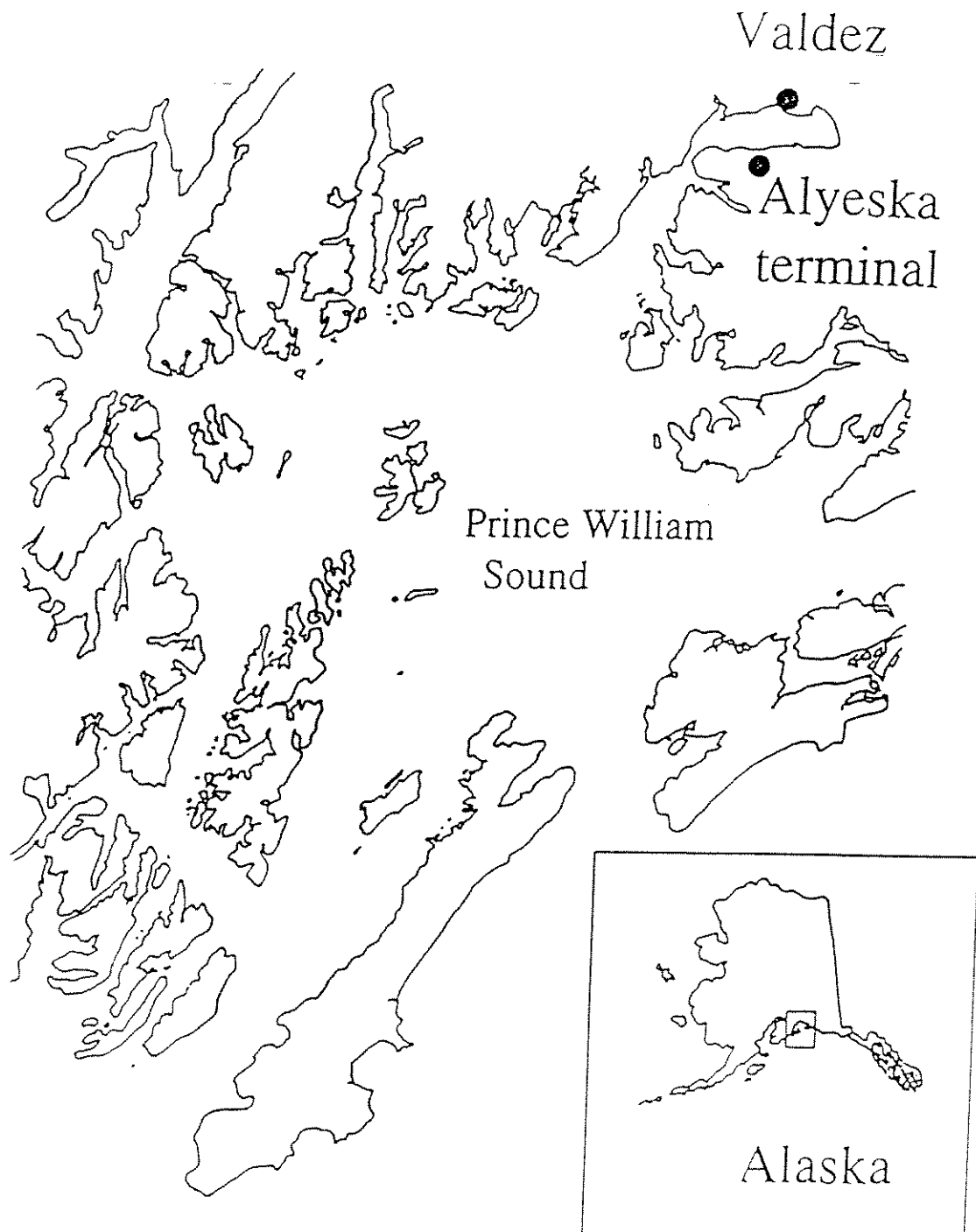


Figure A-1 Map of Prince William Sound showing locations of Valdez and Alyeska Terminal.



*The opinions expressed
in this RCAC
commissioned report are
not necessarily those of
RCAC.*

Figure A-2. Major shipping routes of commercial vessels arriving to Port Valdez / Prince William Sound.

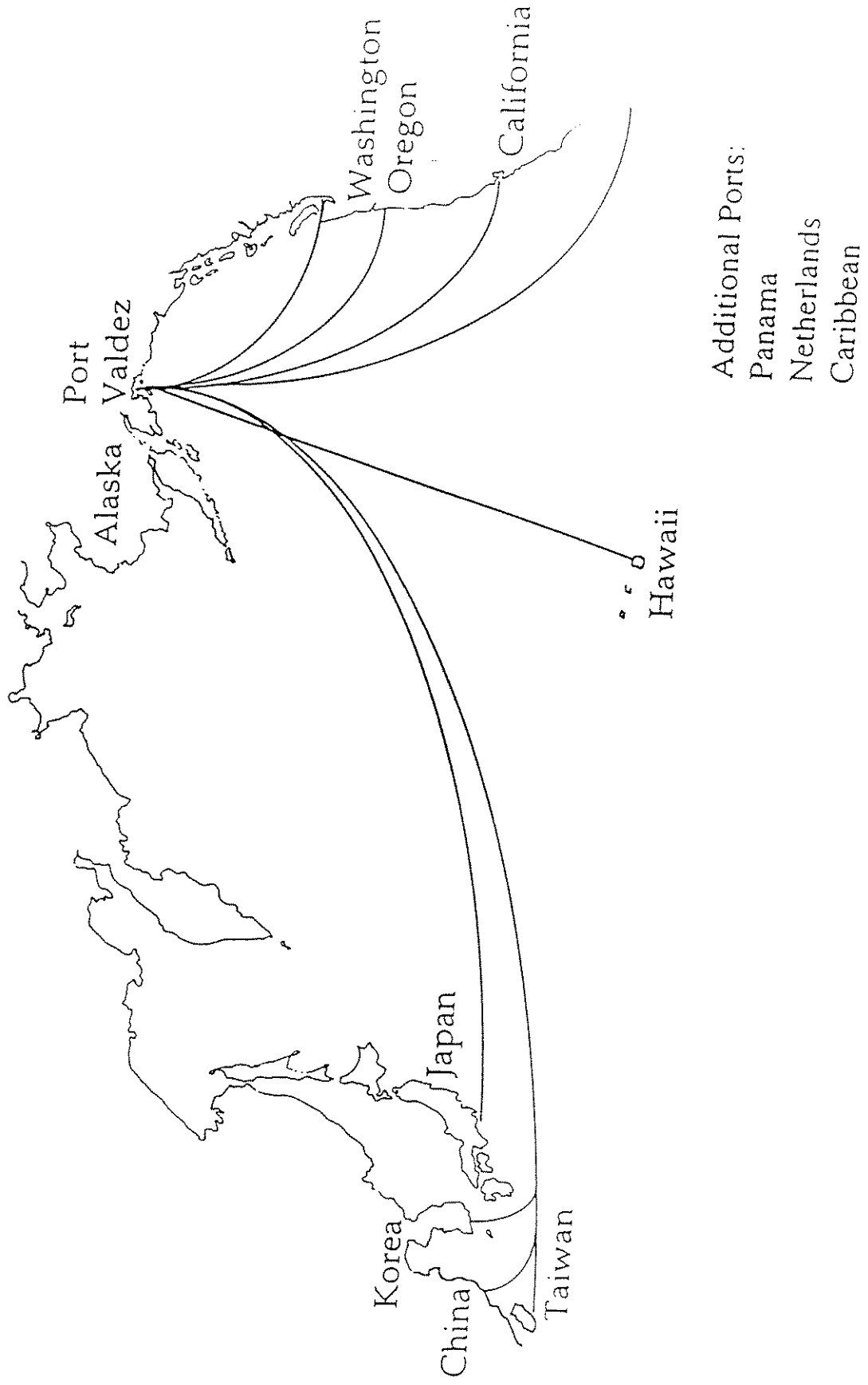


Figure A-3. Regional distribution of last port of call for oil tankers arriving to Prince William Sound during 1996. Shown are the percentage of all tanker arrivals (n=629) that originated in the respective regions for that year. (Source: RCAC, unpubl. data).

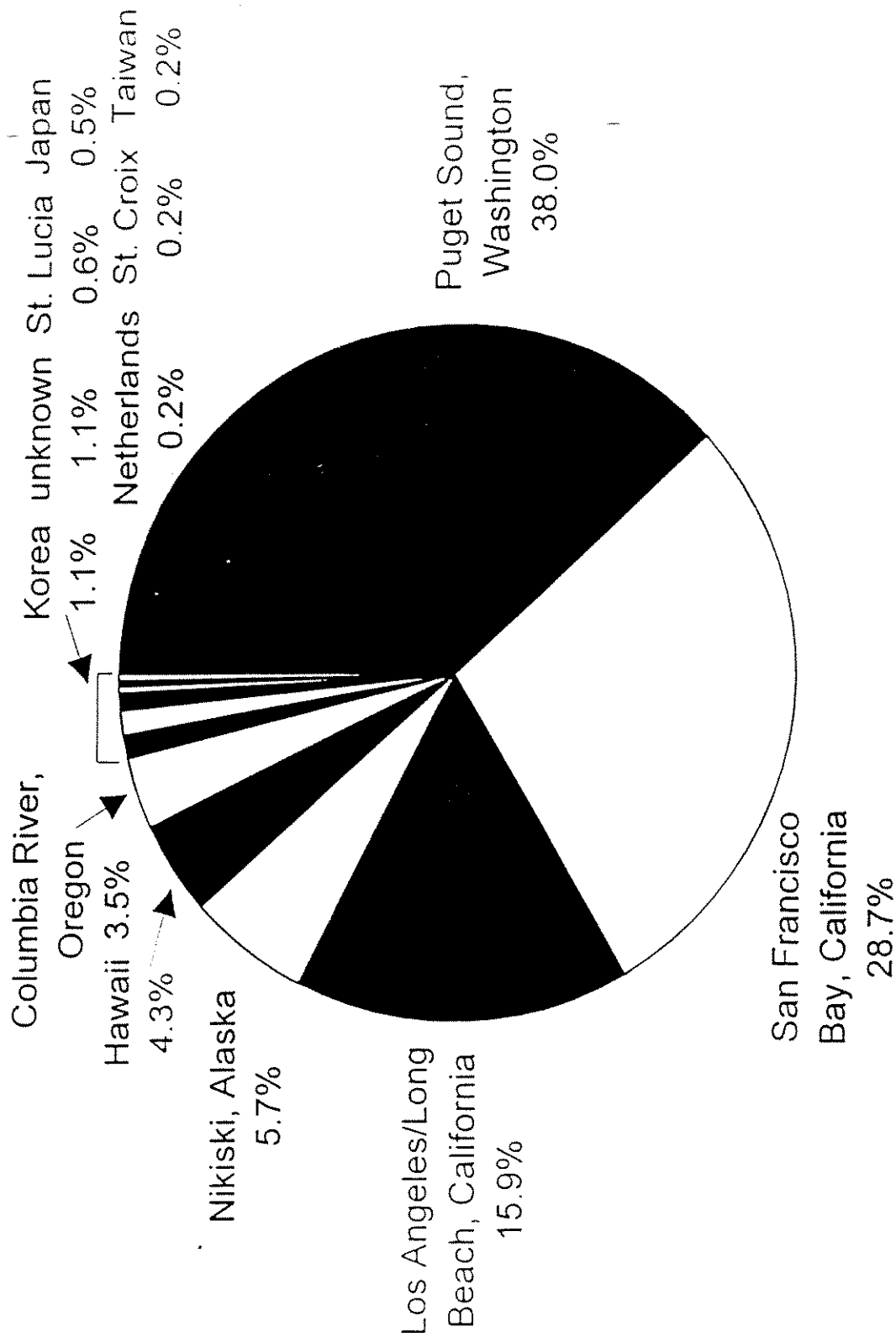


Figure A-4. Characteristics of Oil Tanker traffic arriving to Port Valdez for 1987-1994. Shown are the number of tankers that visit the port each year and the cumulative number of arrivals for these vessels each year. (Source: Wiegers et al. 1997.)

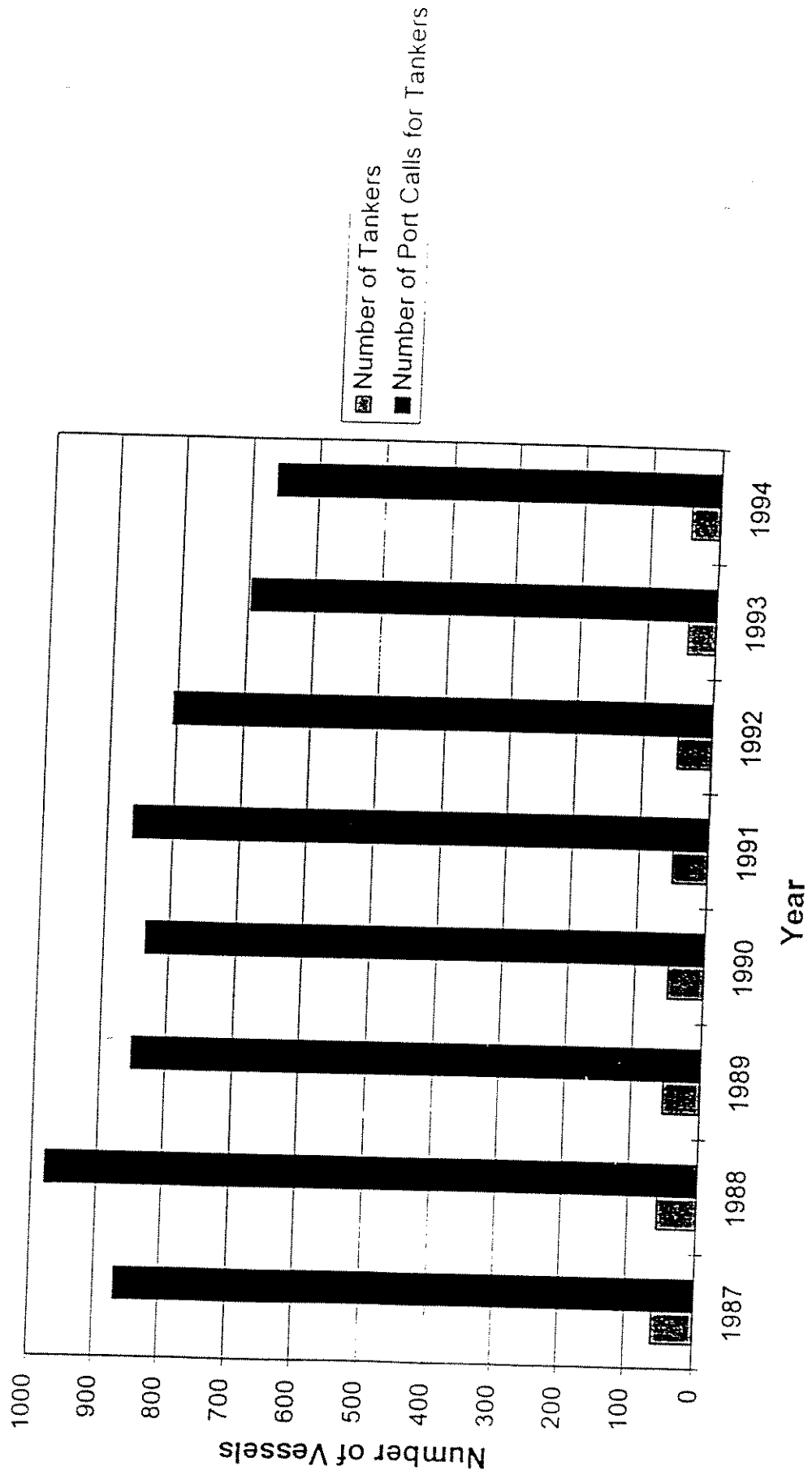
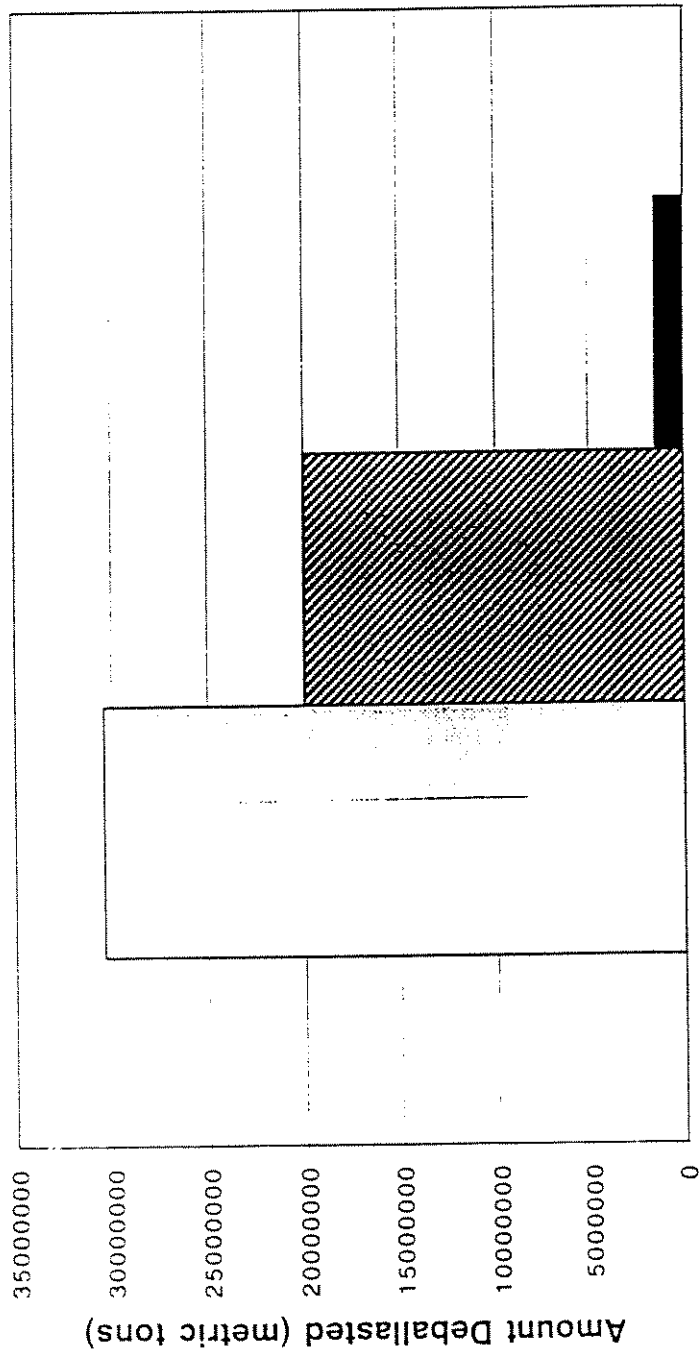


Figure A-5. Estimated annual quantity of segregated ballast water discharged into Chesapeake Bay, Prince William Sound, and San Francisco Bay from commercial vessels. Estimates were based upon information from the following sources: Smith et al., 1996 and Ruiz et al., unpubl. data (Chesapeake Bay); Wieggers et al. 1997 (Prince William Sound); Carlton et al., 1995 (San Francisco Bay). (Note: San Francisco Bay estimates do not include ballast water from domestic sources, whereas estimates for the other two sites include domestic and foreign sources.)



□ Chesapeake Bay: Estimated from 1996 Bulker traffic into Baltimore and Norfolk.

▨ Prince William Sound: Estimated from Tanker Traffic.

■ San Francisco Bay: Estimated from 1991 Bulker, General Cargo, and Tanker Traffic from Foreign Ports into San Francisco and Oakland.

Table B-1. Number of nonindigenous species reported for marine and estuarine habitats at various sites and global regions.

