

Final Report to NOAA Community-Based Restoration Program

Monterey Bay *Undaria* Removal Project

January 28, 2009

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Part 1: Recent global and local history on the invasive Asian kelp *Undaria pinnatifida*

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Chapter 1: Recent global history of *Undaria*

Native geographic range

The Asian kelp *Undaria pinnatifida* (Harvey) Suringar is a brown alga (Figures 1-3) native to the Sea of Japan (Figure 4). The coastal waters in the Sea of Japan include Russia to the north, China and North and South Korea to the west, and Japan to the south and east. *Undaria* is most commonly found in Japan and both North and South Korea.

Biology and phenology

As a brown alga in the order Laminariales (the kelps), *Undaria pinnatifida* grows from an intercalary meristem located between the base of the blade and the top of the stipe. Sporophyte morphology varies by location (Castric-Fey et al. 1999a, Stuart et al. 1999). The typical form of *Undaria* in California consists of a small holdfast (<6 cm tall) with numerous small haptera, a short stipe (<20 cm), a highly folded and ruffled sporophyll (when mature) just above the holdfast, and a central stipe with a pinnate single blade (to 2 m) (Figure 1).

The heteromorphic life cycle alternates between a macroscopic sporophyte (spore-producing phase) and microscopic gametophytes (male and female producers of gametes). In Japan, sporophytes recruit in winter, mature in spring, and senesce in summer during peak water temperatures (Thornber et al. 2003). In California, non-perennial native kelps are all “summer annuals” that reproduce in the summer and senesce in the fall, then recruit the following spring after the gametophytes have over-wintered. *Undaria* is atypical as a “winter annual”, with gametophytes that over-summer instead of over-winter (Thornber et al. 2003). Being out of phase with native kelps could be a competitive advantage, since *Undaria* typically recruits early, grows rapidly, and can reduce available light by shading, thereby negatively affecting the recruitment of native algae.

The influence of temperature on growth rate varies by location, and optimal temperatures range from 0-14 °C (Skriptsova et al. 2004), but can be as high as 20 °C (Floc’h et al. 1991, Castric-Fey et al. 1999b). Silva et al. (2002) suggest temperatures along the eastern Pacific would allow expansion as far north as British Columbia. *Undaria* most often invades harbors and calm bays, which is likely a result of the vector of transmission (hull-fouling) rather than limitation by habitat type (Hay 1990). Growth on open coasts has been reported throughout the world (e.g., Hay and Luckens 1987, Floc’h et al. 1991, Campbell and Burrige 1998, Aguilar-Rosas et al. 2004). Conditions within Monterey Bay favor expansion of *Undaria* out of the harbor and onto the protected, rocky coastline of the Monterey Bay National Marine Sanctuary.

Commercial use

Commonly known as ‘wakame’, *Undaria* has been commercially grown in Japan and Korea since the 1940s (Yamanaka and Akiyama 1993), with annual harvests of 70-100,000 tons (Yoshikawa et al. 2001, Agatsuma et al. 2002). The kelp is grown for human consumption, serving as the main ingredient in miso soup and some seaweed salads. Extracts from the kelp are

also being tested for pharmaceutical applications. For example, Khan et al. (2008) used methanol extracts from *Undaria* to test for anti-inflammatory activity in mammalian tissues. In addition to human uses, *Undaria* is also grown as feed for commercially farmed abalone and urchins (Park et al. 2008).

Intentional introductions

Due to its commercial value, *Undaria* was intentionally introduced outside of its native range for cultivation (e.g., Brittany coast of France) (Figure 5). These commercial ventures generally failed (Hay 1990), but not because the kelp was unable to survive. In fact, 'escaped' individuals from these failed attempts at mariculture were blamed for the inadvertent introduction of *Undaria* to the coast of France (Castric-Fey et al. 1999). However, in most cases, humans have unintentionally mediated the global expansion of *Undaria* via transoceanic shipping and hull fouling (Hay 1990).

Current global distribution

Recently Silva et al. (2002) summarized the global spread of *Undaria*. It was first noted outside of Asia in 1971, when it arrived in Etang de Thau, a lagoon on the Mediterranean coast of France, presumably with a shipment of Pacific oysters. *Undaria* continued to spread throughout Europe, reaching the Atlantic coast of Spain in 1988, the lagoon of Venice, Italy in 1992, England in 1994, and spread northward to Belgium and the Netherlands by 1999 (Figure 5). Beyond Europe, it reached New Zealand in 1987, Tasmania in 1988, Argentina in 1992, and Australia in 1996. In 2000 it finally arrived to the United States at international shipping ports in southern California (Long Beach/Los Angeles).

Control attempts

Management efforts vary depending on the nature of the invasion and the country invaded. Australia and New Zealand, for example, have aggressive programs to prevent introductions, detect recent invasions, and rapidly respond to eradicate nascent populations. In New Zealand, the government directed the Ministry of Fisheries to develop a national pest management strategy for several of the most significant invasive species, including *Undaria*. They determined that "future decisions on the management of *Undaria* should be made in light of the relative threat it poses to the marine environment", and was given funding to establish "an appropriate framework for the management of *Undaria*." One outcome of this directive was a discussion paper on options for managing *Undaria* (Sinner et al. 2000), which outlines four options for managing *Undaria*, and a "do-nothing" option. *Undaria* has already invaded several open coast locations in New Zealand, making eradication unlikely. Rather than focusing on areas with *Undaria*, Sinner et al. (2000) proposed a strategy of targeting areas of high value that have not yet been invaded, and concentrating efforts to monitor, detect, and rapidly remove *Undaria* from these areas.

The Monterey Bay National Marine Sanctuary is certainly a "high value area", both for its unique natural characteristics and its economic importance (i.e. tourism and fishing) to the central coast of California. In order to assess the risk *Undaria* poses to the function and composition of these native communities, monitoring studies are needed. Developing an effective management strategy requires an understanding of how native species of algae, invertebrates, and fishes respond to *Undaria*. The lessons learned in central California will be informative for southern California, and likely apply to other regions of the world.

Successful eradication programs should have six requirements: 1) sufficient human and monetary resources; 2) clear lines of authority among management entities/agencies; 3) the target organism is susceptible to control measures; 4) re-inoculation is eliminated; 5) ability to detect target organism at low densities; and 6) restoration or management may be required after removal (Wotton et al. 2004).

Impact studies

The published literature on *Undaria* is primarily descriptive, highlighting new occurrences or reporting on its phenology and demography in recently invaded habitats. Few studies have assessed the impact of *Undaria* on native communities, in part because of the recent invasion of the kelp into these habitats and, in some cases, due to the lack of baseline data for comparisons before and after the invasion. In one of the few manipulative experiments designed to study the interaction of *Undaria* with native algae, Valentine and Johnson (2003) altered percent cover of native algae (100% removal vs. undisturbed control), spore availability (enhanced spore release from added adults vs. background levels), and location (two sites in Tasmania) in a fully factorial design. Disturbance was a key factor leading to the establishment of *Undaria*. Dormant gametophytes responded opportunistically to canopy removal and increased ambient light levels. In some cases *Undaria* declined and native species recovered, but the short duration of the experiment (two seasons) did not address whether continued disturbance is needed for long-term establishment.

Chapter 2: History of *Undaria* in Monterey Harbor

Initial discovery in Monterey Harbor

In August 2001 Dr. Pam Roe, while on a field trip with her students from CSU Stanislaus, noted *Undaria* growing in the Monterey Harbor, and alerted the MBNMS about the invader. Dr. Roe brings her marine biology class to the Monterey Harbor every other year, examines boat slips on H-tier and identifies and counts invertebrates and algae. Dr. Roe noted *Undaria*, all of which were roughly <30 cm (they were not measured) and did not see any mature *Undaria*. After seeing an article about *Undaria* in the MBNMS newsletter, Dr. Roe and her class began to work with MBNMS research intern Kelly Newton. In April 2002 Dr. Roe brought a class to the harbor after a rocky intertidal trip and collected 325 lbs of *Undaria* from the Monterey Harbor at H-tier, all of which were pre-reproductive. All of this work was done topside (i.e. without divers).

Survey to characterize extent of invasion in Monterey Harbor

In October 2002 two undergraduate research divers from the University of California at Santa Cruz began a senior thesis project to characterize the distribution of *Undaria* in the Monterey Harbor. In cooperation with the sanctuary and City of Monterey, the students sub-sampled the entire harbor over several weeks, using a stratified random sampling design. There are several types of man-made structure within the harbor that serve as substrate for the invader. The primary surfaces surveyed included boat hulls, all submerged portions of the floating docks, pier pilings, and cement walls and supports. Divers noted that neither *Undaria* nor native algae grew on the light-deprived bottom surfaces of the floating docks and boat hulls, but instead were most common on the sides of the docks and boats, where direct sunlight was available.

During the initial surveys 79 *Undaria* were found and removed (Figure 6). Based on these initial surveys, efforts were focused on B-tier, which had the highest initial infestation of the invasive kelp. In the Fall 2003 a topside survey of all floating docks indicated *Undaria* had spread widely throughout the harbor (Figure 7). It was at this stage that the MBNMS began to seek external funding to support more systematic removal efforts.

Diana Kohtio, a graduate student at Moss Landing Marine Labs, began to conduct research and assist with the management program in the spring of 2004. She completed her M.Sc. in the spring of 2008. Kohtio coordinated management and research efforts within the Monterey Harbor and was supported by the NOAA CRP grant.

Rationale for removal effort in Monterey Harbor

National regulatory directive

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 established an Aquatic Nuisance Species Task Force (ANSTF) to coordinate activities among Federal agencies and between Federal agencies, regional, State, tribal and local organizations involved in carrying out the Act. The mission of the ANSTF is to develop and implement a program for waters of the United States to:

- Prevent the introduction and dispersal of aquatic nuisance species;
- Monitor, control and study such species; and
- Educate and inform the public and stakeholders about ANS prevention and control.

In February 2002, the ANSTF developed a five-year Strategic Plan (www.anstaskforce.gov) as a road map to achieve four national goals, the second of which is to “minimize the harmful effects

of aquatic nuisance species already introduced into the waters of the United States.” The ANSTF recognizes that new non-indigenous species will invade U.S. oceans, despite the best prevention strategies. Once a species has been introduced and identified as “invasive” (i.e. causing or having the potential to cause ecological and/or economic harm), the ANSTF seeks to minimize harm to public interest priorities by preventing and controlling further spread, using environmentally sound methods. In addition to developing species-specific control plans, other important activities promoted by the ANSTF include survey and monitoring efforts, and research and education specifically related to monitoring and control.

Sanctuary regulatory directive

In 2009 the MBNMS updated its management plan, which is required by the National Marine Sanctuaries Act (16 U.S.C. §1434(e)) for all national marine sanctuaries, and ensures that each sanctuary properly conserves and protects its living and cultural resources. Issue selection was based on an extensive public process of scoping and issue prioritization. Twenty scoping meetings were held between November 2001 and January 2002, and the MBNMS received over 12,500 written comments. Invasive species was among the top ten issues. The working group was lead by a coalition of non-governmental agencies, researchers, and local authorities, including The Ocean Conservancy, Save Our Shores, Monterey Harbormaster’s office, Moss Landing Marine Lab, and Elkhorn Slough National Estuarine Research Reserve. As a result of this process, invasive species has been elevated to a priority issue for the MBNMS.

