

Rapid Assessment Channel Survey for Exotic Species in San Francisco Bay - November 2005

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Introduction

Exotic species constitute one of the main environmental stressors in the San Francisco Estuary. To further assess the extent of this problem, we conducted a Rapid Assessment (RA) survey of exotic species at stations along the main channels along the axis of San Francisco Bay in the late fall of 2005. The survey employed methods that were developed in RA surveys conducted in the Bay in 1993 and 1996, and sampled several of the same stations. Samples were taken from fixed and floating hard substrates, and thus provide a snapshot of the composition and distribution of exotic fouling species along the axis of the Bay.

The survey was funded by the California State Coastal Conservancy, and was a companion study to a shore survey conducted in the spring of 2004. We especially want to thank the San Francisco BayKeeper organization for providing a fine boat for the day; two great BayKeeper volunteers, Captain Geoff Potter and Jim Hayward; and Amy Castain of the BayKeeper organization for making the arrangements.

Methods

Fouling organisms from navigational buoys, dolphins or bridge pylons adjacent to the main shipping channels at nine sites along the axis of the Bay were sampled on November 27, 2005. At each site, surface temperature and salinity were measured from the boat with a YSI meter before sampling. To collect the samples, two free divers entered the water, scraped fouling organisms off the structure and into a mesh dive bag, using a specially-designed scraper and

attempting to sample surfaces in all orientations and down to maximum safe free-diving depth, typically collecting several liters of material. Where the currents were strong, the boat dropped the divers upcurrent and collected them downcurrent of the structure. At sites 1 and 6, currents were strong enough to make complete sampling difficult. At all sites, visibility in the water was poor, as is typical in the Bay.

On the boat, the samples were emptied into basins, and initially sorted and identified, with a roughly one liter sample from each station stored in a ziplock bag in a cooler before sampling the next station. The samples were put on ice at the end of the day, and processed in the laboratory at the San Francisco Estuary Institute over the next two days. Sorting to major taxa was completed with the assistance of Rebecca Sorell, and the specimens were examined as live or fresh material and identified to the lowest possible taxon by John Chapman and Andrew Cohen. Specimens were fixed and preserved by appropriate techniques, and representative voucher specimens will be deposited as appropriate with the Invertebrate Zoology Department of the California Academy of Sciences and the University of California Jepson Herbarium.

Organisms were classified by invasion status as native, cryptogenic or exotic, using a "weight of the evidence" approach as defined in Cohen (2004). The criteria used were essentially those listed by Chapman and Carlton (1994) as modified by Cohen *et al.* (2005). Organisms that were not identified to a sufficiently low taxon to determine their origin status were classified as indeterminate. In most cases, determinate organisms were identified to species, but in a few cases higher taxon identification allowed determination of origin status (for example, identification to genus when the genus is known only from other ocean regions [and therefore exotic status], or when all known species in the genus are native to the study region [and therefore native status]).

Results

The 9 sites sampled ranged from near the Alfred P. Zampa Bridge at the west end of the Carquinez Strait to the Dumbarton Bridge in the southern part of the South Bay (Table 1). Temperatures varied only slightly between sites and were slightly higher at the South Bay sites, ranging overall from 12.9 to 14.6 °C. Salinities were highest in the Central Bay (30.0-31.0 ppt), and decreased southward to 25.6 ppt at the Dumbarton Bridge and northward to 18.5 ppt at the Zampa Bridge.

There were 236 records of 100 distinct taxa. Diversity (counting both determinate and indeterminate taxa) ranged from 16 to 40 taxa per site with a mean of 26.2, and tended to be a little higher at sites in the central part of the Bay, though this was not consistent. Relatively low diversity at sites 1 (buoy near Zampa Bridge) and 6 (buoy over Harding Rock) may in part have resulted from incomplete sampling at these sites due to strong currents. The pattern of diversity based on determinate taxa paralleled this, and ranged from 12 to 31 taxa. Out of these, the number of native species ranged from 0 to 11, with a mean of 4.4. The number was highest for the Central Bay sites, and decreased both northward and southward.