Region	No. of NIS	References
San Francisco Bay, California (USA)	212	Carlton, 1979a; Cohen and Carlton, 1996
Coos Bay, Oregon (USA)	70	Carlton, unpublished manuscript
Great Lakes (USA)	138	Mills et. al., 1993
Hudson River (USA)	113	Mills et. al., 1996
Chesapeake Bay (USA)	130	Ruiz et. al., 1997 in progress
Hawaii (USA)	150	Eldredge et. al., in progress
Australia	80	Pollard and Hutchings, 1990a, b; Thresher and Martin, 1995
Japan	30	Asakura 1992; Ruiz et. al., unpublished database
New Zealand	80	B. Hayden, personal communication
Mediterranean Sea	240	Por, 1978; Boudouresque, 1994; Ribera, 1994
Northern Europe	75	Jansson, 1994; Leppakoski 1994; Eno, 1997

Table B-2 Nonindigenous species reported for marine and estuarine habitats of the Baltic Sea. The native region and common name is included for species where available in original references (Skora and Stolarski, 1993; Leppakoski, 1993; Jansson, 1994; Ojaveer et al., 1995)

TAXON	SPECIES	COMMON NAME	NATIVE
Planta			
Bacillariophyceae	<i>Odontella sinensis</i>		IndoPacific
	<i>Coscinodiscus wailesii</i>		
	<i>Pleurosia leavis</i> f. <i>polymorpha</i>		
	<i>Thalassiosira</i> sp		
Charaphyceae	<i>Chara connivens</i>		Europe
Dinophyceae	<i>Procenterum minimum</i>		cosmopolitan
Spermatophyta	<i>Elodea canadensis</i>	Canadian water weed	N. America
Invertebrata			
Cnidaria			
Hydrozoa	<i>Cordytophora caspia</i>	freshwater hydroid	Black & Caspian Seas
Annelida			
Polychaeta	<i>Polydora redeki</i>		W. Europe
	<i>Marenzelleria viridis</i>		N. America
Mollusca			
Bivalvia	<i>Dreissena polymorpha</i>	zebra mussel	Black & Caspian Seas
	<i>Mya arenaria</i>	softshell clam	N. America
Gastropoda	<i>Potomopyrgus antepodirum</i>	New Zealand mud snail	New Zealand
Arthropoda			
Decapoda	<i>Eriocheir sinensis</i>	Chinese mitten crab	SE Asia
	<i>Orconectes limosus</i>		N. America
	<i>Rhithropanopeus harrisi</i>	mudcrab	N. America
Copepoda	<i>Acartia tonsa</i>		N. America
Amphipoda	<i>Corophium curvispinum</i>		Black & Caspian Seas
Cirripedia	<i>Balanus improvisus</i>	bay barnacle	N. America
Mysidacea	<i>Hemimysis anomala</i>		Black & Caspian Seas
	<i>Mesomysis kowalewski</i>		Black & Caspian Seas
Cladocera	<i>Cercopagus pengoi</i>		Caspian Sea
Bryozoa			
Cheilostomata	<i>Victorella pavidia</i>		Black & Caspian Seas?
Chordata			
Fish			
	<i>Acipenser guldenstaedtri</i>		Europe
	<i>A. baeri</i>		Central Asia
	<i>Oncorhynchus mykiss</i>	rainbow trout	N. Pacific
	<i>O. gorbuscha</i>	pink salmon	N. Pacific
	<i>O. nerka</i>	sockeye salmon	N. Pacific
	<i>O. keta</i>	chum salmon	N. Pacific
	<i>O. tshawytscha</i>	chinook salmon	N. Pacific
	<i>Salvelinus namaycush</i>	lake trout	N. America
	<i>S. fontinalis</i>	brook trout	N. America
	<i>Catostomus catostomus</i>	sucker	Asia
	<i>Coregonus peled</i>	cisco	C. Asia
	<i>Ictalurus melas</i>	black bullhead catfish	N. America
	<i>Cyprinus carpio</i>	common carp	Asia
	<i>Neogogius melanastomus</i>	round goby	Black Sea
Bird	<i>Branta canadensis</i>	Canada goose	N. America
	<i>Cygnus olor</i>	mute swan	C. Asia
Mammal	<i>Ondatra zibethica</i>	muskrat	N. America
	<i>Mustela vison</i>	mink	N. America

Table B-3 Nonindigenous species reported for marine and estuarine habitats of Tasmania, Australia
 The native region and common name is included for species where available in original reference (C: Hewitt and R. Thresher, unpubl. data)

TAXON	SPECIES	COMMON NAME	NATIVE
Planta			
Dinophyceae	<i>Alexandrium tamarense</i>		Global Temperate
	<i>Gymnodinium catenatum</i>	red tide	E Pacific and N Europe
Phaeophyceae	<i>Undaria pinnatifida</i>		Japan, Korea, China
Invertebrata			
Annelida			
Polychaeta	<i>Hydroides elegans</i>		Europe
	<i>Sabella spallanzanii</i>		Europe, Med
Arthropoda			
Decapoda	<i>Carcinus maenas</i>	green crab	N. Europe
	<i>Cancer novaezelandiae</i>		New Zealand
	<i>Halicarcinus innominatus</i>		New Zealand
	<i>Petrolisthes elongatus</i>		New Zealand
Echinodermata			
Asteroidea	<i>Asterias amurensis</i>		NW Pacific
	<i>Astrostele scabra</i>		New Zealand
	<i>Pateriella regularis</i>		New Zealand
Bryozoa			
Cheilostomata	<i>Cryptosula pallasiana</i>		N Atlantic, cosmopolitan
	<i>Membranipora membranacea</i>		N Atlantic, cosmopolitan
Mollusca			
Bivalvia	<i>Corbula gibba</i>		SE Asia
	<i>Crassostrea gigas</i>	Japanese oyster	Japan
	<i>Musculita senhousia</i>		NW Atlantic
	<i>Neilo australis</i>		New Zealand
	<i>Perna canaliculatis</i>		New Zealand
	<i>Soletellina donacoides</i>		New Zealand?
	<i>Teredo navalis</i>	common shipworm	Europe
	<i>Theora lubrica</i>		NW Pacific
	<i>Venerupis largillierti</i>		New Zealand
Gastropoda	<i>Maoricolpus roseus</i>		New Zealand
Polyplocophora	<i>Chiton glaucus</i>		New Zealand
Chordata			
Ascidiacea	<i>Asciella aspersa</i>		N Europe
	<i>Botryllus schlosseri</i>		NE Atlantic
	<i>Ciona intestinalis</i>		N Atlantic
Fish	<i>Forsterygion varium</i>		New Zealand
	<i>Oncorhynchus mykiss</i>	rainbow trout	NE Pacific
	<i>Salmo salar</i>	atlantic salmon	N America
	<i>Salmo trutta</i>	brown trout	Britain

Table B-4 Nonindigenous species reported for marine and estuarine habitats of Great Britain. The native region and common name is indicated for species where available in original reference (Etno, 1996).

TAXON	SPECIES	COMMON NAME	NATIVE
Planta			
Coccinodiscophyceae	<i>Thalassiosira punctigera</i>		
	<i>Thalassiosira tealata</i>		
Bacillariophyceae	<i>Coccinodiscus wailesii</i>		
	<i>Odoniella sinensis</i>		
Rhodophyceae	<i>Pleurosigma planctonicum</i>		
	<i>Asparagopsis armata</i>		
	<i>Bonnemaisonia hamifera</i>		
	<i>Pikea cialornica</i>		
	<i>Grateloupia filicina</i> var. <i>luxurians</i>		
	<i>Grateloupia doryphora</i>		
	<i>Agardhiella subulata</i>		
	<i>Solieria (tenera) filiformis</i>		
	<i>Solieria chordalis</i>		
	<i>Anthithamnionella spirographidis</i>		
	<i>Anthithamnionella ternifolia</i>		
	<i>Polysiphonia harveyi</i>		
	Phaeophyceae	<i>Colpomenia peregrina</i>	
<i>Undaria pinnatifida</i>			
Chlorophyceae	<i>Codium fragile atlanticum</i>		
	<i>Codium fragile tomentosoides</i>	dead man's fingers	
Magnoliopsida	<i>Spartina anglica</i>		
Invertebrata			
Cnidaria			
Hydrozoa	<i>Gonionemus vertens</i>		IndoPacific? Europe?
	<i>Rhizogeton nudum</i>		
	<i>Clavopsella navis</i>		
Anthozoa	<i>Haliplanella lineata</i>	striped anemone	Japan, Korea
Annelida			
Polychaeta	<i>Gonidaella gracilis</i>		N America (Atlantic)
	<i>Marenzelleria viridis</i>		N America (Atlantic)
	<i>Clymenella torquata</i>		N America (Atlantic)
	<i>Hydroides dianthus</i>		N America (Atlantic)
	<i>Hydroides ezoensis</i>		Japan, Korea
	<i>Ficopomatus enigmaticus</i>		Australia
	<i>Janua brasiliensis</i>		S America
	<i>Pileolaria berkeleyana</i>		Japan, Korea
Pycnogonida	<i>Ammothea hilgendorfi</i>		Japan, Korea
Arthropoda			
Cirripedia	<i>Elminius modestus</i>		Australia, New Zealand
	<i>Balanus amphitrite</i>		
Copepoda	<i>Acartia tonsa</i>		
Ostracoda	<i>Eusarsiella zostericola</i>		N America (Atlantic)
Amphipoda	<i>Corophium sextonae</i>		New Zealand
Decapoda	<i>Eriocheir sinensis</i>	Chinese mitten crab	IndoPacific
Mollusca			
Gastropoda	<i>Crepidula fornicata</i>	slipper shell	N America (Atlantic)
	<i>Rapana venosa</i>		
	<i>Urosalpinx cinerea</i>		N America (Atlantic)
Bivalvia	<i>Aulacomya ater</i>		S America (Pacific)
	<i>Crassostrea gigas</i>	Japanese oyster	Japan
	<i>Troostrea lutaria</i>		New Zealand
	<i>Ensis amencanus</i>	razor clam	N America (Atlantic)
	<i>Mercenaria mercenaria</i>	hardshell clam	N America (Atlantic)
	<i>Petricola pholadiformis</i>		N America (Atlantic)
	<i>Mya arenaria</i>	softshell clam	N America (Atlantic)
Ascidiacea	<i>Styela clava</i>		Asia
Nematoda			
Dracunculoidea	<i>Anguillicola crassus</i>		IndoPacific? Europe?
Chordata			
Mammal	<i>Myocastor coypus</i>	nutria	South America

TABLE B-5. Nonindigenous species reported from marine and estuarine habitats from southern California to Alaska. Shown for each species are its native range, its range along the coast of North America, and associated references. This list summarizes the current state of knowledge concerning nonindigenous species in each region based upon existing and often incomplete surveys. (see text for discussion)

Geographic Range Abbreviations and References:

SF= San Francisco Bay (Carlton, 1979a; Cohen and Carlton, 1996) SCA=Southern California, below San Francisco Bay (Carlton, 1979a; Crooks, 1997; Lambert and Lambert, 1995; Scagel et al., 1989; Maggs and Ward, 1996; Curtis, 1997) NCA= Northern California, above San Francisco Bay (Carlton, 1979a) OR= Oregon, including Columbia River (Carlton, 1979a; Carlton, 1997; Cordell and Morrison, 1996) NW=Washington and British Columbia (Carlton, 1979a; Goff et al., 1992; Renfrew et al., 1989; Scagel et al., 1989; Harrison et al., 1982; Abbot, 1974; Elston, 1997; Carlton, 1992b; Cordell and Morrison, 1996; Merilees, 1995; McMahon, 1983; John Chapman, pers. comm) AK= Alaska (Carlton, 1979a; Robert Benda, pers. comm 1997; Scagel et al., 1989) # =species present in Kozloff(1987) and probably established in NW but locality requires further confirmation.

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
Chlorophyta	<i>Bryopsis</i> sp.		?	X					
Diatomacea	<i>Codium fragile tomentosoides</i>	dead man's fingers	Japan	X				X	
	<i>Gonioceros armatum</i>		Australasia			X	X		
Phaeophyta	<i>Pseudonitzschia australis</i>		Japan			X	X		
Rhodophyta	<i>Sargassum muticum</i>	Japanese weed	NW Atlantic	X	X	X	X	X	X
	<i>Callithamnion byssoides</i>			X					
	<i>Gelidium vagum</i>			X					
	<i>Lomentaria hakodatensis</i>		Japan					X	
	<i>Pilkea yoshizakii</i>		Japan		X			X	
	<i>Polysiphonia denudata</i>		NW Atlantic		X				
Angiosperm	<i>Agrostis alba</i>	red top grass	Europe	X					
	<i>Agrostis maritima</i>	creeping bent grass	Europe				X		
	<i>Chenopodium macrosperrum</i>	goose-foot	S.America	X			X		
	<i>Cotula coronopifolia</i>	brass buttons	S.Africa	X			X		
	<i>Juncus gerardi</i>	saltmeadow rush	NW Atlantic				X		
	<i>Lepidium latifolium</i>	broadleaf peppergrass	Eurasia	X		X	X		
	<i>Limosella subulata</i>	awl-leaved mudwort	Europe, eN.America	X					
	<i>Lythrum salicaria</i>	purple loosestrife	Europe	X					
	<i>Myriophyllum aquaticum</i>	parrot's feather	S.America	X					
	<i>Myriophyllum spicatum</i>	Eurasian milfoil	Eurasia, N.Africa	X					X
	<i>Polygonum patulum</i>	smartweed	eEurope	X					
	<i>Rorippa nasturtium aquaticum</i>	true watercress	Europe	X					
	<i>Salsola soda</i>	saltwort	s.Europe	X					
	<i>Spargularia marina</i>	sand-spurrey	Europe				X		
	<i>Spargularia media</i>	saltmarsh sand-spurrey	Europe	X					
	<i>Spargularia salina</i>	elodea	S.America	X					
	<i>Egeria densa(m)</i>	water hyacinth	S.America	X					
	<i>Eichornia crassipes</i>	yellow flag	Europe	X					
	<i>Iris pseudacorus</i>			X					

Table B - 5, continued...

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
	<i>Polypogon elongatus</i>	curly-leaf pondweed	S.Ameria	X					
	<i>Potamogeton crispus</i>	smooth cordgrass	Europe	X				X	
	<i>Spartina alterniflora</i>	English cordgrass	nwAtlantic	X	X				
	<i>Spartina anglica</i>	dense-flowered cordgrass	England	X					
	<i>Spartina densiflora</i>	saltemadow cordgrass	Chile	X					
	<i>Spartina patens</i>	narrow-leaf cattail	seUS	X					
	<i>Typha angustifolia</i>	Japanese eelgrass	Eurasia	X				X	
	<i>Zostera japonica</i>		Japan				X		
	<i>Trochammima hadai</i>		Japan	X					
Protozoa(Foraminifera)	<i>Ancistrocoma pelseneeri</i>		Europe	X					
Protozoa(Mollusc host)	<i>Ancistrum cyclidoides</i>		Europe	X					
	<i>Boveria teredinii</i>		nAtlantic	X					
	<i>Sphenophyra dosimiae</i>		Europe	X					
Protozoa(Crustacean host)	<i>Cothurnia limnorica</i>		Europe	X					
	<i>Lobochona prorates</i>		?	X					
	<i>Mirofolliculina</i> sp.		?	X			X		
	<i>Citona</i> sp.	boring sponge	nAtlantic?	X				#	
Porifera	<i>Halichondria bowerbanki</i>	Bowerbank's halichondria	nAtlantic	X			X	X	
	<i>Halictona loosanoffi</i>	Loosanoff's halicolona	nAtlantic	X			X		
	<i>Microciona prolifera</i>	red beard sponge	nwAtlantic	X				X	
	<i>Prosuberites</i> sp.		nwAtlantic	X					
Cnidaria(Hydrozoa)	<i>Blackfordia virginica</i>	club hydroid	Black&Caspian Seas	X			X		
	<i>Cladonema uchidai</i>	freshwater hydroid	Japan	X					
	<i>Clava multicornis</i>		nAtlantic	X			X	X	
	<i>Cordylophora caspia</i>		Black&Caspian Seas	X		X			
	<i>Corymorpha</i> sp.		nAtlantic?	X					
	<i>Garveta franciscana</i>		nIndian Ocean?	X					
	<i>Gonothyrax clarki</i>		nAtlantic	X			X	#	
	<i>Macotias inexpectata</i>		Black Sea	X					
	<i>Obelia</i> spp.		nAtlantic	X			X	#	
	<i>Sarsia tubulosa</i> (= <i>Syncoryne minabilis</i>)		nAtlantic	X			X	X	X
	<i>Ectopleura crocea</i> (= <i>Tubularia</i>)		nwAtlantic	X	X		X	X	X
	<i>Zaniclea costata</i>		nwAtlantic	X		X			
Cnidaria(Scyphozoa)	<i>Aurelia "aurita"</i>	moon jelly	nPacific	X					
Cnidaria(Anthozoa)	<i>Diadumene ?cineta</i>	orange anemone	Europe?	X					
	<i>Diadumene franciscana</i>	SanFrancisco anemone	?	X	X				
	<i>Diadumene leucolena</i>	white anemone	nwAtlantic	X	X		X		
	<i>Haliplanella luciae</i>	orange-striped green anemone	Japan	X	X		X	X	
Platyhelm(Turbellaria)	<i>Pseudostylochus ostreophagus</i>		Japan	X					
	<i>Leptoplana limnoria</i>		Japan	X				X	

Table B - 5, continued...

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
	<i>Melanoides tuberculata</i>	red-rim melania	Africa to E. Indies	x					
	<i>Nassarius fraterculus</i>	Japanese nassa	nwPacific		x			x	
	<i>Ocenebra inornata</i>		Japan					x	
	<i>Ocenebra inornata</i>		Japan					x	
	<i>Potamopyrgus antipodarum</i>	New Zealand mud snail	New Zealand					x	
	<i>Urosalpinx cinerea</i>	Atlantic oyster drill	nwAtlantic	x	x	x		x	
Mollusca(Gastropoda-op)	<i>Aeolidiella takanomosus</i>	Vermillion Japanese aeolis	Japan		x				
	<i>Babakina festiva</i>	single-stalk aeolis	Japan	x					
	<i>Boonea bisuturalis</i>	two-groove odostome	nwAtlantic	x	x				
	<i>Catriona rickettsi</i>		?						
	<i>Cumanotus beaumonti</i>	polyp aeolis	nwAtlantic			x	x	#	
	<i>Cuthona perca</i>	Lake Merritt cuthona	?	x					
	<i>Eubranchius misakiensis</i>	Misaki balloon aeolis	Japan?	x					
	<i>Okenia plana</i>	flat okenia	Japan	x	x				
	<i>Philine auriformis</i>	tortellini snail	N.Zealand; Australia?	x	x	x			
	<i>Sakuraeolus enosimensis</i>	white-tentacled Jap.snail	Japan	x					
	<i>Tenellia adpersa</i>	miniature aeolis	Europe	x	x			x	
Mollusca(Gastropoda-pul)	<i>Myosotella myosotis (= Ovatella)</i>		Europe?	x					
Mollusca(Bivalvia)	<i>Arcuatula clemissa</i>	ribbed mussel	nwAtlantic						
	<i>Anomia chinensis</i>	Chinese jingle	nwPacific						
	<i>Corbicula fluminea</i>	Asian clam	China, Korea, Japan	x			x	x	
	<i>Crassostrea gigas</i>	Japanese oyster	Japan						
	<i>Crassostrea virginica</i>	Eastern oyster	nwAtlantic						
	<i>Gemma gemma</i>	amethyst gem clam	nwAtlantic	x		x			
	<i>Laternula limicola</i>								
	<i>Lyrodon pedicellatus</i>	blacktip shipworm	?	x					
	<i>Macoma petalum</i>	Baltic clam	nwAtlantic	x					
	<i>Mercenaria mercenaria</i>	northern quahog	nwAtlantic		x				
	<i>Musculista senhousia</i>	Japanese mussel	Japan, China	x	x	x		x	
	<i>Mya arenaria</i>	softshell clam	nAtlantic	x		x	x	x	x
	<i>Mytilus galloprovincialis</i>	Mediterran. mussel	Med. Sea	x	x		x		
	<i>Nuttallia obscura</i>		Japan? Korea?						x
	<i>Ostrea conchophila</i>	Olympia oyster	ePacific				x		
	<i>Petricola pholadiformis</i>	false angelwing	nwAtlantic	x	x				x
	<i>Potamocorbula amurensis</i>	Amur River corbula	sChina to Siberia, Japan	x					
	<i>Teredo navalis</i>	naval shipworm	?	x	x		x	x	
	<i>Theora fragilis</i>	Asian semele	wPacific	x	x				
	<i>Trapezium tiratum</i>	Japanese trapezium	nwPacific			x			x
	<i>Venerupis philippinarum</i>	Japanese littleneck clam	wPacific	x	x	x			x

Table B - 5, continued...