A 2009 MBNMS regulation prohibits introducing or otherwise releasing from, within, or into the Sanctuary an introduced species, except striped bass (*Morone saxatilis*) released during catch and release fishing activity. The regulation defines “introduced species” as (1) a species (including, but not limited to, any of its biological matter capable of propagation) that is non-native to the ecosystem(s) protected by the Sanctuary; or (2) any organism into which altered genetic matter or genetic matter from another species has been transferred in order that the host organism acquires the genetic traits of the transferred genes.

In addition to the new regulation, the MBNMS also developed an action plan to address introduced species through the efforts of an inclusive working group. This action plan provides guidance on future strategies and actions that the MBNMS and its partners might pursue to stem the tide of introduced species.

The goals of the MBNMS action plan on introduced species are to maintain the natural biological communities and ecological processes in the MBNMS; to protect them from the potentially adverse impacts of introduced species by preventing new introduced species from establishing in the MBNMS; and to detect, control (limiting the spread) and where feasible, eradicate environmentally harmful species that are introduced to the MBNMS waters.

Introduced species are a major economic and environmental threat to the living resources and habitats of the MBNMS and to the commercial and recreational uses that depend on these resources. Once established, introduced species are extremely difficult if not impossible to eradicate. Introduced species are an increasingly common global threat, and the rate of invasions continues to accelerate at a rapid pace. Although the open coast is resistant to invasions, estuaries are particularly vulnerable to invasion. Large ports, such as San Francisco Bay, can support hundreds of introduced species, many of which significantly impact native ecosystems.

There are a variety of terms used to describe introduced species. Some of the more common terms are exotic, invasive, alien, nuisance and non-indigenous species. This action plan generally uses the term “introduced” except when citing other authorities or when specifically

referring to introduced species that are known to have “invasive” characteristics (i.e., spread rapidly, out-compete native species and are likely to cause environmental harm). In using the term “introduced,” this action plan refers to species that have been moved dramatically beyond their original distribution by human activities. This plan is not intended to address gradual changes in species composition caused by climate change.

In general, introduced species in the marine and estuarine environment alter species composition, threaten the abundance and/or diversity of native marine species, especially threatened and endangered species, interfere with ecosystem function and disrupt commercial and recreational activities. Introduced species may cause local extinction of native species either by preying upon them directly or through competing for prey. For example, the European green crab, now found in Elkhorn Slough, both preys on the young of valuable species such as oysters and Dungeness crab and competes with them for resources. Introduced species may cause changes in physical habitat structure. For example, burrows caused by the isopod *Sphaeroma quoyanum*, originally from New Zealand and Australia, are found in banks throughout Elkhorn Slough and may exacerbate the high rate of tidal erosion in the Slough. Introduced species pose a significant threat to the natural biological communities and ecological processes in the MBNMS and may significantly impact threatened and endangered species. Introduced species also pose significant economic costs to industries such as water and power utilities, commercial and recreational fishing, and agriculture.

Scientific concern

The Invasive Species Specialist Group (ISSG), which is part of the International Union for Conservation of Nature (IUCN), hosts a Global Invasive Species Database (www.issg.org) listing the ‘100 Worst’ invaders. *Undaria* is listed because of its high reproductive capacity, rapid growth, and demonstrated ability to invade new sites all over the world. The ecological impact of *Undaria* varies depending on where it has invaded, but in general, removal of *Undaria* should benefit multiple species. *Undaria* competes for space and sunlight with native algae. Native algae competing with *Undaria* in the Monterey Bay National Marine Sanctuary include *Dictyoneurum californicum* and *Ulva* species. It is unclear how *Undaria* has affected benthic invertebrates, but both direct (e.g., overgrowth) and indirect (e.g., trophic changes, habitat structure) effects are likely. Quantitative research on the impacts of *Undaria* on native species is sorely lacking and desperately needed within the MBNMS.

The effects of *Undaria* are still largely unknown, but in some areas within the Monterey harbor it has already established itself as the dominant alga. As a numerically dominant alga, *Undaria* alters benthic habitat structure and may exclude native algae, which can in turn alter trophic linkages among herbivores and their predators. The potential for *Undaria* to significantly alter nearshore habitats is high and this threat has served as sufficient motivation for the past efforts of the Monterey Bay National Marine Sanctuary, Monterey Bay Sanctuary Foundation, and the City of Monterey, and particularly the Monterey Harbormaster’s office.

Control methods in Monterey Harbor

Since December 2002, volunteer divers have removed *Undaria* by hand and topside volunteers have used rakes to clear the sides of floating docks in Monterey harbor. The strategy is to remove all visible *Undaria* before they become reproductive, which is generally within two months of recruitment and at a total length of at least 75 cm. Identifying and manually removing individuals >30 cm is straightforward and quick for volunteers. However, for newly recruited

Undaria it is more difficult to differentiate them from similar-looking, young native kelp species (e.g., *Dictyoneurum* and *Macrocystis*). It is also time consuming for volunteer divers to remove the smallest (<5 cm) *Undaria* recruits and place them in collection bags. Once detached, these small individuals are difficult to handle, and move rapidly with the slightest water motion, much like a small feather in a slight breeze.

Since removal of small (<20 cm), pre-reproductive individuals (i.e. sporophylls absent) is difficult and time consuming, we investigated alternative methods to eliminating pre-reproductive individuals. We hypothesized that removal rates would be greatly increased if these individuals could be completely (or partially) removed and released into the water column instead of collecting and disposing them (the current method). Floc'h et al. (1991) and direct observations suggest reattachment and continued development by these fragments is unlikely. Therefore we designed two sets of field experiments to test whether pre-reproductive individuals that have been removed can:

- 1) re-attach and continue to grow (H_0 : *Undaria* will reattach and continue to grow);
- 2) continue to grow unattached (H_0 : *Undaria* will continue to grow); and/or
- 3) develop sporophylls and release spores (H_0 : *Undaria* will develop sporophylls).

Analyses of the results of field experiments are still underway, but qualitatively it appears that a holdfast without the meristem cannot continue to grow. However, pieces with the meristem intact (either the holdfast or the blade) can continue to grow and eventually produce sporophylls, but it is not known whether spores produced from these individuals are viable.

A proven eradication method used heated water to kill gametophytes on the hull of a sunken trawler. Water above 60 C for 5 seconds kills gametophytes of *Undaria* in the Chatham Islands, New Zealand (Wotton et al. 2004). Cleaning a single 40-m long, steel-hulled trawler cost NZ\$380,000 and NZ\$45,000 for monthly diver inspections over a 2 yr period from May 2001 to April 2003. They were able to successfully eradicate *Undaria*.

Monitoring the spread of *Undaria* within and beyond Monterey Harbor

Surveys were conducted within the harbor using a systematic sampling approach encompassing all habitat types and across all seasons. Within the general harbor area, most of the benthos is sandy with relatively little hard substrate. *Undaria* is unable to recruit to unconsolidated sediments. Rocks, which were rare, were found almost exclusively along the margin of the harbor. In addition to the rocks, pier pilings and other man-made structures serve as the primary hard surfaces suitable for *Undaria* attachment, so most survey efforts focused in areas with these hard substrates. Divers surveyed all depths (2-10 m) in the harbor using a timed search technique to maximize area covered. Once *Undaria* was found in a new area, divers intensively sampled the area with belt transects (if along the rocky margin) or sampled the entire structure (e.g., pier piling, sea wall) and all adjacent structures. These dives occurred monthly and included 2-4 divers. Due to the shallow depths and limited hard substrate, divers covered substantial distances.

California Department of Fish and Game (CDFG) divers surveyed beyond Monterey Harbor each October from 2004-2007. Divers searched the pilings of Wharf 1 and 2, the sea wall separating the marina from the outer harbor, Breakwater Cove Marina, and along the southern edge of the main breakwater. With the exception of the pilings under Wharf 1, *Undaria* was not found by the divers.

Part 2: Management of the invasive Asian kelp *Undaria pinnatifida*

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Chapter 3: Management overview of *Undaria*

NOAA HRC mission

The NOAA Office of Habitat Restoration “interacts with the NOAA Fisheries Regional Offices to manage, conserve and enhance habitats for fishery resources, protected species and other living marine resources.” (www.nmfs.noaa.gov/habitat) Within this Office, the Habitat Restoration Center (HRC) is devoted to “restoring the nation’s coastal, marine, and migratory fish habitats...work[ing] with a wide array of partners to restore mangrove, salt marsh, seagrass, oyster, coral reef, kelp forest, and river habitats.” (www.nmfs.noaa.gov/habitat/restoration) The UMP and HRC share goals of 1) engaging local community volunteers and encouraging stewardship of coastal habitats, 2) collaborating with public, private, and agency partners to leverage success, and 3) using monitoring to evaluate project success. The Monterey Bay Sanctuary Foundation worked closely with staff from the Monterey Bay National Marine Sanctuary and the Sanctuary Integrated Monitoring Network (SIMoN) to develop a proposal requesting matching funds from the HRC in 2004. The proposal was funded in March 2005 and supported the UMP through September 2008. This project can be found on the OHR site at: (http://seahorse2.nmfs.noaa.gov/hcrpdb_app/class/rcdb_abstracts.jsp?PROJECT_ID=1488)

Overview of project proposal

Programs funded by the HRC organize management actions and track effectiveness by using very specific project objectives. These objectives are either *structural* or *functional*, and each includes an action or desired output, a measurable target, and a timeline to reach that target. Structural objectives relate to the distribution, abundance or physical condition of organisms or discrete components of the environment. Structural objectives typically deal with physical aspects of the project (e.g., rebuilding physical habitat or restoring biogenic habitat). Functional objectives focus on the growth and response of populations or complexes within the environment; these are process-oriented objectives. This type of objective tracks how a population or system component responds to management actions (e.g., increased recruitment, increased percent cover).

Expected benefits

The expected benefits of *Undaria* removal include: 1) reducing the reproductive capacity of the extant population, 2) reducing the rate of spread within Monterey Harbor, 3) restoring the native community, and 4) reducing the risk of hull-fouling and subsequent spread to uninfected harbors to the north (e.g., Moss Landing, Santa Cruz, and Pillar Point harbors). Manual removal of *Undaria* is currently the only feasible method that can be used in Monterey Harbor. Removing individuals, especially those that have not yet released spores (each individual can release up to 100 million spores (CSIRO)), will dramatically reduce population growth and spread. In Tasmania at Tinderbox Marine Reserve, eradication was not achieved but removal efforts resulted in a significant reduction in sporophyte abundance as compared to untreated control areas (McEnulty et al. 2000). Ongoing removal efforts in New Zealand (costing

~NZ\$500,000/yr) target areas of high value (e.g., marine protected areas) or with intense vessel traffic, such as harbors, and have also shown lowered sporophyte numbers. In Monterey Harbor, the limited efforts thus far have significantly reduced the standing stock of sporophytes for short periods of time, but a sustained and systematic effort is needed to have lasting effects (Lonhart, pers. obs.).

