Project Report for the

Southern California Exotics Expedition 2000

A Rapid Assessment Survey of Exotic Species in Sheltered Coastal Waters

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For the

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Executive Summary

In recent decades, the world has witnessed an array of harmful invasions by exotic marine and freshwater organisms. To provide the public and policymakers with better information on the status of exotic species in Southern California waters, the California Department of Fish and Game and the California State Water Resources Control Board, with supplemental funding from the National Fish and Wildlife Foundation, commissioned a Rapid Assessment Survey of selected sheltered waters between San Diego and Oxnard in the summer of 2000. The primary objective of the survey was to assess the status of exotic invasions within certain habitat types in the region. Secondary objectives included obtaining data for comparisons between habitats and regions and for comparisons with past surveys; obtaining baseline data for future assessments of changes in invasion status and the effectiveness of prevention or control efforts; detecting new invasions and documenting significant range extensions; and identifying new species.

Methods

A team of taxonomic experts was assembled to sample and identify organisms at a number of sites within the region. Participants included staff and faculty from Western Washington University, Oregon State University/Hatfield Marine Science Center, San Francisco Estuary Institute, California State University at Fullerton, Los Angeles County Museum of Natural History, San Diego Ocean Monitoring Laboratory, California State Water Resources Control Board and the Williams College/Mystic Seaport Maritime Studies Program; and students from California State University at Fullerton, Williams College/Mystic Seaport Maritime Studies Program and Universidad Nacional de Mar del Plata.Twenty-two primary sampling sites and three secondary sites (where the collecting effort was less intensive) were selected to represent the three major commercial port areas in southern California (San Diego, Los Angeles/Long Beach and Port Hueneme), important marina areas and lagoon sites. Sampling was primarily of dock fouling along with adjacent soft-bottom benthos, nearby intertidal sites, and selected subtidal lagoon habitats. Sampling was conducted by a variety of manual techniques. Field identification of specimens was followed by examination of live sampled material in the laboratory by the expedition team and identification to lowest possible taxon. Laboratory work was conducted at the Los Angeles County Museum of Natural History (Polychaete Collection) and the San Diego Ocean Monitoring Laboratory, with followup work at participants' home institutions. Representative voucher collections were deposited with the Los Angeles County Museum of Natural History.

Results

Salinities at most sites ranged from 31.5 to 36.5 psu, with one lower salinity site (San Dieguito Lagoon at 18.5 psu). Surface water temperatures ranged from 19.5 to 27°C, and were generally lower at the higher latitudes. The expedition collected 67 species that have been identified as exotic (Tables ES-1). Sixty-five of these species were found on floating piers and associated structures, which were sampled at a total of 21 sites; 20 species were found on fixed subtidal

structures or shallow subtidal bottom in sampling at 5 sites; and 14 species were collected in benthic grabs at 13 sites. One exotic species, the Atlantic ribbed mussel *Geukensia demissa*, was collected at the single intertidal beach site (Colorado Lagoon), and was not collected in any of the other habitats. One exotic species, the barnacle *Balanus amphitrite*, was collected at 2 of the 5 sites where barnacles were collected from intertidal pilings, and was also collected from floats or subtidal structures at some sites.

Table ES-1. Summary data on exotic species collected

Habitat sampled	Floats	Subtidal	Benthic	Beach	Piling	All
Number of sites sampled	21	5	14	1	5	25
Number of primary sites sampled	20	3	13	1	5	22
Number of species collected	65	20	13	1	1	67
Average species collected/site	16.2	5.2	1.8	1	0.4	15.2
Average species collected/primary site	16.7	6.3	1.9	1	0.4	16.7

The largest numbers of exotic species were found on floating piers, with an average of 16.7 exotic species collected at each primary site and a range of 10-22 exotic species per primary site. Collections taken from fixed subtidal structures or subtidal bottom at three primary sites averaged 2.1 and ranged from 1-12 exotic species per site (though the collection effort at the site where only one exotic species was collected was very limited). An average of 1.9 exotic species were collected in each benthic grab at 13 primary sites, with a range of 0-7 species per site. One exotic species was collected at the single intertidal beach site sampled.One exotic species was collected at 2 of the intertidal piling sites, for an average of 0.4 exotic species per piling site. Combining all habitats sampled, the number of exotic species collected ranged from 6 to 22 per primary site. There was no trend in the number of exotic species collected at primary sites relative to latitude, salinity or temperature.

The exotic organisms collected included representatives of seven high-level taxonomic groups. Sea squirts, crustaceans, bivalves and polychaetes were especially widespread (Table ES-2). Most of the exotic organisms collected are native to the northwestern Pacific, primarily the region including Japan, Korea and northern China. Another substantial group of organisms come from the North Atlantic, especially the northwestern Atlantic, with a smaller group from the southwestern Pacific (mainly Australia and New Zealand) and Indian Ocean.

Table ES-2. Exotic organisms collected: diversity and frequency by higher taxonomic groups

Taxon	Exotic species collected	Sites where collected
Macroalgae (seaweeds)	3	5
Cnidaria (anemones, etc.)	2	7
Annelida (polychaete worms)	10	18
Mollusca (bivalves, snails, etc.)	5	18
Arthropoda (crustaceans, etc.)	26	22

Bryozoa	6	12
Urochordata (sea squirts)	15	23
Total	67	24

For the exotic species collected on the expedition, the number of initial collection records for both the Pacific Coast and in southern California are greatest in the decades of the 1940s and the 1990s. It is not known whether these spikes result from stronger transport vectors during those periods (such as an increase in World War II-related military vessel traffic in the 1940s and an increase in commercial shipping and ballast water discharges from China, Japan and Korea in the 1990s), or whether they simply reflect greater collecting effort during those periods.

Transport as fouling organisms attached to the hulls of ships, or as wood-boring (or associated crevice-occupying) organisms in the hulls of wooden ships, is a possible vector for the transport of two-thirds of the exotic species collected by the expedition; ballast water discharges are a possible vector for over two-fifths of the species; and historic imports of Atlantic and Japanese oysters for commercial aquaculture are each a possible vector for about a tenth of the species.

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Introduction

In recent decades, the world has witnessed an array of harmful invasions by exotic marine and freshwater organisms. These include:

- The Atlantic comb jelly, *Mnemiopsis leidyi*, which was introduced into the Black and Azov Seas in the early 1980s. It became phenomenally abundant and consumed much of the seas' crustacean zooplankton, contributing to the decline of the region's anchovy and sprat fisheries and of the fishing fleets of six nations that depended on them (Travis 1993).
- European zebra mussels, *Dreissena polymorpha*, which appeared in the Great Lakes in the late 1980s. Zebra mussels have become a massive nuisance, causing millions of dollars of damage primarily by blocking the water intake systems of cities, factories and power plants. Within a few years' time, the mussels had spread across much of North America, from Canada to New Orleans and from the Hudson River to Oklahoma (Nalepa and Schloesser 1993)
- Toxic red tides that have appeared in many parts of the world, and which were caused in some cases by dinoflagellates introduced by ballast water or shellfish imports for aquaculture (Hallegraeff *et al.* 1989; Hallegraeff and Bolch 1991). Human neurotoxins produced by the dinoflagellates accumulate in clams or mussels, sickening and occasionally killing people that eat them. During a red tide outbreak in New Zealand, people walking along the shore became ill from airborne toxins (O'Hara 1993).
- The cholera-causing bacterium *Vibrio cholerae*. In 1991, when the South American epidemic strain of this bacteria was discovered in oysters and fish in Mobile Bay, Alabama, the U.S. Food and Drug Administration sampled ships arriving from South America and found the same strain of cholera in the ballast water of a third of them (*U.S. Federal Register* 1991; McCarthy and Khambaty 1994). Some medical researchers believe that ballast water discharges were responsible for initially introducing the cholera strain into South America (Ditchfield 1993; Epstein *et al.* 1993), triggering an epidemic that resulted in at least a million cases and ten thousand deaths (Tauxe 1995).

These and other well-publicized aquatic invasions, including the introduction to the Pacific Coast of the European green crab *Carcinus maenas* (Cohen *et al.* 1995) and the Chinese mitten crab *Eriocheir sinensis* (Cohen and Carlton 1997), have led to increasing public concern about the status and impacts of non-native species.

