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CENTER FOR BIOLOGICAL DIVERSITY

Protecting endangered species and wild places through science, policy, education, and environmental law

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303 (d) Deadline: 1/31/06

January 30, 2006

Board Members
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Re: Revision to the Federal Clean Water Act § 303(d) List of Water Quality Limited Segments for California – Comments for Northern California

Dear Board Members,

The following comments are submitted on behalf of the Center for Biological Diversity regarding the State Water Resources Control Board's ("State Board's") proposed revision to the Clean Water Act § 303(d) list of "impaired" waterbodies. The comments herein focus on water quality limited segments that are located in northern California; we will submit those regarding southern California separately.

The Center is greatly concerned with the continued decline of water quality throughout the state and the resulting impacts to aquatic species. The increasing number of waterbodies on the § 303(d) list is indicative of pervasive, severe problems to overcome, and unfortunately, the Center believes there are additional waterbodies that are impaired but are not currently proposed for listing. The Center formally requests that additional waterbodies be added to the revised list, and also expresses support for your proposal to add the lower Klamath River, portions of the San Joaquin River, the Cosumnes River, Delta waterways, and Bodega Bay. Comments and evidence to support these actions follow.

Specifically, the Center formally requests the State Board add the following waterbodies to the revised 303(d) list of impaired waterbodies for exotic species:

Humboldt Bay
South Fork Joaquin River
Middle Fork Kings River

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I. INVASIVE SPECIES

"Unlike some chemical pollutants that can degrade over time, biological pollutants have the potential to persist, multiply, and spread. In addition to their economic costs, invasive species can have a devastating effect on natural areas, where they have strangled native plants, taken over wetland habitats, crowded out native species, and deprived waterfowl and other species of food sources."

GAO, October 22, 2005

The introduction of invasive species is one of the single largest environmental problems confronting the country today, increasingly considered by scientists, academics, and others as a leading threat to address in the twenty-first century (GAO 2002; Cohen 2002; Cohen 2004; Groat 2000). It is also one of the most costly, creating an enormous taxpayer burden that—by conservative estimates—approaches $200 billion dollars every year (GAO 2002). But while the economic costs from invasive species are colossal, native aquatic species and beneficial uses of water are paying the true price—the sum of which is incalculable.

Invasive species are second only to habitat destruction as the greatest overall threat to native plants, fish, and wildlife in the United States (Cohen 2004; Wilcove 1998). Their introduction is believed responsible for population declines among almost half the species currently listed in the U.S. under the federal Endangered Species Act (GAO 2005), and was a contributing factor in 65% of all extinctions that occurred in North America during the last century (Cohen 2004; Miller 1989).

The negative impacts from invasive species may be most profound within freshwater and estuary ecosystems. Studies indicate that invasive species adversely affect twice the number of fish and wildlife species as other types of pollution (Cohen 2004; Wilcove 1998). And indeed, some scientists report that invasive species are the primary threat to freshwater fauna throughout the western U.S. (Cohen 2004), and also to biological diversity, regional economies, and public health in coastal areas around the world (Cohen 1997).

It is believed that hundreds of exotic species are introduced to U.S. waters every day. Though many cannot survive in their new environment, a significant number become extremely well positioned to take over. These are the ones that have no natural predators in their new home, tolerate a wide-range of environmental conditions, and have high reproductive rates—a combination that assures they will not merely survive, but flourish.

But unfortunately, our review of available information shows that impacts from exotic species are not limited to these areas, and are causing adverse biological responses, degradation of biological populations and communities, and declining trends in water quality within a number of other areas. These include:

(1) Humboldt Bay,
(2) South Fork San Joaquin River,
(3) Middle Fork Kings River.

Scientific data and studies show these water quality segments are "impaired" pursuant to criteria recently adopted by the State Board (specifically, §§ 3.8, 3.9, 3.10, and/or 3.11), and that preparation and implementation of TMDLs for these water bodies is warranted, appropriate, and required by law. We formally request the State Board include these water bodies in the revised 2006 list of water quality limited segments and quickly take related actions to remediate these problems.

Our comments and evidence supporting these actions follow.

study conducted by DFG, "[m]ore than a third (35%) of the species identified on fouling panels [in Humboldt Bay] were introduced. In fact, in several cases the major space-occupying organism was an introduced species..."

Table 1: Species designations for different categories of organisms found in Humboldt Bay and adjacent estuarine areas during surveys conducted in 2000-2001.

Non-indigenous	Probable Introductions	Status Uncertain	Total
67	17	13	97

Source: Boyd 2002; DFG 2002

While the number of exotic species now documented in Humboldt Bay is alarming, it is likely this number is even higher than studies reveal. Only recently have the presence or problems of exotic species been examined in Humboldt Bay, and even since the first and last comprehensive surveys were conducted, two additional exotic species, *Zostera japonica* and the mahogany clam, were discovered (DFG 2002). It can only be expected that others have invaded its waters and shores as well.

But still, the number of exotic species currently documented in Humboldt Bay is comparable to those catalogued in larger, and more industrialized ports—where problems from exotic species have undergone much more extensive study and research. In fact, the number of exotic species currently known to occupy Humboldt Bay is only slightly less than that in the Delta waterways (*see* Table 2), which the State Board has recognized are impaired.

Moreover, studies show that exotic species, such as *Stenothoe valida*, are being transported into Humboldt Bay from ships traveling from San Francisco Bay and other U.S. ports (Boyd 2002)—traffic that is not subject to ballast water regulations under state or federal laws. Exotic species are also being introduced from the outer layers of the boats themselves, with many, such as barnacles and organisms that live on or in the barnacles, arriving on the hulls of ships, and from extensive aquaculture operations in the Bay (*Id.).*

C. The Ecological Costs

Many of the exotic species now invading Humboldt Bay are notorious for their destructive and deleterious impacts, and are wreaking havoc for native species and designated beneficial uses as they spread. These issues are briefly summarized below, and are discussed in detail in the supporting evidence we have submitted for our comments as well as other studies that are included in the administrative record.

1. The European Green Crab (Carcinus meanas)

In 1995, scientists discovered the European green crab had reached Humboldt Bay. This vicious predator decimated the soft-shell clam industry in Maine and Canada when it was accidentally introduced during the 1950's, and was first recorded on the West Coast in 1989. It is now abundant in portions of Humboldt Bay, causing serious harm to aquatic habitat and a number of native species.

As summarized by Boyd (2002), the green crab:

> "...preys on a multitude of organisms, including clams, oysters, mussels, marine worms and small crustaceans, making it a major potential competitor of the native fish and bird species...[T]hey pose a direct threat to shorebirds, as they have similar diets...In addition, the green crab is an intermediate host to marine worms that could potentially be harmful to local shore birds.

Green crabs are also creating problems for Dungeness crabs and other shellfish in Humboldt Bay. As recounted by the California Department of Fish and Game (DFG 2002), "[g]reen crabs may impact juvenile Dungeness crabs that settle by the thousands in Humboldt Bay and may also prey upon juvenile cultured oysters, clams and mussels. (Green Crab Study 2001)." "They have the potential to restructure the crab population in ecosystems in which they establish themselves, as they feed on the larvae of other crab species devastating their near shore nurseries...Recent experiments in south Humboldt Bay (Meyer 2001) suggest that this species could be a significant predator of small bivalves if it becomes widespread" (Boyd 2002).

resolve and reverse this growing concern, adding necessary force to regulatory mechanisms that have proven unsuccessful alone.

Scientific data and studies show Humboldt Bay is an "impaired" water body pursuant to criteria adopted by the State Board (specifically, §§ 3.8, 3.9, 3.10, and/or 3.11), and preparation and implementation of a TMDL is warranted, appropriate, and required by law. This conclusion is based on the following:

1. Historic, baseline conditions in Humboldt Bay included no exotic species.
2. Surveys in Humboldt Bay have documented a growing number of exotic species.
3. Numerous rare, threatened, and endangered species have declined in abundance in Humboldt Bay since exotic species were introduced.
4. Numerous studies link the decline of aquatic habitat and other beneficial uses in Humboldt Bay to exotic species invading its waters.
5. Available data show exotic species are creating adverse biological responses in Humboldt Bay.
6. Available data show exotic species are degrading biological populations and communities in Humboldt Bay, which in turn, also impairs recreational fishing and other beneficial uses.
7. Available data show a declining trend in water quality in Humboldt Bay.

This has been met with disastrous results, enabling exotic species to "surmount barriers that normally hinder upstream-directed invasions" and occupy virtually every segment of the watersheds (Knapp 2001). Today all of the watersheds in the Sierra Nevada are occupied by as many as five nonnative trout species (Knapp 1996, citing Jenkins 1994), and it is estimated that 63% of all high mountain lakes contain one or more of these veracious predators (Knapp 1996; Bahls 1992; Jenkins 1994). Most of the remaining fishless lakes "are small (<2 ha), shallow (<3 m), and generally incapable of supporting trout populations" (Knapp 1996, citing Bahls 1992).

Native amphibians are disappearing as a result, with populations being consumed and replaced by nonnative, hybridized trout species, and completely extirpated from many areas. Nonnative trout are also having direct and indirect effects on a number of other species, reducing populations of traditional predators like garter snakes (Matthews 2002) as well as native salmonids and others (Cohen 2004; Knapp 2001; Knapp 1996; Matthews 2001; Sarnelle 2004). These and other effects are impairing designated beneficial uses of the South Fork San Joaquin and Middle Fork Kings Rivers, including spawning, reproduction, and/or early development habitat; cold freshwater habitat; habitat for rare, threatened, or endangered species; and recreational uses.

Despite well-documented evidence showing these deleterious impacts, DFG continues to discharge these exotic species today. While it did temporarily suspend nonnative trout introductions in some wilderness areas in 2003, this brief moratorium was soon lifted and stocking has since resumed in many areas throughout the Sierra Nevada, including the South Fork San Joaquin and Middle Fork Kings Rivers (Knapp 2005). A further discussion of these issues follows.

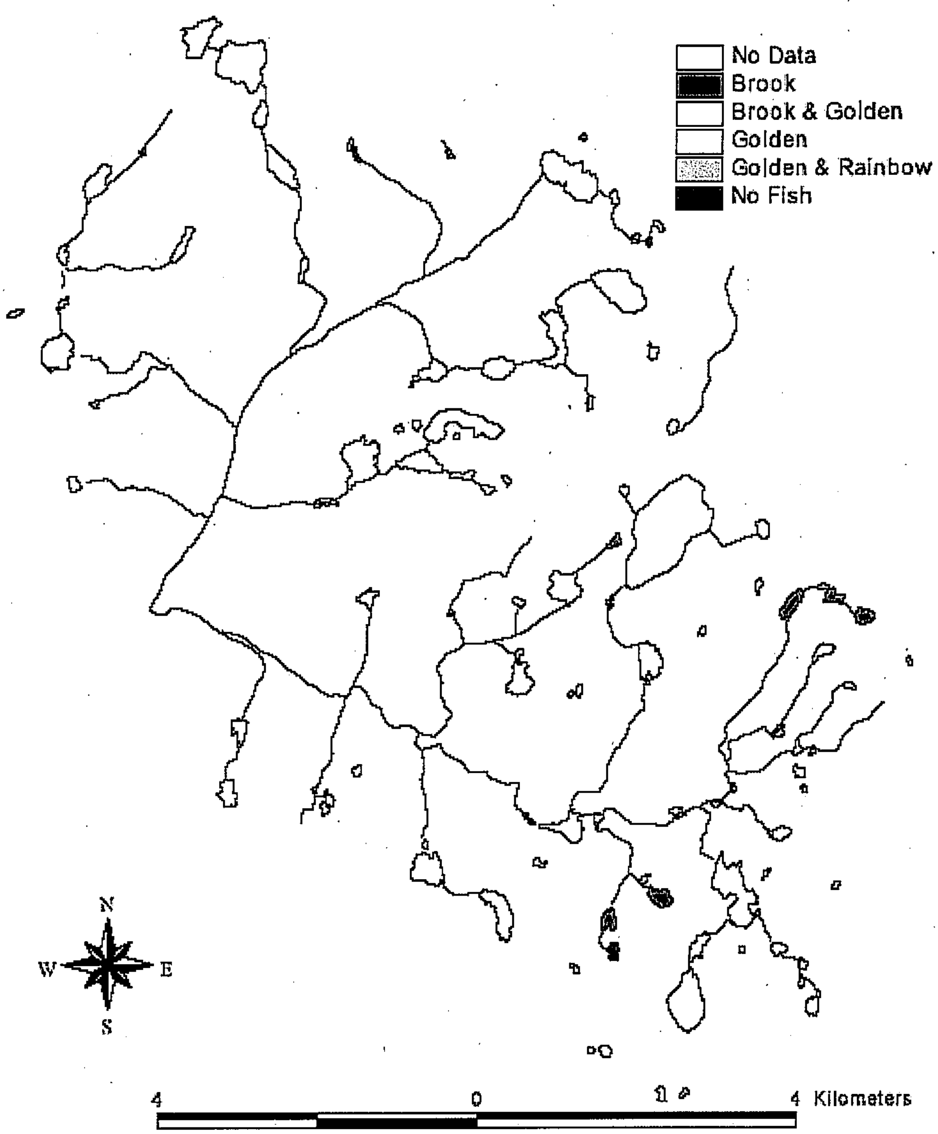
C. The Invasion of the South Fork San Joaquin and Middle Fork Kings Rivers

The State Board has proposed adding the San Joaquin River to the TMDL list for problems tied to exotic species, a proposal the Center wholeheartedly supports. However, the State Board has only proposed to add stretches that lie below the Friant dam, drawing an arbitrary line in the watershed. Exotic species do not stop at this point, but to the contrary, begin at the very top of the drainage.

Numerous studies show that exotic trout now pervade the upper reaches of the San Joaquin River, including the South Fork San Joaquin and Middle Fork Kings Rivers (*see*, for example, Bradford 1989; Bradford 1991; Bradford 1993; Bradford 1994; Bradford 1998; Cohen 2004; Knapp 2000; Knapp 2001; Knapp 1996; Matthews 2001; Matthews 2002; Sarnelle 2004; Vredenburg 2004; Zardus 1997). Most comprehensive of these is a study led by Drs. Roland Knapp and Kathleen Mathews, in which surveys were undertaken in more than 1,700 lentic water bodies in the South Fork San Joaquin and Middle Fork Kings Rivers, all of which were historically fishless (Knapp 2001). This study documents widespread occurrence of three exotic

Current Distribution of Exotic Species

Upper Pitue and French Creek Watersheds
South Fork San Joaquin River Basin



This map shows the current distribution of exotic trout species in the upper Piute Creek and French Creek watersheds, Sierra National Forest. Data were compiled by Dr. Roland Knapp based on records provided by Region 5 of the California Dept. of Fish and Game.

SOURCE: Knapp, R.A. Sierra Nevada Aquatic Research Laboratory, University of California. Non-native Trout in Natural Lakes of the Sierra Nevada: An Analysis of Their Distribution and Impacts on Native Aquatic Biota. Sierra Nevada Ecosystem Project: final report to Congress. Volume III. (1996). [See Appendix II for original map and report].

1991; Bradford 1993; Bradford 1994; Bradford 1998).

As stated by Knapp (1996):

> Several attributes of this species make it particularly vulnerable to predation and subsequent extirpation by non-native trout. First, adult mountain yellow-legged frogs are highly aquatic and are found primarily in lakes (most of which now contain trout). Second, in contrast to tadpoles of other Sierran anurans that complete metamorphosis to the terrestrial stage in a single summer, mountain yellow-legged frog tadpoles generally require at least two years before metamorphosis to the terrestrial stage. This overwintering requirement restricts breeding to bodies of water that are deep enough to avoid oxygen depletion when ice-covered (>1.5 m; Mullally and Cunningham 1956; Bradford 1983). The majority of these deeper lakes, however, now contain introduced trout.

As also summarized by Knapp (1996):

> There is substantial evidence that introduced trout have severely reduced the abundance of mountain yellow-legged frogs in the Sierra Nevada. As early as 1924, Grinnell and Storer (1924) reported that mountain yellow-legged frog tadpoles and introduced trout rarely co-occur in lakes and ponds in the Sierra Nevada. This observation has been quantified repeatedly in different parts of the Sierra Nevada (Bradford 1989; Bradford and Gordon 1992; Bradford et al. 1993; Drost and Fellers 1994). This lack of overlap is assumed to be the result of predation by trout on the mountain yellow-legged frog, an assertion supported by Needham and Vestal (1938), who observed trout preying on mountain yellow-legged frogs in a lake into which trout had recently been introduced. Given that the presence of fish generally makes a pond or lake unsuitable for mountain yellow-legged frogs, that lakes smaller than 1 ha are generally too shallow to support mountain yellow-legged frogs (Matthews and Knapp 1995), and that 34-85% of formerly fishless lakes larger than 1 ha now contain introduced trout...the amount of suitable habitat for mountain yellow-legged frogs has likely been reduced by a similar amount.

Knapp and Matthews (2000) took this information a step further in the South Fork San Joaquin and Middle Fork Kings Rivers, conducting extensive surveys in more than 1,700 lakes within the watersheds to quantify the impacts of exotic species to mountain yellow-legged frogs and other species (Knapp 2000). This study confirmed previous reports and found a direct causal link between exotic trout introductions and the disappearance of the species "at the scales of the landscape, watershed, and individual water body" (*Id.*).

Specifically, Knapp and Matthews found that mountain yellow-legged frogs "were three times more likely to be found and six times more abundant in fishless than in fish-containing water

This study also found a negative association "...between snake presence and trout presence: 24% of trout-free lakes also contained snakes while only 12% of trout-containing lakes contained snakes" (*Id.*).

4. Other Damage

Available information establishes that exotic species have degraded and continue to degrade beneficial uses in many additional ways, including:

- **Native Fish:** Studies show "...the introduction of salmonid fishes into headwater lakes can result in disproportionately larger effects on native fishes than introductions lower in drainages. In many river basins, remaining populations of native fishes are concentrated in headwater refugia where they are protected by natural barriers from introduced fishes that are already established at lower elevations. However, introductions of nonnative fishes into headwater lakes provide point sources capable of invading all downstream habitats, as the fish surmount barriers that normally hinder upstream-directed invasions..." Knapp 2001

- **Zooplankton:** "Several studies have documented [negative] effect[s] of introduced trout on zooplankton communities in lakes in the Sierra Nevada. Stoddard (1987) found that the presence or absence of fish (primarily salmonids) was by far the most important predictor of the distribution of zooplankton species among 75 alpine and subalpine lakes in the central Sierra Nevada, with large-bodied species found in fishless lakes and small-bodied species found in lakes with trout. Other studies on Sierran lakes have produced very similar results (Richards et al. 1975; Morgan et al. 1978; Goldman et al. 1979; Melack et al. 1989; Bradford et al. 1994a)." (Knapp 1996) (*see also* Sarnelle 2004).

- **Lake benthic macroinvertebrates:** "In addition to their effects on zooplankton communities, fish are also capable of altering the structure of lake benthic macroinvertebrate communities. In the Sierra Nevada, high elevation fishless lakes contain mayfly larvae (Ephemeroptera), caddisfly larvae (Trichoptera), aquatic beetles (Coleoptera), and true bugs (Corixidae) that are absent in lakes that contain introduced trout (Reimers 1958; Melack et al. 1989; Bradford et al. 1994a)." (Knapp 1996).

- **Nutrients:** "Model results suggest that trout introductions routinely increase phosphorus (P) regeneration from previously inaccessible benthic and terrestrial sources. Because P derived from benthic and terrestrial sources represents a new source of nutrients for plankton, even small increases in nutrient availability can result in increased algal biomass and production. To support the importance of this increased

6. Available data show exotic species are degrading biological populations and communities in these watersheds, which in turn, is also impairing their recreational opportunities and other beneficial uses.
7. Available data show a declining trend in water quality in both watersheds.

IV. CONCLUSION

The beneficial uses in Humboldt Bay, the South Fork San Joaquin River, and Middle Fork Kings River have been severely degraded and impaired by exotic species. These impacts are documented in a growing body of scientific information, including studies contained in the appendices to our comments as well as additional studies and information within the administrative record. This information conclusively demonstrates that many native species are disappearing as these exotic species spread, pushing the mountain yellow-legged frog and others to the brink of extinction.

It is imperative that additional steps are taken to reverse these problems, and the implementation of TMDLs would be a big leap in the right direction. Relevant laws and policies support this action for Humboldt Bay, the South Fork San Joaquin River, and Middle Fork Kings River. We urge you to make wise and appropriate use of your authority to protect and restore the beneficial uses of these water bodies, and add each to the 2006 § 303(d) list

For Clean Water,

Cynthia Elkins
Center for Biological Diversity

species have impaired the beneficial uses of certain California waters.

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303 (d) Deadline:
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Board Members
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Re: Revision to the Federal Clean Water Act § 303(d) List of Water Quality Limited Segments for California – Supporting Evidence for Comments

Dear Board Members,

Please include the enclosed information as part of the administrative record for the review and update of the § 303(d) list of water quality limited segments for California. These documents pertain to those segments located in Northern California, and specifically, Humboldt Bay and the South Fork San Joaquin and Middle Fork Kings River watersheds. Our comments will be submitted separately by email.

Thank you for your time and consideration of this information.

For Clean Water,

Cynthia Elkins
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Shelter Cove, CA 95589
celkins@biologicaldiversity.org

APPENDIX 1

Humboldt Bay

NON-INDIGENOUS MARINE SPECIES OF HUMBOLDT BAY, CALIFORNIA

A Report to the California Department of Fish and Game

February 28, 2002

Principal Investigators:

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EXECUTIVE SUMMARY

During this survey, we collected and identified 95 species that are possibly non-indigenous marine species (NIS) in Humboldt Bay. There were representatives from most major groups of organisms, ranging from vascular plants to fish. The largest number of non-indigenous species is found in various invertebrate groups, including polychaetes (24 species), amphipods (20 species), and bryozoa (8 species). Previous studies in Humboldt Bay (Barnhart et al. 1992) were not focused on identification and enumeration of introduced species, but many of the non-indigenous species found in this study have been reported in that earlier work.

A number of introduced species have been in Humboldt Bay for a long time, in some cases going back to the first settlement of the region by Europeans in the mid 1800's. Almost immediately following initial settlement, maritime trade began, with shipping of lumber and lumber products to all parts of the world. It appears that sometime in the 1860's, the most abundant plant of Humboldt Bay salt marshes, *Spartina densiflora*, was brought into the bay from South America, probably as shingle or dry ballast (Barnhart et al. 1992).

Intentional introductions have also accounted for a number of species that are numerous in the bay. All along the California coast, efforts to introduce and grow oysters were pursued beginning in the 1890's (Bonnot 1935). Following attempts to grow eastern oysters and European oysters that failed, Japanese oysters were successfully introduced into Humboldt Bay. A significant commercial aquaculture activity continues around the planting, growth, and harvesting of Japanese oysters in the bay. The cultch (seed oysters) for this species is now produced in Puget Sound and shipped in bags to Humboldt Bay. These shipments provide continuing opportunities for introductions from Puget Sound. We identified one species of algae, previously unreported from Humboldt Bay, which has probably arrived from Puget Sound in this manner. Other examples of species that were introduced intentionally include the Eastern soft shell clam (*Mya arenaria*) and the Japanese cockle (*Venerupis phillippinarium*).

As intentional introductions took place, unintentional introductions also occurred. Early methods of transporting marine organisms from one area to another might take several days and packing in wet algae was a common way to retard dessication. Numerous small juveniles of other species or species inconspicuous by their size might be concealed among the algae or attached to blades. In this manner, small polychaetes, species attached to algae blades, and small crustaceans were inadvertently introduced into the bay as the packing material was disposed of by tossing it into bay waters.

We included in this study species that are clearly the result of introductions and those that have been characterized as cryptogenic (Cohen and Carlton 1995; Carlton 1996). Cryptogenic species are organisms that appear to be widespread in bays, ports, and estuaries of the world and cannot be identified as definitely native or exotic to a particular region. Carlton (1996) has proposed that many of these species are the result of maritime trade and other human activity that go back hundreds of years. Some cryptogenic species occurrences are the result of intentional or unintentional introductions that are lost in time and history. Others are of uncertain relationship to species that have a wide range of occurrence but may be genetically distinct in parts of their range. In yet others, their present day occurrence is merely an indication of their capacity to adapt to a wide range of environmental conditions. Of the 95 species that we identified as possible introductions to Humboldt Bay, 23 have been classified as cryptogenic.

We compared the occurrence of introduced species in Humboldt Bay to their occurrence mentioned in previous studies done along the Pacific coast of North America (Cohen and Carlton 1995; Ruiz et al. 2000). In particular, we compared the reported occurrence of species in San Francisco Bay to the south and in Coos Bay, Oregon to the north. Of the 95 species in Humboldt Bay, 31 have been reported from all three bays. There are 23 species that are found in San Francisco Bay and Humboldt Bay. There were no species that were found to co-occur only in Coos Bay and in Humboldt Bay. Twenty-seven of the introduced species we report are found only in Humboldt Bay. These data on co-occurrence suggest that San Francisco Bay could be an important source area for introductions to Humboldt Bay, a finding consistent with ship and small boat traffic moving between these two locations. The number of species that appear to be found only in Humboldt Bay (27) suggests that there may be factors in the nature of shipping or other human influences that are unique to the bay.