Table 1. Site Name, Site Number and Near-surface Temperature and Salinity

Site Name	Site Number	Location	Temperature (°C)	Salinity (ppt)
Carquinez Buoy	1	Carquinez Strait, just W of Zampa Bridge	13.3	18.5
Dolphin #11	2	San Pablo Bay	12.9	23.5
Buoy #8	3	San Pablo Bay	13.1	27.6
Buoy #12	4	Central Bay	13.0	30.9
Buoy #2 (CB)	5	Central Bay, NE of Angel Island	13.1	30.0
Buoy HR	6	Central Bay, over Harding Rock	12.9	31.0
Buoy #2 (SB)	7	South Bay, E of Brisbane	14.6	30.3
San Mateo Bridge	8	South Bay, pylon on E side of channel	14.5	28.8
Dumbarton Bridge	9	South Bay, pylon on W side of channel	13.5	25.6

Table 2 Number of Taxa by Invasion Status and Site (see Table 1 for site names and locations)

Location	Carquinez	San Pablo		— Central —			— South —		All Sites	
Site Number	1	2	3	4	5	6	7	8	9	
Native	1	2	4	11	10	7	1	4	0	23
Cryptogenic	4	5	3	8	10	6	3	2	2	15
Exotic	10	14	13	12	10	2	8	19	18	34
Indeterminate	3	3	4	4	10	7	4	9	3	28
Total	18	24	24	35	40	22	16	34	23	100

We estimated the number and percentage of taxa that are exotic by treating the number of taxa classified as exotic as a low estimate, and those classified as either exotic or cryptogenic as a high estimate (Cohen *et al.* 2005), and calculated percentages as a percentage of the determinate taxa (Table 3). The estimated ranges of the number of exotic taxa were between 10 and 20 for most sites, with a noticeably lower estimated range of 2-8 exotic taxa for site 6, the site nearest the Bay mouth. The estimated range for percent exotic was also lowest at this site (13-53% exotic), and steadily increased up the estuary in either direction. The highest estimated range, 90-100% exotic, was for the Dumbarton Bridge site in the southern part of the South Bay.

Table 4 lists the 34 exotic species collected by the survey, all of which were previously known from the Bay. The assemblage characterized by the bryozoan *Conopeum* cf. *tenuissimum* covering the hydroid *Garveia franciscana*, and hosting large numbers of the isopod *Synidotea laevidorsalis*, dominated the northernmost sites. The compound tunicate *Didemnum* sp., a recent invader that can overgrow both fouling and some bottom types, was collected at San Mateo Bridge in the South Bay. The complete collection data for the survey are provided in the Appendix.

Table 3 Estimates of Number of Exotic Taxa and the Percent Exotic, by Site (see Table 1 for site names and locations; see text for explanation of estimates)

Location	Carquinez	San Pablo		— Central —		— South —		All Sites		
Site Number	1	2	3	4	5	6	7	8	9	
Number	10-14	14-19	13-16	12-20	10-20	2-8	8-11	19-21	18-20	34-49
Percent	67-94%	67-91%	65-80%	39-65%	33-66%	13-53%	67-92%	76-84%	90-100%	47-68%

Table 4 Exotic Species Collected

PORIFERA	MOLLUSCA: BIVALVIA	<i>Jassa marmorata</i>
<i>Clathria prolifera</i>	<i>Musculista senhousia</i>	<i>Melita nitida</i>
<i>Halichondria "bowerbanki"</i>	<i>Mya arenaria</i>	<i>Melita rylovi</i>
CNIDARIA: HYDROZOA	<i>Venerupis philippinarum</i>	<i>Monocorophium acherusicum</i>
<i>Ectopleura crocea</i>	ARTHROPODA: CIRRIPIEDIA	<i>Stenothoe valida</i>
<i>Garveia franciscana</i>	<i>Amphibalanus amphitrite</i>	BRYOZOA
CNIDARIA: ANTHOZOA	ARTHROPODA: ISOPODA	<i>Anguinella palmata</i>
<i>Diadumene lineata</i>	<i>Dynoides dentisinus</i>	<i>Conopeum cf. tenuissimum</i>
<i>Diadumene sp.</i>	<i>Paranthura japonica</i>	<i>Schizoporella unicornis</i>
ANNELIDA: POLYCHAETA	<i>Pseudosphaeroma campbellensis</i>	CHORDATA: TUNICATA
<i>Typosyllis nipponica</i>	<i>Sphaeroma quoianum</i>	<i>Didemnum sp.</i>
MOLLUSCA: GASTROPODA	<i>Synidotea laevidorsalis</i>	<i>Molgula manhattensis</i>
<i>Hopkinsia plana</i>	ARTHROPODA: AMPHIPODA	<i>Styela clava</i>
<i>Sakureolis enosimensis</i>	<i>Amphithoe valida</i>	CHORDATA: PISCES
<i>Urosalpinx cinerea</i>	<i>Incisocalliope derzhavini</i>	<i>Tridentiger trigonocephalus</i>