To provide the public and policymakers with better information on the status of exotic species in Southern California waters, the California Department of Fish and Game and the California State Water Resources Control Board, with supplemental funding from the National Fish and Wildlife Foundation, commissioned a Rapid Assessment Survey of selected sheltered waters between San Diego and Oxnard in the summer of 2000. This survey was the seventh in a series of Rapid Assessment Surveys for exotic marine organisms on the Pacific Coast. Four surveys were conducted in San Francisco Bay in 1993, 1994, 1996 and 1997; a survey of Puget Sound was conducted in 1998; and a survey of three regions in Washington state (in central Puget Sound, southern Puget Sound, and Willapa Bay) was conducted in the spring of 2000. The primary goal of each survey was to provide general information on the extent of biological invasions within a region in terms of the number and distribution of non-native species that are present. To this end, multi-institutional teams of taxonomic experts were assembled to quickly sample and identify a broad suite of organisms at a number of sites within the region. Participants in the current study included staff and faculty from Western Washington University, Oregon State University/Hatfield Marine Science Center, San Francisco Estuary Institute, California State University at Fullerton, Los Angeles County Museum of Natural History, San Diego Ocean Monitoring Laboratory, California State Water Resources Control Board and the Williams College/Mystic Seaport Maritime Studies Program; and students from California State University at Fullerton, Williams College/Mystic Seaport Maritime Studies Program and Universidad Nacional de Mar del Plata.

Methods

As in past surveys, our primary objective was to conduct a rapid assessment of the status of exotic invasions within defined regions and habitat types through non-quantitative or semi-quantitative census methods. Secondary objectives were to obtain data for comparisons between habitats and regions, and for comparisons with past surveys; to obtain baseline data for future assessments of changes in invasion status and the effectiveness of prevention or control efforts; to detect new invasions and document significant range extensions; and to identify new species.

Twenty-two primary sampling sites and three secondary sites were selected to represent the three major commercial port areas in southern California (San Diego, Los Angeles/Long Beach, and Port Hueneme), important marina areas and lagoon sites (Table 1). We mainly sampled dock fouling (organisms growing on the sides and undersides of floating piers and associated floats, bumpers, tires, ropes, etc.) along with soft-bottom benthos adjacent to these sites, some nearby intertidal sites, and selected subtidal lagoon habitats. Primary sampling sites were selected during a reconnaissance trip in June 2000. Three secondary sites, all representing highly modified or artificial lagoon environments, were added during the survey and sampled briefly by a subset of the expedition team. The summary data on number of exotic species collected are provided for both primary sites alone and for all sites (in Table 3), and the data on number of exotic species collected versus latitude, salinity and temperature variables are provided for primary sites alone (in Figures 2-4).

Near surface (0-0.3 m) salinity and temperature were measured at all primary sampling sites, usually using two refractometers and two thermometers and reported as the average of the two readings. Salinity measurements are presented in this report in Practical Salinity Units (psu), which are comparable to parts per thousand (ppt). Latitude and longitude were measured with a hand-held GPS unit.

At each primary sampling site samples were collected by the expedition team during a period of approximately one hour, using a variety of manual techniques. Tools included hand scrapers, a custom-made long-handled scraper with a steel mesh net, and sieves. Benthic (bottom) samples were taken with an Ekman grab, washed onto a 0.5 mm sieve and sorted by eye to major taxonomic group on site. Field identification of specimens was followed by examination of live sampled material in the laboratory by the expedition's team of taxonomic experts, and identification to lowest possible taxon.[1] A one-liter representative voucher collection was obtained from each main sampling site, plus additional samples of material of interest. The samples were kept on ice in insulated coolers until examination in the laboratory. Laboratory work was conducted at the Los Angeles County Museum of Natural History and the San Diego Ocean Monitoring Laboratory. Organisms were identified by expedition team members, with some material retained by individuals for further study at their home institution, and other material prepared for shipment to specialists for additional work. Specimens of Pacific oysters (*Crassostrea gigas*) were preserved in 95% ethanol for future DNA analysis to assess their probable transport mechanisms. After examination was completed, voucher samples and most of the other specimens were fixed in 10% formalin and transferred to 70% ethanol. The voucher collections were deposited with the Los Angeles County Museum of Natural History.

Additional information on the participants and the survey schedule is provided in the Appendix.

Table 1. Sampling sites

Site number	Site name	Location	County	GPS latitude	GPS longitude
SCX-01	Chula Vista Boat Ramp	San Diego Bay	San Diego	32° 37' 16"	117° 06' 11"
SCX-02	Fiddler's Cove	San Diego Bay	San Diego	32° 39' 07"	117° 08' 58"
SCX-03	Shelter Island	San Diego Bay	San Diego	32° 42' 36"	117° 14' 03"
SCX-04	Seaforth Landing	Mission Bay	San Diego	32° 45' 52"	117° 14' 17"
SCX-05	San Dieguito Lagoon		San Diego	32° 58' 04"	117° 15' 35"
SCX-06	Snug Harbor Marina	Agua Hedionda Lagoon	San Diego	33° 08' 52"	117° 19' 56"
SCX-07	Oceanside Harbor		San Diego	33° 12' 34"	117° 23' 41"
SCX-08	Huntington Harbor Yacht Club	Anaheim Bay	Orange	33° 42' 45"	118° 03' 40"
SCX-09	Long Beach Yacht Club	Alamitos Bay	Los Angeles	33° 45' 13"	118° 16' 51"
SCX-10	Colorado Lagoon	Alamitos Bay	Los Angeles	33° 46' 16"	118° 08' 05"

1 Molecular genetic analyses are needed to reliably distinguish among bay mussels in the *Mytilus edulis*-complex. Molecular analyses of mussels in this complex in California waters south of Monterey Bay have mainly found *M. galloprovincialis* (McDonald and Koehn 1988; Sarver and Foltz 1993), though there is evidence of small numbers of *M. trossulus* or hybrids (Sarver and Foltz 1993; Suchanek *et al.* 1997) and of mitochondrial introgression of *M. trossulus* genes (Geller 1994). In this study we assumed that any collections of *M. edulis*-complex mussels in southern California included at least some *M. galloprovincialis*.

SCX-11	Long Beach Downtown Marina		Los Angeles	33° 45' 29"	118° 11' 22"
SCX-12	Pilots' Dock at Pier F	Long Beach Harbor	Los Angeles	33° 44' 50"	118° 12' 56"
SCX-13	Impound Marina	Long Beach Harbor	Los Angeles	33° 45' 50"	118° 14' 40"
SCX-14	Newmarks Yacht Harbor	Los Angeles Harbor	Los Angeles	33° 45' 52"	118° 14' 59"
SCX-15	Island Yacht Anchorage	Los Angeles Harbor	Los Angeles	33° 46' 22"	118° 14' 52"
SCX-16	Watchorn Basin	Los Angeles Harbor	Los Angeles	33° 43' 13"	118° 16' 35"
SCX-17	Cabrillo Beach Boat Ramp	Los Angeles Harbor	Los Angeles	33° 42' 47"	118° 16' 06"
SCX-18	King Harbor		Los Angeles	33° 50' 47"	118° 23' 49"
SCX-19	Marina del Rey		Los Angeles	33° 58' 20"	118° 27' 08"
SCX-20	Port Hueneme Sportfishing	Port of Hueneme	Ventura	34° 08' 53"	119° 12' 07"
SCX-21	Jack's Landing	Channel Islands Harbor	Ventura	34° 09' 49"	119° 13' 22"
SCX-22	Anacapa Isle Marina	Channel Islands Harbor	Ventura	34° 10' 23"	119° 13' 37"
SS-A	Huntington Harbor - Back Lagoon	Anaheim Bay	Orange	33° 43' 43"	118° 03' 36"
SS-B	Rainbow Lagoon		Los Angeles	33° 45' 47"	118° 11' 29"
SS-C	Venice Lagoon		Los Angeles	not recorded	not recorded

Results

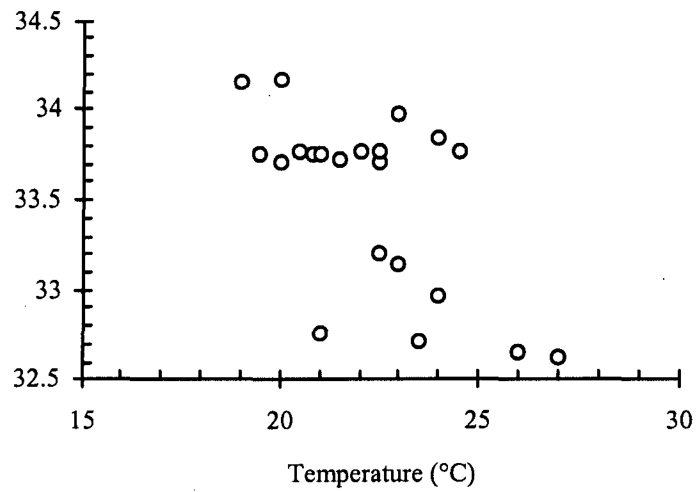
The Expedition sampled at 22 primary and 3 secondary sites from Oxnard to San Diego. The salinities at nearly all these sites were very close, mainly ranging from 34 to 36.5 psu (Table 2). Island Yacht Anchorage, at the mouth of the Dominguez Channel at the back end of Los Angeles Harbor, was slightly lower at 31.5 psu. San Dieguito Lagoon with a salinity of 18.5 psu was the only sampled site with significantly lower salinity than is found in the near-shore ocean. Surface water temperatures ranged from 19.5 to 27°C (Table 2), being generally lower at higher latitudes (Fig. 1).