ACKNOWLEDGEMENTS

We were most ably assisted by a number of co-workers, graduate students, and undergraduate students from Humboldt State University. Much of the collecting of marine algae and assistance in identification were provided by Gisela Fritz and Giacomo Renzullo. Fish collections were often supervised by Erin Cole, who was assisted by Daniel Norman, Debra Parthree, Joseph Pecharich, Rebecca Quinones, Tara Smith, Gus Theisfeld, Jolyon Walkley, and Jason Weber. Intertidal and benthic collections were done by Lorrie Bott, Bonnie Lesley, and Susan Tharratt, assisted by Michael Fleming, Ryan Jenkinson, Marty Meyer, and Matt Strickwerda. Intertidal and benthic samples were sorted by Rebecca Flores, Jayna Schaaf, and Emma Womack. Andrew Stevens very competently performed the analysis of benthic sediment samples. Karen Warburton assisted in the preparation of the final report.

Susan McBride, the local University of California Extension Sea Grant Marine Advisor, shared her field data on the distribution of the European green crab in Humboldt Bay. David Hull, Executive Director of the Humboldt Bay Harbor, Recreation, and Conservation District, facilitated access to information on oyster culture and dredging activities in the bay.

Michael Sowby and Marian Ashe of the California Department of Fish and Game provided direction and oversight to the survey. Their encouragement and support are much appreciated.

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INTRODUCTION

There has long been an interest among biologists in the introduction of species from one part of the globe to another (Elton 1958). Early investigations were focused on terrestrial species, with minimal attention to marine and estuarine species. Increased global maritime trade during the past 25 years has resulted in greater attention to inadvertent introductions of marine species, particularly to the possibility of transport and introduction of species from ballast water (Carlton 1985). A number of studies have been completed of introductions to bays and estuaries along the coast of California, with particular emphasis on San Francisco Bay (Cohen and Carlton 1995). A recent review article (Ruiz et al. 2000) summarized the occurrence of introduced species in marine and estuarine habitats of North America, including the Pacific coast. Noticeably absent in that publication was any listing of introduced species from Humboldt Bay.

Previous work on marine organisms found in and around Humboldt Bay did not specifically identify species that had been intentionally or inadvertently introduced into Humboldt Bay (Barnhart et al. 1992). In addition to maritime commerce, mariculture activities in Humboldt Bay go back at least 100 years (Bonnot 1935). A number of species of oysters and other shellfish have been brought to the bay, with varying degrees of success in establishing breeding populations of non-native bivalves. Similar activities have taken place at other bays and estuaries along the coast of California (Ruiz et al. 2000).

There is clearly a long history of maritime commerce in Humboldt Bay. The first shipments of lumber from the bay occurred in the 1850's, shortly after the arrival of European and American settlers. In recent times, the maritime trade has been focused on timber and paper products that are shipped to other coastal ports and to overseas destinations (Barnhart et al. 1992). In the period of maritime commerce under sail, ships were frequently ballasted with dry or "shingle" ballast. In Humboldt Bay, one of the most prominent examples of an introduced species (*Spartina densiflora* from South America) apparently dates from the early period of timber commerce (Kittlelson and Boyd 1997).

The purpose of this survey was to specifically examine locations throughout Humboldt Bay for the occurrence of introduced species. Such species have recently been recognized under the term "non-indigenous species," or NIS (Ruiz et al. 2000, and many other recent authors). In this study, use of the term NIS is essentially equivalent to terms such as "introduced," "non-native," and "exotic." This investigation is not focused on the historical aspects of NIS in Humboldt Bay, but it is clear that the present occurrence of NIS in the bay is the result of maritime activities (shipping and mariculture) that go back to the 1850's.

A significant objective of this survey is to provide a reliable baseline of information for further studies and monitoring of NIS that may arrive in the bay as a result of increased maritime trade and other activities. Although many ships enter Humboldt Bay after a direct transit of the Pacific Ocean, others may visit ports along the entire west coast before entering the bay. Fishing vessels in the bay also regularly visit ports along the coast, including ports in Oregon, Washington, and Alaska. A number of fouling organisms are known to settle and grow on boat hulls below the water line or other submerged surfaces of these vessels as they move from one port to another along the coast. Fishing vessels and pleasure craft capable of ocean voyages consequently may act as vehicles for the transport of NIS from one location to another, contributing to the spread of NIS that may initially be restricted in occurrence. For Humboldt Bay, San Francisco Bay is the most likely source of NIS that may arrive secondary to an initial introduction there. We were fortunate that a relatively recent and thorough survey of NIS in San Francisco Bay (Cohen and Carlton 1995) was available for comparison to NIS found in Humboldt Bay.

METHODS AND MATERIALS

This study is the most thorough survey of algae, invertebrates, and fish recently undertaken in Humboldt Bay. Beginning in July 2000, 58 sites were visited to collect marine algae (Fig. 3), invertebrates were collected at 21 intertidal sites, 5 marina locations, and benthic samples were obtained at 87 stations (Figs. 1,2). Fish were surveyed using a variety of collection methods, including seines, traps, and trawls at over 300 locations throughout the bay (Fig. 4). In total, 471 collections were examined for exotic species in Humboldt Bay.

Intertidal sites were visited at low tides and a variety of collection methods were used to obtain organisms. Hand tools were used to remove animals and plants from solid surfaces. Sediment samples (when collected) were passed through a 1.00 mm stainless steel screen and all organisms retained on the screens were transferred to jars or plastic bags. All organisms were preserved in the field with 10% buffered formalin in sea water. Samples of algae were collected and preserved both to identify the algal species and as substrates for small motile organisms such as crustaceans and polychaetes.

Benthic samples were obtained used a Smith-McIntyre grab deployed initially from the Humboldt State University research vessel "Coral Sea". As the Smith-McIntyre grab reached the bottom, the depth and exact location (as determined from the GPS receiver on board RV Coral Sea) was recorded. As the grab was brought back on board, it was examined to insure a minimum sample volume of 6 liters. If the sample was of acceptable volume, the top screens were removed, and a sediment sample taken for later determination of sediment grain size. The remaining sediment was then passed though a 1.00 mm screen and all organisms or larger sediment particles retained on the screen were transferred to a container. Ten percent buffered formalin was then added to the container and the container thoroughly agitated to insure adequate mixing of the preservative solution with contents of the container.

The "Coral Sea" has too much draft to maneuver easily into the shallow channels of Arcata Bay and South Bay, so a shallow draft vessel, the MV "Ironic" was chartered to deploy the Smith-McIntyre grab in those locations (Fig. 2). As benthic samples were acquired from this vessel, depth was recorded from the on-board fathometer and GPS coordinates (latitude and longitude) were taken with a hand held (Garmin 12) unit. Sediment samples were taken and collections preserved in a manner identical to procedures used on the "Coral Sea."

At four marina locations in Humboldt Bay (Fig. 1), fouling organisms were collected using hand tools to remove materials from bumper tires, docks, and marina floats. Divers using SCUBA went into the water at the Woodley Island Marina to remove materials from the undersides of floating docks. All materials collected were preserved in 10% buffered formalin in seawater.

Upon return to the laboratory, samples taken in the field were transferred as necessary to permanent containers. All samples were examined on each day they were taken to insure that adequate label information had been completed. Each collection was assigned a unique identifying number.

Trained assistants then undertook sorting of the samples into major taxonomic categories. "Sort" records contained information about the sorting process and unusual species or groups that were encountered. Sorting was accomplished with compound microscopes and sorting trays, maximum magnification 30X.

Sorted samples were then examined by specialized taxonomic specialists (Lorrie Bott, Bonnie Lesley, Susan Tharratt). These individuals all had extensive experience in the identification and enumeration of marine invertebrate species of Humboldt Bay and adjacent outer coast benthic and pelagic invertebrate species. As species were identified and enumerated, data sheets reflecting that information were completed. The tables accompanying this report reflect the occurrence of introduced species encountered during this survey.

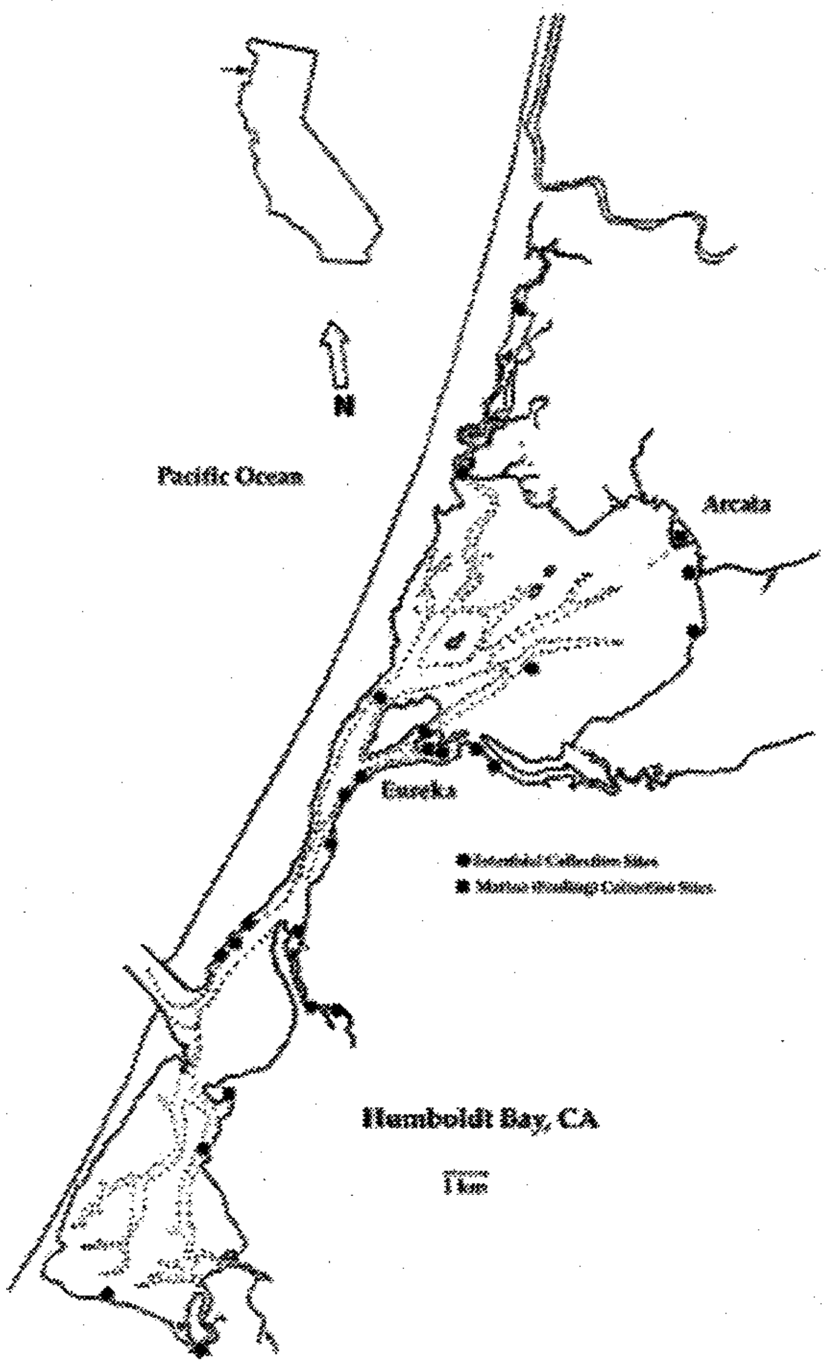

Figure 1. Intertidal and marina (fouling) collection sites for marine and estuarine invertebrates in 2000, 2001. Collections were done at 21 intertidal sites and 5 marina locations.

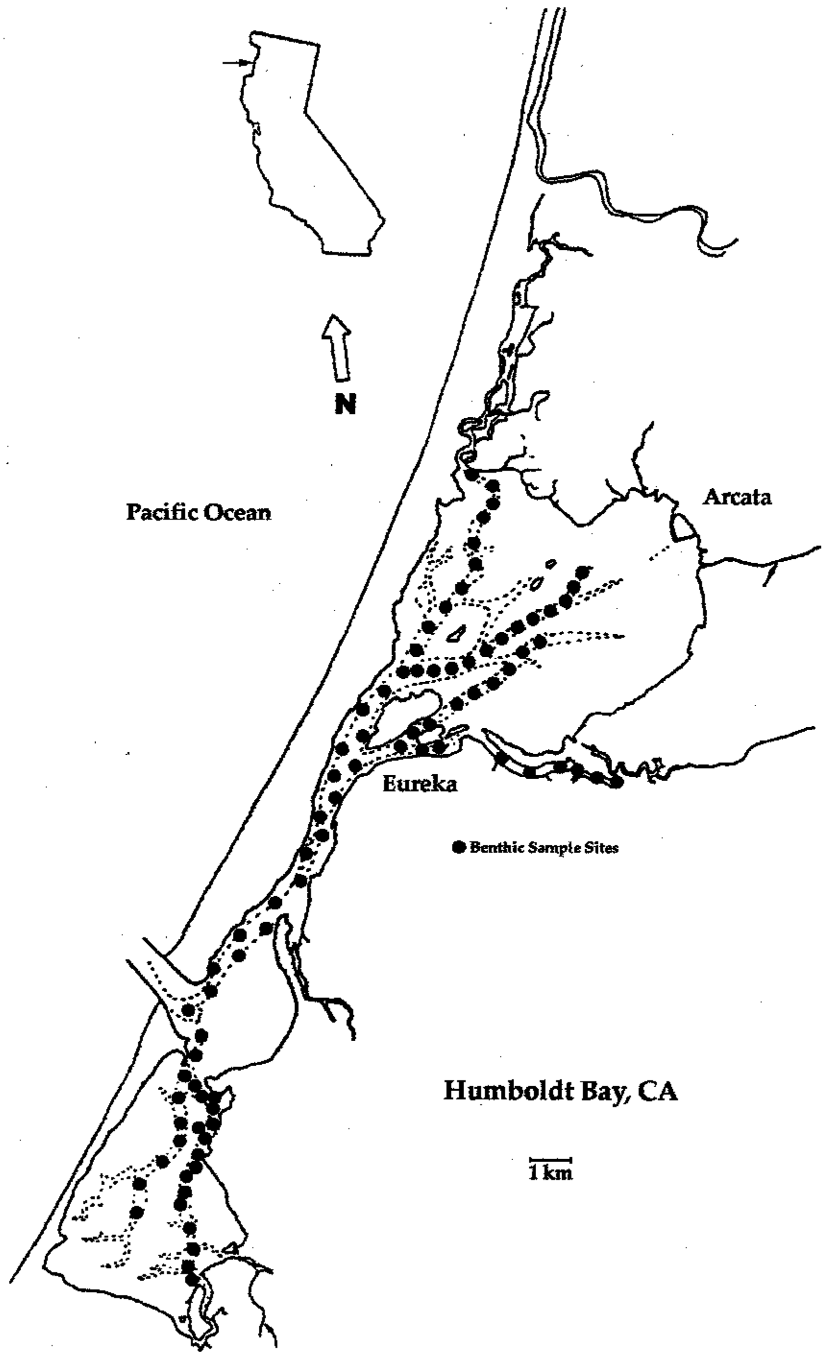

Figure 2. Benthic collection sites for marine invertebrates in 2000, 2001. Collections were done at 87 benthic locations using a Smith-McIntyre grab.

Methods for Sampling Exotic Algae

The sampling protocol for identifying the NIS algae in Humboldt Bay is based on the directive not to sample the plankton and not to quantify the abundance of exotic species. Locations in Humboldt Bay were therefore selected for sampling NIS algae only if they had hard substrata where attached green, red, and brown algae could grow. Soft bottom sites where the flowering plant *Zostera japonica* might grow were also selected. Site selection was not random. Sites were deliberately chosen to represent as many habitats as possible in Humboldt Bay, and in particular to capture locations where ballast water and mariculture operations could be introducing exotic organisms (Fig. 3). About half of the sites were visited at least twice, with the second visit occurring during a different season. People on foot walked through each site during low tides and removed any algal species that could not be named immediately. Collected algae were brought back to the laboratory in a cooler and then preserved in 4% formaldehyde in seawater. A compound microscope was used to identify all of the species in these collections. Prior to any of the field sampling, a potential list of exotic algae (Table 1) was compiled based upon Cohen and Carlton (1995) and communications with other phycologists. This was particularly valuable as some of these exotic algae have not been reported in the literature and are quite diminutive. Representative voucher specimens were made only for those exotic algae found and the reproductive condition of these taxa was recorded. The identification of the one exotic red alga found, *Lomentaria hakodatensis* Yendo, was confirmed by Dr. Paul Silva at the UC Berkley herbarium.

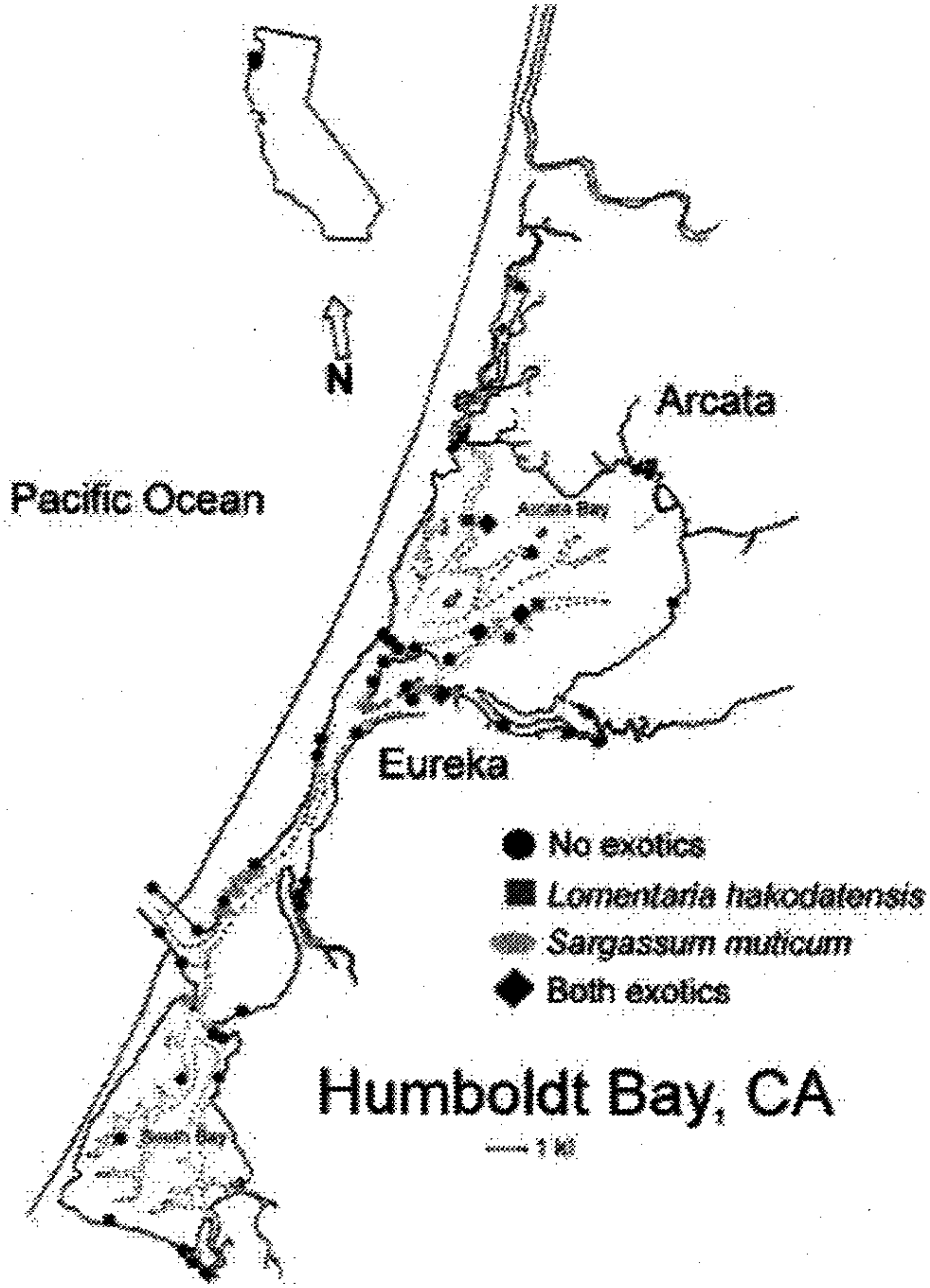

Figure 3. The distribution of the 58 sites that were sampled for exotic algae during 2000 and 2001. The red alga *Lomentaria hakodatensis* and the brown alga *Sargassum muticum* were the only two exotics found, and the map indicates only those sites where these taxa were attached and growing. See Table 2 for more information about each site.

Table 1. A list of exotic algal species from the northeast Pacific Ocean that could potentially occur in Humboldt Bay, CA.

Phylum	Species name & authority	Comments
Chlorophyta (green algae)	*Caulerpa microphysa* (Weber-van Bosse) Feldmann	Currently being sold from aquarium stores in California.[1]
	Caulerpa racemosa (Forsskål) J. Agardh	Currently being sold from aquarium stores in California.[1]
	Caulerpa serrulata (Forsskål) J. Agardh	Currently being sold from aquarium stores in California.[1]
	Caulerpa taxifolia (M Vahl) C. Agardh	Currently being sold from aquarium stores in California[1] and is growing in southern CA harbors. Physiologically, this aquarium variety could establish up to British Columbia.[2]
	Codium fragile subsp. *tomentosoides* (van Goor) P.C. Silva	This taxon does occur episodically on the outer coast of Trinidad in tide pools.
Heterokontophyta, Phaeophyceae (brown algae)	*Acinetospora* Bornet	An ectocarpoid brown filament seen by Dr. Erik Henry in Vancouver, B.C. (pers. comm.)
	Ascophyllum nodosum (L.) Le Jolis	Large rockweed
	Sargassum muticum (Yendo) Fensholt	Large rockweed
	Scytothamnus J.D. Hooler & Harvey	An ectocarpoid brown filament seen by Dr. Erik Henry in Vancouver, B.C. (pers. comm.)
	Undaria pinnatifida (Harvey) Suringar	A kelp

Table 1. (continued)

	Waerniella Kylin	An ectocarpoid brown filament seen by Dr. Erik Henry in Vancouver, B.C. (pers. comm.)
Rhodophyta (red algae)	*Callithamnion byssoides* Arnot ex Harvey	A threadlike, branched filament
	Caulacanthus ustulatus (Turner) Kützing	A tough, corticated, branched alga; forms a turf
	Gelidium vagum Okamura	A tough, corticated, branched alga; forms a turf
	Lomentaria hakodatensis Yendo	A soft, corticated, branched alga
	Polysiphonia denudata (Dillwyn) Greville ex Harvey	A threadlike, branched filament
Anthophyta (flowering plants)	*Zostera japonica* Ascherson & Graebner	

[1] Frisch S.M., S.N. Murray. 2001. The availability of species of *Caulerpa* and "live rock" in retail aquarium outlets in southern California. Abstracts, 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA. p. 30.

[2] Woodfield R.A, K.W. Merkel. 2001. Invasive marine chlorophyte, *Caulerpa taxifolia,* discovered at two southern California sites. Abstracts, 82nd Annual Meeting of the Western Society of Naturalists, Ventura, CA. p. 51.

Collection methods: fish

Sampling Gears

Field sampling of Humboldt Bay took place between August 2000 to December 2001. Locations along the periphery of the bay were chosen by reviewing a NOAA navigational chart. The goal was to collect data along the entire margin of the bay. Sloughs and channels that branch off of the bay were similarly chosen. Interior sections of the bay, including channels, beach areas, rubble areas, mudflats and eelgrass beds were also sampled. Gears used to sample fishes included: a 32 ft. head rope bottom trawl with 2 in. stretch mesh in body and 1 in. stretch mesh in cod end, an epibenthic otter trawl net measuring 16ft with 3mm stretch mesh in the body, a 150 ft. by 8 ft. beach seine with 10 mm. mesh, a gill net measuring 150 ft. by 8 ft. with 3 in. mesh, a variety of pole seines measuring 15 ft. by 5 ft. with 3mm. mesh, 20 ft. by 6 ft. with 6 mm. mesh, and 50 ft. by 6 ft. with 6 mm. mesh. Standard minnow traps were also used.

Coordinates

Geographical coordinates were collected at each site. These coordinates were obtained in latitude/longitude in degrees, minutes and seconds, using a Trimble hand held GPS unit, GeoExplorer II. When collecting geographic position on board the *Coral Sea,* the GPS unit on board the vessel was used.