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
Arthropoda(Ostracoda)	<i>Aspidochorda limnoriae</i>		Europe		x	x			
	<i>Eusarsiella zostericola</i>		nwAtlantic	x					
	<i>Spinileberis quadraculata</i>		Japan			x			
Arthropoda(Copepoda)	<i>Redekea californica</i>								
	<i>Acartiella sinensis</i>		China	x					
	<i>Limnoithona sinensis</i>		Yangtze R., China	x					
	<i>Limnoithona tetraspina</i>		YangtzeR., China	x					
	<i>Mytilicola orientalis</i>		wPacific	x					
	<i>Oithona davisae</i>		Japan	x					x
	<i>Pseudodiaptomas forbesi</i>		YangtzeR., China	x					
	<i>Pseudodiaptomas inopinus</i>		Asia	x					
	<i>Pseudodiaptomas marinus</i>		China,Japan	x					
	<i>Sinocalanus doerrii</i>		China	x					
	<i>Tisbe gracilis</i>		China	x					
	<i>Tortanus sp.</i>		Europe		x				
	Arthropoda(Cirripedia)	<i>Balanus amphitrite</i>	striped barnacle	?	x				
<i>Balanus improvisus</i>		bay barnacle	Indian ocean	x					
Arthropoda(Neballia)	<i>Epinebalia sp.</i>		nAtlantic	x					x
	<i>Acanthomysis aspera</i>		?	x					
Arthropoda(Mysidacea)	<i>Acanthomysis sp.</i>		Japan	x					
	<i>Deltamysis holmquistae</i>		?	x					
Arthropoda(Cumacea)	<i>Nippoleucon himuensis</i>		?	x					
	<i>Caecijaera horvathi</i>		Japan	x					
Arthropoda(Isopoda)	<i>Dynoides dentisimus</i>		Japan	x					
	<i>Eurylana arcuata</i>		Japan,Korea	x					
	<i>Gnorimosphaeroma rayi</i>		N.Zealand or Chile	x					
	<i>Iais californica</i>		Japan						
	<i>Limnoria quadripunctata</i>		Australia,N.Zealand	x					
	<i>Limnoria tripunctata</i>		?	x					
	<i>Paranthura sp.</i>		?	x					
	<i>Sphaeroma quoyanum</i>		wPacific?	x					
	<i>Sphaeroma walkeri</i>		Australia,N.Zealand	x					
	<i>Synidotea laevidorsalis</i>		Indian Ocean	x					
	<i>Sineleobus sp. (= Tanais stanfordi)</i>		nwPacific	x					
	<i>Ampelisca abdita</i>		?	x					
	<i>Ampithoe longimana</i>		nwAtlantic	x					
Arthropoda(Tanaidacea)	<i>Ampithoe valida</i>		nwAtlantic	x					
	<i>Caprella acanthogaster</i>		nwAtlantic	x					
Arthropoda(Amphipoda)	<i>Caprella mutica</i>		Japan to Vladivostok	x					
	<i>Chelura terebrans</i>		Atlantic	x					

Table B - 5. continued...

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
	<i>Corophium acherusicum</i>		Atlantic	X	X	X	X	X	X
	<i>Corophium altenense</i>		seAsia?	X					
	<i>Corophium heteroceratum</i>		China	X					
	<i>Corophium insidiosum</i>		nAtlantic	X	X	X	X	X	X
	<i>Corophium uenoi</i>		Japan	X	X	X			
	<i>Euobrolgus spinosus</i>	(= <i>Paraphoxus</i>)	nwAtlantic	X	X	X	X		
	<i>Gammarus daiberi</i>		nwAtlantic	X					
	<i>Grandidierella japonica</i>		Japan	X		X	X		
	<i>Jassa marmorata</i>		nwAtlantic	X			X		
	<i>Leucothoe sp.</i>		?	X				X	
	<i>Melita nitida</i>		nwAtlantic	X			X		
	<i>Melita sp.</i>		?	X					
	<i>Paradexamine sp.</i>		wPacific?	X					
	<i>Parapleustes derzhavini</i>		wPacific?	X			X		
	<i>Stenothoe valida</i>		?	X	X				
	<i>Transorchestia enigmatica</i>	shorehopper	Chile? N.Zealand?	X					
Arthropoda(Decapoda)	<i>Carcinus maenas</i>	green crab	Europe	X		X	X		
	<i>Eriocheir sinensis</i>	Chinese mitten crab	China,Korea	X		X	X		
	<i>Exopalaemon modestus</i>		China,Korea,Russia?					X	
	<i>Oronectes virilis</i>	virile crayfish	midw U.S.	X					
	<i>Pacifastacus leniusculus</i>	signal crayfish	Oregon to B.C.	X					
	<i>Palaemon macrodactylus</i>	oriental shrimp	Korea,Japan,nChina	X	X		X		
	<i>Procamburus clarkii</i>	red swamp crayfish	seU.S.	X					
	<i>Rhithropanopeus harrisi</i>	Harris mudcrab	nwAtlantic	X			X		
Arthropoda(Insecta)	<i>Anisolabis maritima</i>	maritime earwig	nAtlantic	X					
	<i>Neochetina bruchi</i>		Argentina	X					
	<i>Neochetina eichorniae</i>		Argentina	X					
	<i>Trigonotylus uhleri</i>		nwAtlantic	X					
Kamptozoa	<i>Barentsia benedicti</i>		Europe	X	X		X	#	
	<i>Urnatella gracilis</i>		e&midwU.S.	X					
Bryozoa	<i>Acyonidium sp.</i>		wPacific?		X		X		
	<i>Anguilla palmata</i>	ambiguous bryozoan	nAtlantic	X	X				
	<i>Bowerbankia gracilis</i>	creeping bryozoan	nwAtlantic?	X	X		X	#	
	<i>Bugula "neritina"</i>		?	X	X		X		
	<i>Bugula stolonifera</i>		nwAtlantic	X	X				
	<i>Conopeum tenuissimum</i>		nwAtlantic	X	X		X		
	<i>Cryptosula pallasiana</i>		nAtlantic	X	X		X	#	
	<i>Nolella blakei</i>				X				
	<i>Schizoporella unicornis</i>		nwPacific	X	X	X	X	X	X
	<i>Triticella sp.</i>		wPacific?			X	X	X	
	<i>Victorella pavida</i>		Indian Ocean?	X					

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
Chordata(Tunicata)	<i>Watersipora "subtorquata"</i>		nwPacific?	x	x				
	<i>Zoobotryon verticillatum</i>		subtropical?	x	x				
	<i>Ascidia sp.</i>		?	x					
	<i>Ascidia interrupta</i>				x				
	<i>Botryllus aurantius</i>		Japan	x					
	<i>Botryllus schlosseri</i>		neAtlantic	x					
	<i>Botryllus violaceus</i>	golden star tunicate (= <i>Botrylloides</i>)	nwPacific			x	x		
	<i>Botryllus sp.</i>		?	x					
	<i>Ciona intestinalis</i>		nAtlantic	x	x				
	<i>Ciona savignyi</i>		Japan?	x	x			x	x
	<i>Diplosoma mitsukurii</i>		nwPacific	x	x				
	<i>Microcosmus squamiger</i>				x				
	<i>Molgula manhattensis</i>		nAtlantic	x	x				
	<i>Polyandrocarpa zorritensis</i>				x				
	<i>Styela canopus</i>				x				
	<i>Styela clava</i>				x				
	<i>Styela plicata</i>				x				
	<i>Symplegma oceania</i>				x				
	<i>Acanthogobius flavimanus</i>				x				
	Chordata(Fish)	<i>Alosa sapidissima</i>	yellowfin goby	nChina to Okhotish Sea	x	x			
<i>Ameiurus catus</i>		American shad	Japan,sKorea,China Labrador to Florida	x	x				
<i>Ameiurus melas</i>		white catfish	NewYork to Miss.	x					
<i>Ameiurus natalis</i>		black bullhead	central N.America	x					
<i>Ameiurus nebulosus</i>		yellow bullhead	central N.America	x					
<i>Carassius auratus</i>		brown bullhead	central N.America	x					
<i>Cyprinodon variegatus</i>		goldfish	China	x					
<i>Cyprinus carpio</i>		sheepshead minnow carp	wn,Atlantic	x		x			
<i>Dorosoma petenense</i>		threadfin shad	Eurasia	x					
<i>Gambusia affinis</i>		mosquitofish	midw U.S., Florida-Guat	x					
<i>Ictalurus furcatus</i>		blue catfish	midw/seU.S., Mexico	x					
<i>Lepomis cyanellus</i>		green sunfish	midw/seU.S., RioGrand,Mex	x					
<i>Lepomis gulosus</i>		warmouth	midw/seU.S., nMex	x					
<i>Lepomis macrochirus</i>		bluegill	midw/seU.S., RioGrande	x					
<i>Lepomis microlophus</i>		redear sunfish	midw/seU.S.,Mex,RioGR	x					
<i>Lucania parva</i>		rainwater killifish	midw/seU.S.	x					
<i>Menidia beryllina</i>		inland silverside	Mass.toMex, RioGR	x					
<i>Micropterus dolomieu</i>		smallmouth bass	midw/seUS, RioGR	x					
<i>Micropterus salmoides</i>		largemouth bass	central N.Am central N.Am	x					

TAXON	SPECIES	COMMON NAME	NATIVE TO	SF	SCA	NCA	OR	NW	AK
	<i>Morone chrysops x saxatilis</i>	white bass (hybrid)	wAtlantic				x		
	<i>Morone saxatilis</i>	striped bass	St.Lawrence - Louisiana	x			x		
	<i>Notemigonus crysoleucas</i>	golden shiner	central N.America	x					
	<i>Percina macrolepida</i>	bigscale logperch	Louisiana - N.Mexico	x					
	<i>Pimephales promelas</i>	fathead minnow	central N.America	x					
	<i>Pomoxis annularis</i>	white crappie	midw/se U.S.	x					
	<i>Pomoxis nigromaculatus</i>	black crappie	midw.se U.S.	x					
	<i>Salmo salar</i>	Atlantic salmon	Atlantic					x	x
	<i>Tridentiger bifasciatus</i>	shimofuri goby	Japan	x					
	<i>Tridentiger trigonocephalus</i>	chameleon goby	Japan,China,Siberia	x					
Chordata(Amphibian)	<i>Rana catesbalana</i>	bullfrog	eN.America	x					
Chordata(Reptile)	<i>Pseudemys scripta</i>	pond slider	seU.S.	x					
Chordata(Mammal)	<i>Ondatra zibethicus</i>	muskrat	eN.America	x					

TABLE B-6. Nonindigenous species reported from marine and estuarine habitats in Alaska. Mechanisms of introduction include: RI=release by an individual, SF=ship fouling, CO=commercial oysters, BW=ballast water, OA=Atlantic oysters, IP=intentional plantings. A single asterisk before the name indicates the species has been reported from Alaska, but existence of present populations is unconfirmed. A double asterisk indicates the species is found at aquaculture facilities with occasional escapees reported.

TAXON	SPECIES	COMMON NAME	NATIVE TO	MECHANISM	REFERENCE
Angiosperm	* <i>Myriophyllum spicatum</i>	Eurasian milfoil	Eurasia, N.Africa	RI	Susan Walker, USFWS, pers. comm.
Rhodophyta	<i>Sargassum muticum</i>				
Cnidaria(Hydrozoa)	* <i>Sarsia tubulosa</i>		Japan		Scagel et. al., 1989
	* <i>Tubularia crocea</i>		nAtlantic	SF	Carlton, 1979a
Annelida(Polychaeta)	* <i>Capitella capitata</i>		nwAtlantic	SF, CO	Carlton, 1979a
	<i>Heteromastus filiformis</i>		NeAtlantic		Carlton, 1979a
Mollusca(Bivalvia)	** <i>Crassostrea gigas</i>		nwAtlantic	BW, OA	Wiegiers et. al., 1997
	<i>Mya arenaria</i>	softshell clam	nwPacific	CO	Carlton, 1979a
Arthropoda(Amphipoda)	* <i>Corophium acherusicum</i>		nAtlantic	OA, IP	Carlton, 1979a
	* <i>Corophium insidiosum</i>				Crawford, 1937
Chordata(Tunicata)	* <i>Ciona intestinalis</i>		nAtlantic	OA, SF	Crawford, 1937
Chordata(Pisces)	** <i>Salmo salar</i>	Atlantic salmon	Atlantic	IP	Carlton, 1979a
					Robert Benda, pers. com.

Table 3.7 Aqul species with unsuccessful introduction to Northwestern North America from Washington to Alaska. Indicated for each species are donor region(s), recipient region(s), date of first record, probable vector of introduction and reference(s). [Source: Table provided by G. Hansen]

Abbreviations:

Donor/Recipient Regions: AUS-TAS=Tasmania, Australia, AUS=Australia, BC=British Columbia, C-SFB=San Francisco Bay, C=California, CAN-NF=Newfoundland, CAN-NS=Nova Scotia, CAN-Q=Quebec, CH=China, EUR=Europe, FR-BRIT=France, Brittany, FR-MED=French Mediterranean, FR=France, GB=Great Britain, HEL=Helgoland-Germany, IT=Italy, J=Japan, MED=Mediterranean, MX=Mexico, N=Norway, NETH=Netherlands, NE-ATL= Northeast Atlantic, NE-PAC= Northeast Pacific, NW-ATL=Northwest Atlantic, NW-PAC= Northwest pacific, N-ATL= North Atlantic, N-PAC=North Pacific, NY=New York, Long Island Sound, NZ=New Zealand, O=Oregon, PAC=Pacific, PWS=Prince William Sound, R-ARC=Russian Arctic, White Sea, R-SIB=Siberia, S-ATL= South Atlantic, S-AUS=Southern Australia, S-C=Southern California, SCAN=Scandinavia, SE-AK= Southeast Alaska, SP=Spain, USA-NC=North Carolina, USA-NE=New England, W=Washington
Vector: A=Aquaculture, B=ballast water, L=lobster or bait packing, M=Marginal dispersal through currents, OA=oystersAtlantic,OJ=oystersJapan, OBC=oysters British Columbia, ROK=roe-on-keip; S=scientific research, ?=unknown vector or date

SPECIES	DONOR	RECIPIENT	DATE	VECTOR	REFERENCE
<i>Ascophyllum nodosum</i>	USA-NE	BC	1950's	L	Scagel, pers. comm.
<i>Macrocystis integrifolia</i>	SE-AK	PWS	1980's	ROK	AK Fish and Game, pers. comm.
<i>Macrocystis pyrifera</i>	C	PWS	1980's	ROK	AK Fish and Game, pers. comm.
<i>Pachymenia carnosa</i>	J	W, SE-AK	1970's	?	GIH, personal observation
<i>Porphyra yezoensis</i>	J	W, BC, SE-AK	1980's	A	AK Fish and Game, pers. comm

Table B - 8. Checklist of intertidal invertebrates of Port Valdez, Alaska
 [Source: Table provided by J. Chapman, Oregon State University.]

Surveys: W=Wiegers et al., 1997; B=Both Surveys; S=SERC/OSU Survey
 Local Range: A=Alaska; WA=Washington; BJC=Baja California; C=California; SC=Southern California
 Status: I=Introduced; C=Cryptogenic; N=Native
 Geographical Range: A=Australia; BS=Black Sea; CS=Caspian Sea; I=India; J=Japan
 MED=Mediterranean; NEA=Northeast Atlantic; NEP=Northeast Pacific
 NWA=Northwest Atlantic; SAM=South America
 * See text for mechanisms and estimated date of introduction

Species	Survey	Range	Status	Geographic Range
Cnidaria				
<i>Anthopleura artemesia</i>	W	C	N	
Nemertea				
<i>Paranemertea</i> sp.	B	C	N	
Aschelminthes				
<i>Priapulid caudatus</i>	B	C	N	
Echiurida				
<i>Echiurus echiurus alaskensis</i>	B	WA	N	
Oligochaeta				
Unidentified spp.	B			
Polychaeta				
<i>Abarenicola</i> sp.	S			
<i>Amphitrite cirrata</i>	S	C	C	NWA
<i>Barantolla americana</i>	W	C	N	
<i>Brandiomaldane</i> sp.	B			
<i>Capitella capitata</i> sp. complex	B	C	C	NEA, NWA, A
<i>Eteone longa</i>	B	C	C	NEA
<i>Euchone analis</i>	W	WA	C	NEA
<i>Exogone lourei</i>	W	C	N	
<i>Fabricinae</i> sp.	S			
<i>Fabricia sabella</i>	B	C	C	NEA, NWA
<i>Glycera capitata</i>	W	C	N	
<i>Glycine picta</i>	B	WA	N	
<i>Harmothoe imbricata</i>	S	C	C	NEA, NWA, J, MED
<i>Heteromastus filiformis</i> *	B	C	I	A, NZ, J, NEA, NWA, MED, SAF
<i>Laonome kroyeri</i>	W	WA	N	
<i>Leitoscoloplos panamensis</i>	B	C	N	
<i>Lumbrineris luti</i>	W	WA	N	
<i>Microphthamus szelkowi</i>	W	A	N	
<i>Nereis vexillosa</i>	S	C	N	
<i>Owenia fusiformis</i>	B		C	NEA, NWA
<i>Pholoe glabra</i>	W	C	N	
<i>Polydora quadriloba</i>	W	C	N	
<i>Potamilla</i> sp.	W			
<i>Prionospio steenstrupi</i>	W	C	N	
<i>Pygospio elegans</i>	B	C	N	
<i>Spio filicornis</i>	W	C	C	NEA
<i>Sphaerosyllis brandhorsti</i>	S	A	N	
<i>Syllis</i> sp.	W			
<i>Tharyx glandaria</i>	W	C	N	
Copepoda				
<i>Daniellsenia cinctus</i> spp.	S		N	
<i>Daniellsenia typica</i>	W	WA	C	NEA, NWA, MED
<i>Harpacticus finmarchicum</i>	W			
<i>Halectinosoma gothiciceps</i>	W			
<i>Harpacticus superflexus</i>	W	WA	N	
<i>Harpacticus uniremis</i>	B	C	C	NEA, NWA, J.