Table 2. Salinity, temperature and depth of benthic grab

Site number	Site name	Salinity (PSU)	Temperature (°C)	Grab depth (m)
SCX-01	Chula Vista Boat Ramp	36.5	27	–
SCX-02	Fiddler's Cove	35.5	26	–
SCX-03	Shelter Island	35.5	23.5	6
SCX-04	Seaforth Landing	34.5	21	–
SCX-05	San Dieguito Lagoon	18.5	24	–
SCX-06	Snug Harbor Marina	35	23	–
SCX-07	Oceanside Harbor	34.5	22.5	6.5
SCX-08	Huntington Harbor Yacht Club	34	22.5	6.5
SCX-09	Long Beach Yacht Club	34	20.8	3
SCX-10	Colorado Lagoon	34	22	–
SCX-11	Long Beach Downtown Marina	35	21	–
SCX-12	Pilots' Dock at Pier F	34.5	19.5	9
SCX-13	Impound Marina	34.5	20.5	5.5
SCX-14	Newmarks Yacht Harbor	34	22	–
SCX-15	Island Yacht Anchorage	31.5	22.5	–
SCX-16	Watchorn Basin	34.5	21.5	2
SCX-17	Cabrillo Beach Boat Ramp	35	20	1.5
SCX-18	King Harbor	34.5	24	7.5
SCX-19	Marina del Rey	34.5	23	5
SCX-20	Port Hueneme Sportfishing	35	19	6.5
SCX-21	Jack's Landing	35.5	20	5
SCX-22	Anacapa Isle Marina	35	20	4
SS-A	Huntington Harbor - Back Lagoon	not recorded	not recorded	not recorded
SS-B	Rainbow Lagoon	35	24.5	–
SS-C	Venice Lagoon	36.5	not recorded	–

Dock fouling was sampled at the 20 of the 22 primary sites where there were floating piers. At San Dieguito Lagoon (Site 5) and Colorado Lagoon (Site 10) there were no floating piers, and organisms were collected instead from bridge and supports and structures and the adjacent bottom. Benthic grabs were taken at 13 primary and one secondary site (the back lagoon at Huntington Harbor, Secondary Site A), at depths ranging from 1.5 to 9 m (Table 2). Collections of barnacles from the intertidal reaches of pilings were made at five of the primary sites, intertidal molluscs and mollusc shells were collected from the shore of Colorado Lagoon in Anaheim Bay, and molluscs were collected from shallow subtidal rocks at Island Yacht Anchorage (Site 15) in Los Angeles Harbor. Organisms were collected from shallow bottom and structures (walls, bridge supports) at two of the secondary sites, the Venice Lagoon and Rainbow Lagoon (Secondary Sites C and B, respectively). Floating piers at the remaining secondary site, the back lagoon in Huntington Harbor, were examined for ascidians only.

Figure 1. Variation of temperature with latitude



Exotic Species Collected

The Expedition collected 67 species that have been identified as exotic (Tables 3 and 5). Sixty-five of these species were found on floating piers and associated structures, which were sampled at a total of 21 sites; 20 species were found on fixed subtidal structures or shallow subtidal bottom in sampling at 5 sites; and 14 species were collected in benthic grabs at 13 sites. One exotic species, the Atlantic ribbed mussel *Geukensia demissa*, was collected at the single intertidal beach site (Colorado Lagoon, Site 10), and was not collected in any of the other habitats. One exotic species, the barnacle *Balanus amphitrite*, was collected at 2 of the 5 sites where barnacles were collected from intertidal pilings, and was also collected from floats or subtidal structures at some sites.

Table 3. Summary data on exotic species collected

Habitat sampled	Floats	Subtidal	Benthic	Beach	Piling	All
Number of sites sampled	21	5	14	1	5	25
Number of primary sites sampled	20	3	13	1	5	22
Number of species collected	65	20	13	1	1	67
Average species collected/site	16.2	5.2	1.8	1	0.4	15.2
Average species collected/primary site	16.7	6.3	1.9	1	0.4	16.7

The largest numbers of exotic species were found in the collections made on floating piers, with an average of 16.7 exotic species collected at each primary site and a range of 10-22 exotic species per primary site (Tables 3 and 4). Collections taken from fixed subtidal structures or subtidal bottom at three primary sites averaged 2.1 and ranged from 1-12 exotic species, but the collection effort at Site 15 (Island Yacht Anchorage), where only one exotic species was collected, was very limited. An average of 1.9 exotic species were collected in each benthic grab at 13 primary sites, with a range of 0-7 species. One exotic species was collected at the single intertidal beach site sample; and one exotic species was collected at 2 of the intertidal piling sites, for an average of 0.4 exotic species per piling site.

Table 4. Number of exotic species collected, by habitat and site

FLOATING PIERS AND ASSOCIATED STRUCTURES														
Site number	1	2	3	4	6	7	8	9	11	12	13	14	15	16
Species collected/site	20	19	19	21	17	12	14	22	10	18	15	19	17	13
Site number	17	18	19	20	21	22	A							
Species collected/site	17	13	21	11	15	20	7							
SUBTIDAL FIXED STRUCTURES AND SHALLOW BOTTOM														
Site number	5	10	15	B	C									
Species collected/site	6	12	1	7	0									
BENTHIC GRAB														
Site number	3	7	8	9	12	13	16	17	18	19	20	21	22	A
Species collected/site	0	0	1	0	2	2	3	2	1	0	5	7	2	0
INTERTIDAL BEACH														
Site number	10													
Species collected/site	1													
INTERTIDAL PILINGS														
Site number	6	7	9	10	12									
Species collected/site	0	0	0	1	1									
ALL HABITATS SAMPLED														
Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species collected/site	20	19	19	21	6	17	12	15	22	13	10	20	16	19
Site number	15	16	17	18	19	20	21	22	A	B	C			
Species collected/site	18	15	17	14	21	13	18	22	7	7	0			

Combining all habitats sampled, the largest number of exotic species were collected at Long Beach Yacht Club in Alamitos Bay and at the Anacapa Isle Marina in Channel Islands Harbor (Sites 9 and 22), with 22 collected at each. These sites also had the largest number of exotic species collected from floating piers, but few from benthic grabs (Table 4). Among primary sites, the smallest number of exotic species (6) was collected at the San Dieguito Lagoon (Site 5), where there were no floating piers to sample. Colorado Lagoon in Alamitos Bay (Site 10), which also had no floating piers, had an intermediate number of exotic species (13). The largest number of species collected from benthic grabs occurred at two of the northernmost sites, 7 species at Jack's Landing in Channel Islands Harbor (Site 21) and 5 species at the Port Hueneme Sportfishing docks in the Port of Hueneme (Site 20).

There was no trend in the number of exotic species collected at primary sites relative to latitude, salinity or temperature. Figures 2, 3 and 4 show the data for organisms collected at floating piers and associated structures.