Fishes

The focus of fish sampling was in areas that have not ever been thoroughly sampled in the past, including small channels, sloughs, riprap areas, areas in the vicinity of the jetties and flocculent mud flats. Much of the sampling was done from shore, using the pole seines of various sizes (Fig. 4). The beach seine was deployed from a small aluminum skiff. Sampling of the major channels required trawling from R/V *Coral* Sea using the 32 ft. head rope trawl net. The smaller trawl net was used mostly in eel grass beds, and was deployed from Humboldt State University's 27 ft. by 12 ft. aluminum pontoon boat. Minnow traps were used to sample around riprap and at the north and south jetties.

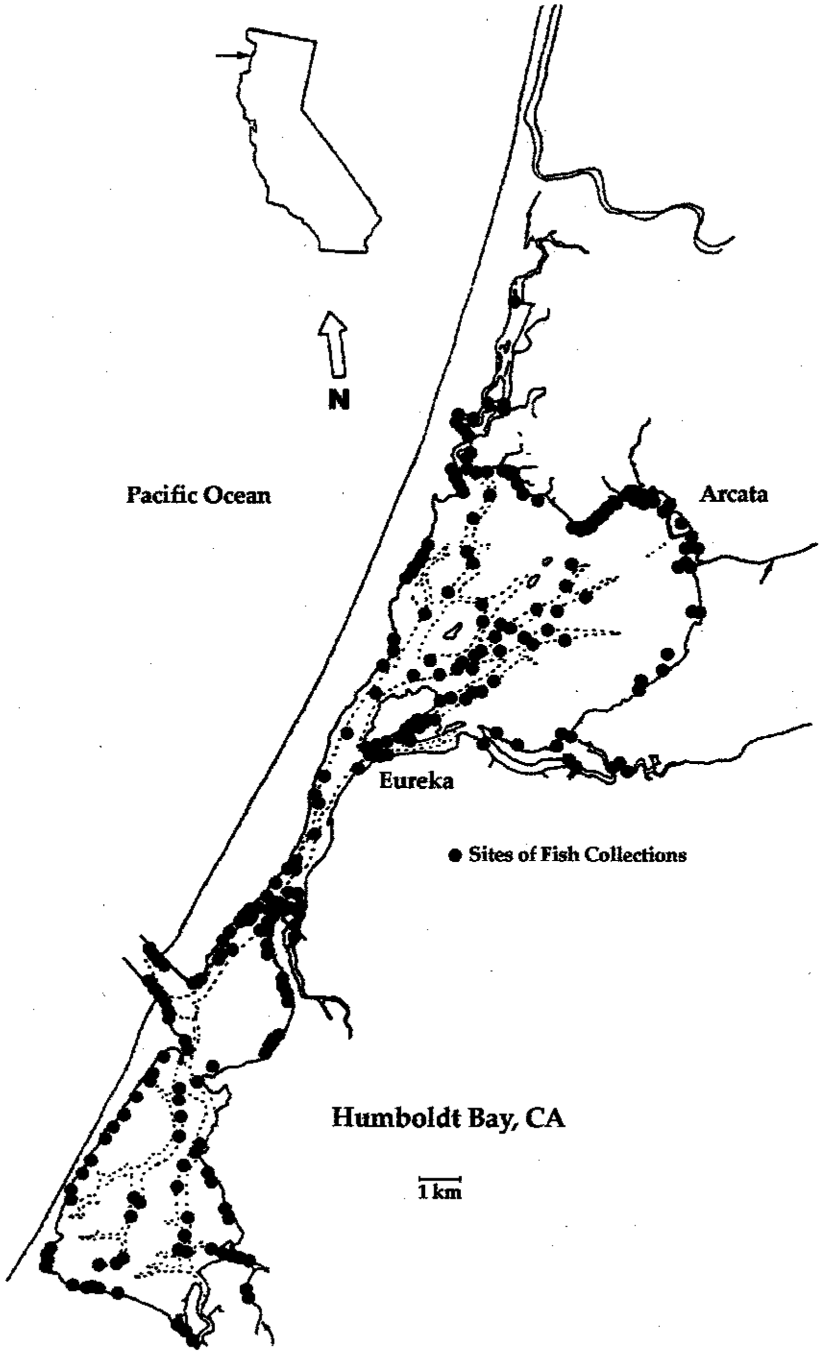

Figure 4. Collection sites for marine and estuarine fish in Humboldt Bay, 2000, 2001. Collections were done at 360 locations in and bordering Humboldt Bay.

Sediment samples

The sediment cores taken from each benthic sample were examined using standard methods (Shepard 1963). A variety of descriptive parameters were recorded for each of the sediment samples. A partial reporting of the parameters recorded is contained in Table 6.

SPECIES ACCOUNTS

ALGAE

Sargassum muticum (Yendo) Fensholt — Phaeophyta

This species is a native of Japan that first appeared during 1945 in Puget Sound where it was probably introduced on the shells of oyster spat (Abbott and Hollenberg 1976, Critchley et al. 1990). Sexual thalli of *S. muticum* were already present in Humboldt Bay by 1965 (Dawson 1965). The present survey found this species on low intertidal and shallow subtidal riprap near the entrance to Humboldt Bay, as a brackish water site in the Elk River, and at several shallow subtidal sites in Arcata Bay (Fig. 3, Table 2). Thalli of *S. muticum* in the latter area were frequently attached to very large abandoned oysters that have subsequently been surrounded by eelgrass beds. Drift *S. muticum* is common in Humboldt Bay and thalli frequently have receptacles in which gametes are presumably produced. *S. muticum* is absent from the entrance channel itself, as well as local rocky intertidal sites on the outer coast (pers. obs.).

Chondracanthus teedii — Rhodophyta

This red alga (as *Gigartina tepida*) has been recorded from Puget Sound, Washington to Baja California and the Gulf of California (Abbott and Hollenherg 1976). It has not been reported previously from Humboldt Bay, despite being in the range of occurrence for this species. Dawson (1965) did not report it, nor did later authors (DeCew et al., in prep).

This survey: Found on oyster shell in Arcata Bay (common), pilings of the Samoa bridge, Eureka Boat basin, Woodley Island Marina. There is a strong possibility that this alga has appeared recently in the bay as a result of transport from Puget Sound on oyster cultch transplanted into Arcata Bay.

Lomentaria hakodatensis Yendo — Rhodophyta

A red alga that is native to Japan (Abbott and Hollenberg 1976, Lüning K. 1990). It was reported at Isla Guadalupe, Mexico in 1925 and British Columbia in the 1950's. It is now located at several other west coast locations in between Mexico and British

Columbia (DeCew et al., in prep; Hawkes and Scagel 1986). In 1965, Dawson did not report *L. hakodatensis* as occurring between Cape Mendocino and Crescent City; this stretch of shoreline includes Humboldt Bay (Dawson 1965). In 1990 DeCew found sterile drift material of *L. hakodatensis* in the King Salmon area of Humboldt Bay, and "rare" attached sterile specimens occurred on Eureka boat docks (DeCew et al., in prep). In the present survey, attached *L. hakodatensis* was very common in every oyster lease site sampled where it grew on old oyster shells lying on top of mudflats located in the low intertidal to shallow subtidal zones (Fig. 3, Table 2). Its distribution was patchier on the Eureka boat dock and in Klopp Lake. Its arrival into Humboldt Bay could have occurred with the importation of Japanese oyster spat reared in Puget Sound, where *L. hakodatensis* also occurs, or this exotic alga could have established itself via fragments or spores dispersed from Coos Bay, Oregon to the north, or Point Arena, California to the south; these are the two closest known locations for this exotic alga. *L. hakodatensis* appears to be spreading in Humboldt Bay by fragmentation, which it is known to do at other locations (DeCew et al., in prep), and by spores. In contrast to DeCew's 1990 report of sterile thalli in Humboldt Bay, in this survey we found tetrasporangial material of *L. hakodatensis*. It is not known if these tetrasporangia were releasing sexual or asexual spores.

VASCULAR PLANTS

Spartina densiflora Brongn.

This is the dominant salt marsh plant at Humboldt Bay. It occupies an approximate elevation range from 6 to 8 ft. above MLLW. *Spartina densiflora* was probably introduced from the west coast of South America sometime in the later half of the 19th century. During that period, a flourishing trade in redwood lumber existed between Humboldt Bay and ports in Chile and Peru. It is probable that *Spartina densiflora* seeds were transported in dry ballast commonly used to stabilize sailing vessels in the latter 19th century.

This survey: Widespread in salt marshes around Humboldt Bay.

Cotula coronopifolia Linnaeus, 1758

This plant occurs in salt marshes and freshwater marshes around the bay. It is found in marsh habitats along the California coastline and is native to South Africa

(Cohen and Carlton 1995, Hickman 1993). The introduction of this plant in San Francisco Bay is estimated to have been 1878 by Cohen and Carlton (1995).

This survey: Widespread in the salt mashes and adjacent freshwater marshes of Humboldt Bay.

Zostera japonica

During the course of this survey, individuals familiar with introduced species in Humboldt Bay encouraged us to look carefully for *Zostera japonica,* which has been found in other bays on the Pacific coast. It is conspicuously absent in Humboldt Bay. Coos Bay, Oregon contains the closest known population of this plant.

INTRODUCED ANIMALS

PORIFERA

Cliona sp. (possibly *C. celata*)

There is an uncertain complex of species found in the genus *Cliona.* In Humboldt Bay, these sponges are widely distributed in benthic habitats, oyster growing areas, and at marinas. It seems probable that this sponge has been present for most of the 20th century in Humboldt Bay.

This survey: Common at marinas, Mad River slough, Arcata Bay oyster growing areas.

Halichondria bowerbanchia Burton, 1930

This sponge is widely distributed in Humboldt Bay, it occurs in benthic habitats, at marinas, and on solid substrates in intertidal sites. Native to the Atlantic, it probably was introduced during attempts in the first half of the 20th century to grow *Crassostrea virginica* in the bay.

This survey: Mad River slough, marinas.

Microciona prolifera (Ellis and Solander, 1786)

This sponge is native to the Atlantic and also has been described from San Francisco Bay. It is widely distributed in benthic habitats, as a fouling organism at marinas, and at low intertidal elevations. Although not previously listed (Barnhart et al. 1992) it probably has been in the bay since at least 1950, based on its widespread occurrence.

This survey: Marinas, Mad River Slough Channel benthic stations.

Aurelia aurita (Linnaeus, 1758)

These jellyfish are seen occasionally in deeper waters of the bay. They do not occur in the dense swarms that have been seen at Tomales Bay and in southern parts of San Francisco Bay. The taxonomy of this species in currently uncertain, but it seems clear that *Aurelia aurita* as described for the central California coastline is not the same as the Atlantic species.

This survey: Medusae occasionally onserved in channels of Humboldt Bay, especially near the bay entrance. Strobilus form in the life cycle has not been collected in the bay.

Diadumene leucolena (Verrill, 1866)

This anemone is native to the Atlantic coast of the U. S. and is widely distributed in Humboldt Bay. It occurs at marinas and in low rocky intertidal sites. It is uncertain when this species was introduced to the bay but it probably was introduced with ship fouling. It is known to occur widely in San Francisco Bay (Cohen and Carlton 1995) and in Coos Bay, Oregon (Carlton 1979).

This survey: Widespread on low intertidal rocks, marinas of the bay.

Diadumene lineata

This Asian species is widely distributed in Humboldt Bay and was identified as *Halliplanella luciae* in previous studies (Barnhart et al. 1992). It seems likely that this species was introduced with Japanese oysters, *Crassostrea gigas*. The species is widely distributed on the west coast of the North America from Newport Bay in southern California to British Columbia (Cohen and Carlton 1995).

This survey: Abundant on oysters grown in the bay, in fouling at marinas, and in low intertidal rocky locations.

Nematostella vectensis Stephenson, 1935

This small anemone is typically found in shallow pools in salt marshes around the bay and is occasionally abundant. Cohen and Carlton (1995) listed this species as cryptogenic in San Francisco Bay, but Hand and Uhrlinger (1994) believed that *N. vectensis* is native to estuarine areas in the Balthic Sea of northern Europe. It has been reported from Humboldt Bay (Barnhart et al. 1992) and other estuarine salt marsh locations from central California to Puget Sound.

This survey: Abundant in pools of salt marshes surrounding the bay.

Obelia dichotoma (Linnaeus, 1758)

This species has a confused history of certain identifcation in California bays and estuaries. The origin of the species is also uncertain (Cohen and Carlton 1995) because of a long history of introductions in many parts of the world.

This survey: Abundant at marinas in Humboldt Bay. Growth in the spring is lush, identification is more certain with key features easily visible. By late summer many colonies have been grazed extensively by nudibranchs.

ANNELIDA: Polychaetes

Autolytus cornutus (Agassiz, 1862) SYLLIDAE

Type locality: New England; intertidal (Hartman 1968)

Distribution: New England coast; CA; intertidal in holdfasts of kelp; pelagic (Hartman 1968). Pettibone (1963) lists distribution as Arctic, Labrador to Chesapeake Bay, in low water to 75 fathoms. This species in found at low water under rocks, on pilings, in muddy sands, with algae, sponges, hydroids, barnacles, mussels. Specimens have been dredged from 25 m (Pettibone 1963).

This survey: Species was found among mussel/algae on pilings (Woodley Island) and subtidally among shell fragments and mixed sediments in North Bay Channel. It was occasionally common in piling samples among mussels/algae at Woodley Island. Previously recorded as *Autolytus* sp. in Humboldt Bay from subtidal samples containing mixed sediments and shell fragments (Barnhart et al. 1992). Also found in samples from the shallow continental shelf off Humboldt Bay (COE study). Bay populations are cryptogenic.

Boccardiella hamata (Webster, 1879 : original description) SPIONIDAE

Type locality: by Webster, from Virginia (1879a) and New Jersey (1879b); inhabiting bivalve shells. Blake and Kudenov (1978) established new genus, *Boccardiella*, replacing *Boccardia*.

Distribution: *Boccardia hamata* is known on the Pacific coast (as *B. uncata*) from British Columbia to Baja California (Berkeley and Berkeley 1952). It has been reported from oyster beds, estuarine mud, *Dodecaceria* sp. masses, and other littoral conditions. In Japan, on mud flats; East coast and gulf coasts of North America, penetrating oyster shells and gastropod shells (Hartman 1951). Uraguay (as *Polydora uncatiformis*) in brackish water (Munro 1938).

Habitat: In central California, *B. hamata* inhabits algal holdfasts, hermit crab shells, and estuarine muds. It constructs tubes in sand in algal holdfasts of *Egregia* sp. and was found in *Tegula brunnea* shells inhabited by *Pagurus granosimanus* at Cayucos and within *Macrocystis pyrifera* holdfasts at Monterey. Vancouver Island, *Boccardiella* *hamata* was found inhabiting mud in the crevices of sandstone rocks in Scott Bay, Barkley Sound; in silty muds of Morro Bay, CA; and on the east coast, in shells of hermit crabs *Eupagarus pollicaris* and in bottom samples of fine sand-shell mix at 5-6 m depth from the Mystic River. (Sato-Okoshi and Okoshi 1997).

This survey: *Boccardia hamata* was found in estuarine mud at Southport Landing, Klopp Lake, and Mad River Slough #1.

Dipolydora socialis (Schmarda, 1861) SPIONIDAE

Type locality: Chile

Distribution: East and west coasts of N. America; Gulf of Mexico; Chile; Falkland Islands; west Pacific; Sea of Japan; Australia; intertidal to about 400 m (Blake, Hilbig and Scott 1996). Originally described from the eastern Pacific (Chile) and appears to be widely distributed in boreal and temperate seas. *Polydora socialis plena* (Berkeley and Berkeley 1936), *Polydora caeca* var. *magna* (Berkeley 1927) and *Polydora neocardalia* (Hartman 1961) are all considered synonyms for *Dipolydora socialis*. Thought to be able to bore and inhabit soft sediments (Blake 1971; Blake and Evans 1973).

P. socialis is a well-adapted species occurring in soft sediments and sometimes as a borer in calcareous substrates (Blake 1971). This species has been recorded among the dominants in benthic infaunal communities (Blake 1971; unpublished)

This survey: appears to be a widely distributed species in a variety of habitats in Humboldt Bay. Specimens were obtained intertidally from South of Eureka Marina, Eureka Boat Basin, Woodley Island, and Mad River Slough #2, and subtidally in channels. Previously recorded from Humboldt Bay, as *Polydora socialis*, by Barnhart et al. in 1992.

Dodecaceria concharum (Oersted, 1843) CIRRATULIDAE

Type locality: Denmark

Distribution: Cosmopolitan species, found on the west coast from Western Canada to Southern CA (Hartman 1969). Other records from the English Channel, Mediterranean, Black Sea, and the eastern US (N. Carolina) (Knox 1971).

Habitat: This species is found in burrows in shells and calcareous algae. In Humboldt Bay, it is found subtidally in burrows in large, empty bivalve shells in North Bay Channel along with *Polydora websteri, Dipolydora socialis,* and an unidentified phoronid (Sta. 28). *D. concharum* has been previously collected in Humboldt Bay in similar habitats (Barnhart et al. 1992).

This survey: North Bay Channel in shell debris.

Euchone limnicola (Reish, 1959) SABELLIDAE

Type locality: Long Beach Outer Harbor (Hartman 1969)

Distribution: Southern CA, estuarine, in sandy muds (Hartman 1969). Two other *Euchone* species, *E. analis* and *E. incolor* described from benthic in British Columbia and Washington (Orensanz, on line), but *E. limnicola* not found.

This survey: *E. limnicola* was found subtidally in Eureka Channel, Samoa Channel, and East Bay Channel. Common.

Exogone lourei (Berkeley and Berkeley 1938) SYLLIDAE

Distribution: British Columbia; Washington; Oregon; California; ?Mexico; Gulf of Mexico; Texas, Louisiana, Mississippi, Alabama, Florida; Cuba; Spain (Blake, Hilbig and Scott 1995). Other records: Canary Islands (Nunez et al 1992), in Madeira, found in Porifera: Demospongiaria: *Erylus discophorus, Penares candidata, Aaptos aaptos, Cliona viridis,* and *Petrosia ficiformis.*

Previously reported habitat: Intertidal to shallow depth; algal flats dominated by *Caulpera verticillata* and *Halimeda opuntia* f. *triloba, Thalassia testudinum* seagrass meadow (Russell 1991); calcareous crusts on *Spondylus senegalensis* (Nunez et al. 1992). *Exogone lourei* specimens have been found with spicules or spicule fragments in their guts – those of the sponges in which they were found may suggest relationship with sponge is "occasionally parasitic" (Pascual et al. 1996).

This survey: found intertidally from Hookton Slough, South of Eureka Marina, Southport Landing, Klopp Lake, Woodley Island Marina, Mad River Slough #2, Mad River Slough #1, Hilfiker Road, Bracut. Common in subtidal samples, as well. Barnhart et al. (1992) described as abundant in sand and mud in Humboldt Bay.

Fabricia sabella (Ehrenberg 1937) SABELLIDAE

Type locality: Heligoland, North Sea (Hartman 1969)

Distribution: Cosmopolitan in enclosed bays, in mud, Central CA, in estuarine mud. Banse (1979) reports *Fabricia sabella sabella* from Newcastle Island, British Columbia; and elevates *F. sabella oregonica* to (sub)specific rank. Constructs mucoid tubes externally covered with silt, in protected bays and estuaries, over surface of mud.

A tiny worm and that may be easily overlooked; therefore, may be more widely distributed in Humboldt Bay, or alternatively, may be restricted in Humboldt Bay to intertidal and estuarine sites with firmer sandy or clay mud sediments, such as Jacoby Creek (clay/mud) or Samoa Boat Ramp (muddy sand). This is the first record of this species from Humboldt Bay.

This survey: Intertidal mud near the mouth of Jacoby Creek.

Glycera americana (Leidy, 1855) GLYCERIDAE

Type locality: Rhode Island (Hartman 1969)

Distribution: Cosmopolitan; Atlantic and Pacific coasts of N. and S. America; Gulf of Mexico; Straits of Magellan; New Zealand; Southern Australia, intertidal to 530 m (Blake et al. 1994). Recorded from Humboldt Bay by Barnhart et al. 1992

This survey: Fields Landing Channel

Harmothoe imbricata (Linnaeus, 1767) POLYNOIDAE

Type locality: Iceland (Linnaeus 1767) – uncertain if based from actual specimen or just a drawing according to Chambers and Heppell (1989).

Distribution: Cosmopolitan species found throughout the arctic and boreal seas. Widespread throughout the northern hemisphere, extending down to the Mediterranean and to New Jersey in the Atlantic, and from the Yellow Sea around the Pacific Rim to southern California. Ruiz et al. (2000) states cryptogenic.

Habitat: It is abundant in the intertidal and shallow subtidal, but is also found out to abyssal depths. This species utilizes a wide variety of habitats including under rock, subtidal on rock, mud or sand substrates, eelgrass beds, kelp holdfasts, mussel beds and old *Sabellaria* reefs. One of the most widely distributed species of polynoids, free-living as well as commensal with echinoderms and other polychaetes.

Recorded from Humboldt Bay by Barnhart et al. (1992) as abundant, on rock and piling habitats.

This survey: Specimens from intertidal sites include South of Eureka Marina, Southport Landing, Woodley Island Marina, Mad River Slough #1, Samoa Boat Ramp. Not taken subtidally in this survey.

Heteromastus filiformis (Claparede, 1864) CAPITELLIDAE

Type locality: Mediterranean Sea (Hartman 1969)

Native: Atlantic coast of US (New England to Gulf of Mexico)

Distribution: Atlantic coast of US; Greenland, Sweden, Mediterranean; Morocco, South Africa; Peruvian Gulf; New Zealand; Japan; Bering and Chukchi Seas; California: San Francisco Bay, Morro Bay, southern CA?, Bolinas Lagoon; Vancouver Island; Coos Bay; Grays Harbor, WA. (Cohen and Carlton 1995). Blake et al. (2000) lists as widespread in Atlantic and Pacific; Australia, Victoria to Queensland; and Mediterranean.

Habitat: Intertidal in silty and mixed sediments. A dominant species in intertidal muds subject to low oxygen conditions (Blake et al. 2000). Barnhart et al. 1992 failed to include *H. filformis* in species list from sampling of channels; suggests more strictly intertidal. *H. filiformis* may have been introduced to San Francisco Bay in the late nineteenth or early twentieth century with Atlantic oysters or as early ballast water introduction (Cohen and Carlton 1995)

This survey: *H. filiformis* was collected from Mad River Slough #1 and #2, Bracut. Other sites may exist due to the fact that several immature, unidentified capitellid specimens of probable genus *Heteromastus* were found.

Heteropodarke heteromorpha (Hartmann-Schroder 1962) HESIONIDAE

Type locality: Peru, Callao; in sands with shell fragments and some pebbles.

Distribution: New Caledonia; Peru to CA; 3 to 98 m

Habitat: Found in sandy sediments, shallow subtidal.

This survey: only one specimen taken subtidally from North Bay Channel; ?rare.

Marphysa sanguinea (Montagu, 1815) EUNICIDAE

Type locality: England (Hartman 1968)

Distribution: Europe (Great Britain to the Mediterranean); western Atlantic (Massachusetts to the West Indies, Gulf of Mexico, Bermuda and the Bahamas); Japan; China; Australasia to the Red Sea and Africa; eastern Pacific (SF Bay; Los Angeles to Panama). Linero-Arana (1991) reports it from NE Venezuela, as well. Hartman (1969) lists distribution as southern California.
Habitat: In intertidal mud and algal covered estuaries; cosmopolitan in warm or temperate seas.

Listed in Ruiz et al. 2000 (appendix) as *Marphysa "sanguinea"* as: introduced/cryptogenic, established, 1969 1st record in SF Bay, multiple vectors include shipping and fisheries, native to the amphi-Atlantic, probable source region is west Atlantic.

M. sanguinea is reported as a single, cosmopolitan species, though it is likely to be a composite of several difficult to distinguish but distinct taxa. Cohen and Carlton 1995 report it as known to San Francisco Bay since 1969; it is thought to have been introduced via Atlantic oysters or in ballast water. Reported by Hopkins (1969) (listed in Cohen and Carlton 1995 literature as 1986, not '69) as common at concentrations of 10-200 per square meter, but found only in South San Francisco Bay south of Hunter's Point and most commonly in the channels.

Five species reported from California: *M. belli oculata, M. conferta, M. disjuncta, M. mortenseni, M. sanguinea*, and *M. stylobranchiata*. Santa Maria Basin atlas reports only *M. conferta* present in their collections.

This survey: Found at Mad River Slough #1, sparse.

Myxicola infundibulum (Reiner, 1804) SABELLIDAE

Type locality: Mediterranean Sea (Hartman 1969)

Distribution: Central to southern CA, in shelf depths in mixed sediments; Mediterranean and western Europe; cosmopolitan (Hartman 1969) Berkeley and Berkeley (1952) lists western Canada, Alaska, Atlantic, Mediterranean, and Arctic. Introduced to Port Philip Bay, Australia according to Ruiz et al. 2000.