Table B-8. continued

Species	Survey	Range	Origin	Geographic Range
<i>Heterolaophonte</i> sp.	W			
<i>Mesochra pygmaea</i>	W	WA	C	NEA, NWA, A
<i>Microathridion littorale</i>	W	WA	C	NEA, NWA, BS
<i>Nannopus palustris</i>	W	WA	C	NEA, NWA, MED, CS, BS, I, SAM
<i>Paradactylopodia latipes</i>	W			
<i>Paralaophonte perplexa</i>	W	WA	C	NEA, NWA
<i>Rhizorhix</i> sp.	W			
<i>Stenelia</i> sp.	W			
<i>Tisbe inflata</i>	W			
Balanomorpha				
<i>Balanus gladula</i>	B	C	N	
<i>Semibalanus balanoides</i>	B	C	N	
Cumacea				
<i>Cumella vulgaris</i>	B	C	N	
<i>Eudorella</i> sp.	W			
<i>Leptocuma</i> sp.	W			
Isopoda				
<i>Gnorimosphaeroma oregonensis</i>	B	C	N	
<i>Limnoria algarum</i>	W	WA	N	
<i>Limnoria ligatum</i>	S	WA	N	
<i>Idotea aculeata</i>	S	WA	N	
<i>Idotea wosensenskii</i>	B	C	N	
Amphipoda				
<i>Allorchestes angusta</i>	S	C	N	
<i>Carinogammaus markarovi</i>	S	A	N	
<i>Eogammaus confervicolus</i>	S	C	N	
<i>Paramoeta suchaneki</i>	S	WA	N	
<i>Callicippus pacifica</i>	S	WA	N	
<i>Locustogammarus locustoides</i>	S	A	N	
<i>Pontoporeia femorata</i>	S	WA	N	
Decapoda				
<i>Pagurus hirsutiusculus</i>	W	SC	N	
<i>Hemigrapsus oregonensis</i>	W	BJC	N	
<i>Hemigrapsus nudis</i>	S	BJC	N	
Arachnida				
<i>Halobisium occidentale</i>	B	C	N	
Gastropoda				
<i>Aglaja diomedea</i>	B	SC	N	
<i>Aglaja</i> sp.	W			
<i>Cingula katherinae</i>	W	A	N	
<i>Littorina scutulata</i>	S	BJC	N	
<i>Littorina sitkana</i>	B	WA	N	
<i>Lottia delta</i>	S	BJC	N	
<i>Tectura persona</i>	S	C	N	
Bivalvia				
<i>Axincosida serricata</i>	W	BJC	N	
<i>Bankia setacea</i>	S	BJC	N	
<i>Clinocardium nuttallii</i>	B	SC	N	
<i>Lasca adansoni</i>	S	WA	N	
<i>Macoma baltica</i>	B	C	C	NEA, NWA
<i>Macoma brota</i>	W	WA	N	
<i>Mya arenaria</i> *	B	C	I	NEP, NEA, NWA
<i>Mya truncata</i>	W	WA	N	
<i>Mytilus trossulus</i>	B	C	N	
<i>Orbitella rugifera</i>	W	C	N	
<i>Petricola carditoides</i>	S	BJC	N	
<i>Serripes groenlandicus</i>	W	WA	N	

Table B - 9. continued

Species	Survey										Geographic Range										Approximate Distributions			
	Unatt. Surv.					HAN					AU	JA	C-R	VA	SA	BC	WA	OR	CA	AR		EC	NO	GB
	CAL	WEI	CHA	HAN	HAN	AU	JA	C-R	VA	SA	BC	WA	OR	CA	AR	EC	NO	GB						
<i>Palmaria hecatensis</i>					X				X														NE Pac	
<i>Palmaria palmata</i>	X	X							X						X								N Pac, N All	
<i>Phycodrys rigidi</i>	X	X						X	X														N Pac	
<i>Polysiphonia brodiaei</i>		X				X			X					X									widespread	
<i>Polysiphonia hendryi</i> v. <i>deliquescens</i>	X					X			X					X									NE Pac	
<i>Polysiphonia hendryi</i> v. <i>hendryi</i>	X					X			X					X									NE Pac	
<i>Polysiphonia hendryi</i> v. <i>luxurians</i>	X					X			X					X									NE Pac	
<i>Polysiphonia pacifica</i> v. <i>pacifica</i>	X					X			X					X									NE Pac	
<i>Polysiphonia</i> sp.					O				O														NE Pac	
<i>Porphyra cuneiformis</i>	X								X					X									NE Pac	
<i>Porphyra murifordii</i>									X					X									NE Pac	
<i>Porphyra perforata</i>									X					X									N Pac	
<i>Porphyra purpureo-violacea</i>									X					X									N Pac, NE All	
<i>Porphyra</i> sp.									O														N Pac, Arctic	
<i>Pterosiphonia bipinnata</i>	X	X							X					X									N Pac, Arctic	
<i>Ptilota filicina</i>	X	X							X					X									N Pac	
<i>Ptilota serrata</i> (incl. <i>pectinata</i>)	X	X							X					X									N Pac, Arctic	
<i>Rhodomela lycopodioides</i>	X	X							X					X									N Pac, Arctic, N All	
<i>Scagelia occidentale</i> (incl. <i>pylaisaei</i>)	X	X							X					X									N Pac, Arctic, N All	
<i>Tokidodendron kurilensis</i>	X	X							X					X									N Pac	
SEAGRASSES																								
<i>Zostera marina</i>									X					X									N Pac, Arctic, N All	
LICHENS																								
<i>Verrucaria maura</i>									X					X									N Pac, N All	
<i>Verrucaria mucosa</i>									X					X									N Pac, N All	
TOTAL "X"	68	81	20	24	29	24	60	46	101	91	90	85	76	70	42	46	43	42	42	43	42	42	Total Widespread= 21	

Table B - 10. Animal species with potential for introduction to Alaska. These include species which have histories of introduction elsewhere at latitudes above 40° and for which ballast water is the possible medium of transfer. Indicated for each species are donor region, date of first record, possible mechanism of introduction, recipient region and references. [Source: Table provided by J. Chapman, Oregon State University]

Mechanism: A = Aquaculture; B = Ballast Water; Cu = Coastal currents; F = Fouling; I = Intentional; OJ = Oysters Japan
Donor/Recipient: AK= Alaska, BC= British Columbia, BS= Black Sea, C=California, CR=Columbia River,
 EUR= Europe, GL= Great Lakes, K= Kachemak, NEA= North East, Atlantic, NWA=North West Atlantic,
 NEP=North East Pacific, NA=North Atlantic; NWP= North West Pacific, NZ= New Zealand; O=Oregon,
 PS=Puget Sound, W=Washington, SE AK= south east Alaska, SFB=San Francisco Bay, TAS= Tasmania

Species	Donor Region	Date	Mechanism	Recipient Region	Reference
Protozoa					
<i>Trochammina hadai</i>	Japan	1990s	B	SFB	Cohen and Carlton 1995
Coelenterata					
<i>Cordylophora caspia</i>	BS	1930s	F, B	BC	Carlton 1979a, Cohen and Carlton 1995
<i>Aurelia aurita</i>	NWA	1990s	B	O	Cohen and Carlton 1995
Polychaeta					
<i>Boccardia ligerica</i>	NEA	1935	B, F	Korea	Cohen and Carlton 1995
<i>Euchone limnicola</i>	NZ?		B	SFB	Cohen and Carlton 1995
<i>Lyrodus takanosimensis</i>	Japan	1981	B?	BC	J. Carlton, pers. comm.
<i>Neanthes succinea</i>	NEA	1850s?	F, B?	PS	Carlton 1979a, Cohen and Carlton 1995, J. Chapman Pers Obs. 1992
<i>Manayunkia speciosa</i>	NWA	1960s	B, F	C, O	Cohen and Carlton 1995, J. Chapman Pers Obs
<i>Marenzelleria viridis</i>	NWA	1983	B	SF Bay	Hopkins 1986, Cohen and Carlton 1995
<i>Polydora ligni</i>	BC	1932	B, F	C, O, W	Cohen and Carlton 1995
<i>Psuedopolydora kempii</i>	Japan	1940s	B, F, A	C, O, W	Cohen and Carlton 1995
Crustacea					
<i>Balanus improvisus</i>	NA	1853	B, F	C, O, W	Carlton 1979a
<i>Bythotrephes cederstroemi</i>	EUR	1984	B	GL	Carlton and Geller 1993, Yan et al. 1992
<i>Grandidierella japonica</i>	Japan	1930s	OJ, B	C, O, W, BC	Conlan 1990; Carlton 1979a
<i>Jassa marmorata</i>	NA	1800's	F, B	C, O, W, BC	Bennet 1964, Nations 1979, Furlani 1996
<i>Cancer novaezelandiae</i>	NZ	?	B	TAS	Cohen et al. 1995, Miller 1996, J. Chapman Pers. Obs.
<i>Carcinus maenus</i>	EUR?	1989-97	B, Cu	C, O	Carlton et al. 1998
<i>Corophium curvispinum</i>	BS	1970's	B	NEA	Cohen and Carlton 1997, G. Jensen Pers Comm.
<i>Eriocher sinense</i>	Asia	1989-97	B	C, O	Emmett, USFWS, Pers. Com.
<i>Exopalaemon modestus</i>	China	1995	B	CR	

Table B - 10. continued...

Species	Donor Region	Date	Mechanism	Recipient		Reference
				Region	Region	
<i>Hallicarcinus innominatus</i>	NZ	1983?	B	NZ	Furlani 1996	
<i>Nippoleucon hinumensis</i>	Japan	1979	B	C,O,W	Carlton and Geller 1993, Carlton et al. 1990	
<i>Petrolisthes elongatus</i>	NZ	1986?	B	NZ	Furlani 1996	
<i>Pseudodopternus inopinus</i>	China	1990	B	O,W	Cordell et al. 1992	
Mollusca						
<i>Dressinia polymorpha</i>	EUR	1986	B	GL	Mills et al. 1993	
<i>Musculista senhousia</i>	NWP	1990s?	B, F, A	BC	Merilees, 1995, Cohen and Carlton 1995	
<i>Mytilus galloprovincialis</i>	NEA	1800s?	F, B	O	Cohen and Carlton 1995	
Mollusca						
<i>Ensis directus</i>	NEA	1983?	B	EUR	Carlton & Geller 1993	
<i>Nuttallia obscurata</i>	J	1991-97	B, Cu	BC, W, O	Merilees, 1995, Pers. Obs. 1997.	
<i>Potamocorbula amurensis</i>	NWP	1986	B	C	Carlton et al. 1990	
<i>Tritonia plebeia</i>	EUR, NWA	1983	B	NWA	Carlton 1989	
Ectoprocta						
<i>Membranipora membranacea</i>	EUR	1987	B	NWA	Carlton and Geller 1993	
Urochordata						
<i>Botryllus</i> spp.	?	1990s?	B?	NEP	Kozloff 1996	
<i>Botrylloides</i> spp.	?	1990s?	B?	NEP	Kozloff 1996	
<i>Molgula manhattensis</i>	NEA	1900s?	O, B	NEP	Kozloff 1996	
<i>Styela clava</i>	Japan	1900s?	F, B	O, W	Carlton 1996, Kozloff 1996	
Vertebrata						
<i>Gymnocephalus cernuus</i>	NWA	1987	B	GL	Carlton and Geller 1993	

Table B-11. Algal species with potential for introduction to Port Valdez/Prince William Sound. Indicated for each species are donor region(s), recipient region(s), date of first record, probable vector of introduction and reference(s).
 [Source: Table provided by G. Hansen]

Abbreviations/Codes:

Donor/Recipient Regions: AUS=TAS= Tasmania, Australia, AUS=Australia, BC=British Columbia, C-SFB=San Francisco Bay, C=California, CAN-NF=Newfoundland, CAN-NS=Nova Scotia, CAN-Q=Quebec, CH=China, EUR=Europe, FR-BRIT=France, Brittany, FR-MED=French Mediterranean, FR=France, GB=Great Britain, HEL=Heligoland-Germany, IT=Italy, J=Japan, MED=Mediterranean, MX=Mexico, N=Norway, NETH=Netherlands, NE-ATL= Northeast Atlantic, NE-PAC= Northeast Pacific, NW-ATL=Northwest Atlantic, NW-PAC= Northwest Pacific, N-ATL= North Atlantic, N-PAC=North Pacific, NY=New York, Long Island Sound, NZ=New Zealand, O=Oregon, PAC=Pacific, PWS=Prince William Sound, R-ARC=Russian Arctic, White Sea, R-SIB=Siberia, S-ATL= South Atlantic, S-AUS=Southern Australia, S-C=Southern California, SCAN=Scandinavia, SE-AK=Southeast Alaska, SP=Spain, USA-NC=North Carolina, USA-NE=New England, W=Washington
Vector: A=Aquaculture, B=ballast water, L=lobster or bait packing, M=Marginal dispersal through currents, OA=oysters/Atlantic, OJ=oysters/Japan, OBC=oysters British Columbia, ROK=roe-on-kelp, S=scientific research, ?=unknown vector or date

SPECIES	DONOR	RECIPIENT	DATE	VECTOR	REFERENCE
Chlorophyta					
<i>Chara convens</i>	EUR	SCAN	1850	B	Ribera and Boudouresque, 1995
<i>Codium fragile atlanticum</i>	J	NETH, GB, N	1808	?	Silva, 1955; Farnham, 1980, 1994
<i>Codium fragile tomentosoides</i>	J	C-SFB	1977	F	Goff et al., 1992
	USA-NE	CAN-NS	<1989	F	Bird et al., 1993
	EUR	USA-NE	1957	F	Wood, 1962; Carleton and Scanlon, 1985
	USA-NE	USA-NC	1984	F	Searles et al., 1984
	J?	GB	1939, 1900	F	Fletcher et al., 1989; Farnham, 1994; Ribera and Boudouresque, 1995
	J?	NZ	1973	F	Dromgoole, 1975; Adams, 1994; Trowbridge, 1995
	J?	PWS	<1991	B	Hansen, pers. comm.
	R-SIB	SCAN, J	1919	?	Silva, 1957
<i>Codium scandinavicum</i>					
Chrysophyta, Phaeophyceae					
<i>Fucus serratus</i>	GB	CAN-NS	?	B	Date, 1982; Ribera and Boudouresque, 1995
<i>Laminaria japonica</i>	J	FR-MED	1971	OJ	Ribera and Boudouresque, 1995
	J	CH	1930's	A	Ribera and Boudouresque, 1995
<i>Laminaria ochroleuca</i>	FR-BRIT	GB	1948	M	Parke, 1948
<i>Macrocytilis pyrifera</i>	C and MX	CH	1979	A	Lium et al., 1981
<i>Sargassum muticum</i>	J	SEAK to Baja, MX	<1940-1997	OJ	Scagel, 1956; Hansen, 1997; Espinoza, 1990
	J	FR	1972	OJ	Givernaund, 1991
	J, BC	GB	1973	OJ, OBC	Critchley et al., 1983 a, b, 1984; Critchley and Dijkema, 1990
		NETH	1980	M	Prud'homme von Reine and Nienhuis, 1982
		SCAN	1988-89	M	Rueness 1989
		MED	1985	OJ, M	Knoepffler-Peguy et al., 1985

Table B-11 continued

SPECIES	DONOR	RECIPIENT	DATE	VECTOR	REFERENCE
<i>Undaria pinnatifida</i>	J	FR-MED FR-BRIT NZ AUS-TAS GB BC, O AUS N-ATL, J J, CH R-SIB GB J	1971 1983 1987 1982 1995 <1978 1971 ? ? 1983 1983	OJ A F, B B F ? F ? ? F ?	Floch et al., 1991 Castric-Fey et al., 1993 Hay and Luckens, 1987; Hay, 1990; Nelson, 1995 Sanderson and Barrett, 1989; Sanderson, 1990 Fletcher and Manfredi, 1995 Peters and Bremen, 1992 Womersley, 1987 Peters et al., 1993 Peters et al., 1993 Skinner and Womersley, 1983; Adams, 1994 Skinner and Womersley, 1983
<i>Scytothamnus</i> sp.					
<i>Sorocarpus micromorus</i>					
<i>Sphaerotrichia divaricata</i>		BC, NS, GB, MED SCAN, R-ARC AUS-TAS, NZ S-AUS			
<i>Strania attenuata</i>					
<i>Stictyosiphon soritiferous</i>					
Rhodophyta					
<i>Agardhiella subulata</i>	NE-ATL	GB, SP	1973		Farnham, 1994
<i>Anthamion densum</i>	S-ATL	EUR	1960	?	Ribera and Boudouresque, 1995
<i>Anthamion pectinatum</i>	?	FR	1988	A	Curie et al., 1996
	?	IT	1996	A	Curie et al., 1996
<i>Anthamion</i> sp.		NY	<1986	?	Foertch et al., 1995
<i>Anthamionella tenuifolia</i>	S-ATL	GB	1906, 1922	F	Lyle, 1922; Farnham, 1980; Ribera and Boudouresque, 1995
<i>Asparagopsis armata</i>	S-AUS	GB	1922, 1939	F	Ribera and Boudouresque, 1995; Farnham, 1994
<i>Bonnemaisionia hamifera</i>	J	GB	1890, 1911	F	Guiry and Maggs, 1991; Farnham, 1994; Ribera and Boudouresque, 1995
<i>Chondrus giganteus flabellatus</i>	J	FR-MED	1993-94	OJ	?
<i>Cruoria cruoriaformis</i> ?	FR-BRIT	GB	1976	M	Blunden et al., 1981?
<i>Cryptonemia hibernica</i>	?	GB	1971	?	Ribera and Boudouresque, 1995
<i>Furcellaria lumbricalis</i>	GB	CAN-NS	1800's	B	Novaczek and McLachlan, 1989
<i>Gelidium vagum</i>	J	BC, C-SFB	1970's	OJ	Renfrew et al., 1989
<i>Grateloupia doryphora</i>	NE PAC	USA-NE	1990's	B?	Villalard-Bohnsak and Hartin, 1997
	J	EUR	1969	OJ	Ribera and Boudouresque, 1995
<i>Grateloupia filicina</i> var. <i>luxurians</i>	PAC	GB, SP	1947	?	Farnham, 1994
<i>Lomentaria clavellosa</i>	GB, FR	USA-NE	1950's	?	Wilce and Lee, 1964
<i>Lomentaria hakodatensis</i>	J, S-C	BC, W	early 1900's	OJ	South, 1968
<i>Mastocarpus stellatus</i>	NW-ATL	FR-BRIT, MED	1984	A	Cabioch and Magne, 1987; Farnham, 1994
<i>Polysiphonia harveyi</i>	CAN-NF	HEL	1970's	S	Ribera and Boudouresque, 1995
<i>Porphyra yezoensis</i>	J	GB and FR	1976	F?, B?	Maggs and Hommersand, 1990
<i>Soliera chordalis</i>	FR-BRIT	MED		OJ	Ribera and Boudouresque, 1995
<i>Soliera tenera</i>	NW-ATL	GB	1976	M	Farnham and Jephson, 1977
Seagrasses					
<i>Zostera japonica</i>	J	W, BC	early 1900's	OJ	Farnham and Irvine, 1979
					Harrison and Bigley, 1982

Table B-12. Algal species native to Northwestern North America that have been introduced to other global regions. Indicated for each species are donor region(s), recipient region(s), date of first record, probable vector of introduction and reference(s).
 [Source: Table provided by G. Hansen]

Abbreviations:

Donor/Recipient Regions: AUS-TAS= Tasmania, Australia, AUS=Australia, BC=British Columbia, C-SFB=San Francisco Bay, C=California, CAN-NF=Newfoundland, CAN-NS=Nova Scotia, CAN-Q=Quebec, CH=China, EUR=Europe, FR-BRIT=France, Brittany, FR-MED=French Mediterranean, FR=France, GB=Great Britain, HEL=Helgoland-Germany, IT=Italy, J=Japan, MED=Mediterranean, MX=Mexico, N=Norway, NETH=Netherlands, NE-ATL= Northeast Atlantic, NE-PAC= Northeast Pacific, NW-ATL=Northwest Atlantic, NW-PAC= Northwest Pacific, N-ATL= North Atlantic, N-PAC=North Pacific, NY=New York, Long Island Sound, NZ=New Zealand, O=Oregon, PAC=Pacific, PWS=Prince William Sound, R-ARC=Russian Arctic, White Sea, R-SIB=Siberia, S-ATL= South Atlantic, S-AUS=Southern Australia, S-C=Southern California, SCAN=Scandinavia, SE-AK=Southeast Alaska, SP=Spain, USA-NC=North Carolina, USA-NE=New England, W=Washington
Vector: A=Aquaculture, B=ballast water, L=lobster or bait packing, M=Marginal dispersal through currents, OA=oystersAtlantic,OJ=oystersJapan, OBC=oysters British Columbia, ROK=roe-on-kelp; S=scientific research, ?=unknown vector or date

SPECIES	DONOR	RECIPIENT	DATE	VECTOR	REFERENCE
Chlorophyta					
<i>Rosenvingiella polytricha</i>	N-PAC	AUS	1907	?	Farnham, 1994
<i>Chaetomorpha melagonium</i>	N-PAC, N-ATL	AUS	1956		Ribera and Boudouresque, 1995
<i>Cladophora laetevirens?</i>	N-PAC, N-ATL	AUS	1906		Ribera and Boudouresque, 1995
Chrysophyceae-Phaeophyta					
<i>Colpomenia peregrina</i>	PAC	GB	1907		
	ATL	MED	1956		
	PAC	FR-BRIT	1906		
	PAC	USA-NE	1978		
	PAC	MED	1979	OJ	
<i>Leathesia difformis</i>	N-PAC, N-ATL	NZ		F	Adams, 1994
<i>Pilayella littoralis</i>	N-PAC, N-ATL	NZ		F	Adams, 1994
<i>Punctaria latifolia</i>	BC	FR	1972	OBC	Druehl, 1973
<i>Sargassum muticum</i>	NE-PAC	MED	1978		Giaccone, 1978, but see Ribera and Boudouresque, 1995
<i>Scytosiphon dohyi?</i>	PAC	MED	1981	OJ, OBC	Ribera, 1994
<i>Sphaerotrichia divaricata</i>	C	FR-BRIT	1973	A	Farnham, 1994
<i>Macrocystis pyrifera</i>					
Rhodophyta					
<i>Antithamionella spirographidis</i>	Ne and Nw Pac	GB	1920's		Farnham, 1994
<i>Bonnemaisonia hamifera</i>	PAC	AUS	1893		Ribera and Boudouresque, 1995
<i>Ceramium rubrum</i>	N-PAC, N-ATL	GB			Farnham, 1994
<i>Goniotrichopsis sublittoralis</i>	NE-PAC	NZ			Adams, 1994
<i>Grateloupia doryphora</i>	NE-PAC	FR-BRIT, MED	1992		Magne, 1992
<i>Sarcodiotheca gaudichaudii</i>	NE-PAC	GB, S	1969		Farnham, 1994
<i>Pikea californica</i>	NE-PAC	GB	1973		Farnham and Irvine, 1979
<i>Polysiphonia brodiaei</i>	NE-PAC	GB	1967		Farnham, 1994
<i>Polysiphonia harveyi</i>	N-PAC, N-ATL	AUS, NZ			Ribera and Boudouresque, 1995
	NE-PAC	GB	1976		Farnham, 1994

Table B-13 Harmful microalgal species with potential for invasion of Port Valdez/Prince William Sound. Indicated for each species are donor region(s), recipient region(s), date of first record, probable vector of introduction and reference(s).
 [Source: Table provided by G. Hansen]

Abbreviations:

Donor/Recipient Regions. AUS=TAS= Tasmania, Australia, AUS=Australia, BC=British Columbia, C-SFB=San Francisco Bay, C=California, CAN-NF=Newfoundland, CAN-NS=Nova Scotia, CAN-Q=Quebec, CH=China, EUR=Europe, FR-BRIT=France, Brittany, FR-MED=French Mediterranean, FR=France, GB=Great Britain, HEL=Heligoland-Germany, IT=Italy, J=Japan, MED=Mediterranean, MX=Mexico, N=Norway, NETH=Netherlands, NE-ATL= Northeast Atlantic, NE-PAC= Northeast Pacific, NW-ATL=Northwest Atlantic, NW-PAC= Northwest pacific, N-ATL= North Atlantic, N-PAC=North Pacific, NY=New York, Long Island Sound, NZ=New Zealand, O=Oregon, PAC=Pacific, PWS=Prince William Sound, R-ARC=Russian Arctic, White Sea, R-SIB=Siberia, S-ATL= South Atlantic, S-AUS=Southern Australia, S-C=Southern California, SCAN=Scandinavia, SE-AK=Southeast Alaska, SP=Spain, USA-NC=North Carolina, USA-NE=New England, W=Washington
Vector: A=Aquaculture, B=ballast water, L=lobster or bait packing, M=Marginal dispersal through currents, OA=oysters, Atlantic, OJ=oysters, Japan, OBC=oysters British Columbia, ROK=roe-on-keip; S=scientific research, ?=unknown vector or date
Effect: ASP=Amnesic Shellfish Poisoning, DSP=Diarrhetic Shellfish Poisoning, invert.=invertebrate, PSP=Paralytic Shellfish Poisoning

SPECIES	RECORDS	DATE	EFFECT	REFERENCE
1. Cryptogenic species which presently occur between Oregon and Alaska, and which may occur in Port Valdez/Prince William Sound:				
Pyrophyta (Dinoflagellates)				
<i>Alexandrium catenella</i>	C to AK-60 N	early 1900s	PSP	Bressner and Middaugh, 1995; Kvitik et al., 1993
<i>Dinophysis acuminata</i> and <i>D. fortii</i>	FR, CAN-Q, BC, R-SIB	long term	DSP	Cembella et al., 1989; Stamman et al., 1987; Taylor et al., 1994; Konovalova, 1993
Bacillariophyta (Diatoms)				
<i>Chaetoceros concavicornis</i> and <i>C. convolutus</i>	BC, AK	1961	fish kills	Farrington, 1988; Tester and Mahony, 1995
<i>Pseudonitzschia pungens</i> and <i>P. multiseriata</i> , <i>P. australis</i>	CAN-NS, W, O, C	1987	ASP	Wekell et al., 1994; Postel and Horner, 1993
Chrysophyta				
<i>Heterosigma carterae</i>	BC, AK	1976	fish kills	Taylor, 1987; Taylor and Haigh, 1993
2. Species with histories of invasions at sites outside of western North America, which could be introduced to Port Valdez/Prince William Sound:				
Chrysophyta				
<i>Aureococcus anophagefferens</i>	USA-NE	1985	brown tide	Cosper et al., 1990; Shumway, 1990
<i>Chrysochromulina polyplexis</i>	SCAN	1988	fish and invert. kills	Underdal et al., 1989; Aune et al., 1992
<i>Fibrocapsa japonica</i>	FR-BRIT			Ribera and Boudouresque, 1995
Cyanophyta (Bluegreens)				
<i>Nodularia spumigena</i>	SCAN, AUS	1985	trophic effects	Nehring, 1993; Edler, 1985; Jones et al., 1994

Figure B-1. Percent distribution of known nonindigenous marine species among major taxonomic groups for each of six regions in western North America. Percentages are based upon Table B-5 and total number of nonindigenous species is shown for each region (geographic regions as also from Table B-5) in parentheses; the data shown represent the current state of knowledge concerning nonindigenous species in each region (see text for discussion).

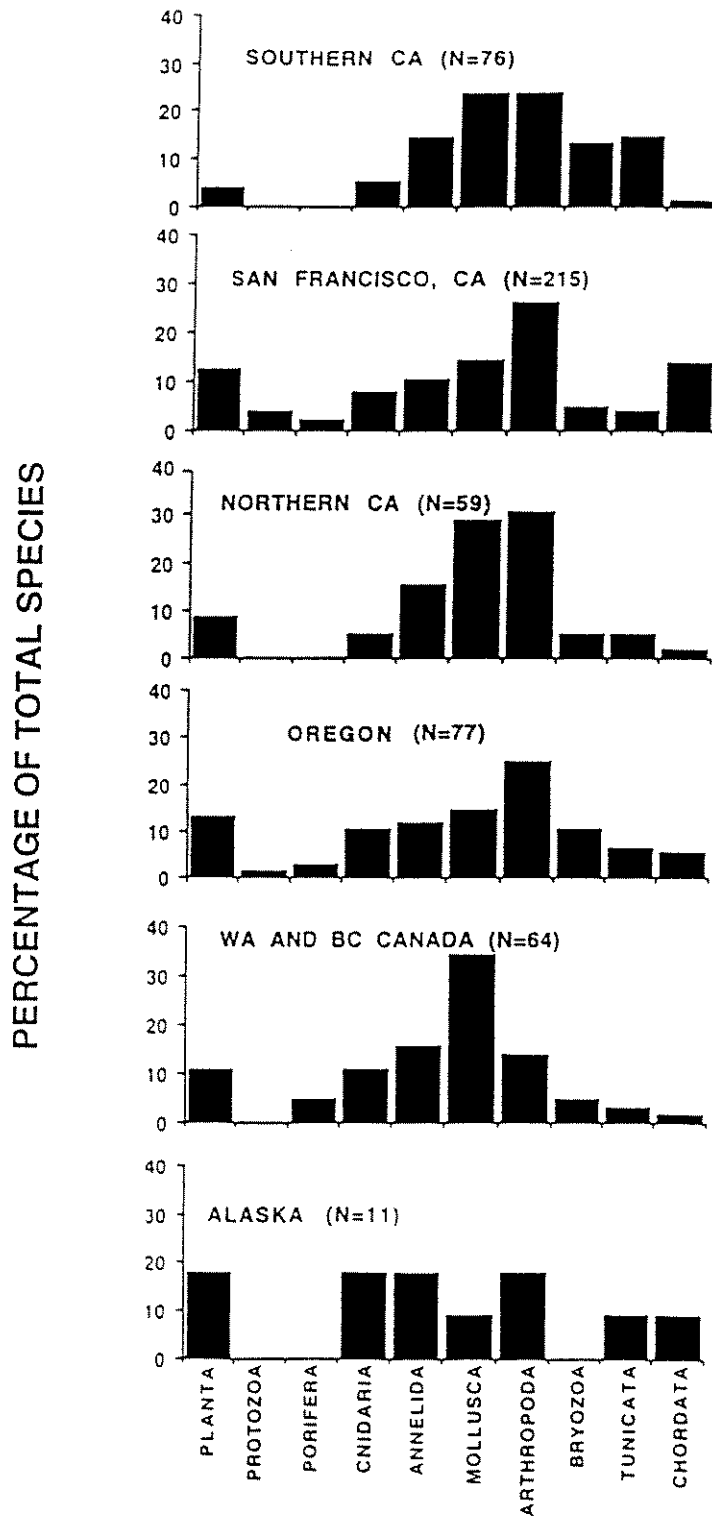


Table C-1. Characteristics of segregated ballast water arriving to Port Valdez, Alaska for each of the 16 oil tankers sampled between 23 May and 6 June 1997. Shown are date of arrival, ballast water source, total ballast water capacity, amount of ballast water on board (as volume and percent capacity) upon arrival, age of ballast water, mean ballast water salinity and temperature. For each ship, the number of tanks that underwent ballast water exchange is also indicated for each ship. Ballast water source corresponds to last port of call in all cases.

Ship Name	Date of Arrival	BW Source	Open Ocean BW Exchange (# tanks)	Total BW Capacity (m3)	Total BWOB (m3)	% Total BW Capacity	Age (days)	Temperature (C°)	Salinity (ppt)
ARCO Spirit	5/23/97	Long Beach, CA	none	38362.79	26752.33	70%	6	16.25	35
ARCO Anchorage	5/25/97	Cherry Pt., WA	none	21873.58	21004.11	96%	4	14.75	29
Baton Rouge	5/26/97	Anacortes, WA	none	37676.73	31447.67	83%	3	11.75	28.25
Long Beach	5/26/97	San Francisco, CA	two	69640.93	60292.88	87%	4	14	32.8
Chevron Mississippi	5/27/97	Anacortes, WA	none	22525.93	19282.02	86%	7	11.75	30.75
Potomac Trader	5/27/97	Cook Inlet, AK	none	17762.19	10271.06	58%	1	11.5	29
ARCO Fairbanks	5/28/97	Cherry Pt., WA	none	36604.02	20979.51	57%	4	14.25	28.5
O/S Washington	5/28/97	Richmond, CA	none	15020.92	no sample	0%	5	no sample	no sample
BT Alaska	6/2/97	San Francisco, CA	none	56392.66	47719.76	85%	6	11	25
S/R North Slope	6/2/97	Portland, OR	none	57450.86	47016.85	82%	4	14	5.25
S/R San Francisco	6/2/97	Anacortes, WA	none	37684.66	29503.51	78%	6	12	28.25
ARCO Juneau	6/2/97	Cherry Pt., WA	none	24428.46	22028.24	90%	4	12.25	28.5
ARCO Independence	6/3/97	Long Beach, CA	none	43413.06	29103.97	67%	6	14	32
OMI Columbia	6/3/97	Barber's Pt., HI	none	22118.90	16293.81	74%	9	13.25	34.75
Prince William Sound	6/4/97	Yosu, Korea	all	41972.01	25562.63	61%	10	11	30
Benecia	6/6/97	Benecia, CA	two	53360.91	47418.37	89%	6	12.8	17.5

Table C-2 Salinity and Temperature of water in Port Valdez at the site and time of arrival for oil tankers sampled between 23 May and 6 June 1997. Shown are mean values (n=2) for measures taken the surface and 10m depth, within 100m of the respective tankers.

Ship Name	Shipside Salinity @ Surface (ppt)	Shipside Salinity @ 10 meters (ppt)	Shipside Temperature @ Surface (C°)	Shipside Temperature @ 10 meters (C°)	
ARCO Spirit	29	30	14	9	9
ARCO Anchorage	27	32	10	5	5
Baton Rouge	23	29	10	6	6
S/R Long Beach	20	32	12	5	5
Chevron Mississippi	27	32	14	8	8
Potomac Trader	25	31	14	9	9
ARCO Fairbanks	22	31	11	9	9
O/S Washington	no sample	no sample	no sample	no sample	no sample
BT Alaska	21	31	13	9	9
S/R North Slope	21	31	13	9	9
S/R San Francisco	21	31	13	9	9
ARCO Juneau	21	31	13	9	9
ARCO Independence	21	31	13	9	9
OMI Columbia	20	31	12	5	5
Prince William Sound	no sample	no sample	no sample	no sample	no sample
S/R Benecia	no sample	no sample	no sample	no sample	no sample

Table C-3 Density of organisms (#/m³) in each taxonomic group that occurred in plankton samples collected from segregated ballast water of 14 different oil tankers arriving to Port Valdez, Alaska between 23 May and 6 June, 1997. Shown are the means and standard errors (for 2 tanks/ship) obtained from quantitative analysis of preserved samples; estimates for abundance within tanks were based upon two vertical net tows (see text for explanation). A grand mean and standard error among all ships is also shown, and was calculated using the estimated density (mean) for each ship. All data presented here were from ballast water of domestic and coastal origin ballast water of foreign origin, and unchanging ballast water is treated in a separate analysis. All organisms were considered to be alive at time of collection, based upon initial observations that demonstrated >95% of organisms in all samples were alive.

	ARCO Spirit		ARCO Anchorage		Bacon Rouge		Petrobras Trader		Chevron Mississippi		ARCO Fueltanks		SR North Slope		ARCO Juneau		SR San Francisco		BT Alaska		ARCO Independence		OMI Columbia		Long Beach		Genesee		Total											
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE										
DINOFAGELLATA																																								
Ceratium			0.82	0.82	1.75	1.75			53.62	53.65																														
Peridinium sp.			7.54	4.25	327.29	16.41	8.66	5.77	271.02	271.17	160.76	45.04	19.42	11.87	4.14	4.14	40.78	7.49																						
DIATOMACEA																																								
Discoid			52.81	14.98	1944.51	128.16	184.78	88.62	2983.59	535.23	1881.88	78.17	133.80	35.71	595.02	215.97	1489.61	238.14	195.93	145.60	63.17	33.70	5.52	1.98	499.55	473.29	90.13	34.04	22.16	255.25	189.87	103.47								
Centrate					231.51	213.63	24.54	10.11	1121.34	252.44	1055.89	281.61	95.24	27.53	88.60	66.55	14.98	14.99	2.02	2.02																				
Pennate			13.26	13.27	189.71	25.55	14.44	5.77			348.53	348.73	5.22	5.22																										
PROTOZOA																																								
Foraminifera	29.34	8.39					2.89	2.89	1.75	0.53							7.07	6.24			1.63	1.63																		
Tintinnida	1.57	1.57					1.44	1.44	0.20	0.20	1.81	1.81							4.04	4.04	4.36	0.01	0.18	0.18																
unid. medusae	4.32	3.54	4.42	4.42	181.04	13.38			0.20	0.20	4.82	1.81					12.07	1.25	4.04	4.04	87.09	69.65	0.18	0.18																
CTENOPHORA																																								
Turbellaria	11.53	1.05			46.99	8.57			4.23	2.62	1.29	1.29	1.30	1.30			0.83		11.12	7.08	4.64	1.37	0.18	0.18																
PLATYHELMINTHES																																								
Müller's goby larvae	84.97	16.78			5.77				2.02	2.02																														
NEMERTEA																																								
pillidium larvae	11.53	11.53															0.69	0.69																						
ANNELIDA																																								
Polydoridae	19.91	9.44	5.41	0.49	0.41	0.43	1.44	1.44																																
Phyllodoctidae	24.53	2.62			6.50	6.50	1.44	1.44																																
Sporididae	176.58	12.06	35.61	2.71	202.05	25.01	8.66	2.89	1.43	1.43	7.72	7.72	0.31	0.31	33.60	9.19	18.72	2.91	9.09	9.10	21.26	0.59	0.14	0.14																
Hephythidae	50.82	17.30	1.47	1.47	5.22	1.73																																		
Syllidae	3.14	3.15			0.43	0.43					0.80	0.80																												
Dorvilleidae	26.20	19.92																																						
Caprellidae			8.70	2.81	688.59	268.67	1.44	1.44			30.87	30.88					7.94	7.94																						
Owenidae			7.71	1.13	5.45	1.98																																		
Megaloniadae	74.40	28.21	154.77	72.28	325.48	48.04	51.97	8.66	79.10	31.02	306.08	44.61	3.82	1.21	166.51	0.51	460.21	184.02	106.10	164.14	30.86	13.03	25.87	14.81	64.09	11.72														
MOLLUSCA																																								
Gastropoda	49.78	8.91	69.71	18.72	1891.36	141.71	43.31	5.77	20.21	10.52	93.02	11.56	1.30	1.30	276.84	59.28	111.93	53.71	184.92	170.87	21.80	5.41	5.14	3.35	156.21	82.19	1.19	1.19	206.91	131.40	490.41	214.71								
Bivalvia	147.76	7.34	417.11	104.62	2896.87	984.53	125.59	4.33	108.88	20.47	138.65	30.56	3.49	1.54	519.51	137.54	526.36	211.08	1542.04	1514.59	3.27	0.01	0.88	0.88	437.39	49.70														
Pteropoda	26.20	26.21																																						
unknown veliger nudibranch	1.05	1.05																																						
CRUSTACEA																																								
Copepoda	44.54	7.86	83.79	39.61	1077.89	32.94	86.61	31.76	12.66	5.00	224.10	2.25			419.75	99.88	112.34	55.79	2099.84	2096.97	284.74	199.64	4.28	2.51	4317.71	387.56	19.10	19.10	827.67	323.55										
nauplii	81.21	9.96	57.99	22.63	332.16	126.16	85.17	7.22	10.70	5.85	182.63	177.58	1.30	1.30	31.02	2.73	104.44	2.91	170.78	160.78	103.11	40.02	1.07	0.01	6.01	3.62	0.62	0.62	83.44	25.17										
cypriids	373.06	96.46	1568.38	165.55	2052.09	249.78	567.33	36.09	148.05	19.71	3260.27	83.64	1142.04	284.41	468.80	104.05	654.51	304.33	266.77	242.66	394.18	85.99	3.74	0.91	669.06	298.97	342.31	187.76	850.04	239.19										
Copepoda	7301.48	948.39	1242.98	255.77	3013.39	194.56	144.36	49.08	53.27	7.20	1389.63	18.68	554.80	154.71	622.89	194.99	704.86	69.11	2043.25	2032.26	1106.91	111.23	8.90	2.53	2398.01	519.76	791.51	268.93	1526.86	504.18										
nauplii					3.49	3.50	14.44	5.77	0.40	0.40	3.22	3.22	6.38	1.16	43.94	20.25	24.13	2.50	5.05	5.05																				
copepodites																																								
Haracticoida																																								
Microsetella sp.																																								
Eutima sp.																																								
unknown Haracticoid																																								
unknown benthic Harp.																																								
Cyclopoida																																								
Clithona spp.	816.86	411.54	28.58	10.90	1.74	1.74	2.89				18.08	9.65			46.62	27.24	23.72	12.91	16.17	16.18	124.95	54.24	0.36	0.36	311.71	1.08	1621.07	893.94	72.91	66.46										
Limnithona sp.											19.61	3.64	935.55	133.20			7.49	4.19	13.14	3.03	39.77	15.74																		
Cyclopoida sp.	460.57	146.27																																						

Copepoda cont.