Figure 2. The number of exotic species collected at floating piers vs. latitude

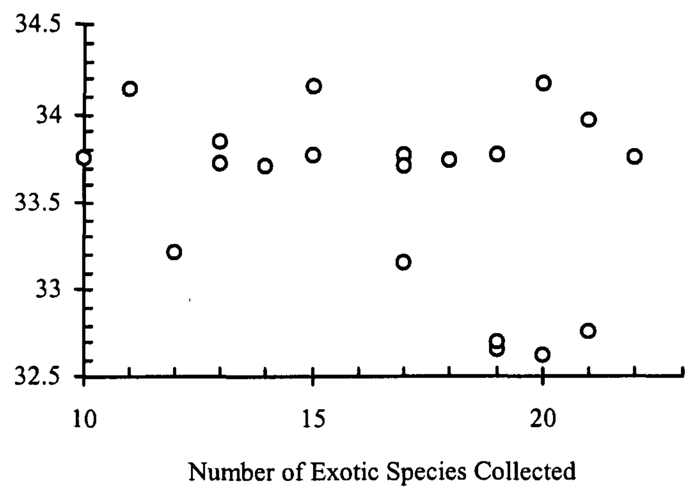


Figure 3. The number of exotic species collected at floating piers vs. salinity

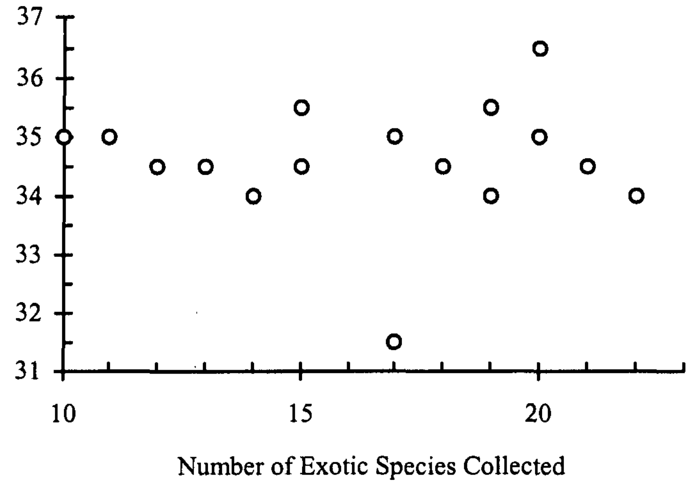
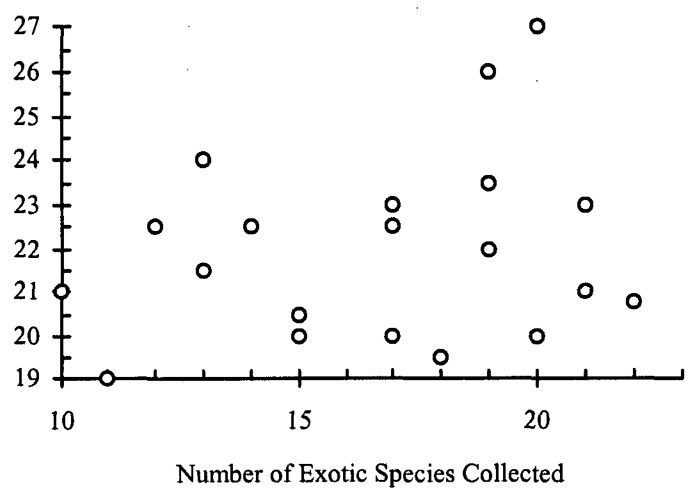


Figure 4. The number of exotic species collected at floating piers vs. temperature



The exotic organisms collected included representatives of seven high-level taxonomic groups (Table 5). Sea squirts, arthropods (mainly crustaceans), molluscs (all of them bivalves), and annelids (all of them polychaetes) were especially widespread, being collected in at least three-quarters of the sites where exotic organisms were found.

Table 5. Exotic organisms collected: diversity and frequency by higher taxonomic groups

Taxon	Exotic species collected	Sites where collected
Macroalgae (seaweeds)	3	5
Cnidaria (anemones, etc.)	2	7
Annelida (polychaete worms)	10	18
Mollusca (bivalves, snails, etc.)	5	18
Arthropoda (crustaceans, etc.)	26	22
Bryozoa	6	12
Urochordata (sea squirts)	15	23
Total	67	24

The most widely-occurring species were the sea squirts *Ciona intestinalis* (collected at 21 sites), *Styela clava* and *Styela plicata* (each collected at 20 sites), and *Botrylloides violaceus* (17 sites); the mussel *Mytilus galloprovincialis* (17 sites); and the sea squirt *Bottyllus schlosseri* (16 sites). These findings are consistent with previous reports of the common occurrence of exotic sea squirts in southern California (Lambert and Lambert 1998).

Table 6. Exotic species collected, by sampling site **(page 1 of 4)**

Species	Sampling sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Phaeophyta														
Sargassum muticum		x										x	x	
Undaria pinnatifida														
Rhodophyta														
Lomentaria hakodatensis		x											x	
Cnidaria: Anthozoa														
Bunodeopsis sp. A					x	x								
Diadumene franciscana						x						x		
Annelida: Polychaeta														
Amblyosyllis speciosa				x									x	
Bispira sp. A													x	
Demonax sp. A	x							x	x		x			
Ficopomatus enigmaticus														
Hydroides dirampa				x										
Hydroides elegans										x	x			
Myrianida pachycera	x		x						x			x		
Nicolea sp. A			x	x		x		x	x		x	x	x	x
Pseudopolydora paucibranchiata											x		x	
Typosyllis nipponica													x	x
Mollusca: Bivalvia														
Crassostrea gigas														
Geukensia demissa										x				
Musculista senhousia	x													
Mytilus galloprovincialis	x			x	x	x			x	x		x		x
Teredo bartschi													x	
Arthropoda: Pycnogonida														
Ammothella hilgendorfi														
Arthropoda: Crustacea: Cirripedia														
Balanus amphitrite	x	x								x	x	x		
Balanus eburneus										x				
Arthropoda: Crustacea: Tanaidacea														
?Sinelobus stanfordi	x													
Arthropoda: Crustacea: Isopoda														
Ianiropsis tridens						x								
Limnoria tripunctata													x	
Paranthura japonica	x	x	x	x		x	x	x	x	x		x		
Sphaeroma quoyanum										x				
Arthropoda: Crustacea: Amphipoda: Gammaridea														
Ampithoe valida														
Aoriodes secunda			x	x		x		x	x			x		x
Chelura terebrans												x	x	
Corophium acherusicum						x	x		x	x				

Table 6. Exotic species collected, by sampling site **(page 2 of 4)**

Species	Sampling sites											No. of sites /species
	15	16	17	18	19	20	21	22	A	B	C	
<u>Phaeophyta</u>												
Sargassum muticum												3
Undaria pinnatifida			x									1
<u>Rhodophyta</u>												
Lomentaria hakodatensis							x					3
<u>Cnidaria: Anthozoa</u>												
Bunodeopsis sp. A												2
Diadumene franciscana	x	x			x			x				6
<u>Annelida: Polychaeta</u>												
Amblyosyllis speciosa												2
Bispira sp. A								x				2
Demonax sp. A					x							5
Ficopomatus enigmaticus	x											1
Hydroides dirampa												1
Hydroides elegans												2
Myrianida pachycera				x	x			x				7
Nicolea sp. A		x	x					x				12
Pseudopolydora paucibranchiata		x		x								4
Typosyllis nipponica		x	x			x		x				6
<u>Mollusca: Bivalvia</u>												
Crassostrea gigas	x											1
Geukensia demissa												1
Musculista senhousia										x		2
Mytilus galloprovincialis	x	x	x	x	x	x	x	x		x		17
Teredo bartschi												1
<u>Arthropoda: Pycnogonida</u>												
Ammothella hilgendorfi			x									1
<u>Arthropoda: Crustacea: Cirripedia</u>												
Balanus amphitrite		x			x							7
Balanus eburneus												1
<u>Arthropoda: Crustacea: Tanaidacea</u>												
?Sinelobus stanfordi												1
<u>Arthropoda: Crustacea: Isopoda</u>												
Ianiropsis tridens	x					x	x					4
Limnoria tripunctata												1
Paranthura japonica	x			x	x	x		x				15
Sphaeroma quoyanum	x											2
<u>Arthropoda: Crustacea: Amphipoda: Gammaridea</u>												
Ampithoe valida							x					1
Aoriodes secunda	x				x	x	x	x				12
Chelura terebrans												2
Corophium acherusicum				x	x	x	x	x				9

Table 6. Exotic species collected, by sampling site **(page 3 of 4)**

Species	Sampling sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Arthropoda: Crustacea: Amphipoda: Gammaridea - continued														
Corophium insidiosum					x	x								
Elasmopus rapax	x		x	x	x	x	x	x	x	x		x		
Ericthonius brasiliensis	x	x	x	x	x	x	x		x			x		
Grandidierella japonica														
Jassa marmorata									x			x		x
Leucothoe alata	x	x	x	x		x	x	x				x		x
Liljeborgia sp.		x	x	x		x	x		x			x		x
Melita sp.								x						x
Metopella sp.									x					
Paradexamine cf. *churinga*								x						
Stenothoe valida														
Arthropoda: Crustacea: Amphipoda: Caprellidea														
Caprella mutica												x		x
Caprella simia														
Arthropoda: Crustacea: Decapoda														
Palaemon macrodactylus					x									
Bryozoa: Chenostomata														
Zoobotryon verticillatum														x
Bryozoa: Cheilostomata														
Bugula flabellata												x		
Bugula neritina														
Cryptosula pallasiana														x
Watersipora arcuata										x				
Watersipora ?subtorquata	x			x		x								x
Urochordata														
Ascidia sp. A	x	x							x					
Ascidia zara			x	x				x						x
Botrylloides violaceus	x	x	x	x				x	x				x	x
Botryllus firmus			x	x										
Botryllus schlosseri		x	x	x		x	x	x	x		x		x	
Botryllus sp. A		x					x							
Ciona intestinalis	x	x	x	x				x	x	x	x	x	x	x
Ciona savignyi	x	x	x	x				x	x					x
Microcosmus squamiger	x	x		x		x	x	x	x			x		x
Molgula manhattensis										x	x			
Polyandrocarpa zorritensis	x	x	x	x			x		x				x	
Styela canopus	x	x	x						x					
Styela clava	x	x	x	x		x	x		x		x	x	x	x
Styela plicata	x	x	x	x			x	x	x	x	x	x	x	x
Symplegma reptans		x	x											
Number of exotics/site	20	19	19	21	6	17	12	15	22	13	10	20	16	19