Chapter 4: *Undaria* Management Program materials and methods

Diver equipment

- Divers provided all of their own SCUBA gear excluding air tanks.
- Mesh goodie bags (provided by project)
- Scraping tools (provided by project and harbor office)

Dockside equipment

- Meter tapes
- Underwater paper datasheet
- Clipboard and pencil
- Heavy duty trash bags

Removal sites and structures

To date, removal sites in the harbor were selected by sanctuary and harbor staff. After hiring Ms. Rita Bunzel as project coordinator, the harbor was systematically surveyed monthly through the entire harbor and all removal efforts tracked. There are three main types of structure that divers surveyed and managed within the marina of Monterey Harbor. The first consists of cement pier pilings at the end of the dock “finger.” These cement pilings have four sides and are usually in water ≤ 7 m deep. The entire submerged piling is searched for *Undaria*. Perpendicular to the main floating dock are “fingers” that create the boat slips (Figure 6). This second type of structure has a bottom (not sampled) and three sides (east, west, and tip). The third structure is the main dock itself, but only the portion between the fingers. To date, neither *Undaria* nor native algae have been found on the bottom of the floating docks (main or fingers), suggesting there is insufficient light for growth. After initial surveys, the bottom of the floating dock was not monitored.

Removal and sampling units

There are three main “sampling units”: fingers, main docks, and pier pilings. In this project a sampling unit is defined as the lowest level of area receiving removal treatments. There is a finite number of pier pilings and dock surfaces, most of which are clearly labeled with slip numbers. Furthermore, the entire harbor is mapped and most areas are numbered, providing spatial information exact to within a few meters. To compare density estimates between sampling units and through time, individuals removed from a given sampling unit were not mixed with *Undaria* from other sampling units. All individuals from a sampling unit are brought to the surface and measured for total length, evidence of damage, and reproductive status. However, not all sampling units were processed for data each time (e.g., if hundreds of *Undaria* were collected from one sampling unit, a subset of individuals was processed for data). Based on efforts to date, collecting data can be very time intensive. Typically data collection stops once 300 individuals have been processed.

Removal frequency

Based on the life cycle of *Undaria* in Monterey Harbor, monthly monitoring was the most appropriate frequency to count new recruits and to target subsequent removal areas with pre-reproductive individuals.

Removal methods

Pier pilings: Once divers were in the water, they carefully and methodically searched the four sides of the pier piling from top to bottom. All *Undaria* observed are removed completely (thallus and holdfast) by hand and placed into a goodie bag. Once a piling had been completed, and if the diver collected material, then the bag was brought to the surface and given to a dockside volunteer, emptied and the contents processed prior to disposing the kelp in a trash bag. If nothing was collected, the diver continued on to the next pier piling.

Finger and main dock procedure: Once divers were in the water, they carefully and methodically searched all three sides (east, west and tip) of the finger. All *Undaria* observed are removed completely (thallus and holdfast) by hand and placed into a goodie bag or immediately placed onto the surface of the finger above the attachment site. The dockside volunteer either emptied the bag and began processing *Undaria* or processed individuals as they were placed on the surface of the dock.

Removal effort measurements

Prior to disposing of the *Undaria* removed by the divers, dockside volunteers collected data on individuals including:

- Maximum length in cm (base of the holdfast to distal part of the thallus)
- Presence of damage (yes or no; typically at the apex)
- Reproductive status categories:
 - Sporophylls absent
 - Sporophylls present, spores not released (immature)
 - Sporophylls present, spores released (possibly mature)

A thin, light band along the margin of the sporophylls indicated spore release (Dr. Mike Graham, pers. comm.). For the purposes of this project, we used a conservative approach and assume that individuals are either immature (no evidence of spore release) or are releasing mature spores. There is some evidence that spores released initially are not viable (Diana Kohtio, pers. comm.).

Disposal of *Undaria*

Trash bags containing *Undaria* were placed in a dumpster at the harbor.

Tracking volunteer service

During the early phase of the project, volunteers checked-in at the Harbormaster's office upon arriving, received a complimentary parking pass and logged their starting time on personal, monthly logs provided by Ms. Tish Sammon, Community Resources Coordinator, Community Resources and Volunteer Services, City of Monterey. Volunteers also logged their ending time. Sheets were collected and processed by Ms. Sammon and her staff. Once Ms. Rita Bunzel came on board as the UMP Coordinator, she attended each volunteer event and kept track of volunteer time and effort. This method of tracking began in May 2006 and continued through September 2007.

Results

Soon after *Undaria* was discovered in the Monterey Harbor, several groups initially removed *Undaria* by hand (e.g., Dr. Roe's classes, harbor staff, sanctuary staff). However, to our knowledge, no records were kept on the number, sizes, or weight of kelp removed during

these initial efforts in 2002. Once the MBNMS became an active leader in management efforts (Fall 2002), records were kept for all *Undaria* removed. The rare exceptions included times when so many *Undaria* were removed that the sheer numbers overwhelmed personnel to count and measure each one; instead, several hundred were measured as a sub-sample and the total wet weight was estimated.

The MBNMS maintains an Excel database that includes a record for every individual measured. Fields within the record include: date, location (e.g., tier, slip number), structure type (e.g., dock, piling, hull), total length (cm), and reproductive status (e.g., juvenile, sporophyll lacking spores, mature sporophyll). This database began in December 2002 and continues to be maintained by sanctuary staff and volunteers. Between December 2002 and July 2008 17,522 individual *Undaria* have been manually removed, measured, and entered into the database (Figure 8). This spans 120 management events (i.e. days) over a 7.5 yr period. The NOAA CRP funding supported 69 events and accounted for the removal of 6,374 *Undaria* between May 2006 and July 2008.

Project Goal and Objectives

The *Undaria* Management Program (UMP) had one functional and two structural objectives. The overarching goal of the UMP is to control *Undaria pinnatifida* in Monterey Harbor using manual removal methods. The following objectives were designed to assist with achieving this goal, and the target values indicate progress through July 2008.

Objective 1 (structural): Reduce *Undaria* density by 50% in Monterey Harbor by March 2007.

Response variable: Number of *Undaria* in Monterey Harbor in fixed and random quadrats.

Target value: $\geq 50\%$ lower than starting value in March 2005.

Ideal value: 100% lower than starting value in March 2005.

Achieved value: 95% reduction (Figure 9).

Objective 2 (structural): The project will reduce the percent cover of *Undaria* by at least 33% by March 2007.

Response variable: Percent cover of *Undaria* in the harbor measured using fixed and random quadrats.

Target value: $\geq 33\%$ lower than starting value in March 2005.

Ideal value: 100% lower than starting value in March 2005.

Achieved value: 88% reduction (Figure 10).

Objective 3 (functional): Reduce total spore production of *Undaria* by at least 25% by March 2007.

Response variable: Number of *Undaria* removed that did not release spores.

Target value: $\geq 25\%$ lower than starting value in March 2005.

Ideal value: 100% lower than starting value in March 2005.

Achieved value: 97% reduction (Figure 11).

Part 3: *Undaria* Monitoring Program (UMP)

Rita Bunzel

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Chapter 5: Volunteer and citizen scientist component of the UMP

Introduction

The Sanctuary Integrated Monitoring Network (SIMoN) at the Monterey Bay National Marine Sanctuary (MBNMS), the California Department of Fish and Game (CDFG), and the City of Monterey's Volunteer Services and Office of the Harbormaster collaborated on the development and implementation of a comprehensive monitoring and management program for the invasive Asian kelp *Undaria pinnatifida* in Monterey Harbor. The *Undaria* Monitoring Program (UMP) raises awareness about *Undaria* in particular and invasive species in general while simultaneously demonstrating the value of community involvement in resource protection.

A native of Japan, *Undaria pinnatifida* was first noted in the Monterey Harbor in August 2001. However, it was not until fall 2002 that a concerted effort to study, and if possible, remove the seaweed was undertaken. This was led by staff from SIMoN and MBNMS. From winter 2002 until spring 2006 volunteer removal efforts and mapping surveys were sporadic, occurring every other month. With funding from the NOAA Restoration Center the *Undaria* Monitoring Program (UMP) was developed in 2006 and Ms. Rita Bunzel was hired as the UMP Coordinator. The UMP implemented a comprehensive management plan that included volunteer recruitment, education, and outreach. The program organized regularly scheduled monitoring and management events, enlisting the help of volunteers from school groups, corporate groups, SCUBA clubs, youth clubs, non-profit organizations, and numerous concerned citizen stewards. From May 2006 to May 2008, the UMP registered 142 volunteers who have accumulated 1393 volunteer hours at 78 scheduled public and group monitoring events that include 15 high school group events, 11 college group events, and 3 corporate group events. The efforts of these volunteers contributed to a significant decrease in the density of *Undaria* found in Monterey Harbor.

The UMP Coordinator presented at 16 special public or private events (Table 1). Program materials were disseminated during these presentations and to academic institutions, state agencies, non-profit organizations, local businesses, SCUBA clubs, media outlets, and concerned citizens.

Formal contact with the public

The UMP Coordinator educated and recruited volunteers with informational presentations, informal public discussions, by providing individual and group science projects, and through print media announcements. Individually tailored program presentations were provided to groups that include local schools such as Santa Catalina, Pacific Grove and Monterey High Schools, informal and formal science education programs like the Monterey Bay Aquarium's Young Women in Science (Figure 12) and Marine Advanced Technology Education (MATE), religious service groups, corporations, SCUBA clubs, senior centers and members of the Vans Warped Tour (Figure 13). Program presentations ranged in duration from 20 minutes to 60 minutes depending on the desired goal of the presentation. Group sizes range from 5 to 55 individuals.

Informal contact with the public

The Monterey Harbor, field site for the project, is located in a high tourist and public foot traffic area. This gives the program visibility that provides a great opportunity to engage the public (both residents and tourists) in discussions and encourage individuals to become stewards of our marine environment. These discussions were typically unplanned events that took place at the field site. However, on at least a dozen occasions, the UMP Coordinator engaged in public discussions at restaurants, community events, recreational areas, and in other coastal locations. The groups ranged in size from as few as 2 individuals or as many as 10. Many were families, local or visiting boaters, tourists or students that engaged in a 10-20 minute discussions. Discussion topics included the natural history of *Undaria*, its global spread, the UMP, and volunteer opportunities.

The UMP partnered with biology programs at local high schools and colleges to provide structured science field projects for groups and individuals. These field projects varied in the degree of difficulty and duration, depending on the academic goal and the age, knowledge and skill level of the student. There were 6 special field projects that were conducted by college students from the Marine Advanced Technology Education (MATE) program at Monterey Peninsula College and by high school students at Monterey and Santa Catalina High Schools.