Table C-4. Summary of quantitative plankton analysis for segregated water of 13 different oil tankers arriving to Port Valdez, Alaska from continental domestic ports between 23 May and 6 June 1997. Shown are the ship sample number, number of species, cumulative density for all taxonomic groups, total ballast water on board at the time of arrival, and estimated total number of organisms in all ballast water on board for each vessel; a mean and standard error are also shown for all biological and volume estimates among ships. Taxonomic diversity (minimum # species) and density (organisms/m³) measures were obtained from quantitative analysis (see Table C-3). Total number of organisms per ship were calculated as the product of total ballast water volume on board and organism density.

SHIPNAME	SHIP#	MINIMUM # SPECIES	TOTAL # ORGANISMS MS/M ³	TOTAL VOLUME (M ³)	TOTAL # ORGANISMS
ARCO SPIRIT	AK001	26.00	11,215.51	26,752.33	300,041,025
ARCO ANCHORAGE	AK002	17.00	3,997.72	21,004.11	83,968,551
LONG BEACH	AK003	15.25	11,752.03	60,292.88	708,563,735
BATON ROUGE	AK004	29.25	16,493.91	31,447.67	518,695,039
POTOMAC TRADER	AK005	19.00	1,452.25	10,271.06	14,916,147
CHEVRON MISSISSIPPI	AK006	15.00	4,986.72	19,282.02	96,154,035
ARCO FAIRBANKS	AK007	20.00	9,831.76	20,979.51	206,265,507
S/R NORTH SLOPE	AK009	11.50	3,128.55	47,016.85	147,094,566
ARCO JUNEAU	AK010	22.00	3,840.57	22,028.24	84,600,998
S/R SAN FRANCISCO	AK011	26.00	4,887.10	29,503.51	144,186,604
BT ALASKA	AK012	12.75	13,500.41	47,719.76	644,236,325
ARCO INDEPENDENCE	AK013	24.00	2,834.68	29,103.97	82,500,442
BENEZIA	AK016	11.00	3,085.96	47,418.37	146,331,193
MEAN		19.13	7,000.55	31,755.41	244,427,243
SE		1.66	1,355.89	4,026.34	63,878,556.94

Table C-5. Comparison of quantitative plankton analysis for segregated ballast water arriving to Port Valdez, Alaska in oil tankers of domestic and foreign origin between 23 May and 6 June, 1997. Shown are the densities (number/m³; mean and standard errors for two tanks) by taxonomic group obtained from a single foreign arrival compared to the mean density measures (number/m³) for 14 domestic arrivals. Ballast water sampled for the single foreign arrival originated in Korea but all tanks had been exchanged at sea; ballast water included here for domestic arrivals was of coastal origin (from last port of call) and was not exchanged in transit.

	Nonexchange Ships (n=14)		Exchange Ship (n=1)	
	Mean	SE	Mean	SE
DINOFAGELLATA				
Ceratium	4.40	3.80	1.60	0.17
Peridinium sp.	59.68	29.55	3.59	3.59
DIATOMACEA				
Discooid	722.16	255.25	91.64	54.86
Centrale	186.87	103.47	29.95	1.65
Pennate	40.80	27.20	-	-
"PROTOZOA"				
Foraminifera	3.31	2.08	2.87	2.87
Tintinnida	0.96	0.40	95.70	26.38
CNIDARIA				
unid. medusa	22.68	13.63	-	-
CTENOPHORA				
PLATYHELMINTHES	0.03	0.03	-	-
Turbellaria	5.86	3.34	-	-
Müller's/Götte's larvae	5.41	4.60	-	-
NEMERTEA				
pillidium larvae	0.87	0.82	-	-
ANNELIDA				
Polynoidae	4.58	2.80	-	-
Phyllodoctidae	2.38	1.63	-	-
Spionidae	97.71	60.64	-	-
Nephtyidae	4.61	3.59	0.72	0.72
Chaetopteridae	-	-	0.72	0.72
Syllidae	0.38	0.23	-	-
Dorvilleidae	1.87	1.87	-	-
Capitellidae	1.03	0.72	-	-
Owenidae	53.87	48.90	-	-
Mageloniidae	0.73	0.50	-	-
unknown larvae	138.68	39.26	-	-
MOLLUSCA				
Gastropoda	206.91	131.40	10.72	3.64
Bivalvia	490.41	214.71	0.72	0.72
Pteropoda	0.03	0.03	-	-
unknown veliger	1.88	1.87	-	-
nudibranch	0.07	0.07	-	-
CRUSTACEA				
Cirripedia				
nauplii	627.67	323.55	8.57	2.92
cyprids	83.44	25.17	6.40	2.09
Copepoda				
nauplii	850.04	239.19	2805.51	891.42
copepodites	1526.86	504.18	1757.46	274.84
Haracticoida				
Microsetella sp.	7.80	3.31	1.43	0.01
Eutropina sp.	58.96	58.55	-	-
unknown Harpacticoid	5.75	3.34	-	-
unknown benthic Harp.	3.07	2.02	-	-
Cyclopoidea				
Oithona spp.	215.05	123.30	769.29	150.27
Limnottiona sp.	72.91	66.46	-	-
Cyclopinia sp.	33.40	32.88	-	-
Copepoda, cont.				
Copepoda, cont...				
Calanoida				
Acartia sp.	651.54	469.51	35.06	18.08
Calanus sp.	0.98	0.47	45.77	20.30
Centropages sp.	1.99	0.74	2.83	2.83
Metridia sp.	0.13	0.13	-	-
Paracalanus sp.	37.28	18.56	-	-
Pseudocalanus sp.	76.58	24.44	34.30	11.66
Pseudodiaptomus spp.	7.25	7.21	-	-
Rhincalanus sp.	0.03	0.03	-	-
Tortanus sp.	8.38	5.22	-	-
Pontellid	6.15	4.04	-	-
Labidocera sp.	0.05	0.04	-	-
Poecilostoma				
Corycaeid	63.24	40.09	-	-
Hemicyclops sp.	0.65	0.62	-	-
"Rudolph"	1.75	1.41	-	-
Amphipoda				
Gammaridea	0.03	0.02	-	-
Hyperidea	0.15	0.10	-	-
Isopoda	0.19	0.07	0.71	0.71
Decapoda				
zoa	25.10	18.36	0.71	0.71
megalopa	0.41	0.19	-	-
Caridea				
Cladoceran	0.02	0.01	-	-
Anomura	2.96	2.24	-	-
Porcellanid zoa				
Pegurid zoa	0.40	0.38	-	-
Mysidacea	0.52	0.32	-	-
Cumacea	3.66	1.59	-	-
Stomatopoda	0.21	0.09	-	-
Ostracoda	0.13	0.13	-	-
0.24	0.24	-	-	
BRYOZOA				
0.06	0.06	-	-	
10.51	4.38	28.56	7.34	
5.46	3.37	-	-	
9.66	4.46	0.71	0.71	
PHORONIDA				
cyphonautes larvae	16.70	15.52	1.44	1.44
CHAETOGNATHA				
ECHINODERMATA				
Asteroidea	1.02	0.87	-	-
Echinoidea	-	-	-	-
CHORDATA				
Larvacea	17.59	8.12	3.58	2.17
Fish	0.08	0.07	-	-
0.06	0.06	-	-	
Cephalochordate				
OTHER				
Eggs	20.62	8.92	278.26	135.38
unknown larvae	3.50	3.29	-	-
trochophore	34.67	11.64	3.92	0.39
pollen	8.84	8.16	-	-

Figure C-1. Comparisons of salinity and temperature measured for segregated ballast water arriving to Port Valdez, Alaska in oil tankers and for surrounding port waters at the time of deballasting. Shown are mean (and standard errors) for ballast water and port water. For the port, data are shown for measures at both the surface and 10m, as significant stratification existed; such stratification was not present within the ballast tanks. Data are shown in Tables C-1 and C-2. For each salinity and temperature, letters which differ above histograms indicate significant differences in pairwise comparisons.

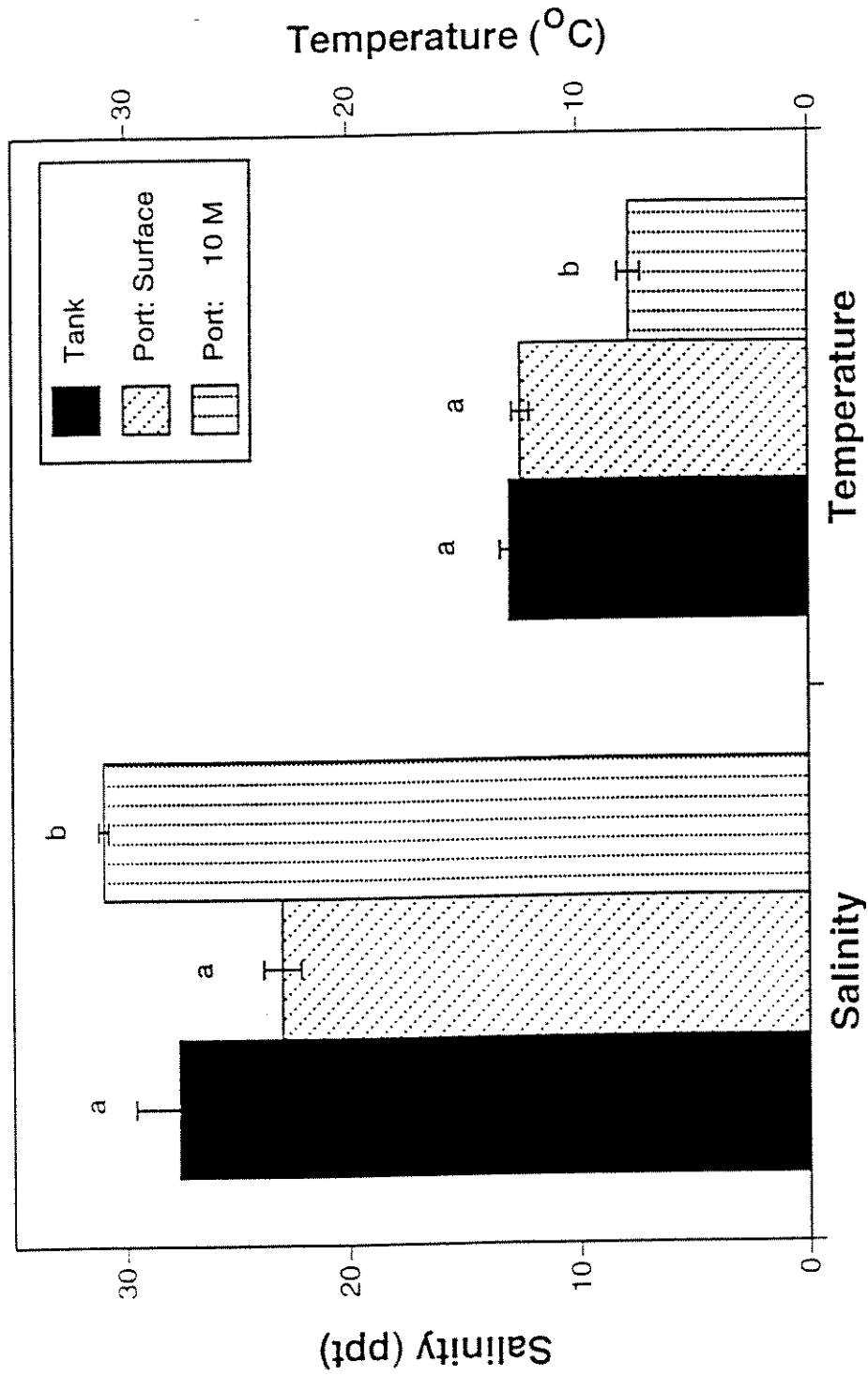


Figure C-2. Relationship between density of organisms in segregated ballast water arriving to Port Valdez, Alaska in oil tankers from domestic ports and age of ballast water. Density measures were those derived from quantitative analysis of plankton samples, and age indicates the number of days since the ballast water was gravitated or pumped aboard.

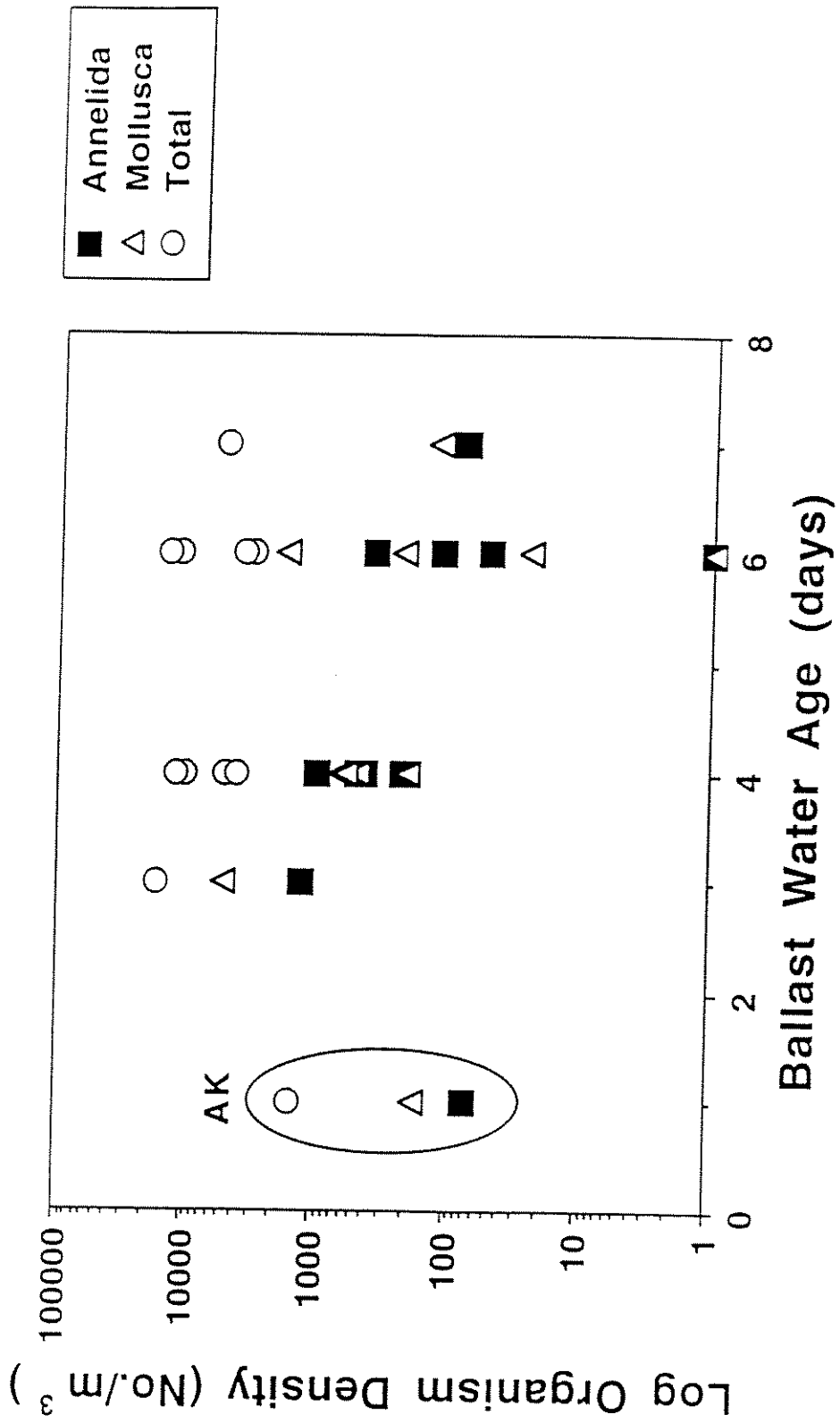


Figure C-3. Comparison of densities for planktonic organisms measured in non-exchanged ballast water of ships from domestic ports versus exchanged ballast water of a single ship from a foreign port. Shown are means and 95% confidence intervals of all non-exchanged ballast samples for the respective taxa.