Table 6. Exotic species collected, by sampling site **(page 4 of 4)**

Species	Sampling sites 15	16	17	18	19	20	21	22	A	B	C	No. of sites /species
<u>Arthropoda: Crustacea: Amphipoda: Gammaridea - continued</u>												
Corophium insidiosum												2
Elasmopus rapax				x	x		x	x				14
Ericthonius brasiliensis				x	x		x	x				13
Grandidierella japonica						x	x	x				3
Jassa marmorata							x					4
Leucothoe alata					x							10
Liljeborgia sp.					x							9
Melita sp.												2
Metopella sp.			x									2
Paradexamine cf. *churinga*	x		x		x		x					5
Stenothoe valida					x		x					2
<u>Arthropoda: Crustacea: Amphipoda: Caprellidea</u>												
Caprella mutica	x					x	x	x				6
Caprella simia	x											1
<u>Arthropoda: Crustacea: Decapoda</u>												
Palaemon macrodactylus												1
<u>Bryozoa: Chenostomata</u>												
Zoobotryon verticillatum		x								x		3
<u>Bryozoa: Cheilostomata</u>												
Bugula flabellata												1
Bugula neritina			x									1
Cryptosula pallasiana						x		x				3
Watersipora arcuata						x		x				3
Watersipora ?subtorquata		x	x		x							7
<u>Urochordata</u>												
Ascidia sp. A												3
Ascidia zara	x	x			x			x				8
Botrylloides violaceus	x	x	x	x	x	x	x	x	x			17
Botryllus firmus												2
Botryllus schlosseri		x	x	x	x		x	x	x			16
Botryllus sp. A												2
Ciona intestinalis	x	x	x	x	x	x	x	x	x	x		21
Ciona savignyi	x	x	x					x	x			12
Microcosmus squamiger			x	x				x	x	x		14
Molgula manhattensis	x									x		4
Polyandrocarpa zorritensis				x								8
Styela canopus												4
Styela clava	x	x	x	x	x	x	x	x	x			20
Styela plicata	x	x	x	x	x		x		x	x		20
Symplegma reptans			x									3

Number of exotics/site	18	15	17	14	21	13	18	22	7	7	0

Most of the exotic organisms collected are native to the northwestern Pacific, primarily the region including Japan, Korea and northern China (Table 7 and Fig. 5). Another substantial group of organisms come from the North Atlantic, especially the northwestern Atlantic, with a smaller group from the southwestern Pacific (mainly Australia and New Zealand) and Indian Ocean. One organism is native to the southeastern Pacific (the tunicate *Polyandrocarpa zorritensis*, reported from Peru), and none are native to the South Atlantic. These patterns of origin are generally consistent with the main shipping connections and historic sources of aquaculture stock for southern California.

Table 7. Origins, earliest records and mechanisms of introduction **(page 1 of 3)**

Native ranges, dates of earliest record (planting, collection or report) on the Pacific Coast of North America, in California, and in Southern California (south of Point Conception), and possible initial mechanisms of introduction to the Pacific Coast are given. Much of this information is expanded and revised from Carlton (1979), Cohen and Carlton (1995), Cohen *et al.* (1998), Lambert and Lambert (1998), Mills *et al.* (2000) and Cohen *et al.* (2001), with additional information provided by L.H. Harris and J.W. Chapman. Earliest records consisting of written accounts that do not state the date of planting, collection or observation are preceded by the symbol " ". Mechanisms given in parentheses indicate less likely mechanisms. Mechanisms are listed as:

SF - in ships' hull fouling or boring
BW - in ships' ballast water or seawater systems
OA - with shipments of Atlantic oysters
OJ - with shipments of Japanese oysters

Species	Native Range	First Pacific Coast Record	First Southern California Record	Mechanism of Introduction
Phaeophyta				
Sargassum muticum	NW Pacific	1944	1970	OJ
Undaria pinnatifida	NW Pacific	2000	2000	SF,(BW)
Rhodophyta				
Lomentaria hakodatensis	NW Pacific	1963?	1963?	?
Cnidaria: Anthozoa				
Bunodeopsis sp. A	not known	1985-87	1996	SF,BW
Diadumene franciscana	not known	1925-40	1977-78	SF,BW
Annelida: Polychaeta				
Amblosyllis speciosa	NW Pacific	2000?	2000?	?
Bispira sp.	not known	2000	2000	?
Demonax sp.	not known	2000?	2000?	?
Ficopomatus enigmaticus	not known	1920	2000	SF
Hydroides dirampa	NW Atlantic	1999	1999	
Hydroides elegans	Indo-Pacific	1931	1931	SF
Myrianida pachycera	SW Pacific	2000?	2000?	?
Nicolea sp. A	not known	2000?	2000?	?
Pseudopolydora paucibranchiata	Indo-Pacific	1950	1950	BW,SF,OJ
Typosyllis nipponica	NW Pacific	1997	2000?	BW,(SF)
Mollusca: Bivalvia				
Crassostrea gigas	NW Pacific	1875	1932	OJ,BW?

Geukensia demissa	NW Atlantic	1894	1940	OA
Musculista senhousia	Indo-Pacific	1924	1965	OJ
Mytilus galloprovincialis	NE Atlantic	1947	1947	BW,SF
Teredo bartschi	Indo-Pacific	1927	1927	SF

Table 7. Origins, earliest records and mechanisms of introduction **(page 2 of 3)**

Species	Native Range	First Pacific Coast Record	First Southern California Record	Mechanism of Introduction
Arthropoda: Pycnogonida				
Ammothella hilgendorfi	NW Pacific	?	?	?
Arthropoda: Crustacea: Cirripedia				
Balanus amphitrite	Indian Ocean	1921	1921	SF
Balanus eburneus	NW Atlantic	1959	?	SF,BW
Arthropoda: Crustacea: Tanaidacea				
?*Sinelobus stanfordi*	not known	1943	2000?	SF,BW
Arthropoda: Crustacea: Isopoda				
Ianiropsis tridens	NW Pacific	?	2000	?
Limnoria tripunctata	not known	1875	1876	SF
Paranthura japonica	NW Pacific	1993	2000	BW,SF
Sphaeroma quoyanum	SW Pacific	1893	1927	SF
Arthropoda: Crustacea: Amphipoda: Gammaridea				
Ampithoe valida	NW Atlantic	1941	1942	BW,OA,SF
Aoridea secunda	NW Pacific	?	?	?
Chelura terebrans	not known	1948	1950	SF
Corophium acherusicum	N Atlantic	1905	1935	OA,SF
Corophium insidiosum	N Atlantic	1915	1949	OA,SF
Elasmopus rapax	not known	1938?	1952	SF,BW?
Erichthonius brasiliensis	not known	1943-45	1943-45	?
Grandidierella japonica	NW Pacific	1966	?	OJ,SF,BW
Jassa marmorata	NW Atlantic	1938	1950	SF,BW
Leucothoe alata	?	1977	?	SF,(OA.OJ)
Liljeborgia sp.	not known	?	?	?
Melita sp.	not known	1993	?	BW,SF
Metopella sp.	not known	?	?	?
Paradexamine cf. *churinga*	W Pacific?	1993	?	BW,SF
Stenothoe valida	not known	1941	1950-51	BW,SF
Arthropoda: Crustacea: Amphipoda: Caprellidea				
Caprella mutica	NW Pacific	1973-77	?	OJ,BW
Caprella simia	NW Pacific	?	?	?
Arthropoda: Crustacea: Decapoda				
Palaemon macrodactylus	NW Pacific	1957	1962	BW
Bryozoa: Chenostomata				
Zoobotryon verticillatum	not known	1905	1905	SF
Bryozoa: Cheilostomata				
Bugula flabellata	?	1905	1905	SF