New this survey: Woodley Island Marina, very common at this site. Also collected from floating dock at Hookton Slough.

Nereis pelagica (Linne or ?Linnaeus, 1758) NEREIDAE

Type locality: Western Europe

Distribution: Cosmopolitan; NW Europe (Norway to Mediterranean Sea); West Africa; New England to Florida; Bering Sea to Panama; Japan: South Pacific; intertidal to 1200 m.

Habitat: Found in a wide variety of habitats – soft sandy sediments (rarely mud), to rocks, encrusting animals, and algal holdfasts. According to Pettibone (1963), it prefers clean, circulating water. Epitokous specimens found in surface waters year-round, most often in spring and summer. Confusion in literature as to specific rank; Hartman (1940) describes ?*Nereis pelagica* based on specimen with a reduction of dorsal ligules in posterior segments, which was later assigned to be a juvenile character (Blake and Hilbig 1994). Hartman (1969) describes *Nereis pelagica neonigripes* (Hartman 1936) from "northern and southern California, intertidal, in rocky habitats" but this subspecies has since been included into stem species by Pettibone 1963.

This survey – found at South of Eureka Marina, and Woodley Island, new record for Humboldt Bay.

Pholoe minuta (Fabricius, 1780) PHOLOIDAE

Distribution: Circumpolar. Widespread in Arctic to northeastern Atlantic to France (Fauvel 1923); northwestern Atlantic off New England (Verrill 1881; Webster and Benedict 1884,1885); northwestern Pacific – northern Sea of Japan (Annenkova 1937); northeastern Pacific to southern Oregon (Hartman and Reish 1950); off South Africa (Ehlers 1913; Fauvel 1914). Intertidal to 1254 fathoms (Pettibone 1953). However, this species may have been identified previously as either *P. tuberculata* or *P. glabra* (see Barnhart et al. 1992).

Pholoe glabra appears to be the most common species in California. *Pholoe minuta* is a widespread species and may be present in California estuaries and other nearshore habitats... Several species appear to have been confirmed with *P. minuta* in the North American literature and a review of these records is needed. Pettibone's (1953) description of *P. minuta* from the Puget Sound appears to be of *P. glabra* (Blake et al. 1995). Blake et al. (1995) list distribution of *P. glabra* as California to Mexico; CA intertidal; subtidal on shelf and upper slope to 300 m.

This survey: Benthic stations in Arcata Bay.

Polydora cornuta (Bosc, 1802) SPIONIDAE

Type locality: Charleston, South Carolina (as redescribed and new neotype designation by Blake and Maciolek 1987)

Distribution: northern Atlantic; eastern Pacific from British Columbia to Southern CA; Salton Sea; ?Mexico; Europe; Australia. Widely reported as *Polydora ligni* Webster, including in Cohen and Carlton (1995). *Polydora amarincola* (Hartman 1936) also synonmy. Common fouling organism in bays of the Pacific coast. Found in mud and sand flats of estuaries; soft sediments. This species has been subject to numerous investigations as reviewed by Blake, Hilbig and Scott (1996) in introduction to Spionidae.

Reported in Humboldt Bay by Barnhart et al. (1992) under both *Polydora ligni* and *Polydora socialis* names. *P. socialis* was described as abundant, from sand and mud in that report.

This survey: Collected at Southport Landing and Klopp Lake.

Polydora limicola (Annekova, 1934) SPIONIDAE

Type locality: in western Pacific at Bering Island, near Kamchatka (Annenkova 1934) Distribution: Los Angeles vicinity, intertidal, along breakwaters, in *Mytilus* colonies, massed in crevices and forming muddy sheaths over rocks and other hard substrata. (Hartman 1969). Eastern and western North Pacific, ?Europe (Blake, Hilibig and Scott 1996).

Material was examined from Washington, Puget Sound, near Tacoma by Blake, Hilbig and Scott (1996) and compared to southern California specimens.

Habitat: Surfaces of rocks on tidal flats, forming dense aggregations in southern CA harbors. Manchenko and Radashevsky (1993) report *P. limicola* as a "fouling organism on the bottoms of ships in the Sea of Japan."

A 'sibling species' to *Polydora ciliata*, according to Manchecnko and Radashevsky (1993), which previously was distinguished from *P. limicola* on strict habitat differences. It is highly likely that some reports of *P. ciliata* from soft sediments may actually refer to *P. limicola* or another species such as *P. aggregata*. (Blake, Hilbig and Scott 1996).

This survey: Mud of Eureka Channel, Field's Landing Channel

Pseudopolydora kempi (Southern, 1921) SPIONIDAE

Type locality: Chilka Lake, India

Distribution: Mozambique; India; Japan; Kurile Islands, with salinities from marine to 6 ppt (Light 1969). Nanaimo, British Columbia (1951) – 1st collection from eastern Pacific; later found at False Bay, San Juan Island (1968); WA and Yaquina Bay (1974); Netarts Bay (1976); Coos Bay (1977). India, Chilka Lake; South Africa; Japan; Korean Archipelago; British Columbia and Puget Sound; California. In mud, sand or sand and mud; intertidal to shallow subtidal (Light 1978); Port Philip Bay, Australia (Ruiz et al. 2000).

California: Morro Bay (1960), Bolinas Lagoon (1967), San Francisco Bay (1972), Bodega Harbor, Tomales Bay, and Anaheim Bay (1975), (references in Carlton 1979, p. 310, Cohen and Carlton 1995), Humboldt Bay (Barnhart et al. 1992). Cohen and

Carlton (1995) speculate that *P. kempi* may have arrived with shipments of *Crassostrea gigas* from Japan, from ballast water, or from ship fouling.

This survey: Widespread in mud at low intertidal and subtidal benthic stations.

Pseudopolydora paucibranchiata (Okuda 1937) SPIONIDAE

Type locality: Japan

Distribution: Japan; California: Los Angeles–Long Beach Harbor, Newport Bay, Alamitos Bay, Elkhorn Slough, SF Bay, Tomales Bay; New Zealand, Wellington Harbor. In sand, lower littoral to shallow subtidal (Light 1978). "Like *P. kempi*, this species appears to have been introduced into North America from Japan." (Light 1978). Cohen and Carlton (1995) state that *P. paucibranchiata* may have been introduced to northeastern Pacific in ballast water or from ship fouling (possibly due to increased ship traffic associated with the Korean War), or with Japanese oysters.

Distribution: Japan; Australia (1973) (see Carlton 1985); New Zealand (?); CA: LA Harbor (1950), Newport Bay (1951), San Diego Bay (1952), Alamitos Bay (1958), Anaheim Bay and Santa Barbara (1975), Mission Bay (1981) (see Carlton 1979a; Blake 1975); Netarts Bay, OR (1976) (see Light 1977; Carlton 1979a, p. 312) (All references in Cohen and Carlton 1995).

This survey: Humboldt Bay, new to this survey, Mad River Slough, low intertidal mud under Samoa Bridge and near mouth of Elk River, benthic stations in Mad River Slough Channel.

Pygospio elegans (Claparede, 1863) SPIONIDAE

Distribution: North Atlantic; Nova Scotia to Massachusetts; Norway to Mediterranean Sea; Baltic Sea; South Africa; North Pacific: western Canada to CA; Sea of Okhotsk; Prudhoe Bay, Alaska (Light 1978). *P. elegans* is common in high intertidal habitats in California (Blake et al. 1996)

This survey: Intertidal mud near mouth of Jacoby Creek and at Southport Landing.

Sabellaria gracilis (Hartman 1944) SABELLARIDAE

Type locality: Port Fermin, CA; shore

Distribution: southern CA, littoral regions, rocky habitats in protected niches (Hartman 1969). Previously described in Humboldt Bay (Barnhart et al. 1992).

This survey: *S. gracilis* found largely attached to shell debris from Samoa Channel, North Bay Channel and Woodley Island Marina (on live mussels). Possibly cryptogenic in Humboldt Bay.

Serpula vermicularis (Linnaeus, 1767) SERPULIDAE

Type locality: western Europe (Hartman 1969)

Distribution: California, intertidal and subtidal depths on hard surfaces; northern Alaska; Cosmopolitan (Hartman 1969). Humboldt Bay, Barnhart et al. 1992

This survey: one specimen collected in North Bay Channel (Sta. 33, BL). Cryptogenic in Humboldt Bay.

Spiophanes bombyx (Claparede, 1870) SPIONIDAE

Type locality: France (Hartman 1969)

Distribution: southern CA: shelf, slope and canyon depths in silty mud; Cosmopolitan (Hartman 1969). New England, Virginia, North Carolina, Florida; Gulf of Mexico; WA to CA; Bering Sea; Netherlands; Bay of Biscay; Argentine Basin; low intertidal to 1,336 m (Blake et al. 1996). "*Spiophanes bombyx* is common in shallow-water benthic communities in sandy sediments. This species may be the dominant organism in such habitats." (Blake et al. 1996).

Distribution: Cosmopolitan, in intertidal sand flats to 119 m (Light 1978). Previously recorded in Humboldt Bay by Barnhart et al. 1992

This survey: Samoa Channel, North Bay Channel, East Bay Channel and Fields Landing Channel.

Spiophanes wigleyi (Pettibone, 1962) SPIONIDAE

Distribution: Western North Atlantic; northeastern North America, North Carolina; Gulf of Mexico; Australia; southwest Africa; eastern Atlantic; Bay of Biscay; Farallones; Santa Maria Basin, off Purisima Point (Blake et al. 1996).

This survey: North Bay Channel, single individual.

Steblospio benedicti (Webster, 1879) SPIONIDAE

Type locality: Gulf of Maine (Light 1978)

Distribution: Gulf of St. Lawrence, Gulf of Maine, Atlantic coast of North America to Florida and Texas; Gulf of Mexico; South America (Maracaibo estuary); central to southern California: San Francisco Bay in huge numbers in mud flats in east bay and Lake Merritt (Hartman, 1936:46); Point Richmond (Jones 1961); Carquinez & Mare Island straits (Lui et al. 1975); Oakland Inner Harbor, Redwood City Harbor, and South Bay (Light 1978); North Sea, Denmark, Holland, France. [All references in Light 1978]. "*Streblospio benedicti* appears to have been introduced from the Atlantic coast of North America into California estuaries in association with the Virginia oyster, *Crassostrea virginica* (Gremlin) (see Carlton, 1975:19)" (Light 1978). "As with *Polydora ligni*, the other spionid discovered in SF Bay in the 1930's, *Streblospio* could have been introduced with Atlantic oysters..., in ballast water, or possibly in ship fouling, and moved along the Pacific coast with shellfish transplants or coastal shipping." (Cohen and Carlton 1995)

Western Atlantic from the Gulf of St. Lawrence to Gulf of Mexico and Venezuela; northern Europe; Mediterranean Sea; Black Sea; SF Bay in 1932; Tomales Bay and Bodega Harbor in 1936; subsequently in other estuaries south to Newport Bay and north to Grays Harbor, Wa. (records in Carlton 1979a, p. 314) (Cohen and Carlton 1995). Ruiz et al. 2000 states "established" in San Francisco Bay, Coos Bay, and Puget Sound.
Recorded from Humboldt Bay in Barnhart et al. 1992

This survey: *Streblospio benedicti* collected in intertidal muds from Bracut, near mouth of Elk River, Mad River Slough, Southport Landing, Klopp Lake and subtidally from Eureka Channel.

Typosyllis hyalina (Grube, 1863) SYLLIDAE

Distribution: Widespread from both north Pacific and Atlantic basins; Mediterranean Sea; Panama; CA north to British Columbia; Japan (Blake 1995). Associated with algae, sponges and mussel beds in intertidal zones; with hard substrata at 69-90 m (Blake 1995). Recorded previously in Humboldt Bay (Barnhart et al. 1992)

This survey: South of Eureka Marina, Eureka Boat Basin, Klopp Lake, Woodley Island Marina, and subtidally in North Bay Channel. It was found among mussels on pilings, in eelgrass beds, and among algae on rocks.

GASTROPODS

Crepidula sp.

There are both native and introduced slipper shells along the coast of Humboldt County. The native species are found along the outer coast, with this introduced species found in the bay. It is typically sparse, only a few were taken in this survey. The slipper shells in San Francisco Bay *are C. glauca* and *C. plana,* the species in Humboldt Bay may be one of these two. Both species are from the western North Atlantic and were probably introduced into San Francisco Bay with *Crassostrea virginica* and the same probably occurred in Humboldt Bay incidental to attempts culture Atlantic oysters. Early attempts to culture Atlantic oysters in Humboldt Bay were not successful.

This survey: *Crepidula* sp. Was collected at Klopp Lake and in oyster beds of Arcata Bay.

Ovatella myosotis

Synonyms: *Alexia setifer*
Alexia setifer var. *tenuis*
Phytia myosotis

First record in Humboldt Bay: 1876 (Cohen and Carlton 1995)

Distribution: Both coasts of North Atlantic – may have been introduced to western Atlantic in late 18th or early 19th century (Berman and Carlton 1991). First collected from San Francisco Bay in 1871; probably introduced with Atlantic oyster. Other records of 1st collection: 1915 in San Pedro Harbor, CA and 1927 in Washington State. Now found on Pacific coast from Boundary Bay, British Columbia to Scammons Lagoon in Baja Mexico (Carlton 1979, p. 414, Cohen and Carlton 1995).

Habitat: Euryhaline; lives under debris near high tide line of salt marshes and protected beaches in lagoons and bays.

Berman and Carlton (1991) studied dietary competition with native snails (*Assiminea californica* and *Littorina subrotundata*) in Coos Bay, OR; did not find competitive superiority by *O. myosotis* (Cohen and Carlton 1995).

This survey: common and abundant in salt marshes around Humboldt Bay.

Urosalpinx cinerea

Common name: Atlantic oyster drill

Distribution: Native to northwestern Atlantic from Gulf of St. Lawrence to Florida (Cohen and Carlton 1995). The oyster drill is native to the east coast of North America where it can be an important predator of young oysters (Cohen and Carlton 1995). The distribution of this species in bays along the coast of western North America suggests that it has been introduced with attempts to culture the eastern oyster *Crassostrea virginica.*

Introduction: Introduced to San Francisco Bay with shipments of Atlantic oysters; 1st collected from oyster beds at Belmont in 1890 (Stearns 1894). Other 1st records: 1931-

Boundary Bay, B.C., 1929 – southern Puget Sound; 1948 – Willapa Bay; 1935 – Tomales Bay; pre 1940's – Newport Bay (Cohen and Carlton 1995).

This survey: Sparse, Klopp Lake (1 individual) and Bracut (1 individual).

OPISTHOBRANCHIA

Alderia modesta Sacoglossa

Distribution: Vancouver Island, British Columbia (Miller 1980) to Newport Bay, Ca (Cadien 1980); New England; British Isles; Norway to France (Behrens 1991).

Habitat: salt marsh

This survey: Mad River Slough #1

Dendronotus frondosus (Ascanius, 1774)

Distribution: Cosmopolitan in northern hemisphere (Robilliard 1970; Thompson and Brown 1976).

Habitat: common in bays and at boat docks (Behrens 1991).

This survey: Woodley Island Marina, Eureka Boat Basin, and Hookton Slough.

BIVALVIA

Crassostrea gigas

Common name: Japanese or Pacific oyster

Distribution: Native to northwestern Pacific from Sakhalin Islands to Pakistan. Introduced from Japan to Europe, Australia, and Pacific Coast of North America. "Introduced" (Smith and Carlton 1975).

Successfully cultured from Prince William Sound, Alaska to Newport Bay, California. "Established, reproducing populations are limited to a few hightemperature areas from southern British Columbia to Oregon..." (Coan, Scott, and Bernard 2000)

There is a long history of attempts to grow oysters in bays and estuaries along the California coast. The native oyster (*Ostrea lurida*) is too small and slow growing to support culture and marketing, thus the many attempts to establish a viable oyster growing industry over the last 100 years (Bonnot 1935). Oyster cultch is brought to Humboldt Bay from Puget Sound and is now placed on "long lines" that keep the oysters suspended above the bottom of low intertidal mudflats in Arcata Bay. Grow out takes 2-3 years before the oysters are of marketable size. In previous years "ground culture" took place by scattering the cultch over the surface of the low mudflats that were built up by depositing waste oyster shell.

There is no question that the transport of oysters from native regions in the western Pacific and from bay to bay along the coast has been a significant source of introductions, going beyond *Crassostrea gigas* itself. Sponges, bryozoans, algae, hydroids, and polychaetes are only a few of the major taxa that have been introduced to Humboldt Bay and other bays and estuaries along the western coast of North America incidental to oyster culture.

First reported for Humboldt Bay by Barnhart et al. 1992.

This survey: Mad River Slough #1 and throughout oyster growing areas in Arcata Bay.

Gemma gemma

Synonyms: *Venus gemma* Totten, 1834
Cyrena purpurea Lea, 1842
Venus manhattensis Jay, 1852
Gemma totteni Simpson, 1860
Parastarte concentica Dall, 1889
Gemma fretensis Rehder, 1939

Common name: Amethyst gem clam

Native to: northwestern Atlantic, from Nova Scotia to Florida and Texas.

First Pacific coast report: 1893 – from the crop of a duck bought in San Francisco; 1890's collected in San Francisco Bay; 1918 – collected in Bolinas Lagoon; 1960's and 70's collected in Bodega Harbor, Tomales Bay, and Elkhorn Slough (Carlton 1979a, p.490) (in Cohen and Carlton 1995).

First reported for Humboldt Bay by Barnhart et al. 1992.

Introduced probably with Atlantic oysters, *Gemma gemma* is one of the most common benthic species in San Pablo Bay (Cohen and Carlton 1995).

Now established in several locations from Humboldt Bay to Elkhorn Slough, California; intertidal to 100 m on mud or sand in estuaries (Coan, Scott, and Barnard 2000 – this information came from JT Carlton in a personal communication and a letter).

This survey: Found during this survey at Klopp Lake and Mad River Slough #1. *Gemma gemma* is widely distributed in low intertidal and subtidal mud sediments of Humboldt Bay. It is sometimes confused with the native clam *Transella tantilla,* with which it can co-occur. It is not known when this clam first appeared in Humboldt Bay, but its widespread occurrence suggests that it has been present for a number of years.

Laternula (Exolaternula) marilina (Reeve, 1860)

Synonyms: *Anatina marilina* Reeve, 1860
A. cristella Reeve, 1863
A. navicula Reeve, 1863
A. limicola Reeve, 1863
A. kamkurama Pilsbry, 1895
A. peichiliensis Grabau & King, 1928

Distribution: Northwestern Pacific from Sakhalin Island to southern Japan & China. First introduced and temporarily established from 1963-1966 at Coos Bay (pers comm JT Carlton, 1966 in Coan, Scott and Bernard 2000). Established in Willapa Bay, WA (Chapman, 1998 email) and Humboldt Bay, CA in mud (Coan, Scott and Bernard 2000).

This survey: First report in Humboldt Bay is this survey. Found in Southport Landing, Klopp Lake, and Mad River Slough #1. Restricted to high intertidal mud flats in Humboldt Bay. "All live specimens but one.... were recovered from northeast Humboldt Bay." (Miller, Coan and Chapman, 1999). This small clam is apparently a recent arrival in Humboldt Bay (Coan et al. 2000). The Miller, Coan and Chapman (1999) report *L. marilina* found in low densities and with a patchy distribution.

Modes of introduction (as reported from Miller, Coan and Chapman 1999):

1. previously introduced but undiscovered northeast Pacific populations
2. transplanted to Humboldt Bay with domestic oyster transplants (Monroe et al. 1973; Barnhart et al. 1992)
3. with internationally transplanted Japanese oyster spat (Woelke, 1955)
4. international ballast water traffic (Carlton & Geller 1995).

Macoma balthica (or *M. petalum*)

This species has been thought to be native to the eastern North Atlantic Basin (Coan et al. 2000). It was probably introduced to bays and estuaries of the Pacific coast along with oysters (*C. virginica*) for culture (Cohen and Carlson 1995). Recent investigations of molecular markers suggest that *Macoma balthica* of previous investigators in San Francisco Bay may be *Macoma petalum*. There has been no comparable work on this species from Humboldt Bay, so we retain the previous species name.

Distribution: Circumboreal, arctic to central California (Coan et al. 2000)

This survey: Found in mud and silt in Humboldt Bay, common.

Mya arenaria (Linnaeus, 1758)

Synonyms: (see Coan et al. 2000, p. 470 for extensive list)

Common name: Soft-shell clam

Native region: Occurred in eastern Pacific in Miocene and Pleistocene, then became extinct. Persisted in Japan and in the North Atlantic

Distribution: Circumboreal; Icy Cape, Alaska, southern Bering Sea to Yukon Delta, south to Elkhorn Slough, CA, juveniles off San Diego; east to Korea, the Kurile Islands, northern Japan; North Atlantic from Iceland to Spain; Black Sea; east coast of North America from Newfoundland to Virginia; intertidal, in mud and sand.

Introductions: 1874 – to California with Atlantic oysters, eventually establishing a continuous distribution to northern Alaska. (Coan et al. 2000)

First record in recent CA: 1874- collected in San Francisco Bay (Newcomb 1874); probably transported with shipments of Atlantic oysters that began in 1869 (Cohen and Carlton 1995). It is not clear whether introductions were deliberate for this species or whether introductions were incidental to attempts to cultivate oysters from the Atlantic coast of North America.

Apparently *Mya arenaria* is not established south of Monterey, CA – although ~2000 were planted in Morro Bay in 1915 (Cohen and Carlton 1995).

First record of *M. arenaria* in Humboldt Bay by Barnhart et al. 1992

This survey: Found at Southport Landing, Mad River Slough #1, Bracut, and Hilfiker and subtidally at Samoa Channel (Sta. 13). It is common and abundant in low intertidal mudflats of Humboldt Bay in areas that are influenced by reduced salinities following winter rainfall. It is taken for bait and food by sport clammers.

Venerupis (Ruditapes) phillippinarum (Adams & Reeve, 1850)

Synonyms: (See Coan, Scott and Bernard 2000, p. 387)

Common name: Japanese Littleneck clam or Manila clam

Distribution: Natural range: from Kurile Islands, northern Japan, and Korea to China (Coan et al. 2000).

Introductions: with oyster seed from Japan – to southern British Columbia & Washington. Now has almost continuous distribution from Queen Charlotte Islands, British Columbia to Willapa Bay, WA, and from Humboldt Bay (JT Carlton letter 1992) to Elkhorn Slough, CA (JT Carlton letter 1992); intertidal in bays and estuaries. Also introduced to Hawaii and the Mediterranean (Coan et al. 2000).

"*Venerupis philippinarum*.... is an Asian clam that was introduced with shipments of Japanese oysters to the northeastern Pacific, where it has become established in numerous bays from British Columbia to central California and is the numerically dominant clam in many of them" (Cohen and Carlton 1995).

Introductions: (All references in Cohen & Carlton 1995)
1924 - planted in oyster beds in Samish Bay, WA (Kincaid, 1947)
1930 - Elkhorn Slough in shipments of Japanese oysters (Bonnot 1935b)
1936 - First record of an established population on Northern American coast: Ladysmith Harbor, Vancouver Island, British Columbia (Quayle, 1938)
1943 – Puget Sound
1946 – Willapa Bay and SF Bay
1949 – Bodega Harbor and Elkhorn Slough
1955 – Tomales Bay
1964 – Humboldt Bay and Gray's Harbor
1966 – Bolinas Lagoon

Many efforts were made to establish *V. phillipinarum* at different areas along the Pacific coast of North America in the 1950's and 1960's. All failed. However, it was established in Netart's Bay, OR in the 1970's (Carlton 1979a, p. 502).

Very common benthic organism in parts of San Francisco Bay (Cohen and Carlton 1995).

This survey: Mad River Slough #1 and Klopp Lake. Although it was recorded from Humboldt Bay in 1964 (Cohen and Carlton 1995), it was not found in abundance until 1996, when the bottom of Klopp Lake on the north end of Arcata Bay became covered with these clams. It is uncertain whether this species competes with the native littleneck, *Protothaca staminea*. In Klopp Lake, it displaced a large part of the population of *Mya arenaria* that had become established there. In other parts of the bay *V. philippinarum* is absent or rare.

CRUSTACEA

Mytilicola orientalis (Mori, 1938) COPEPODA

Distribution: western Pacific; eastern Pacific, from Vancouver Island, British Columbia to Morro Bay, California.

M. orientalis is an endoparasite in introduced and native bivalves and gastropods, including the slipper shell *Crepidula fornicata*, mussels *Mytilus califorianus* and *M. trossulus*, clams *Protothaca staminea, Saxidomus giganteus, Clinocardium nuttalli*, oysters *Ostrea conchaphila*.

Carlton (1979a) notes "[for] all the bays that have been searched, and most if not all mollusks that have been examined, have been found to have *Mytilicola*.

It is purported to be introduced to eastern Pacific via shipments of the Japanese oyster, *Crassostrea gigas*. (Cohen & Carlton 1995).