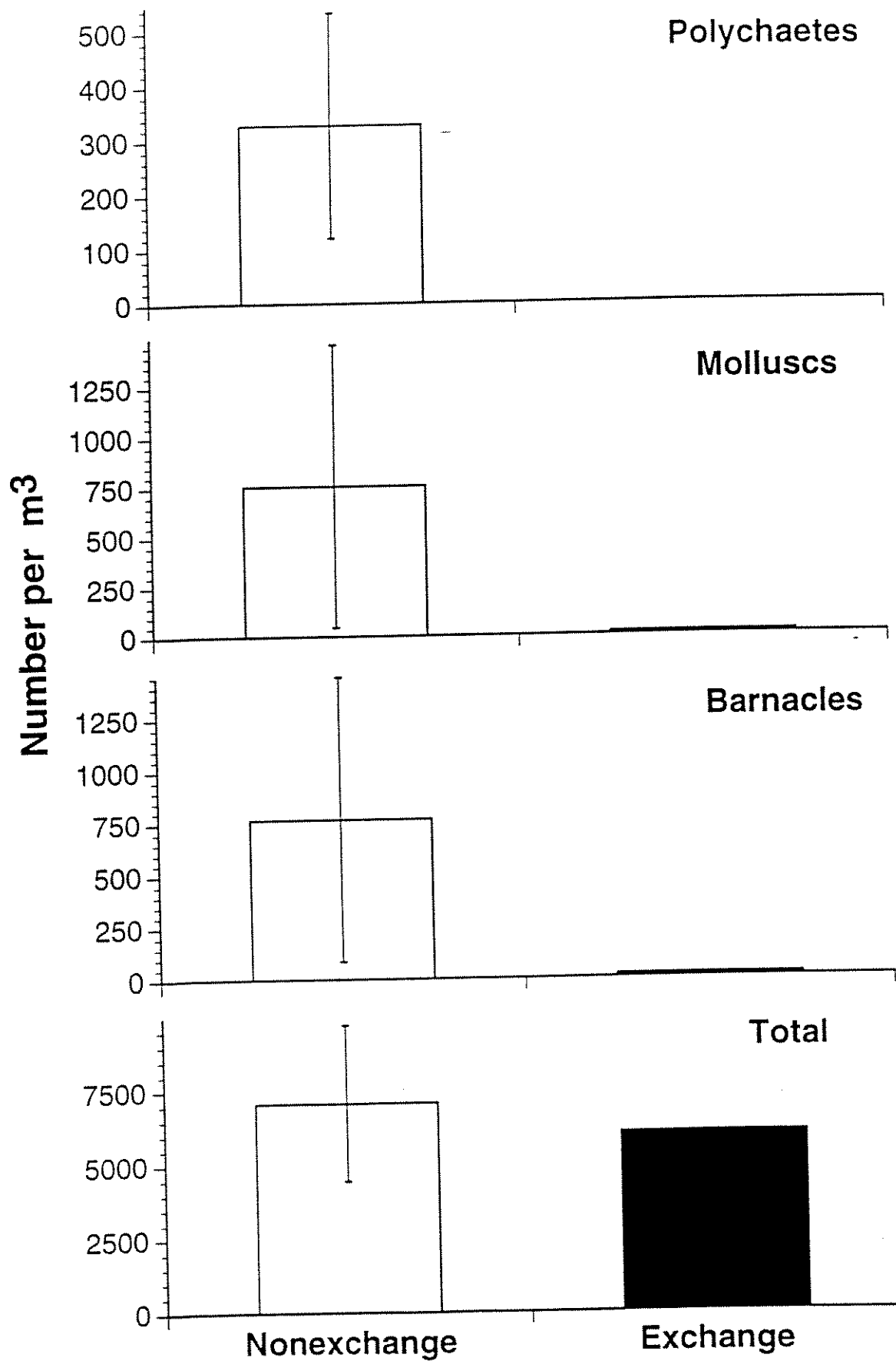


Table D-1. Characteristics of ballast water sampled on two oil tankers that conducted experimental ballast water exchange with segregated ballast water en route to Port Valdez from San Francisco Bay. Shown are the sources of ballast water, location of ballast water exchange, amount (%) of ballast water exchanged, method of exchange, tanks (exchanged and non-exchanged) that were sampled, and the salinities of sampled tanks for each ship.

Ship	Long Beach	Benecia
Original BW Source	San Francisco, CA	Benecia, CA
Exchange BW Source	500-600 mi offshore British Columbia	500-600 mi offshore British Columbia
% Exchanged	300%	100%
Method of Exchange	Flow Through	Flow Through
Original BW Tanks	2 Starboard, 4 Port	2 Starboard, 4 Port
Exchange BW Tanks	4 Starboard, 2 Port	4 Starboard, 2 Port
Original BW Salinity	32 ppt	10 ppt
Exchange BW Salinity	35ppt	25 ppt

Table D-2. Comparison of plankton densities in exchanged versus non-exchanged segregated ballast water following ballast water exchange experiment aboard two tankers en route to Port Valdez from San Francisco Bay in May-June 1997. Densities ($\#/m^3$) and standard error are shown for each taxonomic group by treatment and ship; values shown represent means for 2 tanks (estimated by 2 net tows), based upon quantitative analysis.

	Long Beach				Benecia			
	Exchanged BW		Nonexchanged BW		Exchanged BW		Nonexchanged BW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Dinoflagellata	182.48	162.63	1.20	1.20	246.24	201.95	-	-
Diatomacea					2670.42	2422.57	90.13	34.04
Discoid	1686.09	590.31	499.55	473.29	18.11	16.33	-	-
Centrate	781.93	332.70	-	-	-	-	-	-
Protozoa					5.41	1.72	-	-
Foraminifera	35.44	30.47	3.61	3.61	-	-	-	-
Tintinnida	3.07	1.21	-	-	-	-	-	-
Platyhelminthes			1.20	1.20	-	-	-	-
Turbellaria	-	-	-	-	-	-	-	-
Nemertea	0.16	0.16	-	-	-	-	-	-
Annelida								
Polychaeta								
Chaetopteridae	0.62	0.62	-	-	-	-	-	-
Magelonidae	0.67	0.67	4.78	4.78	-	-	-	-
Nephtyidae	-	-	4.78	4.78	-	-	-	-
Phyllodoceidae	-	-	1.19	1.19	-	-	-	-
Polynoidae	0.27	0.27	35.89	19.03	-	-	-	-
Spionidae	9.58	4.62	852.55	252.96	0.62	0.62	0.62	0.62
unknown larvae	9.92	0.01	64.69	11.72	0.59	0.59	-	-
Mollusca								
Bivalvia	3.12	2.50	437.39	49.70	0.62	0.62	-	-
Gastropoda	8.90	0.21	156.21	82.19	3.05	1.87	1.19	1.19
Pteropoda	0.16	0.16	-	-	0.15	0.15	-	-
Crustacea								
Cirripedia							0.62	0.62
cyprids	0.54	0.54	6.01	3.62	-	-	-	-
nauplii	129.19	16.57	4317.71	387.56	3.86	3.86	19.10	19.10
Copepoda								
copepodites	239.16	28.51	2398.01	519.76	454.53	170.40	791.51	282.93
nauplii	637.30	79.99	669.06	298.97	609.27	345.35	342.31	187.76
Acartia sp.	5.23	1.20	1506.13	210.62	-	-	-	-
Calanus sp.	2.02	0.15	-	-	-	-	-	-
Centrophages sp.	-	-	4.82	4.82	-	-	-	-
Cyclopea sp.	1.24	1.24	-	-	-	-	-	-
Eutropina sp.	-	-	3.58	3.58	-	-	-	-
Labidocera sp.	-	-	0.30	0.30	-	-	-	-
Metridia sp.	0.31	0.31	1.81	1.81	-	-	-	-
Microsetella sp.	-	-	5.87	5.87	4.16	4.16	-	-
Oithona spp.	94.62	8.07	311.71	1.08	213.49	84.32	1621.07	831.94
Paracalanus sp.	0.62	0.62	6.04	6.04	0.62	0.62	-	-
Pontelid	-	-	9.46	3.79	-	-	-	-
Pseudocalanus sp.	18.18	12.90	260.73	61.95	-	-	-	-
Pseudodiaptomus spp.	-	-	-	-	1.98	0.79	100.93	13.68
Tortanus sp.	0.93	0.93	3.00	0.91	-	-	11.66	3.30
Benthic Harpacticoid	-	-	-	-	42.98	14.68	28.14	4.27
Harpacticoid	-	-	-	-	34.42	33.24	-	-
Amphipoda	-	-	0.15	0.15	1.20	0.28	0.31	0.31
Cumacea	-	-	-	-	-	-	-	-
Decapoda	-	-	0.15	0.15	-	-	-	-
zoa	-	-	-	-	-	-	0.75	0.44
Isopoda	-	-	-	-	2.40	1.17	20.68	2.60
Mysidacea	-	-	-	-	-	-	50.54	31.84
Bryozoa			1.20	1.20				
Phoronida	0.16	0.16	-	-	-	-	-	-
Chaetognatha							1.19	1.19
Chordata								
Larvacea	39.59	16.94	38.23	31.01	-	-	0.15	0.15
Fish	-	-	-	-	-	-	-	-
Other								
Blue Green Algae	1.24	1.24	-	-	1.85	1.85	4.91	1.33
Eggs	5.18	1.89	2.39	2.39	-	-	-	-
trochophore	5.57	2.47	142.63	10.19	-	-	-	-
unknown larvae	0.47	0.47	-	-	-	-	-	-

Table D-3. Comparison of plankton densities measured on each of three consecutive days in two ballast tanks of the Arco Juneau, 2-4 June 1997. Density (#/m³) and standard errors are shown for each taxonomic group by tank and day; values represent means of 2 net tows for each tank and day.

	TANK 1						TANK 2											
	Day1		Day2		Day3		Day1		Day2		Day3							
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE						
DINOFLAGELLATA																		
							8.28	8.28										
									8.28	8.28	1.44	8						
DIATOMACEA																		
							379.12	77.57	369.19	122.18	278.63	31.62	81.88	176.28	498.87	49.69	75.34	3
							155.12	37.35	147.77	139.56	11.49	11.49	22.83	22.87	322.97	256.78	5.75	17
									1.44	1.44								
"PROTOZOA"																		
															5.53	5.52		
																		3
CNIDARIA																		
							19.39	6.46	31.15	9.67	8.43	57.46	19.32		6.73	11.43	12.17	19
PLATYHELMINTHES																		
									1.38	1.38					5.53	2.77	2.77	3
															1.38	1.38		
NEMERTEA																		
													1.38	1.38				
ANNELIDA																		
													1.38	1.38				
													1.38	1.38	1.38	1.38		
							24.42	1.44	46.84	19.23	43.86	2.87	42.79	1.38	64.87	4.33	12.37	19
									9.66	9.66			4.15	4.14	22.83	22.87		
											0.72	0.72					0.36	1
													15.87	1.35				
																	2.77	3
							185.99	55.34	25.68	17.46	68.94	88.98	187.18	14.22	149.62	91.17	1.36	23
MOLLUSCA																		
							217.59	3.59	445.78	129.11	33.34	66.78	336.86	21.40	498.25	4.14	99.48	17
							382.44	19.17	686.56	373.54	413.64	126.49	656.98	88.35	843.36	1.77	157.65	19
CRUSTACEA																		
							379.89	82.60	291.38	1.24	215.44	2.87	459.68	34.51	274.67	51.75	26.17	17
							33.75	13.65	72.13	16.92	89.48	8.62	28.29	3.45	55.28	2.77	23.30	6
							364.89	66.78	51.37	11.12	1183.47	821.66	572.79	299.55	182.81	356.15	17.35	38
							428.39	221.22	668.22	19.69	1347.27	215.48	817.77	326.47	1246.33	92.49	441.65	97
							23.70	2.15	33.74	2.14	28.73	17.24	64.18	22.78	56.59	15.18	24.60	23
									6.96	4.85								
									8.62	8.62	5.75	5.75			4.15	4.14	2.65	6
							22.26	0.72	5.70	1.93	295.87	238.45	4.72	8.97	142.16	51.75	245.18	317
										3.23	2.51						1.26	
									2.87	2.87	2.18	2.12					1.57	
							16.52	6.46	87.57	55.98	8.32	2.87	53.14	4.83	128.36	75.92	15.13	6
							17.95	7.96	51.26	29.18	71.81	43.94	4.72	0.69	85.57	19.33	8.82	3
															1.38	1.38		
							1.44	1.44	22.92	2.17	6.32	2.87	1.38	1.38	4.15	4.14	12.37	8
							19.39	9.34	1.38	1.38			4.26	37.27	4.15	1.38		
									9.66	9.66	22.90	17.24			26.22	12.42	0.34	19
							9.34	7.96	22.64	6.82	25.85	14.36	15.18	4.14	33.12		1.99	8
									5.75	5.75							11.43	8
							0.36	0.36	1.38	1.38	0.36	0.36	0.35	0.35	0.35	0.35	0.18	0
							0.36	0.36	2.87	2.87	1.80	1.80	3.15	2.42	1.73	1.35	4.62	6
							331.57	16.17	356.30	149.29	795.69	152.27	189.78	72.47	455.47	12.16	384.91	33
									7.13	4.37	28.73	5.75	1.73	0.35	8.97	7.59	8.17	23
										0.36	0.36	0.35	0.35	0.35	0.35	0.18		
												13.83	5.52					
											1.44	1.44					0.72	
							1.54	4.39	2.87	2.87	2.15	0.72	0.69	0.69	0.69	0.69	0.33	1
							0.36	0.36					8.28	8.28	3.80	1.35		
									0.35	0.35	0.72	0.72					0.36	
									5.75	5.75	14.72	14.56	0.69	0.69	2.74	0.69	4.24	
							0.36	0.36	1.44	1.44	3.60	3.59			0.35	0.35	1.80	1
									4.39	4.39	17.24	11.49					0.23	8
CHAETOGNATHA																		
ECHINODERMATA																		
									7.18	7.18	25.85	25.86	4.15	4.14	5.53		11.92	19
													1.38	1.38				
CHORDATA																		
															1.38	1.38		
							38.78	12.93	25.12	16.40	28.73	11.49	81.43	81.44	82.19	23.47	2.99	6
OTHER																		
									21.54	21.55							2.77	3
							5.27	0.72	4.15	4.14	2.87	2.87	33.12	11.43	24.84	2.77	1.44	

Figure D-1. Percent reduction during ballast water exchange experiment of taxa that derived from the original coastal source and were relatively abundant in non-exchanged tanks. Shown is the percent reduction for each taxonomic group by ship, as calculated from mean densities in Talbe D-2. Missing bars indicate that the respective taxa were not of sufficient abundance to estimate changes for that vessel (see text).

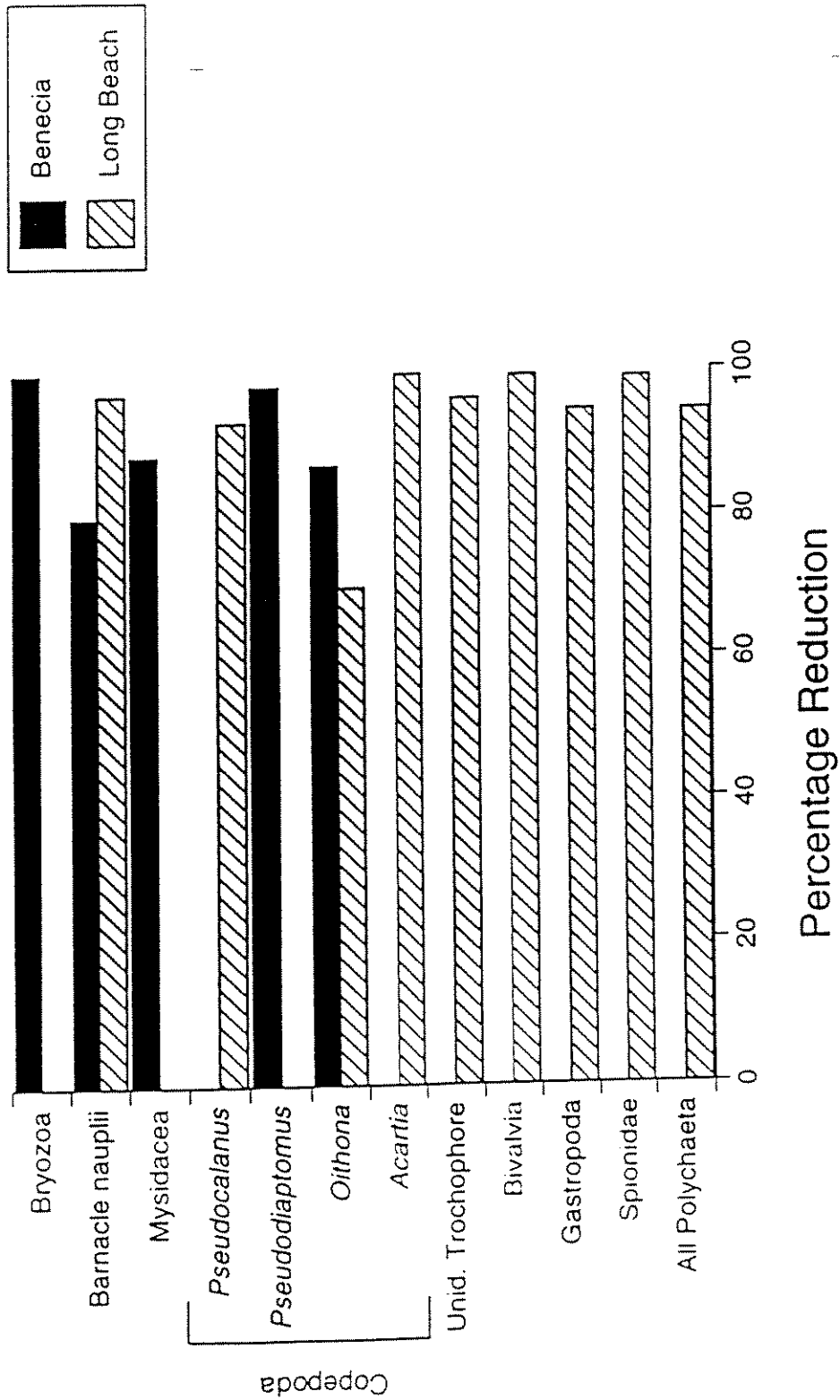


Figure D-2. Percent increase during ballast water exchange experiment of taxa that derived from oceanic waters and were relatively abundant in exchanged tanks. Shown is the percent increase for each taxonomic group by ship, as calculated from mean densities in Table D-2. Missing bars indicate that the respective taxa were not of sufficient abundance to estimate changes for that vessel (see text).

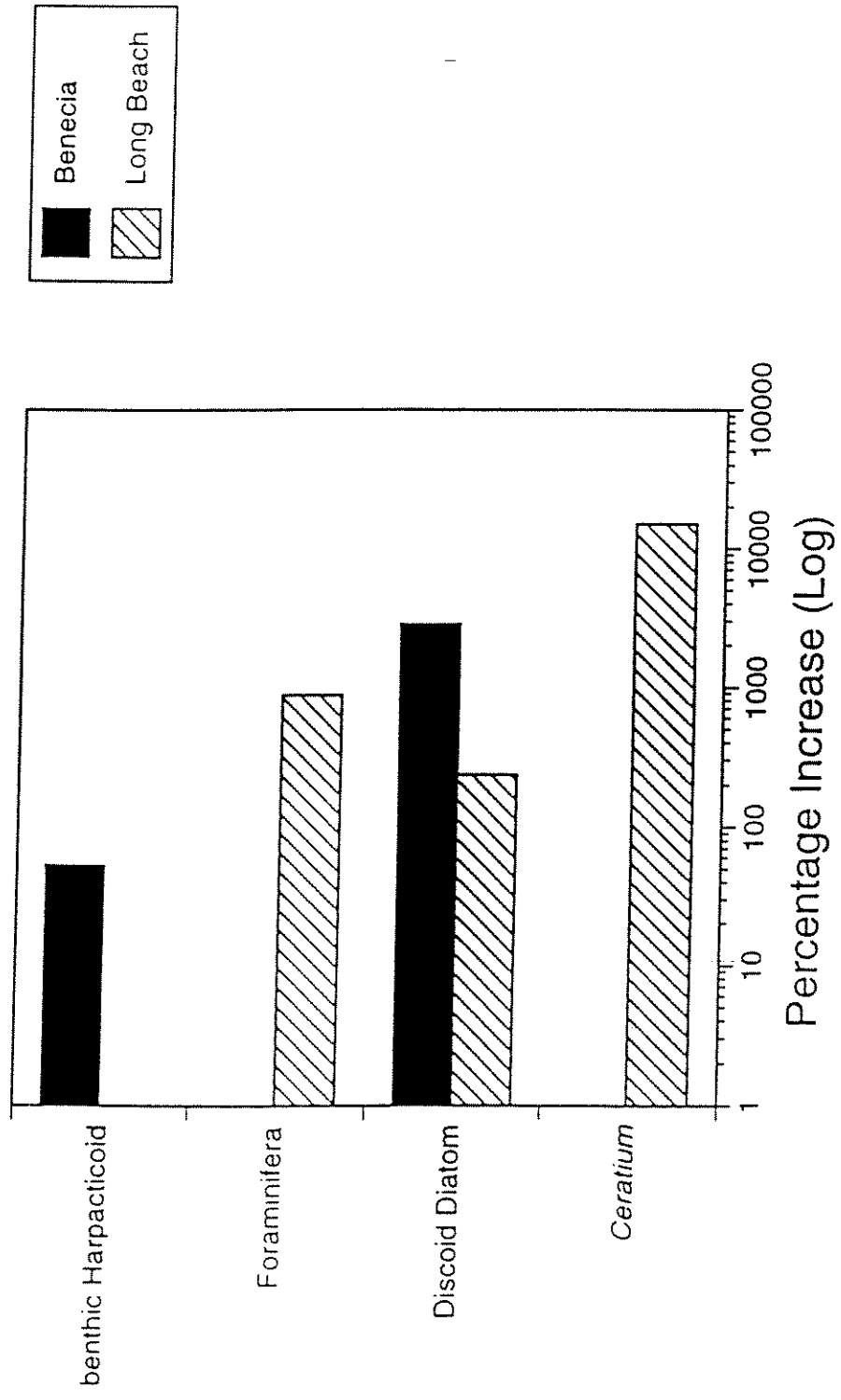


Table E-1. Characteristics of all ballast water arriving to Port Valdez, Alaska for each of 16 oil tankers. Shown are the sources and volumes of clean (segregated) and oily (nonsegregated) ballast water, percent of total ballast water that is nonsegregated, and date of arrival for each vessel. Mean and standard errors are also given for the three volume characteristics (EX indicates ships that conducted some open ocean ballast water exchange; BWOB denotes Ballast Water on Board in metric tons (MT)).