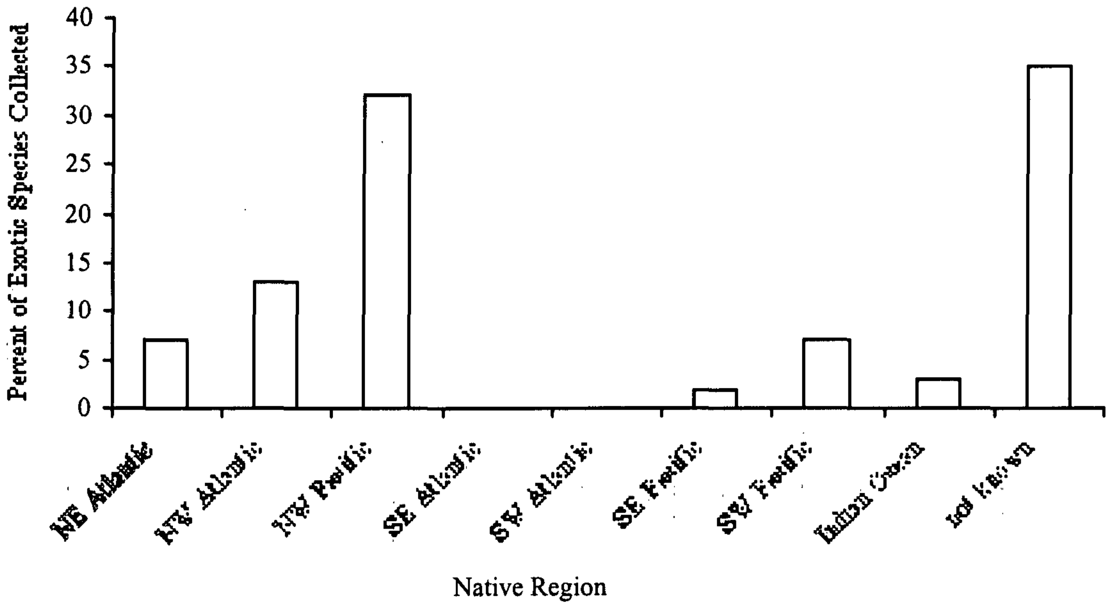
Bugula neritina	not known	1905	?	SF, (OA)
Cryptosula pallasiana	N Atlantic	1943-44	1943-44	OA,SF
Watersipora arcuata	not known	1961	1964	SF
Watersipora ?subtorquata	not known	1961	1963	SF

Table 7. Origins, earliest records and mechanisms of introduction **(page 3 of 3)**

Species	Native Range	First Pacific Coast Record	First Southern California Record	Mechanism of Introduction
Urochordata				
Ascidia sp. A	not known	1983	1983	BW,SF
Ascidia zara	NW Pacific	1984	1984	BW,SF
Botrylloides violaceus	NW Pacific	1973	2000?	OJ,SF
Botryllus firmus	?	2000?	2000?	BW,SF
Botryllus schlosseri	NE Atlantic	1944-47	1965	OA,SF
Botryllus sp. A	not known	2000	2000	BW,SF
Ciona intestinalis	NE Atlantic	1897	1917	SF
Ciona savignyi	NW Pacific	1903	1985	BW,SF
Microcosmus squamiger	SW Pacific	1986	1986	BW,SF
Molgula manhattensis	NW Atlantic	1949	1984	OA,SF,BW
Polyandrocarpa zorritensis	SE Pacific	1994	1994	BW,SF
Styela canopus	NW Atlantic	1945	1972	SF,BW
Styela clava	NW Pacific	1932-33	1933	BW,OJ,SF
Styela plicata	not known	1915	1915	SF,BW
Symplegma reptans	NW Pacific	1997	1997	BW,SF

Figure 5. Exotic species by native ranges

Native ranges of the exotic species collected sorted into major oceanic regions. Where a species' range included more than one region, it was allocated proportionally between regions (e.g. a species with a native range on both sides of the North Atlantic was counted as 0.5 species with a NE Atlantic range and 0.5 species with a NW Atlantic range).



For the exotic species collected on the expedition, the dates of the first collection records on both the Pacific Coast and in southern California show spikes in the 1940s and the 1990s (Fig. 6 & 7). It is possible that these spikes result from stronger or more effective transport vectors during those periods, such as an increase in World War II-related military vessel traffic in the 1940s, and an increase in commercial shipping and ballast water discharges from China, Japan and Korea in the 1990s. However, it is also possible that these spikes simply reflect the strength of the collecting effort during those periods, particularly collecting among taxa or in habitats that tend to harbor large numbers of exotic species. In the 1990s this would include (among many other southern California taxonomists) the work of G. and C.C. Lambert in the tunicates and of L.H. Harris in the polychaetes, as well as the current expedition.

Figure 6. Exotic species by date of first Pacific Coast record

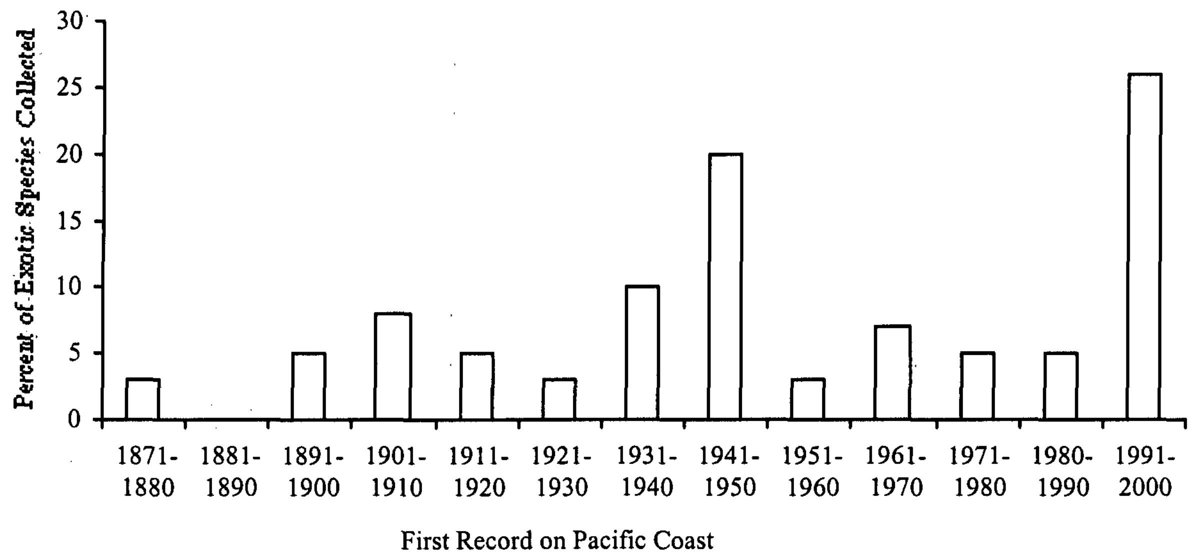
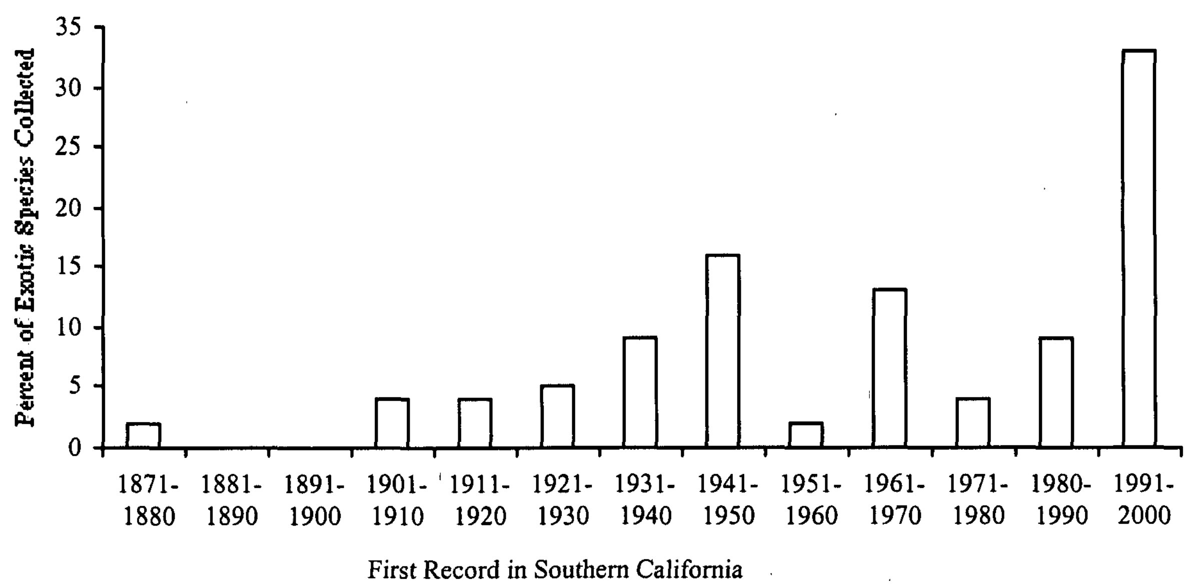


