenic	1	
Halichondria panicea	Cryptogenic	4	

Species Name	Introduction Status	Cryptogenic	Likely Introduced or Likely Native
Phylum Sipuncula			
Phascolosoma agassizii	Cryptogenic	19	
Thysanocardia nigra	Cryptogenic	1	