Education and outreach materials

UMP education and outreach materials were distributed at all presentations and discussions (Table 2). The UMP Coordinator developed a comprehensive set of materials to aid volunteers in understanding the natural history and identification of *Undaria* and to provide informational materials to boaters, academic institutions, local businesses, non-profit organizations and concerned citizens. These materials include:

- Recruitment and information flyers
- Identification cards
- *Undaria* pressings for identification
- Life stages reference guide for volunteers
- Handout of frequently asked questions
- Volunteer forms: groups hold harmless and sign in sheets, questionnaires, medical history forms and liability releases, volunteer recognition certificates
- Program forms: operations manual, volunteer position descriptions, safety checklist, parking forms, incident reports, SCUBA tank fill cards, data sheets

All of these UMP materials have been packaged as a template and were distributed to the Ventura Harbormaster and the Channel Islands National Marine Sanctuary in 2007 to assist in developing an *Undaria* Monitoring Program in their own harbor.

In addition to distributing program materials during public events, presentations and discussions, the UMP Coordinator notified partner organizations like Surfrider Foundation, Bay Net and Blue Planet Divers of public monitoring days via email. This method was effective in securing groups of volunteers, student volunteers and SCUBA diving volunteers. Program flyers distributed and placed in local marine businesses, at academic institutions and at local public notice boards also served to broadcast *Undaria* information and public monitoring events. Several of the program partners also disseminated program information and recruited volunteers through their website links. These website links include: the Sanctuary Integrated Monitoring Network (SIMoN) at <http://sanctuarysimon.org/monterey/sections/other/invasives.php>, the City

of Monterey at <http://www.monterey.org/volunteer/> and blueplanetdiver.org. Print and television media exposure was key in disseminate program information regionally. Television (KTVU) and newspaper coverage (Monterey County Weekly and Monterey Herald) highlighted the public monitoring events and community participation, which helped stimulate volunteer enrollment in the program from as far as San Francisco. Local SCUBA clubs and partner organizations regularly include program announcements in their quarterly newsletters (Bottom Timers, Otter Limits, Compass) and forward public monitoring date announcements to their members.

Chapter 6: *Undaria* Management Program administrative protocols

Below is a summary of the administrative protocol used to support the operations of the *Undaria* Management Program (UMP). This serves as a summary of past experiences and a guide for future management operations of the UMP and is based on the experiences of Rita Bunzel, UMP Coordinator from 2006-2008.

Partnerships

The *Undaria* Management Program (UMP) is a collaborative effort between the Monterey Bay National Marine Sanctuary (MBNMS), the City of Monterey and the California Department of Fish and Game. The UMP Coordinator and MBNMS staff run day-to-day operations for the program and supervise topside and SCUBA diving volunteers. The City of Monterey provides support to the UMP through volunteer referrals, distribution of program materials, and through the unlimited access they provide to the study site via the Office of the Harbormaster. The California Department of Fish and Game supports removal efforts by providing MBNMS staff with a memorandum of understanding to handle an invasive species, scientific collecting permits, and diver support once per year. The outreach activities are currently supported by a grant administered by the Monterey Bay Sanctuary Foundation.

Field materials

UMP materials can be divided into outreach materials and field equipment. Specific event materials and volunteer forms are also provided regularly to partnering institutions and are currently kept in the Monterey office of the Monterey Bay National Marine Sanctuary. Field equipment is cleaned and maintained by the UMP Coordinator. Small equipment (e.g., slates, tapes, mesh collection bags) is currently stored in the Monterey office of the sanctuary. Large pieces of field equipment (e.g., garden rakes, trash bags, carts, and scrapers) are stored in the maintenance area at the Office of the Harbormaster.

Database

An excel database was created to manage the information as part of the UMP. This database was maintained regularly by the UMP Coordinator and contains the following:

- Partners - Names and contact information, type of partnership, dates of activities
- Volunteer Contact Info - Name, address, phone, email, volunteer position, completed forms on file, hours contributed
- Material Distribution - The where, when, what for the distributed of the program materials
- Presentations - Organizations name, number in group, when, where and how long.
- Program Event Dates - Dates, names of participants, area surveyed, total volunteer hours (Table 3)
- Finances - monthly accounting for the program
- Funding - Potential funding sources along with contact information and communication records

Volunteer forms

Volunteer forms must be completed to participate in UMP activities. The forms vary for volunteer positions and organized group events (see breakdown below). Volunteer information

is entered into a database managed by the UMP Coordinator and the forms are photocopied - one set remains with the UMP Coordinator and the other set is sent to the partner that is accepting liability for the volunteer (i.e. either MBNMS or the City of Monterey). Dockside volunteers are covered by the City of Monterey, so their forms are submitted to Ms. Tish Sammon, Director of the Volunteer Services Office, City of Monterey. SCUBA divers are covered by MBNMS and their forms are submitted to Ms. Karen Grimmer, Deputy Superintendent at the MBNMS. A NOAA Request for Personnel Action Form is completed internally by MBNMS staff and is then submitted to headquarters in Washington, DC. This action opens a NOAA volunteer file and covers the diver for workman's compensation insurance in the event of a diving accident. Participants 18 years and younger, that are not part of an organized group, must have a parents or guardians signature to participate. Forms are distributed electronically to potential volunteers via email and through list serves with partnering institutions. Hard copies are provided on-site at each monitoring event. Required forms are listed below.

Dockside volunteers:

- Volunteer interest questionnaire
- City of Monterey General Liability Release

SCUBA diving volunteers:

- Volunteer SCUBA diver questionnaire
- Volunteer SCUBA diver medical history form
- NOAA Volunteer Service Agreement
- NOAA Waiver of compensation
- NOAA Request for Personnel Action
- Copy (front/back) of SCUBA certification card

Groups or special events:

- City of Monterey Release from Liability and Hold Harmless Agreement - signed by representative of group
- Special event sign-in form

Monitoring events

Public monitoring event announcements are distributed 7-10 days prior to the event date. Announcements are distributed to potential volunteers electronically through email notices from partner institutions, flyer postings in the local area, and email announcements to concerned and interested students, local citizens, academic groups, clubs, and non-profit organizations. The email announcement contains the what, when and where for the event and importantly requests an RSVP by potential volunteers. All email announcements contain attachments with the volunteer forms. Volunteers are asked to prepare the forms in advance of the meeting date. These same forms are also available on-site the day of the event.

Monitoring events are divided into three main components: paperwork, training and fieldwork.

Paperwork

UMP events begin with meet and greet period. After volunteers complete forms the safety protocol procedures are reviewed. In addition, a brief UMP history is presented.

Training

After completing the necessary paperwork, volunteers are given an introduction to the natural history of *Undaria* and UMP efforts. Then volunteers are trained to collect data, identify *Undaria*, how to manually remove it, and if divers are present, the harbor diving protocol is reviewed.

Fieldwork

When available, SCUBA divers begin surveying pilings, removing all *Undaria* encountered. Dockside volunteers support divers, record data, and survey the submerged surfaces of pilings, using rakes to remove *Undaria* as needed.

Debriefing (optional)

After activities have concluded dockside, the group can re-assemble to discuss the day's events, take pictures, record dive information, and debrief with the UMP Coordinator.

Safety

UMP field operations fall under the purview of the City of Monterey, Office of the Harbormaster. The UMP Coordinator is trained in harbor safety protocol and acts as a representative of the City of Monterey. During the safety protocol briefing the UMP Coordinator reviews the Volunteer Safety Checklist and has all participants initial that they have been provided, understood and will comply with all safety protocols. A first aid kit is on hand dockside in the event of a minor injury and more extensive medical aid is available at the Harbormasters Office. The UMP Coordinator carries a cellular phone dockside at all times to respond quickly in the event of serious injury or accident. A City of Monterey Accident Report must be completed for injuries or accidents occurring dockside. Diving incidents must be reported to both the City of Monterey and MBNMS as soon as possible. The UMP operates with a diving emergency plan for the Monterey Harbor.

Field gear

The program operates with a basic set of gear.

- Metric measuring tapes - water resistant and/or water proof preferred
- Clipboards and pencils
- Underwater mesh collecting bags - 2 small bags with metal jaw opening
- 5-pronged garden rakes (provided by Harbor Master)
- Gear tub - to hold items listed above and a first aid kit, water, sunscreen, etc.
- *Undaria* pressings (all stages of development) used as teaching tools in species identification

The program was loaned (4) SCUBA tanks and provided them to volunteers wishing to dive but without their own tanks. This option is less expensive than renting SCUBA cylinders for volunteer divers—the only expense incurred is the air fill and the annual visual inspection.

Volunteer recognition

Recognizing volunteers for their contributions is an important part of the UMP. We recognize our volunteers with certificates of participation, pre-printed, re-usable grocery bags

(provided by the MBNMS) and MBNMS volunteer pins. In addition, some volunteers are nominated and attend the Annual Sanctuary Volunteer Awards Reception and the City of Monterey Volunteer Appreciation Day.

Outreach

Outreach and recruitment activities are conducted regularly for both formal and informal education programs, recreational clubs and interested individuals. The UMP seeks volunteers of all ages and backgrounds. Although there is no minimum age requirement to participate in the program, in general kids ≥ 12 years old do best with the activities. Outreach to academic institutions is primarily focused on local high schools and selected college science classes. The UMP offers students and educators a tailored presentation to their group, special class projects, mentoring programs, and community service hours. Youth clubs, after school programs, and summer camps often have interest in presentations and volunteer group activities. SCUBA divers are recruited using several methods. The UMP Coordinator sends announcements to SCUBA diving clubs, distributes program flyers to local dive shops, has web links and announcements distributed in partner newsletters, and utilizes partner list serves to send program flyer announcements.

Chapter 7: Volunteer recruitment plan

Overview

The Monterey Bay National Marine Sanctuary and the City of Monterey created a citizen-based science program to monitor and manage the Asian kelp *Undaria pinnatifida* from the Monterey Harbor. This citizen-based program is an effort to engage the local community in actively participating with conservation and restoration efforts by the Office of National Marine Sanctuaries, to build on the work of local scientists, and to support efforts to actively manage this invasive seaweed.

Informational presentations

Presentations are a simple means of targeting small groups of individuals capable of engaging in volunteer activities. The UMP Coordinator contacted school groups, dive clubs and community organizations via email announcements, mailings and poster displays to solicit interest in receiving an informational presentation on the marine invasive seaweed and how they can help. Presentations were adapted to the group for which the presentation was given. PowerPoint presentations included background info/overview, natural history of the species, biology and characteristics (illustrations, images), distribution, current science, and volunteer roles.

The list of school groups, dive clubs and community organizations contacted include:

- Monterey Bay SCUBA diving clubs
- Monterey Institute of International Studies – Environmental Club
- Marine Academy of Ocean Science – Monterey High School
- Santa Catalina School
- Robert Louis Stevenson School
- Carmel High School
- City of Monterey, Senior Center
- Girl Scouts of Monterey Bay

Print material distribution

Notices were strategically placed in high visibility sites at the Monterey Harbor to notify boaters and harbor users about the invasive seaweed and how they can participate in the program. Similar notices were made available at local dive shops, schools, and at interested local organizations and institutions.

The UMP collaborated with supporting local businesses, organizations and institutions to leverage program announcements through their membership newsletters. For example, the Monterey Harbor distributes a newsletter quarterly. The UMP information was included in the fall newsletter.