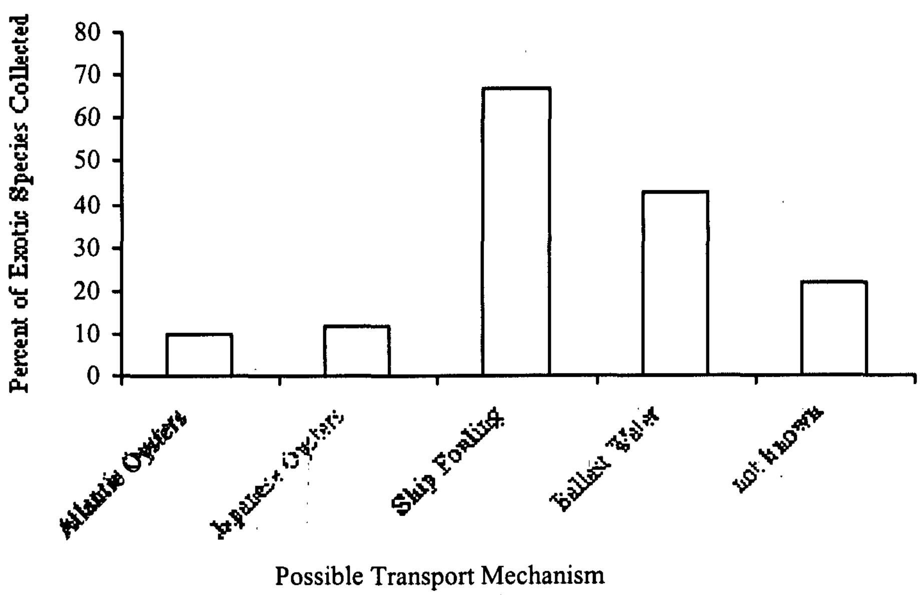
Figure 7. Exotic species by date of first Southern California record



Transport as fouling organisms attached to the hulls of ships, or as wood-boring (or associated crevice-occupying) organisms in the hulls of wooden ships, is a possible vector for the transport of two-thirds of the exotic organisms collected by the expedition (Fig. 8), an unsurprising result given that much of the collecting focussed on fouling communities on structures such as floating piers and attached or associated structures including tires, ropes, bumpers and boat hulls, and on fixed structures including pilings, bridge supports and seawalls. Ballast water discharges are a possible vector for over two-fifths of the exotic species collected. Historic imports of large quantities of oysters for commercial aquaculture, including the Virginia oyster *Crassostrea virginica* from the northwestern Atlantic and the Pacific oyster *Crassostrea gigas* from Japan, are each a possible vector for about a tenth of the exotic species collected, which aside from the oysters themselves could include a variety of organisms living in or on the shells of the oysters, or in the mud or water in which the oysters were transported. *Crassostrea virginica* is not established in southern California, but the expedition collected *C. gigas* at Island Yacht Anchorage in the back portion of Los Angeles Harbor, and during a reconnaissance trip for the expedition in June 2000 we found a population of *C. gigas* growing on rocks in the back part of Agua Hedionda Lagoon. Given the locations of these populations, it is possible that they arrived in southern California by entirely different transport vectors: the Los Angeles population resulting from accidental ship-borne transport in ballast water or attached to the hull, and the Agua Hedionda population resulting from spawn escaping from an oyster-farming operation at the mouth of the lagoon.

Figure 8. Exotic species by possible mechanisms of transport to the Pacific Coast

In many cases more than one possible transport mechanism is listed for a species, so that the total for all species exceeds 100%. Less likely mechanisms (given in parentheses in Table 7) were not included. Mechanisms are as described in Table 7.



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Appendix 1. List of Participants

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Appendix 2. Expedition Schedule

Wednesday, August 23, 2000
Assemble the team in Los Angeles

Thursday, August 24, 2000

1.	SCX-17	Cabrillo Beach Boat Ramp	Los Angeles, Los Angeles Co.
2.	SCX-16	Watchorn Basin	Los Angeles, Los Angeles Co.
3.	SCX-14	Newmark's Yacht Harbor	Los Angeles, Los Angeles Co.
4.	SCX-15	Island Yacht Anchorage	Los Angeles, Los Angeles Co.

Friday, August 25, 2000

5.	SCX-21	Jack's Landing (Cisco Sportfishing Center)	Oxnard, Ventura Co.
6.	SCX-22	Anacapa Isle Marina	Oxnard, Ventura Co.
7.	SCX-20	Port Hueneme Sportfishing	Port Hueneme, Ventura Co.

Saturday, August 26, 2000

8.	SCX-01	Chula Vista Boat Ramp	Chula Vista, San Diego Co.
9.	SCX-02	Fiddler's Cove (Navy Yacht Club Marina)	Coronado, San Diego Co.
10.	SCX-03	Shelter Island	San Diego, San Diego Co.

Monday, August 28, 2000

11.	SCX-04	Seaforth Landing (Mission Bay)	San Diego, San Diego Co.
12.	SCX-05	San Dieguito Lagoon	Del Mar, San Diego Co.
13.	SCX-06	Snug Harbor Marina (Agua Hedionda Lagoon)	Carlsbad, San Diego Co.
14.	SCX-07	Oceanside Harbor	Oceanside, San Diego Co.

Tuesday, August 29, 2000

15.	SCX-19	Marina del Rey	Los Angeles, Los Angeles Co.
16.	SS-C	Venice Lagoon	Los Angeles, Los Angeles Co.
17.	SCX-18	King Harbor	Redondo Beach, Los Angeles Co.

Wednesday, August 30, 2000

18.	SCX-12	Pilots' Dock at Pier F	Long Beach, Los Angeles Co.
19.	SCX-11	Downtown Long Beach Marina	Long Beach, Los Angeles Co.
20.	SS-B	Rainbow Lagoon (at Hyatt Tides Hotel)	Long Beach, Los Angeles Co.
21.	SCX-13	Impound Marina (in Cerritos Channel)	Long Beach, Los Angeles Co.

Thursday, August 31, 2000

22.	SCX-10	Colorado Lagoon (on Alamitos Bay)	Long Beach, Los Angeles Co.
23.	SCX-09	Long Beach Yacht Club (in Alamitos Bay)	Long Beach, Los Angeles Co.
24.	SCX-08	Huntington Harbor Yacht Club	Huntington Beach, Orange Co.
25.	SS-A	Huntington Harbor-Back Lagoon	Huntington Beach, Orange Co.

Friday, September 1, 2000
Departure

Appendix 3. Recent name changes for some species mentioned in this report

Current Name	Previous Name(s)*
Annelida: Polychaeta	
Ficopomatus enigmaticus	*Mercierella enigmatica*
Mollusca: Bivalvia	
Geukensia demissa	*Ischadium demissum, Arcuatula demissa*
Musculista senhousia	*Musculus senhousia*
Arthropoda: Crustacea: Tanaidacea	
?Sinelobus stanfordi	*Tanais* sp., *Tanais vanis*
Bryozoa: Cheilostomata	
Watersipora ?subtorquata	*Watersipora cucullata, Watersipora subovoidea*
Urochordata	
Botrylloides violaceus	*Botryllus aurantius*
Styela canopus	*Styela partita*

* Includes some names used erroneously for Pacific Coast records.

Yasaman Golban

From: Linda Sheehan [lsheehan@cacmc.org]
Sent: Friday, June 11, 2004 8:20 AM
To: Yasaman Golban
Subject: Fw: invasions stuff

----- Original Message -----
From: Andrew Cohen
To: Linda Sheehan
Sent: Thursday, June 10, 2004 11:51 PM
Subject: Re: invasions stuff

Linda,

Below is apotential reference list (this is likely to grow as I work this weekend). It includes douments that I'm pretty sure i'm going to cite (marked by [1]); a few articles that I think are relevant but haven't seen yet and would like to get copies of (marked by [2]); and documents that I might cite but am as yet less sure of (not marked). In brackets after the documents I've noted whether I'm sending them to you as an attachment, whether I have hard copies I can provide you, or whether I have copies you could copy.

-Andy

Potential Reference List as of 10 June 2004

[1] Documents that I'm pretty sure to cite.