This survey: encountered frequently in *Mytilus trossulus* and *Crassostrea gigas*.

Iais californica (Richardson, 1904) ISOPODA

Type locality: Sausalito, CA collected by Dr. Ritter and party (Richardson 1905, p.455)

Distribution: Cryptogenic; New Zealand, Tasmania, Australia; Singapore; eastern Pacific, from Coos Bay to Baja Mexico; in estuaries.

Iais californica is a small commensal isopod living on *Sphaeroma quoyanum*, an introduced isopod from New Zealand. Presumably introduced along with its host, *Sphaeroma*, on this coast in ship fouling by 1893. Known to San Francisco Bay since 1904. Has been collected in most bays and harbors where *Sphaeroma* is found, and not from where *Sphaeroma* is absent. Considered "native elements of estuarine fauna of California" since their descriptions as *Janiropsis californica* and *Sphaeroma pentadon* (Rotramel 1971). Occasionally found on the native isopod, *Gnorimosphaeroma oregonensis*, but this isopod actively removes it, unlike *S. quoyanum*.

Not recorded by Barnhart et al. 1992 for Humboldt Bay that might suggest a relatively new introduction, since *Sphaeroma quoyanum* (= *S. pentadon*) was also not recorded in 1992.

This survey: Hookton Slough; Klopp Lake; Mad River Sloughs #1 and #2; Bracut; Jacoby Creek.

Limnoria lignorum (Rathke 1799) ISOPODA

Distribution: Cryptogenic; east and west coasts of North America as far south as 40°N; Europe from Norway to southern Britain. Fairly worldwide distribution in temperate-tropical waters. (Naylor 1992).

Cohen and Carlton (1995) suggest that *L. lignorum* is a species that is "possibly native from Alaska to Humboldt County."

A boreal wood-boring species, on the bases of exposed piling and sublittoral. It occupies the upper level of *Limnoria* attack when two or more species occur together (Jones 1963 as stated in Naylor 1992).

Native region unknown.

Collected in Samoa, California in 1949, along with *Limnoria quadripunctata* (Menzies 1957). In those records, and from our 2000 collections, *L. lignorum* was taken in far fewer numbers that *L. quadripunctata*.

This survey: We consider this species as cryptogenic to this area, especially in consideration of the fur trade routes in the later part of the 1800's, which could have brought this species further south from Alaska.

Limnoria quadripunctata (Holthuis, 1949) ISOPODA

Type locality: Holland.

Distribution: temperate species occurring on south and western coasts of Britain from Kent to the Isle of Man; Holland; New Zealand; South Africa and the Californian coast of N. America (Naylor 1972).

Native region unknown.

Wood boring, occurring in the middle zones of piles infested with *Limnoria*.

This survey: South of Eureka Marina, Hilfiker Road, and Bracut.

Sphaeroma quoyanum (H. Milne Edwards, 1840) ISOPODA

Distribution: Atlantic coast of N. America to Key West and western Florida (Menzies and Krruezynski 1983); Pacific coast from Coos Bay to Baja Mexico; New Zealand, Australia, Tasmania.

Reported from Humboldt Bay in the 1920's and 30's and from Coos Bay in the 1950's.
Burrows into all types of soft substrate, including clay, peat, mud, sandstone, and soft or decaying wood, and wood that has been bored by shipworms and gribbles. (Cohen and Carlton 1995).

This survey: Common borers in mud banks in Klopp Lake. Also found in Hookton Slough, Mad River Sloughs #1 and #2, Jacoby Creek and Bracut. Most likely introduced via ship fouling.

Leptochelia savignyi (Kroyer, 1842) TANAIDACEA

Distribution: Cosmopolitan; Mediterranean, on the Dutch coast, along Atlantic shores from Britanny to Senegal; British Isles, limited to south-west coast of England, the Channel Islands, west and south-west Ireland; east and west coast of North America; Brazil; Indo-West Pacific; South Africa; Hawaii; Tuamotu Archipelago (Holdich and Jones 1983). Other records: Bermuda and Puerto Rico.

Distribution: *L. dubia* occurs in tropical and subtropical shallow waters throughout the world; it is known from Santa Maria Basin, California south to La Jolla, San Diego County, CA. (Blake and Scott 1997). In Tomales Bay, *Leptochelia* is one of the most abundant crustaceans inhabiting the soft bottom and may attain densities of 30,000 per square meter (Mendoza 1982).

Inhabits a wide range of substrates, from rocks and sand to mud and silt (Blake and Scott 1997). Found intertidally in self-constructed tubes among *Zostera* roots and weeds on rocks. Also noted to be a common inhabitant of the shallow sublittoral (J. Kitching, pers comm., in Holdrich and Jones 1983, p.48).

Reported for Humboldt Bay by Barnhart et al. (1992) as *L. dubia.*

This survey: found at Mad River Sloughs, #1 and #2; South of Eureka Marina; Southport Landing; Woodley Island Marina. Also collected subtidally from North Bay Channel.

Sinelobus standfordi (Richardson, 1901) TANAIDACEA

Distribution: Galapagos Islands; Brazil; West Indies; Mediterranean; Senegal; South Africa; Tuamotu Archipelago; Hawaii; Kurile Islands; England; eastern Pacific.

Has been reported from "Arctic cold, north Pacific temperate, southern temperate waters, tropical warm Atlantic" waters" (Cohen and Carlton 1995). Given this broad distribution, it is likely that a *species complex* is involved, and thus Carlton is hesitant to apply the name of a warm tropical tanaid from the Galapagos Islands to the San Francisco Bay population.

Widespread throughout the estuarine margin of San Francisco Bay, including Lake Merritt in Oakland, Corte Madera Creek in Marin, and in San Pablo Bay. The only other record appears to be from Humboldt Bay as *Tanais* sp., from S. Larned, personal communication (1989) "Levings and Rafi (1978) noted that there were no previous records of *T. standfordi* from the west coast of North America." (Cohen and Carlton 1995).

This species is cosmopolitan and occurs in shallow intertidal and estuarine areas, including some records from freshwater (Sieg and Winn 1981).

This survey: Collected from Humboldt Bay locations: Mad River Slough #1 and #2, and at Klopp Lake.

Nebalia pugettensis (Clark, 1932) LEPTOSTRACA

Distribution: Cohen and Carlton (1995) suggest that *Nebalia pugettensis* is a native, at least to San Francisco Bay. Kozloff (1987) lists it as one of two species (the other being undescribed) for the Pacific Northwest region. Abundant in the lower intertidal, and also subtidally. It prefers situations where algae and other organic detritus are decomposing (Kozloff 1987).

This survey: On algal and other plant debris at low intertidal locations.

Ampithoe valida (Smith, 1873) AMPHIPODA

Distribution: North American Pacific coast; and N. American Atlantic coast, from Chesapeake Bay to Cape Cod, Cape Ann and New Hampshire; in estuaries and brackish-water habitats, nestling among Ulvacea, from lower intertidal to depths a few meters.

Distribution: Pacific Ocean: British Columbia and Vancouver Island at 51° latitude south to Newport Bay, California (45°N); ? Japan at Shizuoka Prefecture (35°N). Atlantic Ocean: Piscataqua estuary (43°N), New Hampshire south to Chesapeake Bay, Virginia (37°N) (Conlan and Bousfield 1982). "Warm temperate species occurring mainly along sheltered coasts and estuaries, mainly in mesohaline to brackish waters. It builds tubes on algae and eelgrass on muddy, gravelly beaches in saltmarshes, tidepools and log fouling communities, at low water level to 30 m depth". (Conlan and Bousfield 1982).

This survey: Klopp Lake, Bracut, Elk River Slough (High), Jacoby Creek; Hookton Slough; South of Eureka Marina, Hilfiker Road.

Caprella equilibra (Say, 1818) AMPHIPODA

Type locality: South Carolina; common in bays and on *Gorgonia* in saltwater creeks

Distribution: South Carolina; records for Sweden and Norway to the Mediterranean Sea, including the British Isles; Black Sea [?]; Azores; tropical West Africa; St. Helena Island: South Africa; Madagascar; Mid-North Atlantic and Sargasso Sea; Bermuda; east coast of United States from Connecticut to Georgia; Port Aransas, Texas; Puerto Cabello, Venezuela; Cabo Frio and Rio de Jainero, Brazil; Mid-South Atlantic off Brazil; Mar del Plata, Argentina; Valparaiso, Chile; Taboga Island, Panama; between Panama and the Galapagos Islands; California; Hawaii; Nagasaki, Mukaijima, and Saganoseki, Japan; Philippine Islands; Cook Strait; New South Wales, Victoria, Fremantle, Australia; New Zealand; Tazmania; Hong Kong; Singapore, Malaysia (McCain1968).

New records for Fernandina, entrance to St. Johns River, St. Augustine, Daytona, Cape Kennedy, off Fort Lauderdale, Biscayne Bay, and Panama City, Florida; Grand Isle, La; Galveston and Port Isabel, Texas; Trinidad; Sacco Sao Francisco and Nictherey, Brazil; Estera de la Luna, Sonora, Mexico; Vancouver Island, British Columbia (McCain1968). Collected from various habitats including sea grass, red and green algae, sponges, hydroids, stylasterines, alcyonarians, bryzoans, and colonial ascidians. *C. equilibra* has been observed to catch small gammaridan amphipods, such as *Ampithoe* and *Jassa*, and also several small polychaetes (McCain1968).

Reported by Barnhart et al. 1992 for Humboldt Bay.

This survey: documented specifically for Woodley Island Marina, but is likely to occur more widely throughout Humboldt Bay.

Caprella mutica (Schurin, 1935) AMPHIPODA

Junior synonym: *Caprella acanthogaster humboldtiensis* (Martin 1977)

Distribution: Sea of Japan; Humboldt Bay, San Francisco Bay, and Elkhorn Slough (Monterey Bay), California (Marelli 1981).

Martin (1977) has reported the introduction of this species (as *C. acanthogaster humboldtiensis*) into California, probably from Japan (Marelli 1981).

Chelura terebrans (Philippi, 1839) AMPHIPODA

Distribution: Records for Los Angeles and San Francisco Harbors (Barnard 1950) Associated with the wood-boring isopods of the genus *Limnoria*. Present in California, unconfirmed to the north of CA. Barnard (1950), bores wood, associated with *Limnoria*, introduced (Smith and Carlton 1975)

This survey: found in woody debris on mudflats of South of Eureka Marina. Previous records of being found with *Limnoria* in wood at Field's Landing (unpublished data).

Chaetocorophium lucasi (Hurley, 1954; Karaman 1979) AMPHIPODA

(formerly *Paracorophium lucasi*)
Type locality: Lake Rotoiti, freshwater in Rotorua District, NZ

Distribution: Lake Rotoiti, North Island, New Zealand; ? Lake Waikare, N.Z.; endemic freshwater species derived from the somewhat more cosmopolitan brackish P. excavatum (Hurley 1954) in New Zealand; Humboldt Bay, California.

Chaetocorophium lucasi, a small amphipod from estuarine and freshwater habitats in New Zealand, appears to be a relatively recent introduction to Humboldt Bay. Surveys of local salt marsh habitats in the 1980's failed to detect this species (unpublished data) while samples from the same sites in 2000 often contained hundreds of individuals.

In New Zealand, *C. lucasi* is found in estuarine habitats, associated with slow-flowing rivers while its closely related species, *Paracorophium excavatum* Thomson

1884 (from brackish water in Brighton Creek, near Dunedin, NZ), is found in estuarine harbor flats (Schnabel, Hogg, and Chapman 2000). Humboldt Bay specimens closely agreed with descriptions of *C. excavatum* in Hurley 1954 although males with mature gnathopod 2 morphology figured were not found. Schnabel, Hogg, and Chapman (2000) studied population genetic structure of *C. lucasi* in New Zealand and suggested that *C. lucasi* may represent at least three morphologically cryptic species. Beginning in the late 1970's, logs from New Zealand have been imported into Humboldt Bay and the most likely mode of introduction of this species is with this shipping traffic.

This survey: *C. lucasi* was collected from muddy intertidal habitats around the eastern margin of Humboldt Bay from the northernmost (Mad River Slough) to southernmost (Southport Landing) collection sites, in 2000. However, it was most abundant at sites in North Bay with fresh water input, often in shallow channels or pools in salt marshes (for example, Mad River Slough #1 and #2, Klopp Lake, Bracut and Jacoby Creek).

Corophium acherusicum (Costa, 1857) AMPHIPODA

Locality: Lyttelton Harbor, New Zealand (Chilton Collection)

Distribution: Cosmopolitan; Lyttelton Harbor (type locality), New Zealand; Southern England; coasts of France and Holland; Mediterranean; northern coast of Africa from the Suez Canal to Senegal; Durban Bay; Dar Es Salaam; Baffin's Bay to Brazil on the east coast of America; Alaska, Vancouver and California on west coast; Oahu, Hawaiian Islands; ship's bottoms at Hong Kong (Hurley 1954).

Corophium acherusicum, one of the most widely distributed *Corophium* species, is virtually cosmopolitan in warm temperate bays and harbors. It is found in protected and estuarine situations and tolerates somewhat reduced salinities. It is often abundant as a fouling organism on harbor pilings. In North America, this species has been collected from along the American Atlantic coast north to central Maine and on the west coast from British Columbia to Baja California (Cohen and Carlton 1995; Bousfield 1973).

In Humboldt Bay, *C. acherusicum* was found around the margins of the bay on oyster reefs (Mad River Slough #1), soft sediments (MRSL #2), rocks (Klopp Lake), and on floating docks (Woodley Island; Hookton Slough). In 1992, *C. acherusicum* was collected subtidally from shipping channels in HB (Barnhart et al. 1992). It was not identified during this survey from subtidal samples. This species appears to be an early introduction to west coast bays, with records from 1905 for Yaquina Bay, OR;

1912-13 from San Francisco Bay; and 1915 from Puget Sound (Cohen and Carlton 1995). Although this species was not recorded from Humboldt Bay prior to 1992, this probably reflects lack of sampling effort considering the history of shipping traffic between San Francisco Bay and Humboldt Bay. *C. acherisicum* was probably introduced as a fouling organism on ships, or in ballast water (see Carlton 1979a).

"It is noteworthy that its present known distribution traces out some of the major shipping routes, particularly that from England, through the Mediterranean and Suez Canal, to South Africa." (Hurley 1954, p. 445).

This survey: Six species of *Corophium* were collected in 2000 in Humboldt Bay. Of these, three species are currently considered to be introduced: *C. acherisicum, C. insidiosum,* and *C. uenoi.* Three species are native: *C. brevis, C. salmonis* (1 individual; Hilfiker Rd) and *C. spinicorne. C. acherisicum* was the most abundant *Corophium* species in a variety of habitats, *except* at sites with significant freshwater input. In contrast, *C. spinicorne* was restricted to a few sites with significant freshwater input.

Corophium insidiosum (Crawford 1937) AMPHIPODA

Corophium insidiosum is believed to be native to the North Atlantic. It has been collected from western Europe, Nova Scotia, and the American Atlantic from New Hampshire to Long Island Sound (Bousfield 1973). It has been introduced to the west coast of North America from British Columbia to southern California, to Chile, and to Hawaii (Cohen and Carlton 1995). Although the earliest record of *C. insidiosum* on the Pacific coast of North America dates from 1915, most west coast records are from post - 1931, when this species was first collected from Lake Merritt in San Francisco Bay (Cohen and Carlton 1995).

Corophium insidiosum is believed to have been transported to the northwestern Pacific with shipments of Atlantic oysters or as a fouling organism on ships (Cohen and Carlton 1995).

This survey: In Humboldt Bay, *C. insidiosum* was found intertidally on oyster reefs (Mad River Slough #1), soft sediments (MDSL #2; South of Eureka Marina; Southport Landing), and as a fouling organism at docks and marinas (Hookton Slough; Woodley Island). In samples from Humboldt Bay, *C. insidiosum* was usually collected with other larger *Corophium* species: *C. acherusicum, C. spinicorne,* and *C. brevis.*

Corophium uenoi (Stephensen, 1932) AMPHIPODA

Distribution: Described from Japan, this species was collected in Morro Bay in 1949 (Barnard 1952). Barnard (1952) suggested that this species may have been introduced into the eastern Pacific with oyster spat imported from Japan.

Corophium uenoi was collected from one site in Humboldt Bay – at Southport Landing in the upper-mid intertidal, in an area of freshwater drainage. *Corophium uenoi* was collected with *C. spinicorne, Allorchestes angusta, Hyale plumulosa,* and *Grandidierella japonica. Corophium uenoi* shares many characters with *C. insidiosum;* however, *C. uenoi* individuals are much larger at maturity.

Grandidierella japonica (Stephensen, 1938) AMPHIPODA

Grandidierella is a genus of tube building amphipods widely distributed in tropical and neo-tropical brackish environments (Myers 1970). However, *Grandidierella japonica,* described from muddy brackish habitats in Japan, is a temperate seas species. Previously restricted to bays, river mouths, and brackish lakes in Japan, *G. japonica* was collected in three central California embayments (Tomales Bay, Bolinas Lagoon, and San Francisco Bay) in 1966-1971 (Chapman and Dorman 1975). It was collected in Coos Bay, OR in 1977 and in southern California bays beginning in the early 1980's (Cohen and Carlton 1995).

This survey: In Humboldt Bay, *G. japonica* was first collected in Klopp Lake, a small man-made marine/brackish pond in North Bay. In 2000, *G. japonica* was found throughout the bay, although not particularly abundant in any location. Intertidally, *G. japonica* was found associated with muddy oyster reefs (Mad River Slough #1), soft sediments (Mad River Slough #2, Jacoby Creek, Hilfiker Road, Bracut, Southport Landing) and rocks (Klopp Lake). It was also found in samples from shipping channels and on docks at Woodley Island Marina. It has been suggested that *Grandidierella japonica* was introduced to the West coast with commercial oyster (*Crassostrea gigas*) spat transplants from Japan and that its date of introduction may have been well before 1966 (Chapman and Dorman 1975).

Hyale plumulosa (Stimpson 1853) AMPHIPODA

Humboldt Bay populations are possibly cryptogenic.

Distribution: Eastern Pacific, from southern Alaska to Southern California; western Atlantic from southern Maine (Casco Bay) to North Carolina (Bousfield 1973; Barnard 1979).

Intertidal on protected rocky and stony shores and in salt marshes at base of *Spartina* roots; under fucoids; under small stones and in crevices; occasionally in upper tidepools; mainly in the lower midlittoral, but occasionally up to the drift line (Bousfield 1973).

This survey: Bracut, South of Eureka Marina; subtidally from Eureka Channel (Sta. 23, directly next to Eureka Marina; sediments are black mud, and worm tubes).

Incisocalliope nipponensis (Bousfield and Hendrycks 1995) AMPHIPODA

Synonym: *Parapleustes derzhavini* Ishimaru 1984, in part

In a recent revision of the Pleustidae, *Parapleustes derzhavini* was split into three species: *Incisocalliope derzhavini and I. nipponensis* from Japan and *I. makiki* from the Hawaiian Islands (Bousfield and Hendrycks 1995).

Humboldt Bay specimens, although in good agreement with the description of *I. nipponensis*, also exhibited characteristics of the other two species formerly included in *P. derzhavini*. However, none of the Humboldt Bay specimens were "mature", i.e. no brooding females, and the examination of mature individuals may be necessary to separate these closely related species.

Outside of Japan, *Parapleustes derzhavini* has been collected from Yaquina Bay and Coos Bay, Oregon, and from San Francisco Bay, CA (Chapman 1988). Carlton (1985) suggests that *P. derzhavini* was transported with the fouling fauna on the hulls of ships and with discharged ballast water.

This survey: *I. nipponensis* was collected at only one site in Humboldt Bay in the 2000 survey – at Hookton Slough in South Bay where it was present in moderate numbers collected with bryozoans (*Conopeum* sp. and *Bowerbankia gracilis*), and sponges (*Halichondria bowerbanki*) on a floating dock. Other amphipods collected with *I. nipponensis* were *Ampithoe valida, Melita nitida, Corophium spinicorne, C. acherusicum* and *C. insidiosum.*

Ischyrocerus anguipes (Kroyer, 1838) AMPHIPODA

Distribution: *Ischyrocerus anguipes* is a common European species with a generally subarctic and boreal distribution in the Atlantic ocean. On the American Atlantic coast, *I. anguipes* occurs from the Hudson Strait south to New England and in deeper waters to Cape Hatteras (Bousfield 1973). On the Pacific coast, *I. anguipes* has been collected in samples from Oregon, Dillon Beach, CA (as *I. parvus*), and southern California (also as *I. parvus*) (Barnard 1954,1962). On the east coast *I. anguipes* is a common fouling organism in harbors and bays and is also found in rocky areas from low tide levels to depths of over 50 meters.

This survey: First reported for Humboldt Bay by Barnhardt et al. (1992). In 2000, *I. anguipes* was collected subtidally in shipping channels of Humboldt Bay, in mixed sediments containing large shell fragments.

Jassa slatteryi (Conlan, 1989) AMPHIPODA

May be cryptogenic in Humboldt Bay.

The 1989 revision of the *Ischyrocerid amphipod* genus *Jassa* established fourteen new species, resulting in the assignments of individuals formally assigned to the cosmopolitan species *Jassa falcata* among several new species (Conlan 1989). Conlan (1989) also re-established *Jassa marmorata*, which had been synonymized with *Jassa falcate* by Sexton and Reid (1951). Three species of *Jassa* were collected in 2000 in Humboldt Bay: *J. slatteryi*, *J. borowskae*, and *J. staudei*.

When describing *J. slatteryi*, Conlan (1989) designated Moss Landing Harbor, in Monterey County, California, as the type locality for specimens collected from a floating dock.

Jassa slatteryi has been collected from numerous sites along the west coast of North America from British Columbia, Canada, to Bahia de Los Angeles, Mexico. However, nearly all the records of this species south of British Columbia are from harbors or bays suggesting a possible spread of *J. slatteryi* from its northern population via shipping. *J. slatteryi* has also been collected from bays and harbors in Japan, South Korea, the Galapagos Islands, Chile, Brazil, South Africa, Australia, and New Zealand (Conlan 1990).

California records of *J. slatteryi* (from Conlan 1990) include: Moss Landing Harbor, Morro Bay, Santa Ynez, Newport Harbor, San Diego Harbor, Palos Verdes Point, Carmel Bay, Eureka Harbor, Cayucos, Bodega Bay, Monterey Bay.

This survey: In Humboldt Bay, *Jassa slatteryi* was very abundant in fouling assemblages at large marinas (Woodley Island, Eureka Boat Basin). It was also found in Klopp Lake, on a small dock in Hookton Slough, and subtidally in mixed sediment/shell fragment samples from shipping channels (North Bay Channel and Eureka Channel).

Melita nitida (Smith, 1873) AMPHIPODA

Distribution: Northwestern Atlantic, from Gulf of St. Lawrence to the Yucatan Peninsula, Mexico (Bousfield 1973). Known range on west coast: Straits of Georgia, British Columbia to Elkhorn Slough, California (Chapman 1988).

Widespread in east coast estuaries as a common fouling organism found under intertidal rocks and debris, in *Enteromorpha* or diatom mats, on mudflats, and in mesohaline conditions of 0-25 ppt (Chapman 1988; Cohen and Carlton 1995). Common in west coast estuaries under wood and rock debris in intertidal areas, and on mudflats in thick mats of *Enteromorpha* or diatoms (Chapman 1988).

Reported from oyster beds on Atlantic and therefore is thought to be transported with transcontinental shipments of Atlantic oysters, or possibly in solid ballast or ballast water (Cohen and Carlton 1995).

First reported for Humboldt Bay in this survey. A closely related species, *Melita dentata*, was recorded for Humboldt Bay by Barnhardt et al. (1992). *M. dentata* bay populations are cryptogenic as well, as individuals were found in subtidal channels including Samoa Channel, North Bay Channel.

"The disjunct records of *M. nitida* amongst estuaries north of San Francisco are probably due in part to incomplete collecting" (Chapman 1988).

This survey: *Melita nitida* was found in Humboldt Bay intertidally at Klopp Lake (in the ~50's numerically) and Bracut (in the ~10's).

Microdeutopus gryllotalpa (Costa, 1853) AMPHIPODA

Distribution: Coasts of northwestern Europe; Norway south to the Mediterranean and Black Sea; western Atlantic from Cape Cod and southern Massachusetts, Connecticut, Long Island Sound to Chesapeake Bay (Bousfield 1973).

Microdeutopus gryllotalpa has been collected from intertidal and subtidal sites around docks and piers, on oyster flats, in salt marshes, among *Zostera*, and among *Chaetomorpha* and other algae. It is tolerant of somewhat brackish water (Bousfield 1970),

This appears to be the first record of this species on the west coast of north America. However, it may be present in earlier west coast collections, as *Microdeutopus* sp., or *M. schmitti* (found among algae from Monterey Bay, CA to Cape San Lucas, Baja California (Barnard 1969). Males of *Microdeutopus gryllotalpa* can be distinguished from *M. schmitti* and from other east coast species of this genus by the anteriorly expanded basis of the second gnathopod, as well as by other characters.