Web-based announcements

The Monterey Bay National Marine Sanctuary and the City of Monterey both maintain extensive websites with opportunities for program announcements. In particular, SIMoN (Sanctuary Integrated Monitoring Network) maintains general information on the UMP (see: http://sanctuarysimon.org/monterey/sections/rockyShores/project_info.php?projectID=100184&sec=rs).

Chapter 8: Lessons learned and recommendations

Based on the 2-yr experiences of the UMP Coordinator, there are several recommendations related to continuing and improving up on the program:

- The study site at the Monterey Harbor covers a large area, which caused difficulty for one staff person to oversee and manage the program activities at multiple locations within the harbor. At least 2 topside trained staff should be available when working with group events exceeding 7-8 individuals or when more than 4 SCUBA divers are scheduled. Often researchers and veteran volunteers were enlisted to help manage larger groups of volunteers. I recommend that the UMP create an internship (paid or unpaid) whereby a high school or college student can gain valuable experience working on a scientific education and outreach project and the UMP gains dedicated support to conduct management activities safely.
- UMP volunteers were restricted to working in areas of the harbor that can be accessed by walking on floating docks. However, there are many areas of the harbor where *Undaria* removal is difficult, if not impossible, without the aid of a support vessel. On several occasions, the Monterey Harbor Department provided support with *Undaria* removal in these locations (harbor break wall and entrance, Fisherman's Wharf pilings) that required surface support for SCUBA divers. These areas continue to be surveyed sporadically because access is limited by the availability of Harbor Department staff to operate the boat. Securing access to a small rented or borrowed vessel to monitor and conduct removal of *Undaria* at these hard to reach areas outside the main harbor area would aid the project in conducting more systematic surveys and further the containment of the species in the harbor proper.
- It is recommended that scheduling for public monitoring and removal events correlate to high growth and recruitment periods for *Undaria*. Event dates should be strategically scheduled during high *Undaria* recruitment periods and be scheduled at intervals of 4 to 6 weeks to ensure consistent removal efforts during critical growth period.
- The program gear and supplies initially purchased should be replaced every two years. Below is a recommended list of the gear to purchase for future program operations.
 - Metric measuring tools (e.g., meter tapes)
 - Water-resistant/proof clipboards and writing tools
 - 4 small collecting mesh bags & 2 large collecting mesh bags with metal jaw openings
 - Scraping tools
 - O₂ Kit for diving operations (UMP Coordinator must be DAN-certified)
 - 4 SCUBA tanks
 - SCUBA tank air fill card
 - Small folding outdoor table
 - Harbor access key for mens & womens bathrooms
 - Misc. supplies: sunscreen, scissors, rubber bands, o-rings, pencils, small white board w/pens, stick-on name tags
 - Wet gear tub
 - Weather resistant, portable file case

- Local researchers (graduate and undergraduate students) and public volunteers worked closely to support the UMP. This was a very positive attribute of the program. Volunteers get to work side by side with scientists in the field, helping them collect data, while researchers develop skills communicating with the public about scientific and environmental processes. These researchers provided a wealth of knowledge for the volunteers and acted as mentors for many of the high school-aged students. This diversity of staff translated to a richer experience for the volunteers. I recommended always having the elements of research and outreach working closely together and I suggest making it a requirement of new researchers to participate in outreach activities.
- Finally, the UMP is now more established and capable of sharing ideas and information in a larger forum. I suggest extending opportunities to the UMP Coordinator to attend and present program information at applicable workshops and conferences. The networking opportunities these conferences offer are extremely valuable. It gives the program exposure, opens the door to partnerships and collaboration opportunities and extends the MBNMS mission of education.

Operations

Wish List

- Create a Thank You Volunteers BBQ and awards event for the program volunteers
- Create an *Undaria* Management Program t-shirt given to volunteers who participate a specified number of hours
- Small vessel to monitor and conduct removal of *Undaria* at specific locations outside the main harbor area
- *Undaria* Management Program banner for use during field work
- Create an *Undaria* Management Program poster for distribution

Program registration

Public monitoring events are set three months in advance and email announcements are sent generally 1-2 weeks prior to the event. The public is requested to RSVP for the event. Based on the response size of the volunteers, the monitoring area is identified for the event. This advanced planning works great if the volunteers show up. However, this isn't always the case. Frequently, volunteers sign up then can't make it - yet they fail to notify staff. This is naturally part of the beast when running a volunteer program. Although there is not a perfect solution, I recommend altering the registration methods so individuals can register on-line or via email months in advance of the public event. An email reminder can then be sent out to registered participants. Participants have plenty of time to plan, mark their calendar, and follow up if they need to cancel well in advance of the monitoring events.

I also recommend altering the schedule of public monitoring and removal events from monthly events to dates that correlate better to high growth and recruitment periods for *Undaria*. These more focused events could be larger in size and would probably be all day events versus the current half-day events. Event dates would be strategically scheduled during high *Undaria* recruitment periods and be scheduled at intervals of 4 to 6 weeks to ensure consistent removal efforts during the critical time period. During low *Undaria* recruitment periods when the school year is in session we can focus more energy on volunteer efforts with school groups and youth programs while they are in session and less on public events. Then as *Undaria* growth patterns

increase we begin hosting the larger full-day monitoring events. I believe this adaptive management of the program opens up the opportunity to focus efforts on outreach to school and youth groups during the school year when they are organized.

Group monitoring activities usually involve volunteers working dockside so they fall under the jurisdiction of the City of Monterey. A group representative signs the Group Hold Harmless and a group sign in sheet is provided for volunteer registration. The group sign-in sheet doesn't capture all the detailed contact information and in many cases not all of the volunteers register. So that volunteer records are accurate, I suggest the volunteer group manager now provide a list of participants and contact information (preferably in advance) and that we work with the City of Monterey to re-design a new group sign in sheet and process.

The program has been operating in the harbor regularly for the last year and naturally since we are in a public area the UMP Coordinator and research staff have high public exposure. During public monitoring days both volunteers and interested citizens have a difficult time identifying who's in charge and worse yet believing us. When working with large groups this becomes even more of a problem. The UMP Coordinator and on-site staff should have uniforms to identify themselves to the general public and during monitoring events. The uniform can consist of either a program-designed shirt or a MBNMS staff shirt. Since we work year round in the harbor a logo ball cap and jacket would also be recommended.

Website

To date, the program has had (1) volunteer recruited to the program from the website. When volunteers were queried most responses were that the program information on the website was extensive and informative but the information on volunteering was buried. Depending on the restrictions in place with the agencies web design criteria, I believe there is potential to create a more volunteer user-friendly site. In addition, I would like to create electronic sign-up sheets for monitoring events. Volunteers can sign up and see their name registered for public monitoring days. Pre-registering for an event seems to make volunteers more likely to show up and attend the event. The program materials and forms on the website should be identified more clearly. Program flyers should be updated regularly as well as future program dates. Most importantly, and without delay, the website should be updated with the most relevant scientific data. Volunteers should be able to use this site as a portal to see the scientific translation of their efforts.

Improving outreach

The most successful outreach aspect of the UMP has been working with school and youth groups. These groups can be extremely effective at monitoring and removing *Undaria* from the harbor in just one visit. The experience students have seems to be positive from the reports of teachers and counselors. Many of these kids have never been up-close and personal with the diversity of marine life that grows on the harbor structures. It is a living classroom and the opportunities to engage students as citizen stewards of our oceans are enormous. I believe the impact would be greatest by reaching out to minority and under-served youth in areas like Salinas, Seaside, and Marina. We can expand and further develop relationships with youth groups and after school programs like the Boys and Girls Club and the YMCA.

Often school groups engage in special science projects as whole classes or as individuals. The UMP in 2008 offered special project opportunities to a few school groups and individuals. The UMP Coordinator and teachers designed projects based on the age and knowledge level of

the student. Some students were college-level scientific divers capable of managing more complicated projects. I recommend the program continue to offer group and individual projects as well as expanding the program to accept internships and mentoring programs. Interested partners include Monterey Peninsula College Scientific Diving Class and Seaside High School.

Future funding

Future funding options were evaluated and several foundations appear to be good fits for the UMP outreach and research components. Based on the recommendations I have discussed in this section, I suggest submitting proposals or letters of inquiry to the following foundations:

- Monterey Peninsula Foundation
- Project Aware
- PADI Foundation
- The David and Lucile Packard Foundation
- Marisla Foundation
- Community Foundation of the Monterey Peninsula
- Resources Legacy Fund Foundation
- California Coastal Commission

Specifically, The Monterey Peninsula Foundation and the Community Foundation of the Monterey Peninsula fund programs for minority and youth groups. These foundations would be a natural fit for funding if Sanctuary management agrees to expand the program activities in this area. Some contact was made with representatives of the The David and Lucile Packard Foundation. They fund both outreach and research programs making the UMP a good fit for their funding criteria.

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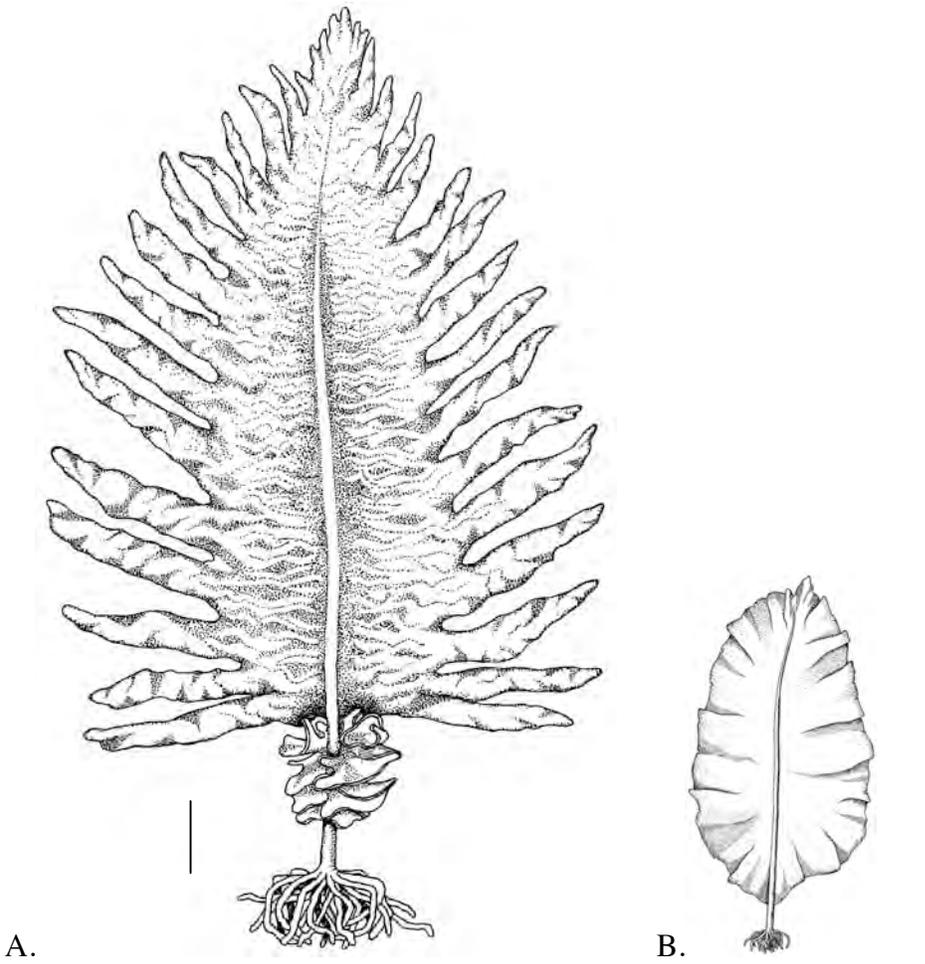


Figure 1. Drawings of the invasive Asian kelp *Undaria pinnatifida*. A. An adult with highly pinnate blade and central midrib above a ruffled, cone-like sporophyll and a small holdfast with numerous finger-like haptera below. B. Juvenile lacking a pinnate blade and sporophyll, but with the distinctive central midrib. Scale bars 5 cm. Illustrations by Rob Gough, with permission.