[2] Documents that I haven't seen but that look relevant, and that I would like to get a copy of.

Other listed documents are ones that I might cite.

[1] Ashe ME (2002) Report to the Legislature: A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California. California Department of Fish and Game, Office of Oil Spill Prevention and Response, Sacramento, CA. [ANC has]

[1] Boyd MJ, Mulligan TJ and Shaughnessy FJ (2002) Non-indigenous Marine

Species of Humboldt Bay, California. In: Ashe ME (ed) Report to the Legislature: A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California, pp Appendix B. California Department of Fish and Game, Office of Oil Spill Prevention and Response, Sacramento, CA [Appendix in Ashe 2002] [ANC has]

Brown LR and Moyle PB (1993) Distribution, Ecology, and status of the fishes of the San Joaquin River Drainage, California. California Fish and Game 79: 96-114 [ANC has]

Cohen AN (2002) Success factors in the establishment of human-dispersed organisms. In: Bullock JM, Kenward RE, Hails RS (eds) Dispersal Ecology: The 42nd Symposium of the British Ecological Society, held at the University of Reading, 2-5 April 2001, pp 374-394. British Ecological Society and Blackwell Publishing, Oxford, UK [ANC can provide copy]

[1] Cohen AN and Carlton JT (1995) Biological Study. Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta. U.S. Fish and Wildlife Service, Washington, DC, 246 + appendices pp [ANC can provide copy]

Cohen AN and Carlton JT (1997) Transoceanic transport mechanisms: Introduction of the Chinese Mitten Crab, Eriocheir sinensis, to California. Pacific Science 51: 1-11 [ANC can provide copy]

Cohen AN and Carlton JT (1998) Accelerating invasion rate in a highly invaded estuary. Science 279: 555-558 [ANC can provide copy]

Cohen AN, Carlton JT and Fountain MF (1995) Introduction, dispersal and potential impacts of the green crab Carcinus maenas in San Francisco Bay, California. Marine Biology 122: 225-237 [ANC can provide copy]

[1] Cohen AN, Harris LH, Bingham BL, Carlton JT, Chapman JW, Lambert CC, Lambert G, Ljubenkov JC, Murray SN, Rao LC, Reardon K and Schwindt E (2002) Project Report for the Southern California Exotics Expedition 2000: A Rapid Assessment Survey of Exotic Species in Sheltered Coastal Waters. In: Ashe ME (ed) Report to the Legislature: A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California, pp Appendix C. California Department of Fish and Game, Office of Oil Spill Prevention and Response, Sacramento, CA [Appendix in Ashe 2002] [electronic copy attached]

[1] Dill WA and Cordone AJ (1997) History and Status of Introduced Fishes in California, 1871-1993. Fish Bulletin 178, California Department of Fish & Game, Sacramento, CA. [ANC has]

[1] Fairey R, Dunn R, Roberts C, Sigala M and Oliver J (2002) Introduced aquatic species in California Coastal Waters, Final Report. In: Ashe ME (ed) Report to the Legislature: A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California, pp Appendix

A. California Department of Fish and Game, Office of Oil Spill Prevention and Response, Sacramento, CA [Appendix in Ashe 2002] [ANC has]

[1] Lambert CC and Lambert G (1998) Non-indigenous ascidians in southern California harbors and marinas. Marine Biology 130: 675-688 [ANC has]

[1] Lambert CC and Lambert G (2003) Persistence and differential distribution of nonindigenous ascidians in harbors of the Southern California Bight. MEPS 259:146-161. [electronic copy attached]

[1] Li H, Moyle, PB and Garrett RL (1976) Effect of the introduction of the Mississippi silverside (Menidia audens) on the growth of Black Crappie (Pomoxis nigromaculatus) and White Crappie (P. annularis) in Clear Lake, California. Trans. Am. Fish. Soc. 105: 404-408 [ANC has]

Marchetti MP, Moyle PB and Levine R (2004) Invasive species profiling? Exploring the characteristics of non-native fishes across invasion stages in California. Freshwater Biology 49: 646-661. [electronic copy attached]

[2] Miller RR and Pister EP (1971) Management of the owens pupfish, Cyprinodon radiosus, in Mono County, California. Trans. Am. Fish. Soc. 100: 502-509.

Miller RR, Williams JD and Williams JE (1989) Extinctions of North American Fishes During the Past Century. Fisheries 14: 22-38 [ANC has]

[1] Moyle PB (1973) The effects of introduced bullfrogs, Rana catesbeiana, on the native frogs of the San Joaquin Valley, California. Copeia 1: 18-22 [ANC has]

[1] Moyle PB (1976) Fish introductions in California: history and impact on native fishes. Biol. Conservation 9: 101-118 [ANC has]

Moyle PB (1997) Invading fishes in freshwater, estuarine, and marine ecosystems of the western United States. Dept. of Wildlife, Fish, and Conservation Biology, Davis, CA, 11 pp. [ANC has]

[2] Moyle PB and Marcciochi A (1975) Biology of the Modoc sucker, Catostomus microps (Pisces: Catostomidae) in northeastern California. Copeia 1973(3): 556-560.

[2] Moyle PB and Nichols RD (1973) Ecology of some native and introduced fishes of the Sierra Nevada foothills in Central California. Copeia 3: 478-490. [I'm missing the last 2 pages, 489-490]

[1] Moyle PB and Nichols RD (1974) Decline of the Native fish fauna of the Sierra Nevada Foothills, Central California. The American Midland Naturalist 92: 72-83 [ANC has]

Moyle PB, Fisher FW and Li HW (1974) Mississippi silversides and logperch in the Sacramento-San Juaquin river system. California Fish and Game 60: 144-149 [ANC has]

Moyle PB, Li HW and Barton BA (1986) The Frankenstein effect: impact of introduced fishes on native fishes in North America. In: Stroud RH (ed) Fish Culture in Fisheries Management, pp 415-426. Bethesda, MD [ANC has]

[1] Moyle PB, Craina PK, Whitener K and Mount JF (2003) Alien fishes in natural streams: fish distribution, assemblage structure, and conservation in the Cosumnes River, California, U.S.A. Environmental Biology of Fishes 68: 143-162. [electronic copy attached]

[2] Pister, EP (1974) Desert fishes and their habitats. Trans. Am. Fish. Soc. 103: 531-540.

Wilcove DS, Rothstein D, Dubow J, Phillips A and Losos E (1998) Quantifying threats to imperiled species in the United States. Assessing the realative importance of habitat destruction, alien species, pollution, overexploitation, and disease. Bioscience 48: 607-615 [ANC has]

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> Date: Thu, 10 Jun 2004 22:20:59 -0700
> To: "Linda Sheehan" <lsheehan@cacmc.org>
> From: Andrew Cohen <acohen@sfei.org>
> Subject: Re: invasions stuff
> Cc:
> Bcc:
> X-Attachments:
>
> Yes go ahead and have her get them. I'm sorry i've been unable to
> carve out a block of time to work on this, but i finally got properly
> starting whilc flying up and back from Seattle in the past two days
> and will spend tomorrow and the weekend working on it. I'll be at home
> tomorrow 510-233-8562.
>
> I have the first two items here or at the office. I don't believe I
> have the other two.
>
>
>
> > Should I have Yasaman go ahead and start gathering these? Do

> you have others she should be working on getting? Thanks again,
> Linda
> >
> > ----- Original Message ----- From: Andrew Cohen To: Linda
> Sheehan Sent: Friday, May 14, 2004 8:22 PM Subject: invasions
> stuff
> >SFBay and Baitworm reports attached.
> >
> >The CDFG report on exotic fish in California: Dill, W. A. and A.
> J.
> >Cordone. History and Status of Introduced Fishes in California,
> >1871-1993.
> >
> >Peter Moyle's summary paper on exotic fish in California: Moyle,
> P. B.
> >1976. Fish introductions in California: history and impact on
> native
> >fishes. Biol. Conserv. 9: 101-118.
> >
> >Regarding the San Joaquin River, see e.g. Brown, L. R. and P. B.
> Moyle.
> >1993. Distribution, ecology, and status of the fishes of the San
> >Joaquin River drainage, California. Calif. Fish and Game 79(3):
> 96-114.
> >
> >
> >Regarding Clear Lake, see e.g. Li, H. W., Moyle, P. B. and R. L.
> >Garrett. 1976. Effect of the introduction of the Mississippi
> >silverside (Menidia audens) on the growth of black crappie
> (Pomoxis
> >nigromaculatus) and white crappie (P. annilaris) in Clear Lake,
> >California. Trans. Am. Fish. Soc. 105: 404-408.
>
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