This survey: In Humboldt Bay, *Microdeutopus gryllotalpa* was collected in North Bay, from muddy oyster reefs in at Mad River Slough #1, mud with rocks at Bracut, mud with *Zostera* and algae at Hilfiker Road, rock and shell in Klopp Lake, and among muddy rocks at Southport Landing in South Bay. Previously this species, as *Microdeutopus* sp., has been collected in the 1980's from shallow pools in a salt marsh adjacent to Mad River Slough (unpublished data).

Microjassa litotes (Barnard, 1954) AMPHIPODA

May be cryptogenic in Humboldt Bay.

Distribution: Confirmed in Humboldt Bay by presence of large (presumably adult) males: Torch Bay, Alaska to Los Angeles Harbor, California. High salinities exposed or semi-exposed coasts subtidally to 17 m. amongst small algae on algal holdfasts (Conlan 1995). Carmel, CA to Bahia de San Cristobal, Baja California (Barnard 1969) though unconfirmed due to lack of adult males (Conlan 1995). Also unconfirmed: Ocean Falls, British Columbia to Pinos Point, California (Conlan 1995).

Microjassa litotes has undergone re-classification at the generic level (Conlan 1995). Barnard and Karaman (1991) have transferred it to *Ischyrocerus*, while Barnard has flip-flopped his assignment between both *Ischyrocerus* and *Microjassa* several times (see Conlan 1995).

This survey: In 2000, *Microjassa litotes* (including adult males) was collected among algae on rocks at the Coast Guard Cove, in central Humboldt Bay.

Paracorophium sp. AMPHIPODA

This amphipod species most clearly resembles one described from New Zealand (Watling and Thomas 1995). Not previously described from Humboldt Bay.

This survey: Collected from mud at the Mad River Slough, Bracut, Klopp Lake, Southport Landing, Eureka Channel. Sparse at all locations, may be widespread in low intertidal mud.

Podocerus cristatus (Thomson, 1879) AMPHIPODA

Type locality: Dunedin Harbor

Originally described from New Zealand in 1879, and has since been recorded from Australia, South Africa, and West Africa. Recorded for the first time on the west coast of N. America during the 1938 Presidential Cruise (Shoemaker 1942, p. 48-49).

Status: Cryptogenic? in Humboldt Bay.

On the west coast of North America, *Podocerus cristatus* has been previously collected from Cayucos, California to Magdalena Bay, Baja California among hydroids, ascidians, and seaweeds to depths of 100 m on the southern California shelf (Barnard 1969; Watling and Thomas 1995). Barnard (1969) describes this species as "probably ubiquitous in tropical and warm temperate seas of the Indo-Pacific region". Watling and Thomas (1995) describe the distribution of *P. cristatus* as "probably circumpolar and circum-warm temperate."

Podocerus cristatus is distinguished from *P. brasiliensis* (southern California open coast and embayments) by the dorsal carinae and from *P. fulanus* (Newport Bay estuaries) by the heavy setation of the palm of gnathopod 2 (Barnard 1962c).

This survey: In Humboldt Bay, *Podocerus cristatus* was very abundant among algae in rocky habitats at the Coast Guard Cove and Samoa Boat Ramp in the central bay. It was also collected from docks at Woodley Island Marina and Eureka Marina and from mixed sediments/shell fragments in shipping channels.

Photis pachydactyla (Conlan, 1983) AMPHIPODA

Status: Possible introduction, or range expansion – additional research needed.

Distribution: Puffin Bay, Alaska south to Edward King Island, Barkley Sound, Vancouver Island, British Columbia (Conlan 1983).

Occurs on exposed and semi-protected coasts on rocky substrates at low water level to 90m depth (Conlan 1983).

This survey: Intertidal near mouth of Jacoby Creek, South Bay in Hookton Slough, benthic mud from Eureka Channel.

Stenothoe valida (Dana, 1853) AMPHIPODA

Distribution: see Cohen and Carlton (1995). *Stenothoe valida* has also been reported from the Hawaiian Islands (Barnard 1971) and possibly from harbors in New Zealand (Barnard 1972).

In Los Angeles Harbor, this species was found associated with *Tubularia crocea* and other hydroids (Barnard 1959). This species was found abundantly from the Eureka Boat Basin and from Woodley Island.

Stenothoe valida has not been previously reported from Humboldt Bay. It has been collected from sites around central San Francisco Bay and probably arrived via ship traffic from San Francisco.

This survey: In Humboldt Bay, *Stenothoe valida* was common among fouling organisms (*Mytilus trossulus*, tunicates) at the two major marinas (Woodley Island; Eureka Boat Basin). Collections made in the fall of 2000 contained exceptionally large, well-chitinized members of this species, and generally included mature males. Woodley Island was constructed in 1978 and the Eureka Boat Basin was completely rebuilt in 1998-99. The restricted distribution of *S. valida* to these two sites suggests a relatively recent introduction.

Carcinus meanas (Linnaeus, 1758) DECAPODA

The European green crab appeared recently (1995) in Humboldt Bay (Miller 1996). It was first collected at Bracut and has since spread to several locations around the bay (McBride, personal communication). It is sparse, trapping usually results in only one or two individuals per trap at a given location. It is known from San Francisco Bay and Bodega Bay to the south and from Coos Bay, Oregon to the north. Cohen and Carlton (1995) provide a good account of its occurrence in San Francisco Bay and a short account of attempts to control this species in eastern North America. Recent experiments in south Humboldt Bay (Meyer 2001) suggest that this species could be a significant predator of small bivalves if it becomes widespread.

This survey: Trapped at several locations around the bay, including Mad River Slough, near Klopp Lake, Bracut, Eureka Slough. Molts (exuviae) were seen at

Southport Landing. The distance to established populations to the north and south suggests transport of larvae to Humboldt Bay in ballast water.

BRYOZOA

Alcyonidium polyoum (Hassall, 1841)

Synonyms: *Alcyonidium mytili* (O'Donoghue, 1923)

Distribution: Atlantic: northern Labrador and Nova Scotia to Chesapeake Bay; Brazil (Osburn 1944); on Ilyanassa shells in Deleware Bay oyster beds (Maurer & Watling 1973); North Carolina oyster beds (Wells 1961). Pacific: Point Barrow, Alaska; Puget Sound – these may be another species according to Cohen & Carlton 1995); while estuarine records in San Francisco and Tomales bays, these they consider to be the Atlantic *Alcyonidium*. Could be ballast water introduction, oyster culture related introduction or ship fouling introduction (Cohen and Carlton 1995).

First report from Humboldt Bay, this survey. Found encrusting on bivalve shell fragment and wood in Samoa Channel (Sta. 13, 18) and encrusting on bivalve shell in North Bay Channel (Sta. 33). This bryozoan is a common element of the fouling fauna at marinas in Humboldt Bay. It also occurs on the undersurfaces of rocks in the protected low intertidal locations around the bay.

Bowerbankia gracilis (Leidy, 1855)

Distribution: Western Atlantic; Greenland to South America (Osburn & Soule 1953); Hawaii; India; England; Saudi Arabia (Soule & Soule 1977, 1985). See taxonomic discussion in Cohen & Carlton (1995). Puget Sound, WA; Coos Bay, OR; Tomales Bay, Los Angeles Harbor, Monterey Harbor, CA.

"...we found *Bowerbankia* on the shell of a live crab in Humboldt Bay...." (Cohen & Carlton 1995). *B. gracilis* commonly found in oyster beds in western Atlantic (Wells 1961; Maurer & Watling 1973); on ships hulls (WHOI 1952); *Bowerbankia* sp. found on seaweed shipped with lobsters to SF (Miller 1969).

A cosmopolitan, fouling organism. The introduced status of this species is still uncertain, although it appears to be native to the western Atlantic (Cohen and Carlton 1995). It is common as a fouling organism in marinas at Humboldt Bay. It also occurs on eelgrass blades, on pilings in the low intertidal, and on the undersides of rocks in protected low intertidal locations. Barnhart et al. (1992) recorded this species and it appears to have been in Humboldt Bay for many years.

This survey: Found in North Bay Channel, Woodley Island Marina, and Eureka Boat Basin.

Bugula neritina (Linnaeus, 1758)

Synonyms: *Sertularia neritina* (Linnaeus, 1758)

Type locality: unknown

Distribution: Cosmopolitan. Eastern Pacific; Monterey, CA (Robertson 1905). Channel Islands south to Galapagos Islands and Panama, and to Angel de la Guardia in Gulf of California (Osburn 1950); off Morro Bay, California; Atlantic; Mediterranean; Hawaiian Islands; Japan (Soule, Soule & Chaney 1995). Broad distribution in temperate, subtropical and tropical waters: Japan; Hawaii; Australia; New Zealand; both coasts of Panama; Florida, North Carolina; Mediterranean; in heated effluent from power plants in southern England. Abundant in southern California north to Monterey and San Francisco Bays. Recorded at Bodega Harbor (Boyd 1972), on the hull of a wooden ship in Humboldt Bay (Carlton & Hodder 1995); Coos Bay, OR (Hewitt 1993); Friday Harbor, WA. Most likely method of introduction is via hull fouling. (Cohen and Carlton 1995). This species is widely distributed in temperate, subtropical, and tropical waters. It was thought until recently that this species was retricted to warm waters of the world, but has been expanding in recent years northward along the Pacific coast of North America. The distinctive red-purple color of this bryozan results in rapid and reliable identification.

This survey: *Bugula neritina* is sparse in Humboldt Bay but is found at marinas and other fouling fauna situations.

Celleporella hyalina (Linne, 1767)

Synonyms: *Schizoporella hyalina* Hincks, 1883
Hippothoa hyalina Canu & Bassler 1923
Hippothoa hyalina var. *rugosa* Canu & Bassler, 1923

Celleporella hyalina Hayward & Ryland, 1979

Distribution: Alaska south to California and possibly to the Galapagos Islands – but has been confused with other species. *C. hyalina* is found in western Atlantic from Arctic to Bay of Biscay (Stayward & Ryland 1979). (from Soule, Soule & Chaney 1995).

Encrusting form on algae, rock and shell from intertidal to 90-130.5 m (Soule, Soule, and Chaney, 1995).

First report from Humboldt Bay, this survey.

Found subtidally in Samoa Channel, North Bay Channel, East Bay Channel, and Field's Landing Channel; intertidally, found at Bracut, Eureka Boat Basin, South of Eureka Marina, and Southport Landing. Among the encrusting substrates it was found on in this survey:

~encrusting on oyster shell fragment (Samoa Channel, Sta. 13)
~encrusting on bivalve shell fragment
~encrusting on polychaete worm tube
~encrusting on eelgrass and bivalve shell fragments (Samoa Channel, Sta. 18)
~encrusting on eelgrass and oyster shell fragments (East Bay Channel, Sta. 61)
~encrusting on eelgrass (Field's Landing Channel, Sta. 38)

Conopeum sp.

This species is possibly *Conopeum tenuissimum*, the same species recorded from San Francisco Bay by Cohen and Carlton (1995). It appears to be native to the western North Atlantic, but has been widely reported from West Africa and Australia (Cohen and Carlton 1995).

This survey: This bryozoa is sparse at Humboldt Bay but was collected from marinas around the bay. It has not been recorded previously from Humboldt Bay and thus may indicate that it is a recent arrival.

Cryptosula pallasiana (Moll, 1803)

Synonyms: *Eschara pallasiana* Moll 1803
Lepralia pallasiana O'Donoghue & O'Donoghue 1925
Cryptosuls pallasiana Osburn 1952

Distribution: Alaska to Oaxaca, Mexico and Chile; western Atlantic from Nova Scotia to Florida; Europe from Norway to Black and Red Seas (Soule, Soule & Chaney 1995). An Atlantic bryozoan (Cohen & Carlton 1995). Eastern Atlantic from Norway and Great Britain to Morocco; Mediterranean and Black Seas (Osburn 1952; Ryland, 1971, 1974); western Atlantic from Nova Scotia to North Carolina (Osburn 1952) and Florida (Winston 1982). Introduced to: Japan (Mawatari 1963); New Zealand (Gordon 1967) and Australia (Ryland 1971; Vail & Wass 1981). Between 1943 & 1972 found in southern California bays and from offshore to 35m off southern California; Mexico; 1952 – Monterey Bay; 1970 – Vancouver Island and British Columbia; 1975 – Bodega Harbor (Boyd 1972; Carlton 1979a, p. 720); 1988 – Coos Bay, OR (Hewitt 1993); 1944-47 – San Francisco Bay (Cryptosula sp. – US Navy 1951); 1963 – Berkeley Yacht Harbor (Banta 1963); San Francisco Bay 1994-95 (all from Cohen and Carlton 1995).

Encrusting a wide variety of substrates, from intertidal to 60 m depth. "This species is one of the most competitive fouling organisms in ports and harbors, where it can cover several centimeters in a few days. It is also able to colonize kelp holdfasts, shell and rock in deeper water..." (Soule, Soule, and Chaney 1995).

First report for Humboldt Bay, this survey. Found from North Bay Channel (Sta. 33), encrusting on bivalve shell fragment. Probably also found in Samoa Channel, as "unknown encrusting ascophoran" on oyster & bivalve shell fragments (Sta. 13). *C. palliasiana* is common and abundant at marinas in Humboldt Bay. It is also found on oyster shells in Arcata Bay, and growing on the undersurfaces of rocks in protected low rocky intertidal locations. This is the first recording of this species in Humboldt Bay, but may have been overlooked by previous work (Barnhart et al 1992). The widespread occurrence of this species in the bay suggests that it has been in the bay for several years.

Method of introduction likely by hull fouling or with Atlantic oysters (Cohen and Carlton 1995).

Schizoporella unicornis (Johnson, in Wood, 1844)

Synonyms: *Lepralia unicornis* Johnson, in Wood, 1844
Lepralia unicornis Johnson, 1847
Schizoporella unicornis Lagaaiji, 1952

Type locality: Britain (Soule, Soule and Chaney 1995).

Distribution: First reports in eastern Pacific; 1927 – WA; 1938 – CA; 1966 – British Columbia (Carlton, 1979a, p. 723). 1986 – Coos Bay, OR. Also reported from Baja California and Galapagos. San Francisco Bay: 1963, 1970, 1993-95 (Cohen and Carlton 1995), in Bodega Harbor (Boyd 1972). Distribution: Atlantic (Hayward & Ryland 1979); Indian Ocean; western Pacific; Hawaii; CA: Monterey Bay south to Channel Islands and off Point Arguello (Soule, Soule and Chaney 1995). Hayward & Ryland (1979) state from Faroe Islands and western Norway south to northwest Africa; western Mediterranean; north of Cape Cod in western Atlantic. (all in Soule, Soule and Chaney 1995).

A conspicuous, orange western Pacific encrusting bryozoan. Yellowish colonies encrusting shells, rocks and ships' hulls; depths from shallow intertidal to > 60 m. (Soule, Soule and Chaney 1995).

This survey: *S. unicornis* is a common species at marinas, on oysters shells in Arcata Bay, and occasionally on eelgrass blades in South Bay. It was recorded previously in the bay (Barnhart et al. 1992)

Probable method of introduction: hull fouling or with Japanese oysters (*Crassostrea gigas*) (Cohen and Carlton 1995).

Watersipora "subtorquata (d'Orbigny, 1852)*" (=W. cucullata)*

Native region of *W. "subtorquata"* is unknown, but northwest Pacific is likeliest (Cohen and Carlton 1995).

Distribution: Widespread introductions: American Samoa, Hawaii, Galapagos, western Mexico, Australia, New Zealand, the Caribbean, Brazil, the Mediterranean, Red and Arabian Seas, Atlantic coast of France (Cohen and Carlton 1995).

Introduced to California in 1960's (Cohen and Carlton 1995):

- ~1963 ? : 1st report in southern CA
- ~1990: Coos Bay, OR (though not found in 1995)
- ~1992: SF Bay
- ~1993-95: Bodega Harbor, Tomales Bay, Half Moon Bay, and Moss Landing Harbor and Monterey Harbor.

Note: taxonomic problem discussion in Cohen and Carlton 1995.

First report for Humboldt Bay, this survey. This bryozoan appears to be a recent arrival (since the 1980's) in California bays (Cohen and Carlton 1995). This species is abundant at marinas, where it forms thick growths of encrusting colonies with edges that are raised off the underlying substrate. Users of the docks refer to it as "Humboldt Bay coral" and call its abundant growth "reefs." Despite its abundance, it has not been previously recorded from Humboldt Bay (Barnhart et al. 1992). The distinctive appearance would have been noticed by previous investigators, so it appears that the arrival of *Watersipora* is recent, followed by rapid spread in marina locations. As is true for a number of bryozoans, the larval dispersal stage is short (less than a day), so transport with ballast water is unlikely. Ship hull fouling appears more probable as the means of entry to Humboldt Bay.

ENTOPROCTA

Barentsia benedeni (Foettinger, 1887)

This poorly known species may be confused with the native *B. gracilis*. The species is known from San Francisco Bay and other bays along the California coast (Cohen and Carlton 1995).

This survey: Found on shell fragments from the North Bay Channel, sparse.

CHORDATA: TUNICATA

Botrylloides sp.
Botryllus sp.
Botryllus tuberatus

These possibly separate taxa are grouped for convenience similar to Cohen and Carlton (1995). The taxonomy of these encrusting ascidians is uncertain, as is also true for their origin. The members of the genus *Botryllus* have zooids in well organized clusters around a common exhalant opening. The *Botrylloides* sp. has larger zooids that are not as well as well organized around the exhalant opening, sometimes appearing as long chains with exhalant openings scattered over the surface of the large colonies.

Despite the common occurrence of these colonial ascidians in bays along the Pacific coast of North America, their appearance is apparently recent. Cohen and Carlton (1995) mention that these species were not recorded in California bays until the mid to late 1940's. The three different types have been recorded from Monterey to British Columbia.

The two *Botryllus* species are probably of Atlantic origin. They have been recorded frequently on the Atlantic coast of North America, typically as members of bay fouling communities (ref). The *Botrylloides* sp. is probably of western Pacific origin (Cohen and Carlton 1995). It is surprising that such widespread and common forms are of relatively recent origin on the Pacific coast.

This survey: *Botrylloides* sp. is the most common and abundant of the three colonial ascidians in Humboldt Bay. It can form mats several cm. in size in fouling communities, on the undersides of rocks in protected rocky low intertidal areas, and on eelgrass blades. It is found in all parts of the bay. The two *Botryllus* forms are common at marinas, on pilings in the low intertidal, and in other fouling situations. None of these species are abundant in areas where salinity drops significantly after rainfall, suggesting that they grow well under stenohaline conditions.

Ciona intestinalis (Linnaeus, 1767)

Although this solitary ascidian is widely distributed in bays and ports of the world, it has appeared only recently in Humboldt Bay. It is often involved in ship fouling and has a history of occurrence in California ports going back to 1897 (Cohen and Carlton 1995). It appeared at the Woodley Island marina in Humboldt Bay about 5 years ago and is now also found at other marina locations.

This survey: *Ciona intestinalis* is common, but not abundant, at the Woodley Island marina and at ???. The initial appearance of this species at the Woodley Island marina within the past 5 to 10 years suggests that it arrived on ship hull fouling from San Francisco Bay. Cohen and Carlton (1995) refer to the absence of this species in bays along the Oregon coastline, although it apparently occurs at Vancouver Island.

Mogula manhattensis (DeKay, 1843)

This solitary, small ascidian is apparently native to the North Atlantic, occurring on both the eastern and western shores. It is a very common element of ship fouling and is abundant on docks, pilings, and on rock or shell bottoms (Cohen and Carlton 1995). It is reported as widespread in San Francisco Bay, Tomales Bay, Bodega Bay, and Coos Bay, Oregon (Cohen and Carlton 1995). It was not recorded as an element of the fouling fauna on settlement plates in Bodega Harbor in the early 1970's (Boyd 1972).

This survey: Common at the Woodley Island marina and other marinas in the bay. It has not been listed in earlier studies (Barnhart et al. 1992), and was collected at Woodley Island for the first time in 1996. The first appearance of this species at the Woodley Island marina suggests arrival as ship hull fouling. Although common at marinas, it is not yet widespread in the bay.

Styela clava Herdman, 1881

This species is another solitary ascidian that is a recent arrival in Humboldt Bay. The species is native to the western Pacific and has been found growing on Japanese oysters (*Crassostrea gigas*), so could have been transported into Humboldt Bay from cultch growing areas in Puget Sound. Cohen and Carlton (1995) report that this species is a common element in ship fouling. It has been reported in other coastal locations from southern California to British Columbia (Cohen and Carlton 1995), with an irregular distribution pattern. It has not been reported previously in Humboldt Bay (Barnhart et al. 1992).

This survey: *Styela clava* was collected at the Woodley Island Marina. It is found among other fouling organisms, but is not abundant. The restricted local distribution of the species to marinas in Humboldt Bay suggests it was brought into the bay on ship fouling.

VERTEBRATES

Gambusia affinis

Mosquitofish were widely planted in California to control populations of mosquitos in estuarine and freshwater environments. The native stocks were taken either from the southeastern U. S. or from the midwestern U. S. (Carlton and Cohen 1995), with introductions to California locations beginning in the 1920's. It is unknown when this species appeared in streams and rivers of Humboldt Bay. It is not tolerant of marine conditions and is found in the upper reaches of Mad River Slough and in essentially freshwater conditions in sloughs bordering Humboldt Bay.