Figure 2. Four juveniles (pinnae absent) and two sub-adults (pinnae present) of the invasive Asian kelp *Undaria pinnatifida* removed from Monterey Harbor. Major marks on the meter tape indicate 10 cm increments.



Figure 3. Single adult of the invasive Asian kelp *Undaria pinnatifida* removed from Monterey Harbor. Note the elongated pinnae, obvious midrib, and the cone-like sporophyll just above the very small holdfast. The rake is 1.5 m.



Figure 4. Native range (green highlight) of the Asian kelp *Undaria pinnatifida*.



Figure 5. Global invasive range (red highlight) of the Asian kelp *Undaria pinnatifida*.

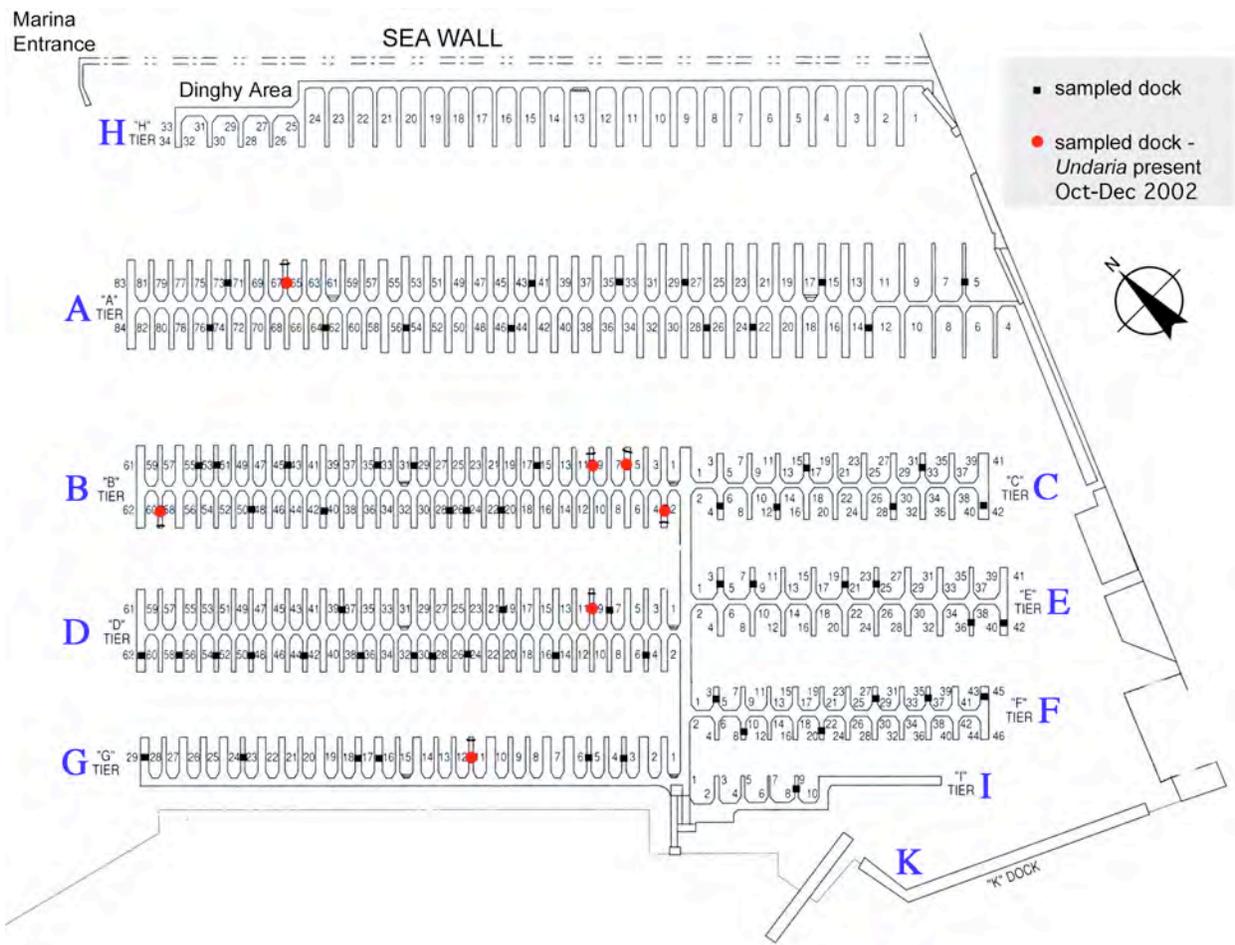


Figure 6. Top view of Monterey Harbor's boat slips in Fall 2002. Letters refer to the tier designation and numbers to the slip number. All black squares indicate which floating docks SCUBA divers surveyed. Red circles indicate floating docks with the invasive kelp *Undaria pinnatifida*.



Figure 7. Top view of Monterey Harbor's boat slips in September 2003. Letters refer to the tier designation and numbers to the slip number. Circled numbers indicate the number of *Undaria pinnatifida* found at that location in Fall 2002. All black squares indicate which floating docks SCUBA divers surveyed. Red squares indicate floating docks with the invasive kelp *Undaria pinnatifida*. A tier was not sampled.

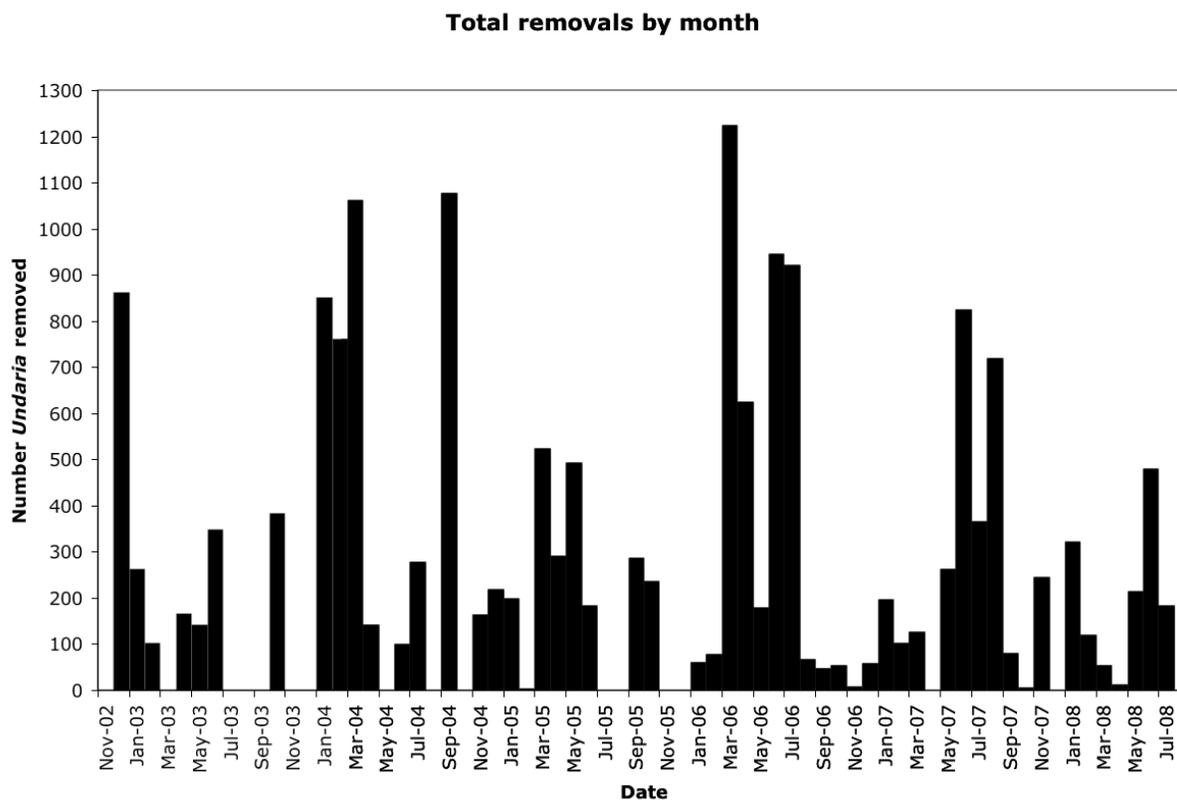


Figure 8. Between December 2002 and July 2008 17,522 individuals of the invasive Asian kelp *Undaria pinnatifida* were manually removed from Monterey Harbor. 120 removal dates were collapsed into monthly totals in this figure. Months with no data were not surveyed.