References

- Chapman, J.W. and J.T. Carlton. 1994. Predicted discoveries of the introduced isopod *Synidotea laevidorsalis* (Miers, 1881). *Journal of Crustacean Biology* 14(4): 700-714.
- Cohen, A.N. 2004. An Exotic Species Detection Program for Puget Sound. Prepared for the Puget Sound Action Team, Olympia, WA. San Francisco Estuary Institute, Oakland, CA, 52 pp.
- Cohen, A.N., L.H. Harris, B.L. Bingham, J.T. Carlton, J.W. Chapman, C.C. Lambert, G. Lambert, J.C. Ljubenkov, S.N. Murray, L.C. Rao, K. Reardon and E. Schwindt. 2005. Rapid Assessment Survey for exotic organisms in southern California bays and harbors, and abundance in port and non-port areas. *Biological Invasions* 7(6): 995-1002.

San Francisco Bay Rapid Assessment Channel Survey for Exotic Species, November 2005												
Buoys, dolphins and pylons sampled 27 November 2005												
Category Number	Category	Species	Invasion Status	CS-Carqueinez Bridge Buoy	SPB-Dolphin #1	SPB-Buoy #8	CB-Buoy #12	CB-Buoy #2	CB-Buoy HR	SB-Buoy #2	SB-San Mateo Bridge Pylon	SB-Dumbarton Bridge Pylon
				1	2	3	4	5	6	7	8	9
		Site Number:										
		Near-Surface Salinity - YSI meter (ppt):		18.5	23.5	27.6	30.9	30.0	31.0	30.3	28.8	25.6
		Near-Surface Temperature - YSI meter (°C):		13.3	12.9	13.1	13.0	13.1	12.9	14.6	14.5	13.5
2.100	Protocista: Algae: Chlorophyta	Bryopsis sp.	C					X				
2.100	Protocista: Algae: Chlorophyta	Enteromorpha sp.	C	X		X		X	X			
2.100	Protocista: Algae: Chlorophyta	Ulva sp.	C	X	X	X	X	X		X	X	
2.100	Protocista: Algae: Chlorophyta	unidentified green alga	-								X	
2.300	Protocista: Algae: Rhodophyta	Cryptopleura violacea	N				X	X				
2.300	Protocista: Algae: Rhodophyta	Mastocarpus papillatus	N				X					
2.300	Protocista: Algae: Rhodophyta	Polyneura latissima	N				X					
2.300	Protocista: Algae: Rhodophyta	Polysiphonia sp.	C		X			X				
2.300	Protocista: Algae: Rhodophyta	small rusty orange feathery alga	-					X		X		
2.300	Protocista: Algae: Rhodophyta	unidentified red alga	-	X							X	
2.700	Protocista: Other Protocista	Gromia oviformis	C				X					
4.000	Porifera	Clathria prolifera	E									X
4.000	Porifera	Halichondria "bowerbanki"	E		X	X	X	X		X	X	X
5.100	Cnidaria: Hydrozoa	Bimeria?	-								X	
5.100	Cnidaria: Hydrozoa	Ectopleura crocea	E			X		X		X	X	X
5.100	Cnidaria: Hydrozoa	Garveia franciscana	E	X	X	X						
5.400	Cnidaria: Anthozoa	Diadumene sp. (not cincta)	E	X	X	X		X			X	X
5.400	Cnidaria: Anthozoa	Diadumene lineata	E								X	X
5.400	Cnidaria: Anthozoa	Metridium senile	N				X			X	X	
7.100	Platyhelminthes	Discosolenia burchami	N		X							
8.000	Nemertea	unidentified nemertean	-				X	X	X	X		
9.100	Annelida: Polychaeta	Capitellidae	C				X					
9.100	Annelida: Polychaeta	Cirratulidae	-					X				
9.100	Annelida: Polychaeta	Eunicidae	-								X	
9.100	Annelida: Polychaeta	Halosyncha	N			X	X					
9.100	Annelida: Polychaeta	Harmothoe imbricata group	C		X		X	X				
9.100	Annelida: Polychaeta	Nereidae	-		X	X						
9.100	Annelida: Polychaeta	Nereis sp.(not N. succinea)	-				X	X			X	
9.100	Annelida: Polychaeta	Nereis vexillosa	-					X			X	
9.100	Annelida: Polychaeta	Ophelidae	-					X				