Table 2. Descriptions of the sites sampled for exotic algae during 2000 and 2001. C = *Chondracanthus teedii,* L = *Lomentaria hakodatensis, S = Sargassum muticum*. All algae were growing on a hard substratum unless otherwise indicated

Sites sampled for exotic algae	Site	Latitude	Longitude	Exotic algae	Site substrates from low to high intertidal
Mad River Slough - Lanphere Rd. Bridge	160	N 40° 48.694'	W 124° 09.975'		mudflat, riprap, marsh plants
North side of Somoa Rd. bridge over Mad River Slough	161	N 40° 50.798'	W 124° 08.659'		mudflat, hard clay, marsh plants
South side of Somoa Rd. bridge over Mad River Slough	162	N 40° 50.783'	W 124° 08.363'	L (drift)	mudflat, hard clay, marsh plants, riprap
Oyster lease by Mad River Slough, north	163	N 40° 50.798'	W 124° 08.659'	L	old oyster ground culture site; shells, eelgrass
Oyster lease by Mad River Slough, south	164	N 40° 50.783'	W 124° 08.363'	C, L, S	old oyster ground culture site; shells, eelgrass
Arcata Marsh boat ramp	165	N 40° 53.885'	W 124° 08.118'		mudflat, hard clay, cement boat ramp
Arcata Marsh - Klopp Lake	166	N 40° 53.885'	W 124° 08.881'	L	brackish lake, sandy benthos
Arcata Marsh - riprap + mudflats	167	N 40° 51.318'	W 124° 05.876'		mudflat, hard clay, riprap; adjacent to Klopp Lake
Old Arcata dock pilings	168	N 40° 50.491'	W 124° 06.480'	S (drift)	mudflat, wooden pilings; Cormorant nesting colony
Millyard riprap	169	N 40° 49.681'	W 124° 05.225'		mudflat, riprap
Oyster lease mid Arcata Bay	170	N 40° 49.448'	W 124° 08.325'	C + L	old oyster ground culture site; shells, eelgrass
Gunther Island north	171	N 40° 49.191'	W 124° 08.953'	L + S	eelgrass, old oyster shells
Gunther Island south	172	N 40° 49.340'	W 124° 08.480'	L + S	eelgrass, old oyster shells
East side of Arcata Bay	173	N 40° 49.040'	W 124° 08.713'	L	old oyster ground culture site; shells, eelgrass
Eureka Slough site one	174	N 40° 48.503'	W 124° 06.553'		mudflat, marsh plants
Eureka Slough site two	175	N 40° 48.422'	W 124° 06.539'		mudflat, marsh plants
Eureka Slough site three	176	N 40° 48.411'	W 124° 06.458'		mudflat, marsh plants
Mouth of Eureka Slough	177	N 40° 48.410'	W 124° 08.620'		eelgrass, mudflat, riprap
Eureka boat ramp and dock	178	N 40° 48.504'	W 124° 09.255'	L + S	mudflat, riprap, wooden pilings, dock
Woodley Island northeast	179	N 40° 48.486'	W 124° 09.546'	L (drift) + S	riprap, mudflat, marsh plants
Woodley Island southeast	180	N 40° 48.478'	W 124° 09.966'	C	riprap
Somoa Bridge, eastern piling	181	N 40° 49.218'	W 124° 10.075'		cement pilings, tidal rapids
Somoa Bridge, east channel piling	182	N 40° 48.548'	W 124° 09.275'		cement pilings, tidal rapids
Somoa Bridge, mid channel piling	183	N 40° 48.827'	W 124° 09.588'		cement pilings, tidal rapids
Somoa Bridge, west channel piling	184	N 40° 49.310'	W 124° 10.210'		cement pilings, tidal rapids
Indian Island East	185	N 40° 48.694'	W 124° 09.976'		mudflat, marsh plants, riprap
Indian Island North	186	N 40° 48.365'	W 124° 10.798'		mudflat, marsh plants
Indian Island West three	187	N 40° 49.025'	W 124° 10.436'	S	mudflat, marsh plants

Sites sampled for exotic algae	Site	Latitude	Longitude	Exotic algae	Site substrates from low to high intertidal
Indian Island West two	188	N 40° 49.109'	W 124° 10.317'		eelgrass, mudflat, riprap
Indian Island West one	189	N 40° 49.236'	W 124° 09.987'		eelgrass, mudflat, riprap
Harbor Office riprap	190	N 40° 48.140'	W 124° 10.775'		riprap, cobble field
Elk River Slough, north	191	N 40° 46.341'	W 124° 11.757'		sand/mudlfat separated from river by dike, rocks
Elk River Slough, south	192	N 40° 46.218'	W 124° 11.776'		sand/mudlfat separated from river by dike, rocks
Elk River Slough, waste water plant	193	N 40° 46.079'	W 124° 11.818'		sand/mudlfat separated from river by dike, rocks
Elk River Slough, railroad trestle	194	N 40° 45.385'	W 124° 11.679'	S	mudflat, trestle supports
Somoa Pacific pilings and riprap	195	N 40° 48.246'	W 124° 11.407'		eelgrass, mudlfat, wooden pilings, riprap
Somoa Pacific riprap	196	N 40° 48.046'	W 124° 11.500'		eelgrass, mudlfat, riprap
Somoa parking lot, north side	197	N 40° 46.372'	W 124° 12.727'		eelgrass, sand/cobble, riprap
Somoa parking lot, old and new boat ramp	198	N 40° 46.315'	W 124° 12.739'	S	sand, cement boat ramps, riprap
Riprap 500 m north of Coast Guard Station	199	N 40° 46.193'	W 124° 12.931'	S	sand, riprap
Riprap in front of Coast Guard station	200	N 40° 46.002'	W 124° 13.032'	S	riprap
Coast Guard Cove, north side	201	N 40° 45.918'	W 124° 13.206'		sand, riprap
Coast Guard Cove, south side	202	N 40° 45.788'	W 124° 13.183'	S	sand, riprap
Inside corner North Jetty	203	N 40° 45.560'	W 124° 13.406'		riprap, high wave energy
Western tip North Jetty	204	N 40° 46.104'	W 124° 14.330'		riprap, very high wave energy
South Jetty mid channel	205	N 40° 45.670'	W 124° 14.372'		riprap, high wave energy
South Jetty inner channel corner	206	N 40° 45.246'	W 124° 13.967'		riprap, high wave energy
South Jetty, southeast corner, bay side	207	N 40° 44.700'	W 124° 13.617'	S	eelgrass, sand/cobble, wooden pilings, riprap
King Salmon, front of power plant	208	N 40° 44.561'	W 124° 12.653'		sand, riprap, high wave energy
Buhne Point, ocean side of riprap	209	N 40° 44.190'	W 124° 13.242'		sand, riprap
Buhne Point, harbor side of riprap	210	N 40° 44.186'	W 124° 13.209'		sand/mud, eelgrass, riprap; very protected
Zoster marina bed, site one	211	N 40° 43.970'	W 124° 13.263'		sandy eelgrass bed
Zoster marina bed, site two	212	N 40° 43.362'	W 124° 14.189'		mud eelgrass bed
Field's Landing (boat ramp, riprap, pilings)	213	N 40° 49.681'	W 124° 08.519'		eelgrass, mudflat/cobble, wooden pilings, cement ramp
Southport Landing	214	N 40° 41.709'	W 124° 14.962'		mudflat, hard clay, wooden pilings
Hookton Slough north	215	N 40° 41.377'	W 124° 13.895'		sand, marsh plants, riprap
Hookton Slough mid	216	N 40° 41.064'	W 124° 13.456'		mudflat, riprap
Hookton Slough south	217	N 40° 40.641'	W 124° 13.317'		mudflat, riprap

Table 3. Locations of collection sites, non-indigenous marine invertebrates in Humboldt Bay.

Intertidal Sites			
Location	**# Assigned**	**Latitude**	**Longitude**
Mad River Slough - Lanphere Christianson Dunes Bridge	1	40° 53.875'	124° 08.133'
Mad River Slough - Samoa Blvd. Bridge	2	40° 51.913'	124° 09.032'
Klopp Lake	3	40° 51.319'	124° 05.512'
Jacoby Creek	4	40° 50.610'	124° 05.030'
Bracut	5	40° 49.878'	124° 05.070'
North Bay Oyster Beds	6	40° 49.381'	124° 07.542'
Samoa Bridge, West	7	40° 49.310'	124° 10.210'
Samoa Bridge, Middle	8	40° 48.827'	124° 09.558'
Samoa Bridge, East	9	40° 48.548'	124° 09.275'
Eureka Slough, Lower	10	40° 48.410'	124° 08.620'
Eureka Slough, Upper	11	40° 48.121'	124° 06.932'
South Eureka Marina	12	40° 48.103'	124° 10.842'
Del Norte Street	13	40° 47.444'	124° 11.275'
Samoa Boat Ramp	14	40° 46.329'	124° 12.741'
Hilfiker Road	15	40° 46.319'	124° 11.758'
Coast Guard Cove	16	40° 45.785'	124° 13.197'
Eel River Wildlife Area	17	40° 45.393'	124° 11.673'
Upper Elk River	18	40° 45.344'	124° 11.285'
Fields Landing	19	40° 43.550'	124° 13.279'
Southport Landing	20	40° 41.709'	124° 14.962'
Hookton Slough	21	40° 40.647'	124° 13.309'

Benthic Sampling			
Location	# Assigned	Latitude	Longitude
Mad River Slough Channel, St. 45	40	40° 51.870'	124° 08.903'
Mad River Slough Channel, St. 46	41	40° 51.714'	124° 08.571'
Mad River Slough Channel, St. 47	42	40° 51.437'	124° 08.571'
Mad River Slough Channel, St. 48	43	40° 51.231'	124° 08.773'
Mad River Slough Channel, St. 49	44	40° 50.991'	124° 08.879'
Mad River Slough Channel, St. 50	45	40° 50.738'	124° 08.880'
Arcata Channel HB, St. 54	46	40° 50.695'	124° 06.460'
Arcata Channel HB, St. 55	47	40° 50.629'	124° 06.931'
Mad River Slough Channel, St. 51	48	40° 50.500'	124° 08.905'
Arcata Channel HB, St. 56	49	40° 50.369'	124° 07.194'
Mad River Slough Channel, St. 52	50	40° 50.284'	124° 09.155'
Arcata Channel HB, St. 57	51	40° 50.199'	124° 07.383'
Mad River Slough Channel, St. 53	52	40° 50.155'	124° 09.298'
Mad River Slough Channel St. 9	53	40° 50.083'	124° 09.479'
Arcata Channel HB, St. 1	54	40° 50.053'	124° 07.622'
Samoa Channel HB, St. 14	55	40° 49.947'	124° 10.556'
Arcata Channel HB, St. 2	56	40° 49.941'	124° 07.955'
Mad River Slough Channel St. 10	57	40° 49.859'	124° 09.721'
Arcata Channel HB, St. 3	58	40° 49.793'	124° 08.278'
East Bay Channel, St. 58	59	40° 49.788'	124° 07.585'
Arcata Channel HB, St. 4	60	40° 49.658'	124° 08.542'
Mad River Slough Channel St. 11	61	40° 49.635'	124° 09.892'
East Bay Channel, St. 59	62	40° 49.623'	124° 07.962'
Arcata Channel HB, St. 5	63	40° 49.515'	124° 08.848'
Arcata Channel HB, St. 6	64	40° 49.394'	124° 09.192'
East Bay Channel, St. 60	65	40° 49.383'	124° 08.273'
Arcata Channel HB, St. 7	66	40° 49.348'	124° 09.508'
Arcata Channel HB, St. 8	67	40° 49.335'	124° 08.884'
Arcata Channel HB, St. 12	68	40° 49.312'	124° 10.170'
East Bay Channel, St. 61	69	40° 49.224'	124° 08.609'
Samoa Channel HB, St. 13	70	40° 49.172'	124° 10.397'

Benthic Sampling			
East Bay Channel, St. 62	71	40° 49.039'	124° 09.150'
East Bay Channel, St. 78	72	40° 48.997'	124° 09.167'
Samoa Channel HB, St. 15	73	40° 48.826'	124° 11.002'
East Bay Channel, St. 77	74	40° 48.807'	124° 09.624'
East Bay Channel, St. 76	75	40° 48.610'	124° 10.005'
Samoa Channel HB, St. 16	76	40° 48.532'	124° 10.936'
Eureka Channel HB, St. 19	77	40° 48.501'	124° 09.326'
East Bay Channel, St. 75	78	40° 48.465'	124° 10.202'
Eureka Channel HB, St. 20	79	40° 48.396'	124° 09.627'
Eureka Channel HB, St. 21	80	40° 48.380'	124° 09.995'
Samoa Channel HB, St. 17	81	40° 48.370'	124° 11.218'
Eureka Channel HB, St. 22	82	40° 48.318'	124° 10.389'
Eureka Channel HB, St. 23	83	40° 48.234'	124° 10.679'
Samoa Channel HB, St. 18	84	40° 48.080'	124° 11.182'
North Bay Channel HB, St. 36	85	40° 47.899'	124° 11.400'
North Bay Channel HB, St. 35	86	40° 47.677'	124° 11.274'
North Bay Channel HB, St. 34	87	40° 47.545'	124° 11.570'
North Bay Channel HB, St. 33	88	40° 47.235'	124° 11.541'
North Bay Channel HB, St. 32	89	40° 47.047'	124° 11.852'
R/V Coral Sea/Borgeld's Class Cruise, St. 87	90	40° 46.824'	124° 11.997'
North Bay Channel HB, St. 31	91	40° 46.680'	124° 11.817'
R/V Coral Sea/Borgeld's Class Cruise, St. 86	92	40° 46.546'	124° 11.937'
North Bay Channel HB, St. 30	93	40° 46.536'	124° 12.135'
R/V Coral Sea/Borgeld's Class Cruise, St. 85	94	40° 46.293'	124° 12.387'
North Bay Channel HB, St. 29	95	40° 46.292'	124° 12.364'
North Bay Channel HB, St. 28	96	40° 46.194'	124° 12.728'
North Bay Channel HB, St. 27	97	40° 45.916'	124° 12.866'
North Bay Channel HB, St. 26	98	40° 45.740'	124° 13.154'
R/V Coral Sea/Borgeld's Class Cruise, St. 84	99	40° 45.608'	124° 13.107'
North Bay Channel HB, St. 24	100	40° 45.430'	124° 13.210'
Entrance Bay Channel HB, St. 25	101	40° 45.204'	124° 13.428'
Entrance Bay Channel HB, St. 44	102	40° 45.065'	124° 13.343'
Field's Landing Channel HB, St. 43	103	40° 44.753'	124° 13.427'
R/V Coral Sea/Borgeld's Class Cruise, St. 83	104	40° 44.670'	124° 13.560'
Southport Channel, St. 70	105	40° 44.604'	124° 13.544'

Benthic Sampling

Field's Landing Channel HB, St. 42	106	40° 44.488'	124° 13.549'
Southport Channel, St. 69	107	40° 44.247'	124° 13.713'
Field's Landing Channel HB, St. 41	108	40° 44.234'	124° 13.340'
Field's Landing Channel HB, St. 40	109	40° 44.087'	124° 13.215'
Southport Channel, St. 68	110	40° 43.915'	124° 13.696'
Field's Landing Channel HB, St. 39	111	40° 43.789'	124° 13.230'
Southport Channel, St. 67	112	40° 43.587'	124° 13.739'
Field's Landing Channel HB, St. 38	113	40° 43.571'	124° 13.361'
Southport Channel, St. 66	114	40° 43.424'	124° 13.923'
R/V Coral Sea/Borgeld's Class Cruise, St. 81	115	40° 43.393'	124° 13.429'
Field's Landing Channel HB, St. 37	116	40° 43.319'	124° 13.545'
R/V Coral Sea/Borgeld's Class Cruise, St. 82	117	40° 43.312'	124° 13.457'
Southport Channel, St. 65	118	40° 43.295'	124° 14.245'
Southport Channel, St. 64	119	40° 43.169'	124° 14.430'
R/V Coral Sea/Borgeld's Class Cruise, St. 80	120	40° 43.107'	124° 13.682'
Southport Channel, St. 63	121	40° 42.988'	124° 14.433'
R/V Coral Sea/Borgeld's Class Cruise, St. 79	122	40° 42.784'	124° 13.752'
Hookton Channel, St. 74	123	40° 42.500'	124° 13.571'
Hookton Channel, St. 73	124	40° 42.289'	124° 13.577'
Hookton Channel, St. 72	125	40° 41.997'	124° 13.610'
Hookton Channel, St. 71	126	40° 41.986'	124° 13.597'

Marina Sites

Location	# Assigned	Latitude	Longitude
King Salmon Marina	150	40° 49.431'	124° 13.111'
Woodley Island, East End	151	40° 48.443'	124° 09.604'
Woodley Island, West End	152	40° 48.422'	124° 10.002'
Eureka Public Marina	153	40° 48.200'	124° 10.700'
Coast Guard "Ready Dock"	154	40° 46.025'	124° 13.027'

Table 4 Locations of non-indigenous species collected in Humboldt Bay, July 2000 – September 2001

TAXON	Year of Presence Humboldt Bay	Status	Locations
ALGAE			
Phaeophyta			
Sargassum muticum	1965	Introduced	widespread:164,168,171,172,178,179,187,194,198,199,200,202,207
Rhodophyta			
Chondracanthus teedii	This survey	Introduced	oyster beds, Arcata Bay, possible range extension:164,170,180
Lomentaria hakadotensis	This survey	Introduced	oyster beds, Arcata Bay:162,163,164,166,170,171,172,173,178,179
VASCULAR PLANTS			
Cotula coronopifolia	~1900	Introduced	2,4,5,10,11,15,17,20,21,162,174,175,176,179,186,187,Humboldt Bay salt marshes
Spartina densiflora	~1870	Introduced	2,4,5,10,11,15,17,20,21,162,174,175,176,179,186,187,Humboldt Bay salt marshes
INVERTEBRATES			
Porifera			
Cliona celata	~1900	Introduced	57, 69, 70, 74
Halichondria bowerbankia	~1950	Introduced	40
Microciona prolifera	~1950	Introduced	40
Cnidaria			
Aurelia aurita	1992	Introduced	
Diadumene leucolena	This survey	Introduced	2, 5, 10, 13, 19, 150, 151, 152
Diadumene lineata	1992 (as Haliplanella luciae)	Introduced	5, 20, 21
Nematostella vectensis	1992	Introduced	4, 5
Obelia dichotoma	This survey	Introduced	154
Polychaeta			
Autolytus cornutus	1992	Cryptogenic	96, 153, 154

TAXON	Year of Presence Humboldt Bay	Status	Locations
Boccardiella hamata	This survey	Cryptogenic	3, 20
Dipolydora socialis	1992	Cryptogenic	40, 42, 53, 55, 57, 61, 69, 70, 81, 82, 84, 88, 96, 109, 154
Dodecaceria concharum	1992	Introduced	96
Euchone limnicola	This survey	Introduced	40, 42, 53, 55, 57, 61, 62, 69, 73, 77, 80, 82, 83, 84, 109
Polychaeta (cont.)			
Exogone lourei	1992	Cryptogenic	2, 3, 4, 5, 20, 21, 40, 57, 61, 69, 70, 80, 81, 82, 84, 88, 96, 109, 153
Fabricia sabella	This survey	Cryptogenic	4
Glycera americana	1992	Cryptogenic	103, 106
Harmothoe imbricata	1992	Cryptogenic	152, 153. 154
Heteromastus filiformis	This survey	Introduced	2, 3, 4, 5, 15, 80
Heteropodarke heteromorpha	This survey	Cryptogenic	88
Marphysa sanguinea	This survey	Introduced	1
Myxicola infundibulum	This survey	Introduced	21
Nereis pelagica	This survey	Cryptogenic	154
Pholoe minuta	This survey	Cryptogenic	69, 88
Polydora cornuta	1992	Introduced	3, 18, 20
Polydora limicola	This survey	Introduced	79, 109
Pseudopolydora kempi	1992	Introduced	5, 12, 15, 40, 42, 53, 61, 62, 69, 77, 80, 83
Pseudopolydora paucibranchiata	This survey	Introduced	2, 15, 40, 42, 53
Pygospio elegans	This survey	Cryptogenic	4, 20
Sabellaria gracilis	1992	Introduced	57, 70, 81, 84, 85, 96, 109
Serpula vermicularis	1992	Cryptogenic	14, 15, 88
Spiophanes bombyx	1992	Introduced	53, 55, 61, 73, 76, 78, 81, 84, 85, 88, 96, 109, 113
Spiophanes wigleyi	This survey	Cryptogenic	88
Streblospio benedicti	1992	Introduced	2, 3, 4, 5, 15, 20, 40, 61, 77, 80, 82
Typosyllis hyalina	1992	Introduced	3, 70, 96, 152, 153, 154
Gastropods			
Crepidula sp.	This survey	Introduced	42
Ovatella myosotis	1992	Introduced	2,4,5,10,11,15,17,20,21,162,174,175,176,179,186,187;widespread in salt marshes
Urosalpinx cinerea	This survey	Introduced	5

TAXON	Year of Presence Humboldt Bay	Status	Locations
Opisthobranchia			
Alderia modesta	This survey	Introduced	2,4,5,10,11,15,17,20,21,162,174,175,176,179,186,187;widespread in salt marshes
Dendronotus frondosus	This survey	Cryptogenic	21, 151, 152, 153
Bivalvia			
Crassostrea gigas	1950's	Introduced	Arcata Bay
Gemma gemma	1992	Introduced	1,2,3;widespread
Laternula marilina	1992	Introduced	4, 20
Macoma balthica (or M. petalum)	This survey	Introduced	4, 12
Mya arenaria	1992	Introduced	4, 5, 20, 61, 70
Venerupis phillippinarum (=Tapes japonica)	1992	Introduced	3, early introductions not successful
CRUSTACEA			
Copepoda			
Mytilicola orientalis	1992	Introduced	1,2,3,4,5,6,7,8,9.10,12,13,14,15,16,17,19,20,21; widespread in oysters, mussels
Isopoda			
Iais californica	This survey	Introduced	4, 21
Limnoria lignorum	1949	Cryptogenic	14
Limmnoria quadripunctata	This survey	Cryptogenic	5
Sphaeroma quoyanum (=S. pentadon)	~1920's	Introduced	4, 5, 20, 21
Tanaidacea			
Leptochelia savignyi	1992 (as *L. dubia*)	Introduced	2, 12, 20, 154
Sinelobus standfordi	1989	Introduced	2, 3, 5
Leptostraca			
Nebalia pugettensis	This survey	Introduced	2, 5, 10, 13, 14, 19, 21
Amphipoda			

TAXON	Year of Presence Humboldt Bay	Status	Locations
Amphitoe valida	This survey	Introduced	3, 4, 5, 15, 18, 20, 21
Caprella equilibra	1992	Cryptogenic	15, 40, 152
Caprella mutica	1977	Introduced	152, 154
Chelura terebrans	This survey	Introduced	12
Chaetocorophium lucasi	This survey	Introduced	1, 2, 3, 4, 5, 10, 20
Corophium acherusicum	1992	Introduced	21, 40, 53, 61, 152
Corophium insidiosum	This survey	Introduced	2, 3, 5, 15, 20, 21, 152
Corophium uenoi	This survey	Introduced	3, 12, 20
Amphipoda (cont.)			
Grandidierella japonica	~early 1980's	Introduced	2, 3, 4, 5, 15, 20, 61, 62, 69, 82
Hyale plumulosa	This survey	Introduced	5, 12, 20, 83
Incisocalliope nipponensis	This survey	Introduced	21
Ischyrocerus anguipes	1992	Introduced	96, 154
Jassa slatteryi	This survey	Cryptogenic	3, 21, 82, 96, 152, 153, 154
Melita nitida	This survey	Introduced	3, 5, 20, 21
Microdeutopus gryllotalpa	This survey	Introduced	2, 3, 5, 15, 20
Microjassa litotes	This survey	Cryptogenic	16
Paracorophium sp.	This survey	Introduced	2, 3, 5, 15, 20, 82
Photis pachydactylata	This survey	Cryptogenic	4, 21, 83
Podocerus cristatus	This survey	Cryptogenic	84, 96, 152, 153
Stenothoe valida	This survey	Introduced	152, 153
Decapoda			
Carcinus meanas	1995	Introduced	4
Bryozoa			
Alcyonidium polyoum	This survey	Introduced	70, 84, 88, 150, 152
Bowerbankia gracilis	1992	Introduced	18, 96, 109, 154
Bugula neritina	1995	Introduced	109, 113, 152, 153, 154
Celleporella hyalina ?	This survey	Cryptogenic	5, 20, 53, 57, 69, 70, 81, 84, 96, 109, 113, 153, 154
Conopeum sp.	This survey	Introduced	18, 21, 70, 109
Cryptosula pallasiana	This survey	Introduced	57, 88, 109
Schizoporella unicornis	1992	Introduced	150, 151, 152, 153

TAXON	Year of Presence Humboldt Bay	Status	Locations
Watersipora ('subtorquata') sp.	This survey	Introduced	109, 153
(= W. cucullata)			
Ectoproct			
Barenstia benedeni	This survey	Introduced	86
Chordata: Tunicata			
Botrylloides sp.	1992	Introduced	20, 151, 152, 153, 154
Botryllus sp.	1992	Introduced	154
Botryllus tuberatus	This survey	Introduced	153
Ciona intestinalis	~1995	Introduced	151, 152
Mogula manhattensis	~1996	Introduced	18, 153, 154
Styela clava	This survey	Introduced	151, 152
FISH			
Gambusia affinis	This survey	Introduced	11 (near mouth of Freshwater Slough)

Table 5. Native ranges of non-indigenous species collected in Humboldt Bay during the period July 2000-Sept 2001.