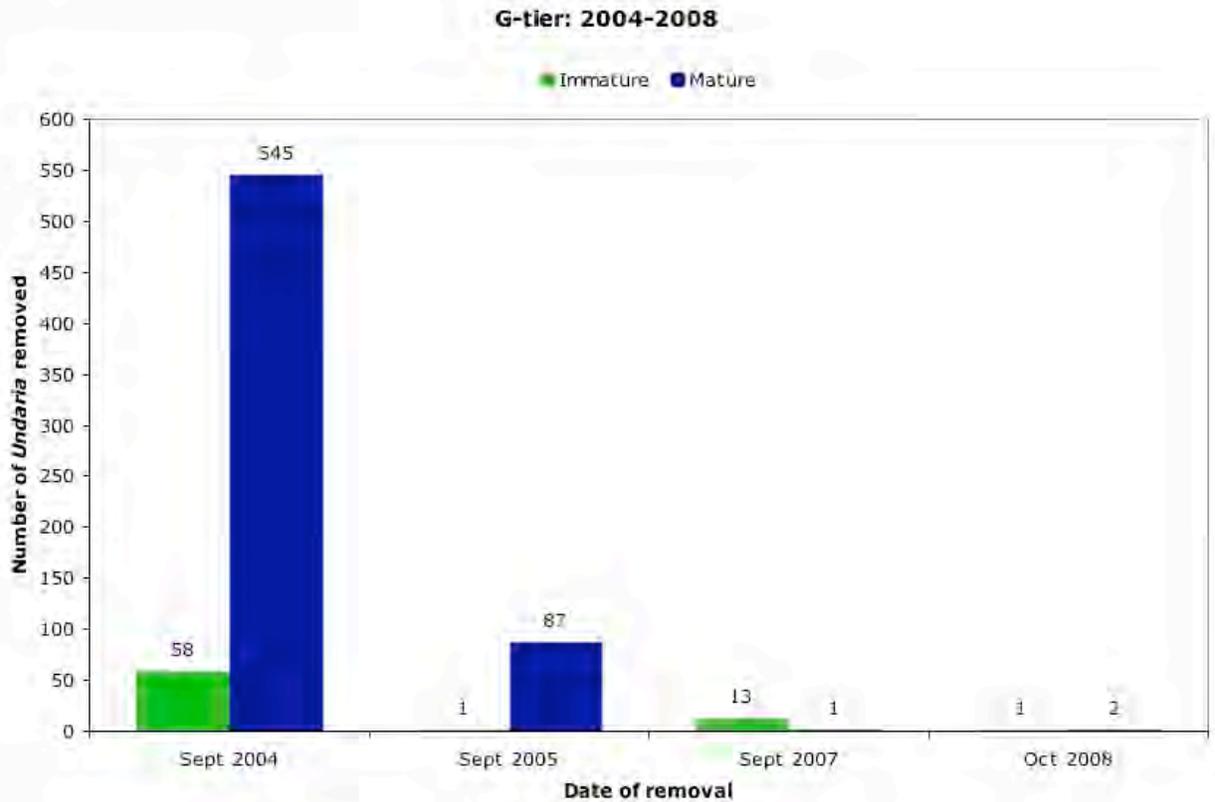


Figure 9. Number of immature (green) and mature (blue) *Undaria pinnatifida* removed from the entire length of G-tier within the Monterey Harbor (includes all slips and pilings). Removal dates were in the middle of September except for 2006 (no data) and 2008 (October data). Over the 4-yr period the total number of *Undaria* removed from G-tier dropped 95.5% (603 to 3), far exceeding the proposed target goal of 50%.

A-tier: 2004-2008

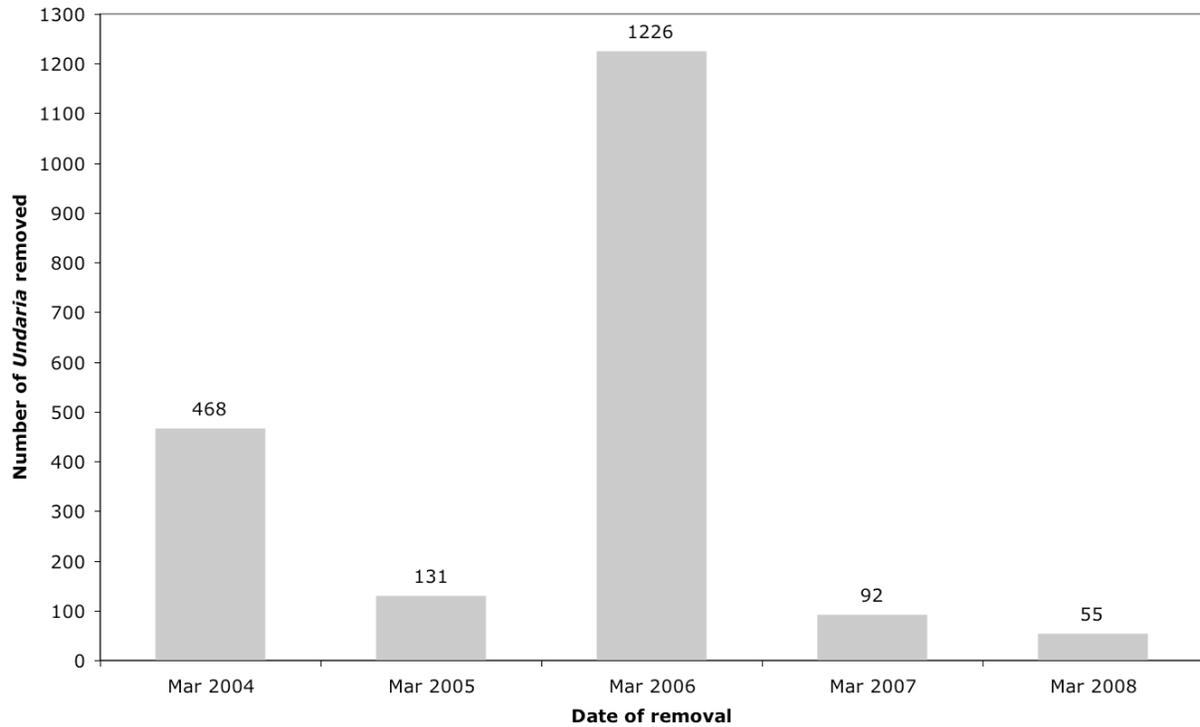


Figure 10. Number of *Undaria pinnatifida* removed from the entire length of A-tier within the Monterey Harbor (includes all slips and pilings). Removal dates were in March. The total number of *Undaria* removed from A-tier dropped 88% (468 to 55), exceeding the proposed target goal of 50%. The cause of the enormous spike in 2006 is unknown. Unlike most other tiers, A-tier has the majority of commercial vessels, many of which frequent southern California harbors infested with *Undaria*. It is possible that A-tier is periodically re-inoculated by southern harbor populations.

G-tier: 2004-2008

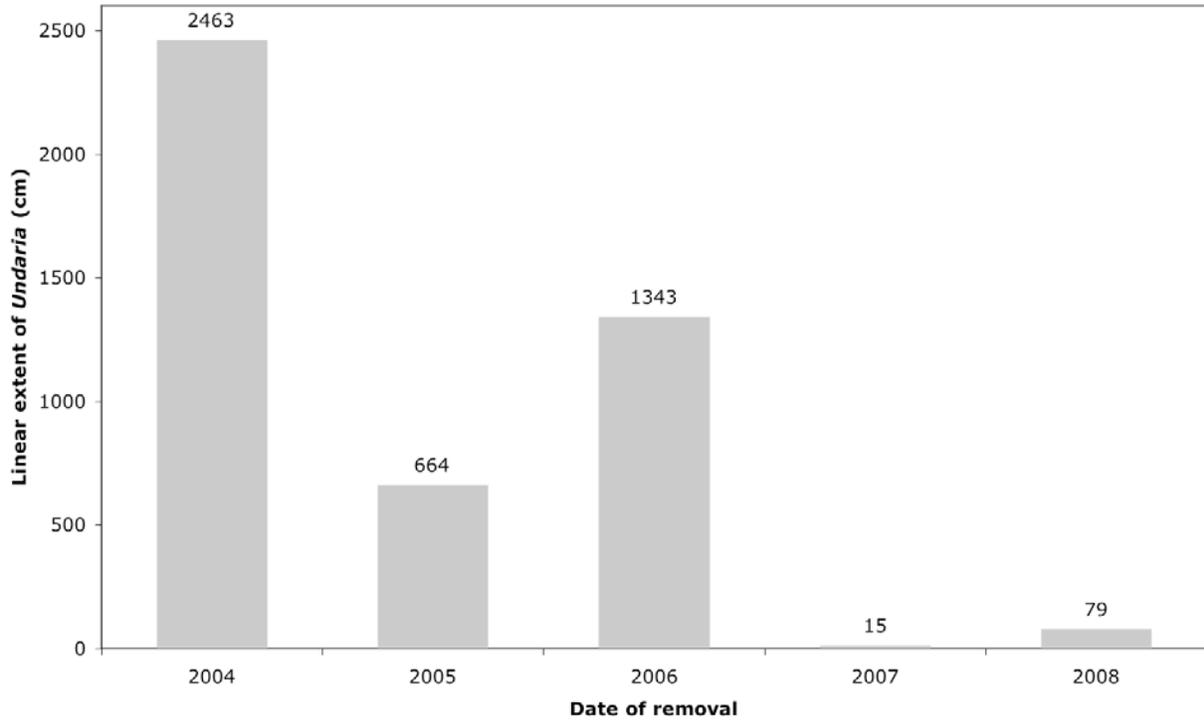


Figure 11. Linear extent (cm) serves as a proxy for the percent cover of *Undaria pinnatifida* removed from the entire length of G-tier within the Monterey Harbor (includes all slips and pilings). Removal dates were in January of each year. Calculating the area covered by each individual was not practical. Instead, total length of all removed *Undaria* was calculated. The 97% drop far exceeds the targeted goal of 33%. The cause of the spike in 2006 remains unclear.



Figure 12. The Monterey Bay Aquarium's Young Women in Science, a program designed to encourage female students' interest in careers in the sciences, participates each summer with the UMP. Students and MBA staff use kayaks to search hard-to-get areas of the harbor. This program "instills a conservation ethic in young people and feeds the dreams of future scientists." Diana Kohtio, UMP researcher, holds up an adult *Undaria* to show the kayakers.



Figure 13. In 2007 and 2008 members of the VANS Warped Tour (a national rock tour comprised of dozens of bands) assist the UMP. Each year the Tour seeks improve as a “green” tour, assisting with local programs and promoting projects that reduce, reuse and recycle human resources. Here 2008 members pose after working in the harbor for several hours.

Table 1. Outreach and education presentations (16) made by the UMP Coordinator.

Organization	Date	Audience	Attending	Minutes
Monterey Peninsula Yacht Club	20-Jul-06	Harbor Commissioners Meeting	13	15
MATE	18-Oct-06	College Student	26	45
Santa Catalina School	24-Jan-07	High School Students	13	20
Sea Otter SCUBA Club	28-Feb-07	SCUBA divers	22	30
Kelp Climbers Club	1-Mar-07	SCUBA divers	17	30
Santa Catalina School	8-Mar-07	High School Students	14	20
MBNMS	13-Mar-07	Sanctuary staff	20	30
Santa Catalina School	27-Mar-07	High School Students	14	20
Sally Griffin Senior Center	2-Nov-06	Seniors	9	30
Scientific Diving Class - MPC	14-Nov-07	Scientific Diving Students	6	30
Seaside High Mentor Program	3-Apr-07	Minority High School Students	5	10
Monterey Boy Scout Troop	8-May-07	8-12 year old boys	16	30
Hewlett-Packard Community Service Monitoring Day	24-May-07	HP San Jose Staff	15	30
Young Women in Science	24-Jul-07	Women ages 11 - 15	55	90
Pacific Grove High School	2-Mar-07	Biology class	6	20
Monterey High School - MAOST	5-Mar-07	Biology class	12	20

Table 2. Distribution of outreach materials by the UMP Coordinator, including location, type of material provided to the public or organization, and dates.