9.100	Annelida: Polychaeta	Orbiniidae	-					X				
9.100	Annelida: Polychaeta	Phyllodocidae?	-					X	X			
9.100	Annelida: Polychaeta	Polynoidae	-				X		X	X		X
9.100	Annelida: Polychaeta	Spionidae	-			X						
9.100	Annelida: Polychaeta	Syllidae	-								X	
9.100	Annelida: Polychaeta	Terebellidae	-				X	X	X	X		
9.100	Annelida: Polychaeta	Typosyllis nipponica	E			X	X		X	X		
12.200	Mollusca: Prosobranchia	Lacuna marmorata	N				X					
12.200	Mollusca: Prosobranchia	Nucella?	-									X
12.200	Mollusca: Prosobranchia	unidentified limpet	N					X				
12.200	Mollusca: Prosobranchia	Urosalpinx cinerea	E									X
12.300	Mollusca: Opisthobranchia	Hopkinsia plana	E	X	X							
12.300	Mollusca: Opisthobranchia	Sakuraeolis enosimensis	E				X				X	
12.500	Mollusca: Bivalvia	Hiatella artica	N					X	X			
12.500	Mollusca: Bivalvia	Modiolus rectus	N					X	X			
12.500	Mollusca: Bivalvia	Musculista senhousia	E		X	X	X	X		X	X	X
12.500	Mollusca: Bivalvia	Mya arenaria	E		X							
12.500	Mollusca: Bivalvia	Mytilus californianus	N						X			
12.500	Mollusca: Bivalvia	Mytilus trossulus/galloprovincialis	C	X	X	X	X	X	X	X		X
12.500	Mollusca: Bivalvia	Ostrea conchaphila	N		X						X	
12.500	Mollusca: Bivalvia	Venerupis philippinarum	E					X			X	
13.130	Arthropoda: Chelicerata: Pycnogonida	Ammothella hilgendorfi	C				X				X	
13.130	Arthropoda: Chelicerata: Pycnogonida	unidentified pycnogonid	-		X			X				
13.210	Copepoda	Nicothoe	C		X							
13.220	Arthropoda: Crustacea: Cirripedia	Amphibalanus improvisus	E	X		X	X			X		X
13.220	Arthropoda: Crustacea: Cirripedia	Balanus crenatus	N			X	X	X	X			
13.220	Arthropoda: Crustacea: Cirripedia	Balanus glandula	N			X	X	X			X	
13.220	Arthropoda: Crustacea: Cirripedia	Balanus sp.	-		X							
13.260	Arthropoda: Crustacea: Isopoda	Dynoides dentisimus	E								X	
13.260	Arthropoda: Crustacea: Isopoda	Gnorimosphaeroma oregonensis	N	X								
13.260	Arthropoda: Crustacea: Isopoda	Ianiropsis ?analoga	N									
13.260	Arthropoda: Crustacea: Isopoda	Paranthurus japonica	E			X					X	X
13.260	Arthropoda: Crustacea: Isopoda	Pseudosphaeroma campbellensis	E	X								
13.260	Arthropoda: Crustacea: Isopoda	Sphaeroma quoianum	E	X			X					X
13.260	Arthropoda: Crustacea: Isopoda	Synidotea laevidorsalis	E	X	X	X	X				X	X
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Ampithoe valida	E	X								
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Apholyale cf. pugettensis	N								X	
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Incisocalliope derzhavini	E		X	X	X	X			X	X
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Jassa marmorata	E		X	X	X	X	X	X		X
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Melita nitida	E		X							
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Melita rylovi	E								X	
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Monocorophium acherusicum	E	X	X		X	X			X	
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Podocerus braziliensis	C				X	X	X			
13.271	Arthropoda: Crustacea: Amphipoda: Gammaride	Protohyale frequens	N					X				

San Francisco Bay Rapid Assessment Channel Survey for Exotic Species, November 2005