Ship Name	Date of Arrival	Segregated BWOB (MT)	Segregated BW Source	Nonsegregated BWOB (MT)	Nonsegregated BW Source	% Nonsegregated BW
ARCO Spirit	23/05/1997	27421.14	Long Beach, CA	55415.16	Long Beach, CA	67%
ARCO Anchorage	25/05/1997	21529.21	Cherry Pt., WA	29174.45	Cherry Pt., WA	58%
Baton Rouge	26/05/1997	32233.86	Anacortes, WA	14414.80	Anacortes, WA	31%
Long Beach (Ex.)	26/05/1997	28306.00	San Francisco, CA	36786.44	37-47N 122-34 W, 38-01N 124-19W	57%
Potomac Trader	27/05/1997	10527.83	Cook Inlet, AK	0.00	none	0%
Chevron Mississippi	27/05/1997	19764.07	Anacortes, WA	2594.36	Anacortes, WA	12%
ARCO Fairbanks	28/05/1997	21504.00	Cherry Pt., WA	28635.50	Cherry Pt., WA	57%
O/S Washington	28/05/1997	508.10	Richmond, CA	43680.19	25 % -Richmond, CA 75% -100mi offshore	99%
S/R North Slope	02/06/1997	48192.27	Portland, OR	50362.60	Portland, OR	51%
ARCO Juneau	02/06/1997	22578.95	Cherry Pt., WA	34292.68	Cherry Pt., WA	60%
S/R San Francisco	02/06/1997	30241.10	Anacortes, WA	11383.47	Anacortes, WA	27%
BT Alaska	02/06/1997	57497.61	San Francisco, CA	14668.72	San Francisco, CA	20%
ARCO Independence	03/06/1997	29831.57	Long Beach, CA	60304.74	Long Beach, CA	67%
OMI Columbia	03/06/1997	16701.16	Barber's Pt., HI	50168.32	Barber's Pt., HI	75%
Prince William Sound	04/06/1997	26201.70	45-40N 156-50E, 40-27N 134-39E	16963.43	Yosu, Korea	39%
Benecia (Ex.)	06/06/1997	22706.44	Benecia, CA	29692.35	Benecia, CA	57%
		Mean =25984.06 MT		Mean = 29908.58 MT		Mean =49%
		SE = 3317.15 MT		SE = 4692.81 MT		SE = 0.06

Table E-2. Characteristics of nonsegregated ballast water sampled at 4 stages of the Ballast Water Treatment Facility in Valdez, Alaska. Shown are the date, source, temperature, and salinity of water sampled at each stage. Temperature and salinity measures represent means of two consecutive samples (see text). Multiple sources indicated water was commingled in the Treatment Facility.

TREATMENT	DATE	SHIP SOURCE(S)	TEMPERATURE (°C)	SALINITY (ppt)
A. CHICK ARMS	05/24/97	ARCO SPIRIT	12	32
	05/25/97	ARCO ANCHORAGE	10.75	29
	05/27/97	S/R LONG BEACH	12	32
	05/27/97	S/R BATON ROUGE	10	28
	05/27/97	CHEVRON MISSISSIPPI	11	31
	05/28/97	ARCO FAIRBANKS	11	29.5
	06/02/97	S/R NORTH SLOPE	14	13
	06/02/97	S/R SAN FRANCISCO	11	31
	06/02/97	BT ALASKA	11.5	31
	06/03/97	ARCO INDEPENDENCE	13	32
	06/03/97	OMI COLUMBIA	15	35
B. 90's TANK	05/24/97	ARCO SPIRIT	12	32
	05/25/97	ARCO ANCHORAGE	12	30
	05/27/97	S/R LONG BEACH/BATON ROUGE	12	32
	05/28/97	CHEVRON MISSISSIPPI	14.5	30
	06/02/97	S/R NORTH SLOPE/ BT ALASKA	10	13
	06/03/97	S/R SAN FRANCISCO/ BT ALASKA	12	32
	06/03/97	ARCO INDEPENDENCE	12	32
	06/04/97	OMI COLUMBIA/ARCO INDEPENDENCE	13	34
C. DAFT	05/24/97	ARCO SPIRIT	12	32
	05/25/97	ARCO ANCHORAGE	13	30
	05/28/97	S/R LONG BEACH/BATON ROUGE	14	31
	05/28/97	CHEVRON MISSISSIPPI/OS WASHINGTON	13	30
	06/02/97	S/R NORTH SLOPE/ BT ALASKA	12	12.5
	06/03/97	S/R SAN FRANCISCO/BT ALASKA	13	32
	06/03/97	ARCO INDEPENDENCE	13	30
	06/04/97	OMI COLUMBIA/ARCO INDEPENDENCE	14	34
D. BTT	05/25/97	ARCO SPIRIT	12	32
	05/26/97	ARCO ANCHORAGE	12.75	33
	05/28/97	S/R LONG BEACH/BATON ROUGE	15	31
	06/01/97	CHEVRON MISSISSIPPI	14	30
	06/03/97	S/R NORTH SLOPE/BT ALASKA	13	23.5
	06/03/97	S/R SAN FRANCISCO/BT ALASKA	13	32
	06/03/97	ARCO INDEPENDENCE	13	29
	06/04/97	OMI COLUMBIA/ARCO INDEPENDENCE	14	32

Table E-3. Percent occurrence of organisms in each taxonomic group that occurred in samples collected from the Ballast Water Treatment Facility in Valdez, Alaska. Shown are the mean number of organisms counted from preserved samples from each of the four locations (with indicated samples sizes). Importantly, these counts do not distinguish between live and dead organisms (see text for discussion). All organisms encountered were included in the classification scheme below.

	CHICK ARMS (n=22)	90's TANK (n=16)	DAFT (n=16)	BTT (n=16)
ARTHROPODS				
AMPHIPODS	4.55	0.00	0.00	0.00
BARNACLE CYPRIDS	13.64	6.25	0.00	0.00
BARNACLE NAUPLII	45.45	25.00	6.25	25.00
COPEPODS				
CALANOIDS	54.55	50.00	6.25	6.25
COPEPODITE	50.00	43.75	12.50	6.25
CYCLOPOIDS	27.27	31.25	18.75	12.50
HARPACTICOIDS	31.82	6.25	0.00	12.50
NAUPLII	45.45	37.5	18.75	12.50
POECILISTOME	13.64	0.00	0.00	0.00
CUMACEANS	4.55	0.00	0.00	0.00
MITE	9.09	0.00	0.00	0.00
MOLLUSCS				
BIVALVES	18.18	6.25	0.00	0.00
GASTROPODS	13.64	0.00	0.00	0.00
NEMATODES	36.36	37.50	93.75	100.00
PLATYHELMINTHES				
TURBELLARIANS	9.09	0.00	0.00	0.00
DINOFLAGELLATES				
CERATIUM	18.18	43.75	25.00	25.00
PERIDINIUM	36.36	18.75	12.5	18.75
DIATOMS				
CHAIN FORMING	18.18	18.75	31.25	6.25
DISCOID	81.82	93.75	81.25	93.75
ROTIFERS	0.00	6.25	0.00	12.50
PROTOZOANS				
TINTINNIDS	31.82	25.00	18.75	56.25
EGGS	50.00	37.50	12.50	25.00

Table E-4. Density of organisms (#/m³) in each taxonomic group that occurred in samples collected from the Ballast Water Treatment Facility in Valdez, Alaska. Shown are the means, standard errors, and maximum counts obtained from preserved samples for each of the four locations (with indicated samples sizes). Importantly, these counts do not distinguish between live and dead organisms (see text for discussion). All organisms encountered were included in the classification scheme below.

	CHICK ARMS (n=16)			90's TANKS (n=9)			DAFT (n=6)			BTT (n=12)		
	Mean	S.E.	Maximum	Mean	S.E.	Maximum	Mean	S.E.	Maximum	Mean	S.E.	Maximum
ARTHROPODS												
AMPHIPODS	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BARNACLE CYPRIDS	0.02	0.02	0.32	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
BARNACLE NAUPLII	0.14	0.06	0.76	0.01	0.00	0.04	0.00	0.00	0.02	0.13	0.06	0.64
COPEPODS												
CALANOIDS	0.14	0.08	1.12	0.04	0.03	0.30	0.00	0.00	0.00	0.11	0.11	1.27
COPEPODITE	0.07	0.02	0.23	0.06	0.04	0.34	0.02	0.02	0.11	0.03	0.03	0.32
CYCLOPOIDS												
HARPACTICOIDS	0.02	0.01	0.10	0.01	0.01	0.06	0.00	0.00	0.00	0.05	0.04	0.32
NAUPLII	0.04	0.01	0.19	0.03	0.02	0.17	0.02	0.01	0.08	0.05	0.04	0.32
POECILISTOME	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CUMACEANS	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MITE	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOLLUSCS												
BIVALVES	0.02	0.01	0.19	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
GASTROPODS	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEMATODES	0.02	0.01	0.08	0.53	0.44	4.03	0.28	0.11	0.76	100.36	11.35	159.95
PLATYHELMINTHES												
TURBELLARIANS	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DINOFLAGELLATES												
CERATIUM	0.02	0.01	0.15	0.27	0.24	2.15	0.19	0.12	0.72	0.11	0.05	0.32
PERIDIINIUM	0.31	0.20	3.06	0.01	0.00	0.04	0.01	0.00	0.02	0.19	0.11	1.27
DIATOMS												
CHAIN FORMING	0.01	0.01	0.11	0.01	0.00	0.04	0.01	0.00	0.02	0.00	0.00	0.00
DISCOID	5.37	2.05	29.15	43.32	25.26	230.28	20.16	10.63	55.06	98.02	33.25	335.17
ROTIFERS	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	2.68	2.65	31.80
CILIATED PROTOZOANS												
TINTINNIDS	0.07	0.04	0.65	0.06	0.05	0.49	0.08	0.05	0.29	0.56	0.26	3.18
EGGS	0.13	0.04	0.51	0.07	0.03	0.23	0.00	0.00	0.00	0.64	0.50	6.04
TOTAL	7.32	2.62	36.73	45.36	26.27	238.94	21.33	11.13	58.31	285.35	53.71	605.88

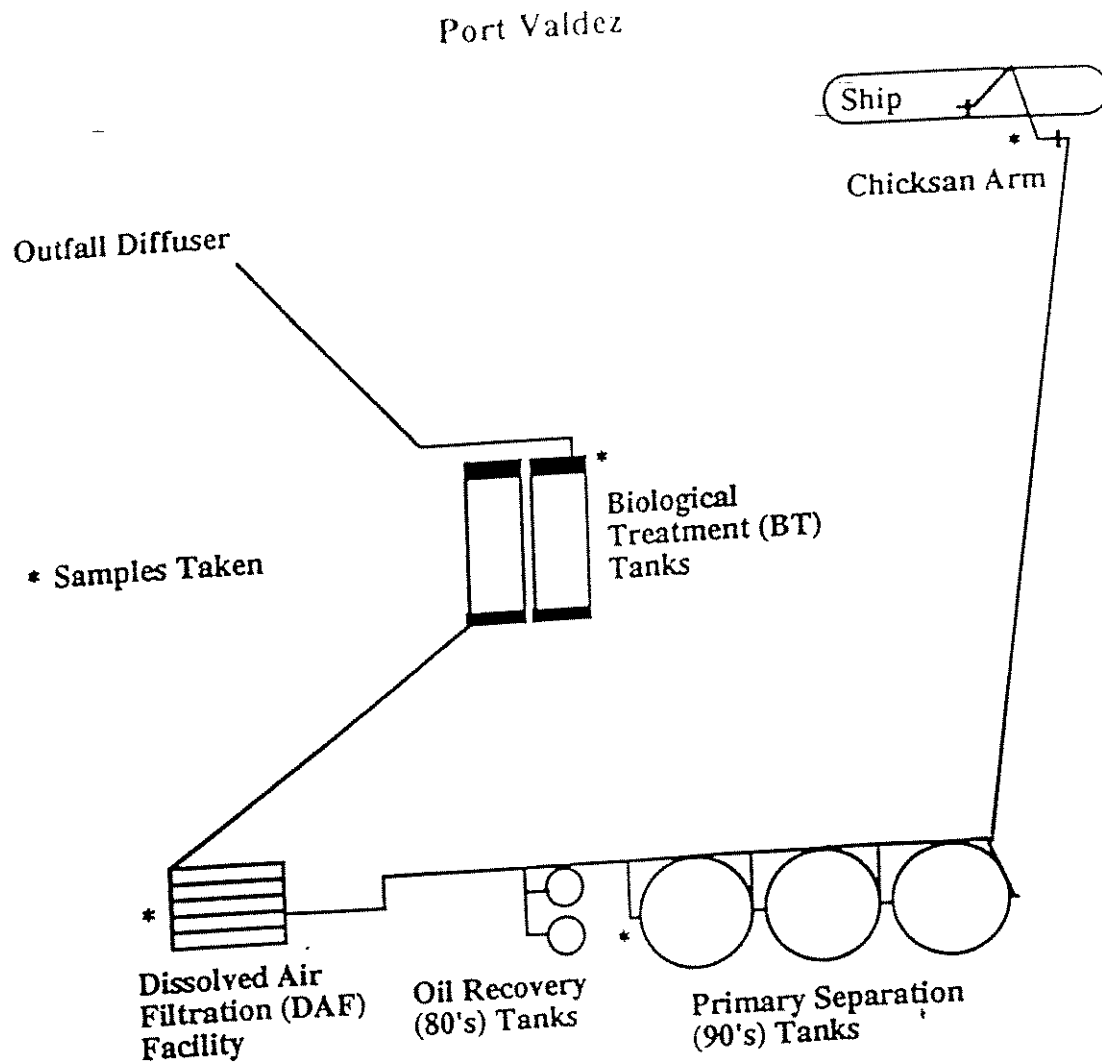


Figure E-1. Diagram of the Ballast Water Treatment Facility in Port Valdez, Alaska. Asterisks (*) indicate the four locations of sample collections in the treatment process: Chicksan Arm, 90s Tanks, DAF Tanks, and BT Tanks.

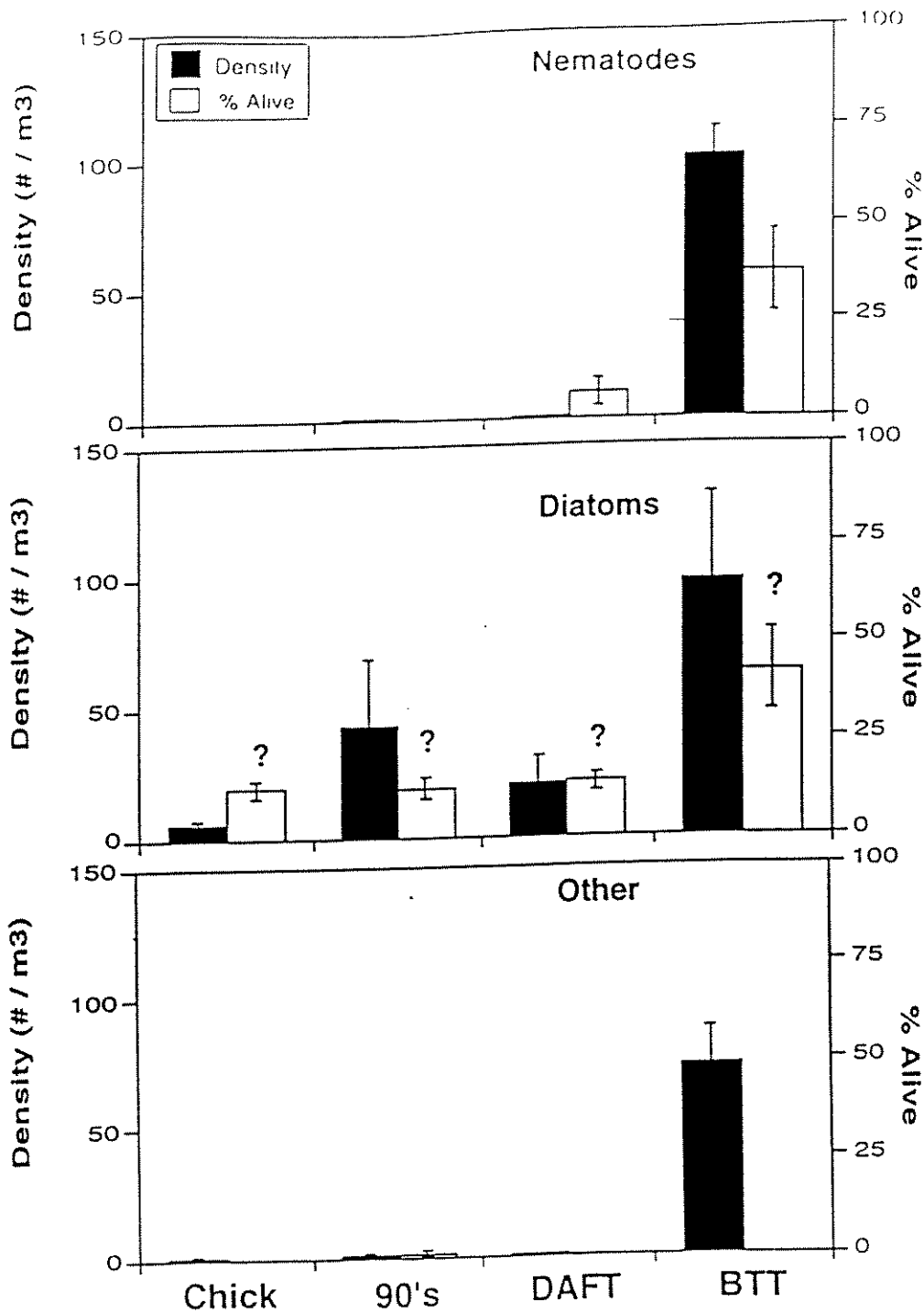


Figure E-2. Total density of organisms and percent alive in samples collected from the Ballast Water Treatment Facility in Valdez, Alaska. Shown are means (+s.e.) for density and % alive for each of three taxonomic groups at the four different stages of treatment. Taxonomic groups include nematodes, discoid diatoms, and all other taxa combined. Question marks denote the rough but conservative estimate on percent alive for diatoms, since this was impossible to determine for some individuals (see text). [Treatment stages: Chick = Chicksan Arms; 90s = 90s Tanks; DAFT = Dissolved Air Filtration Tanks; BTT = Biological Treatment Tanks; Sample sizes as shown in Table 4.]