Location	Type of media	Dates of Distribution
Breakwater Marina	50 ID cards, 100 flyers	August 2006, September 2007
Aquarius Dive Shop - CGP	3 flyers	Every 3 months
Bamboo Reef	2 flyers	Every 3 months
MBDC	2 flyers	Every 3 months
Aquarius	2 flyers	Every 3 months
City of Monterey	Newletter, weblink, flyers	September 2006, February 2007
Monterey Harbormaster	6 flyers	August 2006, February 2007
Compass	2 flyers	August 2006, February 2007
West Marine	2 flyers	July 2006
MATE/MPC	5 flyers	October 2006
MIIS	eFlyers posted on intranet	August 2006, February 2007,
Hopkins Marine Station	6 flyers	August 2006, February 2007
Blueplanetdiver.org	Web site link	February 2007, July 2007
Bay Net	Flyer dist to list serve	January 2007
Coast Guard Pier	4 flyers	August 2006, February 2007
Defense Language Institute	Bottom Timers & Otter Limits	October 2006, February 2007
Naval Postgraduate School	Flyers	Every 2 months
Surfrider Foundation	Flyer dist to list serve	October 2006
Monterey County Weekly	Flyer, ID, images	December 7-13, 2006 article
Monterey County Herald	Flyer, images, id card	October 24, 2006 article
KTVU Channel 2 News	Flyers, ID, images	October 25, 2006 interview
UCSC SCUBA Club	Flyers	October 2006, February 2007

Table 3. Summary of efforts to manage the invasive kelp *Undaria pinnatifida* from June 2006 to September 2007.

Event Dates	Group/Name (* = Diver)	Staff	Location	Start	End	Volunteer Hrs	Staff Hrs
6/15/06		Diana Kohtio, Steve Lonhart*, Rita Bunzel*	A tier pilings N/S	9:30am	1:30pm		12
7/18/06	Women in Science - 55 participants	16 MBA staff, Rita Bunzel, Diana Kohtio, Steve Lonhart	Tiers K, I, F, E, C, A tier extension and South end of Wharf #2 via kayak	10:00am	12:30pm	137.5	
7/24/06	Patti Moran, Heather Weyer, Josh Pederson*, Sophie DeBeukelaere*, Tim Keeney*, Sean Morton*, Huff McGonigal, Nicole Capps, Christian Walters, Claire ?, Bridget Dobrowski	Steve Lonhart*, Diana Kohtio, Rita Bunzel	A tier topside and pilings N/S	9:30am	12:30pm	33	12
8/30/06	Patrick Martone,	Rita Bunzel, Diana Kohtio	Topside Tier B, C, D, E, G, F, I	9:00am	12:00pm	3	6
9/5/06	John Krupa*	Rita Bunzel, Diana Kohtio	Tier A	9:00am	1:00pm	4	8

9/23/06	Enid Irwin Dennis Brady* Ryan Rezek* John Krupa* Patti Moran Robert Johnson	Rita Bunzel, Diana Kohtio	Tiers B, C, N/S	9:00am	12:30pm	21	7
10/18/06	DFG - 8 Divers	Steve Lonhart	Breakwater Marina, mooring.	10am	2pm	32	4
10/21/06	John Krupa * Marc Gabriel * Ryan Rezek * Robert Johnson Monica Huelga Torrey DeTomaso Dennis Brady* Randy Phares*	Rita Bunzel, Diana Kohtio	Tiers A, S-E, F, Wharf #2 survey	9:00am	12:30pm	28	7
11/16/06	Lee Morrow Jonah Mulski	Rita Bunzel	Invert Survey A Tier	9:00 AM	12:00pm	6	3
11/18/06	Rikke Kvist Preisler * T Robert Johnson Glynnis Roberts *T Randy Phares* Monica Huelga Torrey DeTomaso Ryan Rezek*T John Diola* Mark Anderson* T Scott Waltz* Jennifer Garcia Lizo Meyer *T Elder Holiday Elder Gavin Elder Peterson Elder Matanga Elder Wolfgramm	Rita Bunzel, Diana Kohtio	Inside seawall, Tier A, B, C	9:00am	12:30pm	59.5	7

11/19/06	Lee Morrow Jonah Mulski Heather Duncan Jennifer Garcia	Rita Bunzel	Invert Survey A Tier	10:00am	12:00pm	8	2
11/20/06	Lee Morrow Jonah Mulski Heather Duncan Jennifer Garcia	Rita Bunzel	Invert Survey A Tier	9:00am	1:30pm	18	4.5
11/21/06	Lee Morrow Jonah Mulski"	Rita Bunzel	Invert Survey A Tier	10:00am	12:00pm	4	2
11/25/06	Randy Phares Scott Waltz	Rita Bunzel	Coast Guard Pier Survey	9:30am	1:30pm	8	4
11/26/06	Randy Phares Scott Waltz	Rita Bunzel	Coast Guard Pier Survey	9:00am	1:00pm	8	4
11/26/06	Heather Duncan, Jennifer Garcia	Rita Bunzel	Invert Survey A Tier	9:30am	11:00am	3	1.5
11/27/06	Randy Phares Scott Waltz	Rita Bunzel	Coast Guard Pier Survey	9:00am	11:00am	4	2
12/16/06	Rikke Kvist Preisler * T Thomas Preisler Liso Meyer *T Randy Phares* John Diola * Robert Johnson Shannon Emery Gillian Burnett	Rita Bunzel, Diana Kohtio	G tier n/s, B tier south, D tier n/s, A tier south,	9:00am	12:30pm	28	7
1/5/07		Rita Bunzel* Steve Lonhart*	% cover piling 12/13 A tier North, C, E, F-North plus end pilings	9:00am	12:00pm		6
1/13/07	Lizo Meyer *T Ryan Rezek*T John Diola* Glynnis Roberts *T	Rita Bunzel, Diana Kohtio	Tiers A, F-South, G, I	9:00am	12:30pm	14	7
1/24/07	10 Santa Catalina Students, 3 Faculty	Rita Bunzel, Diana Kohtio	Topside -Tiers B, C, D, E, F, G, I	9:00am	2:00pm	65	10

2/10/07	Lizo Meyer* T Ryan Rezek*T Glynnis Roberts *T Stephanie Wight*T	Rita Bunzel, Diana Kohtio	Tiers A, B, D	9:00am	12:30pm	14	7
3/8/07	13 Santa Catalina Students, 1 Faculty	Rita Bunzel, Diana Kohtio	Topside harbor complex	9:00am	2:00pm	70	1
3/17/07	Lizo Meyer* T Randy Phares* Robert Johnson Alex Matsumoto*T John Diola* Valerie Hunt*T Alan Grundy*T Chloe Waters Brian Lamar Gillian Rhett	Rita Bunzel, Diana Kohtio	Tiers A, B,	9:00am	12:30pm	35	7
3/27/07	12 Santa Catalina Students, 2 Faculty	Rita Bunzel, Diana Kohtio	Topside entire harbor	9:00am	2:00pm	70	10
4/21/07	Richard Dauphine *T Chloe Waters Gillian Rhett*T Alex Matsumoto*T Randy Phares* Ryan Rezek*T Robert Johnson	Rita Bunzel, Diana Kohtio	Tiers A, B, C, North E	9:00am	12:30pm	21	7
5/19/07	Alex Matsumoto* John Diola* Chloe Waters	Rita Bunzel, Diana Kohtio	Tiers A, B	9:00am	12:30pm	10.5	7
5/24/07	Hewlett- Packard Group of 15	Rita Bunzel, Diana	Topside all tiers/Measurements on A	8:30am	12:00pm	52.5	7

	Participants	Kohtio					
5/30/07	Steve Lonhart*, Chad King*, Josh Pederson*	Rita Bunzel*, Diana Kohtio*	East side Fisherman's Wharf	9:00am	12:30pm	10.5	7
6/16/07	Chloe Waters	Rita Bunzel, Diana Kohtio	Topside all tiers	9:00am	1:00pm	4	8
6/26/07	Chloe Waters Gabriel Rodriguez*	Rita Bunzel, Diana Kohtio*	A tier - pilings	9:00am	12:00pm	6	6
6/27/07	Gabriel Rodriguez* Sister Bullick Sister Jargel	Rita Bunzel*, Diana Kohtio	A tier pilings	10:00am	12:30pm	7.5	5
6/28/07	Gabriel Rodriguez*	Rita Bunzel*, Diana Kohtio*	A tier - experiment	9:30am	1:30pm	3.5	8
7/10/07	Gabriel Rodriguez*	Rita Bunzel, Diana Kohtio	H tier - Sea wall	9:30am	12:30pm	3	6
7/12/07	Gabriel Rodriguez*	Rita Bunzel, Diana Kohtio	H tier - Seawall	9:30am	12:30pm	3	6
7/17/07	Alex Matsumoto* Gabriel Rodriguez*	Rita Bunzel	Harbor Survey by Kayak; H tier removal	9:30am	1:30pm	8	4
7/18/07		Rita Bunzel	Harbor Survey by Kayak	8:00am	1:00pm		3
7/19/07	Ryan Rezek* Gabriel Rodriguez*	Rita Bunzel	Harbor Survey by Kayak; H tier Dinghy	10:00am	12:30pm	5	2.5
7/21/07	Lori Addison Gabriel Rodriguez*T Angelica Zavalalopez*T Dida Kutz*	Rita Bunzel, Diana Kohtio	Tiers B, C, E North/South	9:00am	12:30pm	14	7

7/24/07	Young Women in Science 55 participants	Rita Bunzel, Diana Kohtio	Tiers K, I, F, E, C, A tier extension and South end of Wharf #2 via kayak	10:00am	12:30pm	137.5	7
7/27/07	Siser Bullick Sister Jargel	Rita Bunzel	A tier Experiment removed	10:00am	12:30pm	5	2.5
8/1/07		Rita Bunzel, Diana Kohtio	Topside Harbor complex	9:00am	12:00pm		6
8/2/07	Sister Bullick Sister Jargel	Rita Bunzel, Diana Kohtio	Topside Harbor Complex	10:00am	12:30pm	5	5
8/8/07	Sister Bullick Sister Jargel Sister ? Sister ?	Diana Kohtio	Topside A tier	11:30am	1:30pm	8	2
8/16/07	Robert Johnson Gabriel Rodriguez*T	Rita Bunzel, Diana Kohtio	Interior breakwall	10:00am	12:30pm	5	5
8/18/07	Chloe Waters Randy Phares* Robert Johnson	Rita Bunzel*, Diana Kohtio	B tier N/S, C tier N/S, Interior breakwall, boat ramp	9:00am	1:00pm	12	8
8/21/07	Warped Tour - Damon Atkinson Ray Harris Shannon Easton Keri Lee Lisa Brownlee Melissa Fornabaio Shawn Harris Steve Caddy, Peggy Harris	Rita Bunzel, Diana Kohtio, Media, Dawn Hayes	A, B, C topside	10:00am	12:30pm	22.5	7.5
9/5/07	Sister Jargel Sister Bullick	Rita Bunzel	A tier topside	10:00am	12:30pm	5	2.5
9/9/07	Jessica Donald*, Sarah Cohen, Amelia	Rita Bunzel*, Diana Kohtio	A tier pilings N, tunicate collections	9:00am	1:00pm	16	8

Rodelo, Alan
Szabo

9/15/07	Rikki Kvist Preisler* Gabriel Rodriguez* Kurt Schallitz* Robert Eric Johnson Karl Charles*	Rita Bunzel, Diana Kohtio	A south, A extension, B, D pilings	9:00am	12:30pm	17.5	7
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Total	1055	285
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