Categories		
Category Number	Category	Typical Members or Common Names
1.000	Bacteria	bacteria, blue-green algae
2.000	Protoctista	
2.100	Protoctista: Algae: Chlorophyta	green algae
2.200	Protoctista: Algae: Phaeophyta	brown algae, kelps
2.300	Protoctista: Algae: Rhodophyta	red algae
2.400	Protoctista: Algae: Other Algae	diatoms, dinoflagellates, blue-green algae, etc.
2.700	Protoctista: Other Protoctista	ciliates, forams, other protozoans
3.000	Plantae	all plants, including mosses, ferns and flowering plants
4.000	Porifera	sponges
5.000	Cnidaria	
5.100	Cnidaria: Hydrozoa	hydroids
5.110	Cnidaria: Hydrozoa: Anthoathecatae	
5.120	Cnidaria: Hydrozoa: Leptothecatae	
5.200	Cnidaria: Scyphozoa	"true" jellyfish and their scyphistomae
5.400	Cnidaria: Anthozoa	anemones, corals, gorgonians, sea pens
6.000	Ctenophora	comb jellies
7.000	Platyhelminthes	flatworms
8.000	Nemertea	ribbon worms
9.100	Annelida: Polychaeta	bristleworms
9.200	Annelida: Oligochaeta	earth worms
11.000	Sipuncula	peanut worms
12.000	Mollusca	
12.100	Mollusca: Polyplacophora	chitons
12.200	Mollusca: Prosobranchia	snails
12.300	Mollusca: Opisthobranchia	sea slugs
12.400	Mollusca: Pulmonata	pulmonate snails
12.500	Mollusca: Bivalvia	clams, oysters, mussels, scallops and other bivalves
12.600	Mollusca: Cephalopoda	squid, octopuses, cuttlefish
13.000	Arthropoda	
13.120	Arthropoda: Chelicerata: Arachnida	scorpions, spiders, ticks, mites
13.130	Arthropoda: Chelicerata: Pycnogonida	sea spiders
13.210	Arthropoda: Crustacea: Copepoda	copepods
13.220	Arthropoda: Crustacea: Cirripedia	barnacles
13.230	Arthropoda: Crustacea: Mysidacea	mysid shrimp (=opossum shrimp)
13.240	Arthropoda: Crustacea: Cumacea	
13.250	Arthropoda: Crustacea: Tanaidacea	
13.260	Arthropoda: Crustacea: Isopoda	pill bugs
13.270	Arthropoda: Crustacea: Amphipoda	
13.271	Arthropoda: Crustacea: Amphipoda: Gammaridea	scuds, sand fleas
13.272	Arthropoda: Crustacea: Amphipoda: Caprellidea	skeleton shrimp
13.280	Arthropoda: Crustacea: Decapoda	crabs, lobsters, crayfish
13.281	Arthropoda: Crustacea: Decapoda: Thalassinoidea	
13.282	Arthropoda: Crustacea: Decapoda: Anomura	
13.283	Arthropoda: Crustacea: Decapoda: Brachyura	true crabs
13.290	Arthropoda: Crustacea: Other Crustaceans	ostracodes, nebalia, brine shrimp, cladocerans, etc.
13.310	Arthropoda: Uniramia: Insecta	insects
16.000	Bryozoa	=Ectoprocts, moss animals
16.100	Bryozoa: Ctenostomata	
16.200	Bryozoa: Cyclostomata	
16.300	Bryozoa: Cheilostomata	
16.400	Bryozoa: Phylactolaemata	freshwater bryozoans
17.000	Kamptozoa	=Entoprocts
18.000	Echinodermata	
18.100	Echinodermata: Asteroidea	sea stars or starfish
18.200	Echinodermata: Ophiuroidea	brittle stars
18.300	Echinodermata: Echinoidea	sea urchins, sand dollars
18.400	Echinodermata: Holothuroidea	sea cucumbers
19.000	Hemichordata	acorn worms
21.000	Urochordata	
21.100	Urochordata: Ascidiacea	sea squirts, tunicates
21.110	Urochordata: Ascidiacea: Aplousobranchia	
21.120	Urochordata: Ascidiacea: Phlebobranchia	
21.123	Urochordata: Ascidiacea: Stolidobranchia	
23.000	Other Invertebrate Phyla	nematodes, rotifers, acanthocephalans, gastrotrichs, etc.
24.000	Chordata	
24.100	Chordata: Pisces	fish
24.200	Chordata: Amphibia	salamanders, frogs, toads