TAXON	Notes - Humboldt Bay	Native Range
ALGAE		
Phaeophyta		
Sargassum muticum	Intertidal, widespread	Japan, Western Pacific
Rhodophyta		
Chondracanthus teedii	Intertidal, range extension to Humboldt Bay	California, Oregon, Washington
Lomentaria hakadotensis	Low intertidal, attached	Japan, Western Pacific
VASCULAR PLANTS		
Cotula coronopifolia	Widespread, Humboldt Bay marshes	South Africa
Spartina densiflora	Pre 1900, described as *S. foliosa* ecotype before 1985, widespread	Chile, South America
INVERTEBRATES		
Porifera		
Cliona celata	Fouling, marinas, benthic	Atlantic Coast, North America
Halichondria bowerbankia	Fouling, marinas	North Atlantic, Europe, North America
Microciona prolifera	Fouling, marinas, benthic	Atlantic
Cnidaria		
Aurelia aurita	Sparse, pelagic	Japan?, North Atlantic
Diadumene leucolena	Intertidal, benthic, fouling	Atlantic Coast, U.S.
Diadumene lineata	Intertidal, benthic, fouling	Japan
Nematostella vectensis	Shallow pools, salt marshes	Baltic Sea, Northern Europe
Obelia dichotoma	Fouling, marinas, low intertidal	Europe, North Atlantic
Polychaeta		
Autolytus cornutus	Low intertidal, benthic	U.S., New England
Boccardiella hamata	Mud, low intertidal	U.S., Virginia, New Jersey
Dipolydora socialis	Low intertidal, benthic	Circumboreal, North Atlantic, North Pacific?, widely distributed

TAXON	Notes - Humboldt Bay	Native Range
Dodecaceria concharum	Borer in bivalves, benthic	Northern Europe
Euchone limnicola	Benthic	Southern California
Exogone lourei	Low intertidal	West Coast, U.S., Gulf Coast, U.S.
Fabricia sabella	Mud, low intertidal	North Sea, Europe
Glycera americana	Mud, low intertidal, benthic	Unknown
Harmothoe imbricata	Low intertidal, attached	Circumboreal, North Atlantic, North Pacific
Heteromastus filiformis	Low intertidal, mud	Atlantic Coast, U.S., European Coast
Heteropodarke heteromorpha	Benthic	Southern hemisphere
Marphysa sanguinea	Mud, low intertidal	Europe, Western Atlantic
Myxicola infundibulum	Fouling, marinas	Mediterannean, Western Europe?, Cosmopolitan
Nereis pelagica	Marinas, low intertidal sand	Circumboreal, North Atlantic, North Pacific
Pholoe minuta	Benthic, Arcata Bay	Circumpolar, North Atlantic, North Pacific
Polydora cornuta	Mud, low intertidal	North Atlantic
Polydora limicola		Western Pacific, California?
Pseudopolydora kempi	Low intertidal, benthic	Western Pacific, India, Japan
Pseudopolydora paucibranchiata	Mud, low intertidal, benthic	Japan
Pygospio elegans	Mud, low intertidal	North Atlantic
Sabellaria gracilis	Fouling, marinas, benthic	Southern California
Serpula vermicularis	Benthic, North Bay Channel	Europe, North Atlantic
Spiophanes bombyx	Benthic	North Atlantic, Cosmopolitan?
Spiophanes wigleyi	Benthic, North Bay Channel	North Atlantic
Streblospio benedicti	Mud, low intertidal, benthic	Atlantic basin
Typosyllis hyalina	Mud, low intertidal, benthic, fouling	Circumboreal, North Atlantic, North Pacific
Gastropods		
Crepidula sp.	Low intertidal, attached	Western Atlantic
Ovatella myosotis	Salt marshes, widespread	North Atlantic
Urosalpinx cinerea	Low intertidal, attached	North Western Atlantic Coast
Opisthobranchia		
Alderia modesta		Pacific Coast, North America?, North Atlantic
Dendronotus frondosus		Cosmopolitan, Northern hemisphere
Bivalvia		

TAXON	Notes - Humboldt Bay	Native Range
Crassostrea gigas	Low intertidal, cultured	Japan
Gemma gemma	Low intertidal, benthic, widespread	North Western Atlantic, Nova Scotia to Florida, Texas
Laternula marilina	Mud, mid intertidal	North Western Pacific, Japan, China
Macoma balthica (or M. petalum)	Mud, intertidal, benthic	Baltic Sea, Europe
Mya arenaria	Mud, mid intertidal	North Atlantic, Japan
Venerupis phillippinarum (=Tapes japonica)	Mud, low intertidal	Japan, Korea, China
CRUSTACEA		
Copepoda		
Mytilicola orientalis	parasitic on *Mytilus* and oysters	Western Pacific, Asia
Isopoda		
Iais californica	Commensal w/ *Sphaeroma quoyanum*	Australia, New Zealand?
Limnoria lignorum	Wood borer, pilings, low intertidal	Circumboreal, North Atlantic, North Pacific
Limmnoria quadripunctata	Wood borer, pilings, low intertidal	Unknown, collected in HB in 1949
Sphaeroma quoyanum (=S. pentadon)	High intertidal, bores in mud banks	New Zealand, Tasmania, Australia
Tanaidacea		
Leptochelia savignyi (as L. dubia)	Widespread, intertidal, benthic	Atlantic Basin
Sinelobus standfordi	Low intertidal	Circumboreal, North Atlantic, North Pacific
Leptostraca		
Nebalia pugettensis	Low intertidal, on algae, plant debris	Possible native
Amphipoda		
Amphitoe valida	Mid intertidal	Circumboreal, North Atlantic, North Pacific
Caprella equilibra	Widespread, epibenthic	North Atlantic?
Caprella mutica	Widespread, epibenthic	Japan?
Chelura terebrans	In woody debris, intertidal	Southern California, Central California
Chaetocorophium lucasi	Mud, low intertidal	New Zealand
Corophium acherusicum	Widespread, epibenthic	New Zealand?, widespread
Corophium insidiosum	Mid intertidal, fouling, benthic	North Atlantic, North America, Europe

TAXON	Notes - Humboldt Bay	Native Range
Corophium uenoi	Mid intertidal	Japan
Grandidierella japonica	Widespread, epibenthic	Japan
Hyale plumulosa	Mid intertidal, benthic	Circumboreal, North Atlantic, North Pacific
Incisocalliope nipponensis	Epibenthic on bryozoans	Japan?
Ischyrocerus anguipes		North Atlantic, Europe
Jassa slatteryi	Fouling, epibenthic, widespread	Eastern Pacific?
Melita nitida	Mid intertidal, epibenthic	Northwestern Atlantic
Microdeutopus gryllotalpa	Mid to upper intertidal	Northwestern Europe
Microjassa litotes	Low intertidal rocks, benthic	native?
Paracorophium sp.		
Photis pachydactylata	Mud low intertidal, benthic	North Pacific to British Columbia
Podocerus cristatus	Low intertidal rocks, algae, benthic	New Zealand, Australia, South Africa
Stenothoe valida	Fouling	Northeastern Pacific?, San Francisco Bay?
Decapoda		
Carcinus meanas	Mid to low intertidal, sparse	Northern Europe
Bryozoa		
Alcyonidium polyoum	Fouling, on shells	Western Atlantic
Bowerbankia gracilis	Fouling	Western Atlantic
Bugula neritina	Fouling	Cosmopolitan, widespread
Celleporella hyalina ?	Fouling	Circumboreal?
Conopeum sp.	Fouling	Western North Atlantic?
Cryptosula pallasiana	Fouling	Atlantic, widespread
Schizoporella unicornis	Fouling	Western Pacific, widespread
Watersipora ('subtorquata') sp.	Fouling	Northwest Pacific?
(= W. cucullata)		
Ectoproct		
Barenstia benedeni	Fouling	
Chordata: Tunicata		
Botrylloides sp.	Fouling, algae, low intertidal rocks	North Atlantic?, Japan?
Botryllus sp.	Fouling	?

TAXON	Notes - Humboldt Bay	Native Range
Botryllus tuberatus	Fouling	?
Ciona intestinalis	Fouling	North Atlantic, North America, Europe
Mogula manhattensis	Fouling	North Atlantic, North America, Europe
Styela clava	Fouling	Western Pacific
FISH		
Gambusia affinis	Brackish to fresh water	

Table 6. Characteristics of benthic sediment samples collected Sept.-Oct. 2000 at Humboldt Bay. C. Sand = coarse sand, VC. Silt = very coarse silt, M&F Silt = medium and fine grain silt. Median and Mean are phi units.

Sample	Latitude	Longitude	Depth (m)	Date	Time (GMT)	% C.Sand & Gravel	% Sand	% VC.Silt	% M&F Silt	% Clay	Median	Mean
Boyd-1	40° 50.053	124° 7.622	n/a	09/28/00	n/a	0.0	27.0	9.2	33.2	30.6	6.0	6.6
Boyd-2	40° 49.941	124° 7.955	n/a	09/28/00	n/a	2.5	54.2	7.3	22.8	13.1	3.0	4.7
Boyd-3	40° 49.793	124° 8.278	n/a	09/28/00	n/a	18.4	67.7	2.1	6.2	5.6	1.5	1.5
Boyd-4	40° 49.658	124° 8.542	6	09/28/00	n/a	3.7	70.2	4.0	13.7	8.4	2.0	3.5
Boyd-5	40° 49.515	124° 8.848	6.5	09/28/00	n/a	42.4	47.9	1.2	4.4	4.2	0.6	-0.4
Boyd-6	40° 49.394	124° 9.192	7.5	09/28/00	n/a	0.0	63.3	5.5	18.8	12.3	2.2	4.3
Boyd-7	40° 49.348	124° 9.508	9.0	09/28/00	15:50	0.0	71.6	5.0	19.7	3.7	2.3	4.0
Boyd-8	40° 49.335	124° 8.884	9.5	09/28/00	16:00	9.9	74.7	2.6	10.6	2.1	1.8	2.2
Boyd-9	40° 50.083	124° 9.479	5	09/28/00	16:16	1.2	84.9	2.2	6.4	5.3	2.2	2.3
Boyd-10	40° 49.859	124° 9.721	5.5	09/28/00	16:23	19.7	66.8	2.3	6.6	4.7	1.9	1.2
Boyd-11	40° 49.635	124° 9.892	6.0	09/28/00	16:33	6.5	84.8	1.4	3.7	3.6	2.1	1.9
Boyd-12	40° 49.312	124° 10.170	14.0	09/28/00	16:42	10.5	86.7	0.3	0.8	1.6	1.7	1.4
Boyd-13	40° 49.172	124° 10.397	13	09/28/00	17:14	18.3	78.9	0.3	0.7	1.8	1.5	0.9
Boyd-14	40° 48.947	124° 10.556	9.5	09/28/00	17:26	0.0	70.3	6.0	20.5	3.2	3.0	4.3
Boyd-15	40° 48.826	124° 11.002	8	09/28/00	18:23	0.0	68.7	9.1	18.8	3.4	3.0	4.2
Boyd-16	40° 48.532	124° 10.936	8.5	09/28/00	18:38	0.9	95.9	0.2	0.8	2.2	2.0	2.0
Boyd-17	40° 48.370	124° 11.218	6.5	09/28/00	18:50	55.1	37.2	1.2	3.2	3.2	-0.6	-0.1
Boyd-18	40° 48.080	124° 11.182	12.0	09/28/00	19:06	18.0	78.6	0.5	1.0	1.8	1.8	1.1
Boyd-19	40° 48.501	124° 9.326	6	09/28/00	19:34	0.0	7.9	10.2	44.8	37.1	6.9	8.0
Boyd-20	40° 48.501	124° 9.627	7	09/28/00	19:46	0.0	22.7	14.0	36.6	26.8	5.8	6.9
Boyd-21	40° 48.380	124° 9.995	6	09/28/00	19:56	0.0	14.6	18.2	40.5	26.6	5.9	7.2
Boyd-22	40° 48.318	124° 10.389	8	09/28/00	20:06	0.0	21.2	18.9	34.4	25.5	5.7	6.9
Boyd-23	40° 48.234	124° 10.679	8	09/28/00	20:15	0.0	31.2	19.2	28.1	21.4	4.9	6.5
Boyd-24	40° 45.430	124° 13.210	7.5	09/29/00	14:44	0.0	98.5	0.2	0.1	1.1	2.2	2.2
Boyd-25	40° 45.204	124° 13.428	14.5	09/29/00	15:01	3.1	95.9	0.0	0.1	0.9	1.7	1.6
Boyd-26	40° 45.740	124° 13.154	12	09/29/00	15:21	33.9	64.3	0.2	0.5	1.1	1.2	-0.2
Boyd-27	40° 45.916	124° 12.886	11.0	09/29/00	15:34	16.2	81.8	0.1	0.6	1.3	1.5	1.1
Boyd-28	40° 46.194	124° 12.728	9.5	09/29/00	15:47	8.6	86.3	1.2	1.7	2.2	2.0	1.9
Boyd-29	40° 46.292	124° 12.364	12	09/29/00	16:08	10.0	89.0	0.0	0.1	0.8	1.2	1.1
Boyd-30	40° 46.536	124° 12.135	12	09/29/00	16:18	9.0	90.2	0.0	0.1	0.7	1.5	1.3
Boyd-31	40° 46.680	124° 11.817	9.0	09/29/00	16:27	20.6	76.0	0.6	1.2	1.6	1.8	0.8

Sample	Latitude			Longitude			Depth (m)	Date	Time (GMT)	% C.Sand & Gravel	% Sand	% VC.Silt	% M&F Silt	% Clay	Median	Mean
Boyd-32	40	°	47.047	124	°	11.852	7.5	09/29/00	16:39	14.0	83.8	0.2	0.5	1.5	2.1	1.8
Boyd-33	40	°	47.235	124	°	11.541	10.0	09/29/00	16:47	36.1	62.0	0.2	0.6	1.1	1.5	0.1
Boyd-34	40	°	47.545	124	°	11.570	12	09/29/00	17:04	65.9	32.1	0.2	0.7	1.1	-2.1	-0.7
Boyd-35	40	°	47.677	124	°	11.274	11.0	09/29/00	17:14	0.0	45.2	13.9	30.9	10.1	4.3	5.1
Boyd-36	40	°	47.899	124	°	11.400	12.5	09/29/00	17:30	47.3	49.3	0.4	1.4	1.6	0.6	-0.2
Boyd-37	40	°	43.319	124	°	13.545	9.5	09/29/00	18:26	0.0	68.0	8.4	20.5	3.1	2.6	3.9
Boyd-38	40	°	43.571	124	°	13.361	11	09/29/00	18:38	0.4	95.6	0.7	1.2	2.1	2.1	2.1
Boyd-39	40	°	43.789	124	°	13.230	10.5	09/29/00	18:48	0.1	71.5	8.5	17.1	2.9	2.7	3.7
Boyd-40	40	°	44.087	124	°	13.215	13.5	09/29/00	18:57	0.6	72.9	3.7	20.9	2.0	2.6	3.7
Boyd-41	40	°	44.234	124	°	13.340	12	09/29/00	19:05	0.2	85.9	1.3	8.4	4.1	2.5	2.9
Boyd-42	40	°	44.488	124	°	13.549	14.0	09/29/00	19:23	0.7	96.6	0.0	0.9	1.7	2.0	2.0
Boyd-43	40	°	44.753	124	°	13.427	0.0	09/29/00	19:33	1.1	95.2	0.0	1.6	2.2	2.1	2.1
Boyd-44	40	°	45.065	124	°	13.343	8.5	09/29/00	19:44	0.2	96.7	0.2	1.9	1.1	2.2	2.2
Boyd-45	40	°	51.870	124	°	8.903	5.3	10/26/00	16:04	0.3	54.0	4.8	19.7	21.3	3.6	6.0
Boyd-46	40	°	51.714	124	°	8.571	4.3	10/26/00	16:21	3.6	83.7	0.9	5.9	5.9	1.5	1.8
Boyd-47	40	°	51.437	124	°	8.571	5.7	10/26/00	16:35	2.7	75.6	0.0	19.7	1.9	2.1	4.3
Boyd-48	40	°	51.231	124	°	8.773	4.7	10/26/00	16:50	0.1	87.7	0.1	9.8	2.3	2.3	2.4
Boyd-49	40	°	50.991	124	°	8.879	8.4	10/26/00	17:18	1.2	60.5	1.1	32.2	5.0	2.4	4.4
Boyd-50	40	°	50.738	124	°	8.880	5.6	10/26/00	17:38	0.0	20.1	4.9	40.3	34.6	7.0	6.7
Boyd-51	40	°	50.500	124	°	8.905	6.9	10/26/00	18:05	38.5	50.1	1.6	7.9	1.9	1.6	0.2
Boyd-52	40	°	50.284	124	°	9.155	7	10/26/00	18:28	0.2	66.7	1.0	25.5	6.6	2.7	4.5
Boyd-53	40	°	50.155	124	°	9.298	8.4	10/26/00	18:37	0.2	55.6	8.1	20.9	15.1	3.3	4.9
Boyd-54	40	°	50.695	124	°	6.460	5.6	10/26/00	20:25	1.4	28.6	9.4	35.0	25.6	5.7	5.5
Boyd-55	40	°	50.629	124	°	6.931	7.9	10/26/00	20:46	2.9	70.7	2.2	19.4	4.7	2.2	3.8
Boyd-56	40	°	50.369	124	°	7.194	6.4	10/26/00	21:05	0.0	7.5	6.7	49.2	36.6	6.6	7.3
Boyd-57	40	°	50.199	124	°	7.383	5.0	10/26/00	21:20	0.3	25.2	8.1	32.8	33.6	5.7	5.6
Boyd-58	40	°	49.788	124	°	7.585	4.7	10/26/00	21:52	0.6	39.1	7.7	45.3	7.3	5.1	4.9
Boyd-59	40	°	49.623	124	°	7.962	6.0	10/26/00	22:07	0.4	46.6	7.9	25.8	19.4	4.4	5.1
Boyd-60	40	°	49.383	124	°	8.273	5.9	10/26/00	22:15	0.0	26.7	16.2	33.8	23.4	5.2	5.7
Boyd-61	40	°	49.224	124	°	8.609	7.5	10/26/00	22:25	0.3	59.2	6.3	23.2	10.9	2.7	4.5
Boyd-62	40	°	49.039	124	°	9.150	6.6	10/26/00	22:36	1.8	78.6	1.3	16.6	1.7	2.3	3.6
Boyd-63	40	°	42.998	124	°	14.433	7.3	10/27/00	n/a	10.2	67.5	7.3	13.2	1.8	2.2	3.1
Boyd-64	40	°	43.169	124	°	14.430	7.3	10/27/00	16:24	0.0	47.1	15.6	24.2	13.1	4.2	4.9
Boyd-65	40	°	43.295	124	°	14.245	9.1	10/27/00	16:42	0.0	55.1	8.7	29.9	6.4	3.4	4.2

Sample	Latitude	Longitude	Depth (m)	Date	Time (GMT)	% C.Sand & Gravel	% Sand	% VC.Silt	% M&F Silt	% Clay	Median	Mean
Boyd-66	40° 43.424	124° 13.923	10.4	10/27/00	16:54	0.5	95.3	0.3	1.3	2.6	2.4	2.4
Boyd-67	40° 43.587	124° 13.739	9.1	10/27/00	17:10	1.2	95.7	0.1	1.2	1.8	2.1	2.0
Boyd-68	40° 43.915	124° 13.696	8.8	10/27/00	n/a	0.0	96.4	0.4	0.8	2.3	2.4	2.4
Boyd-69	40° 44.247	124° 13.713	8.5	10/27/00	17:34	1.4	94.4	0.9	1.3	2.0	2.1	2.1
Boyd-70	40° 44.604	124° 13.544	13.7	10/27/00	17:49	0.0	74.1	5.8	11.9	8.2	2.4	3.9
Boyd-71	40° 41.986	124° 13.597	4.3	10/27/00	18:24	1.5	18.1	17.4	37.7	25.4	5.5	6.7
Boyd-72	40° 41.997	124° 13.610	12.3	10/27/00	18:45	27.4	10.3	3.1	43.9	15.3	5.4	2.7
Boyd-73	40° 42.289	124° 13.577	7.7	10/27/00	19:02	0.0	13.8	15.7	42.8	27.6	6.1	6.3
Boyd-74	40° 42.500	124° 13.571	7.2	10/27/00	19:21	0.0	17.3	17.0	44.6	21.0	5.4	6.1
Boyd-75	40° 48.465	124° 10.202	7.6	10/27/00	20:46	5.9	74.9	0.8	11.9	6.6	2.2	4.7
Boyd-76	40° 48.610	124° 10.005	6.9	10/27/00	20:55	3.2	94.4	0.0	0.7	1.7	2.0	1.9
Boyd-77	40° 48.807	124° 9.624	8.8	10/27/00	21:12	11.0	86.1	0.1	0.9	1.9	1.7	1.4
Boyd-78	40° 48.997	124° 9.167	7.5	10/27/00	21:24	0.0	98.0	0.1	0.4	1.5	1.9	1.9
Boyd-79	40° 42.784	124° 13.752	8.5	10/14/00	16:35	0.0	41.9	13.5	26.7	17.8	4.5	5.6
Boyd-80	40° 43.107	124° 13.682	10.0	10/14/00	16:47	0.0	84.7	3.6	7.1	4.6	2.2	2.7
Boyd-81	40° 43.435	124° 13.456	9.5	10/14/00	16:56	0.0	92.9	2.7	2.0	2.4	2.5	2.6
Boyd-82	40° 44.315	124° 13.450	7.5	10/14/00	17:30	0.0	97.9	0.3	0.4	1.4	2.1	2.1
Boyd-83	40° 44.674	124° 13.556	8.5	10/14/00	17:40	0.0	98.5	0.1	0.2	1.2	1.7	1.7
Boyd-84	40° 45.608	124° 13.107	11.0	10/14/00	18:27	0.0	99.1	0.0	0.1	0.8	1.9	1.9
Boyd-85	40° 46.293	124° 12.387	13.0	10/14/00	19:20	18.5	80.6	0.1	0.1	0.7	1.3	0.8
Boyd-86	40° 46.550	124° 11.933	11	10/14/00	19:42	7.7	86.9	0.9	1.7	2.8	2.2	2.0
Boyd-87	40° 46.824	124° 11.993	8.5	10/14/00	19:58	0.0	99.2	0.0	0.0	0.7	1.5	1.5

DISCUSSION

We found 73 NIS that have possibly been introduced to Humboldt Bay from distant locations. In addition to these introductions, there are some species uncertain as to their origin and status as non-indigenous species. Various lines of evidence suggest that these species of uncertain status may simply be widespread, cosmopolitan species (Carlton 1995). Other evidence suggests that these species are "cryptogenic," meaning that they may be easily transported from one area to another, that they are of uncertain relationship to distant populations recognized as the same species, or that cryptogenic species may be symbiotic with species known to be introduced. We designated 17 species that are probable introductions in Table 7. We found 13 species that are uncertain as to status, they may be introductions or cryptogenic and are still under investigation.

Table 7: Species designations for different categories of organisms found in Humboldt Bay and adjacent estuarine areas 2000-2001.

Non-indigenous	Probable Introductions	Status Uncertain	Total
65	17	13	95

There are 65 species in Humboldt Bay that are clearly NIS (Table 7). A number of these species have been in the bay for over 100 years, exemplified by South American cordgrass, *Spartina densiflora*, arguably the dominant plant now found in Humboldt Bay salt marshes. Others are of very recent origin, exemplified by some ascidians and bryozoans. Yet other species have been introduced intentionally and are the basis of on-going mariculture (e.g., *Crassostrea gigas*, the Japanese oyster). We were able to recognize 60 species of marine or estuarine invertebrates, 3 species of marine algae, and one fish species that are clearly non-indigenous species now found in Humboldt Bay.

Although Humboldt Bay has far fewer species of NIS than San Francisco Bay, there are still enough to cause concern. Maritime trade is expected to continue, with trends toward ever more rapid transit of even major ocean basins like the North Pacific. These rapid transit times could result in more arrivals from the western Pacific basin via ballast water. In this survey we found two amphipod species that are prime candidates for recent arrival via ballast water, *Incisocalliope nipponensis* (from Japan) and a species of *Paracorophium* that appears to be native to New Zealand.

Perhaps of even greater concern, the transit time from San Francisco Bay to Humboldt Bay is now measured in hours or a few days. Ships routinely enter Humboldt Bay after taking on a hold cargo at port facilities of San Francisco Bay and then visiting Humboldt Bay to take on a deck cargo of logs or lumber. These vessels usually take in ballast water while in San Francisco Bay and discharge some ballast water when the deck cargo has been loaded in Humboldt Bay. Such ballast water transport in intracoastal trade can rapidly spread NIS along an entire continental coastline (Carlton 2000). In this survey we identified 23 species that are shared in occurrence with San Francisco Bay and 31 species that occur at other locations along the coast of Pacific Coast of North America (Cohen and Carlton 1995, Ruiz et al. 2000)

Advances in navigational technology and ship building in the last 25 years have resulted in more frequent intracoastal traffic by fishing vessels and ocean-going pleasure boats. Many vessels that enter Humboldt Bay are returning to the bay after weeks or months in other locations, frequently San Francisco Bay. Fishing vessels and pleasure craft are generally not as rigorously maintained as commercial shipping vessels, with the result that a variety of fouling organisms may settle and grow on submerged surfaces, such as the hull. Once in a new location, fouling organisms may successfully produce motile larvae that spread, first to submerged surfaces at marinas, and later may become widespread. In this survey, the solitary ascidian *Mogula manhattensis* is now restricted to marinas and seems to have arrived in Humboldt Bay during the past ten years. This contrasts with the colonial ascidian *Botryllus* (possibly *B. schlosseri*), which appears to have been present in the bay for at least the past 30 years. Both these ascidian species are frequently involved in fouling boat hull surfaces in ports along the east and west coasts of North America (Ruiz et al. 2000). With continued increases in intracoastal traffic it can be expected that such introductions will occur more frequently.

In some instances, the occurrence of NIS in Humboldt Bay indicates that introductions are recent and that populations are sparse. A good example is provided by the European green crab, *Carcinus meanas*. This easily recognized crab was first seen at Humboldt Bay in 1995 (Miller 1996). Since that time it has spread to locations throughout the bay, but remains sparse. A continuing program of censusing populations of these crabs by trapping suggests that they have a high potential to increase in abundance at any time. These crabs first appeared in California in 1983, at Estero Americano on the Solano County coast and in San

Francisco Bay in 1989 or 1990 (Cohen and Carlton 1995). The arrival of these crabs at Humboldt Bay by transport in ballast water is likely.

There are other examples of NIS that we found in this survey that appear to be sparse in their occurrence as a result of recent introduction. The *Paracorophium* sp. amphipod could have been associated with ships bringing in logs from New Zealand. Recent restrictions on logging in forests of northwestern California caused lumber companies to explore alternate sources of logs, one of which was to ship Monterey pine logs from forestry plantations in New Zealand. Economic pressures of this kind in the years ahead will almost certainly result in increased potential for NIS to appear in Humboldt Bay.

Virtually all the ports and bays of North America have at least some non-indigenous marine species that have arrived from other parts of the globe (Ruiz et al. 2000). Humboldt Bay, with a 150 year history of maritime commerce, has received non-native species ever since the earliest period of American and European settlement in the 1850's. There is no doubt that the pace of introductions has increased in the past 20 years. Although Humboldt Bay does not the the number of non-native species found in San Francisco Bay, it is clear that global maritime commerce will continue to be an important source of introductions. Additionally for Humboldt Bay, it will be important to more carefully assess the impact of secondary introductions from initial introductions to other California locations, particularly San Francisco Bay.

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