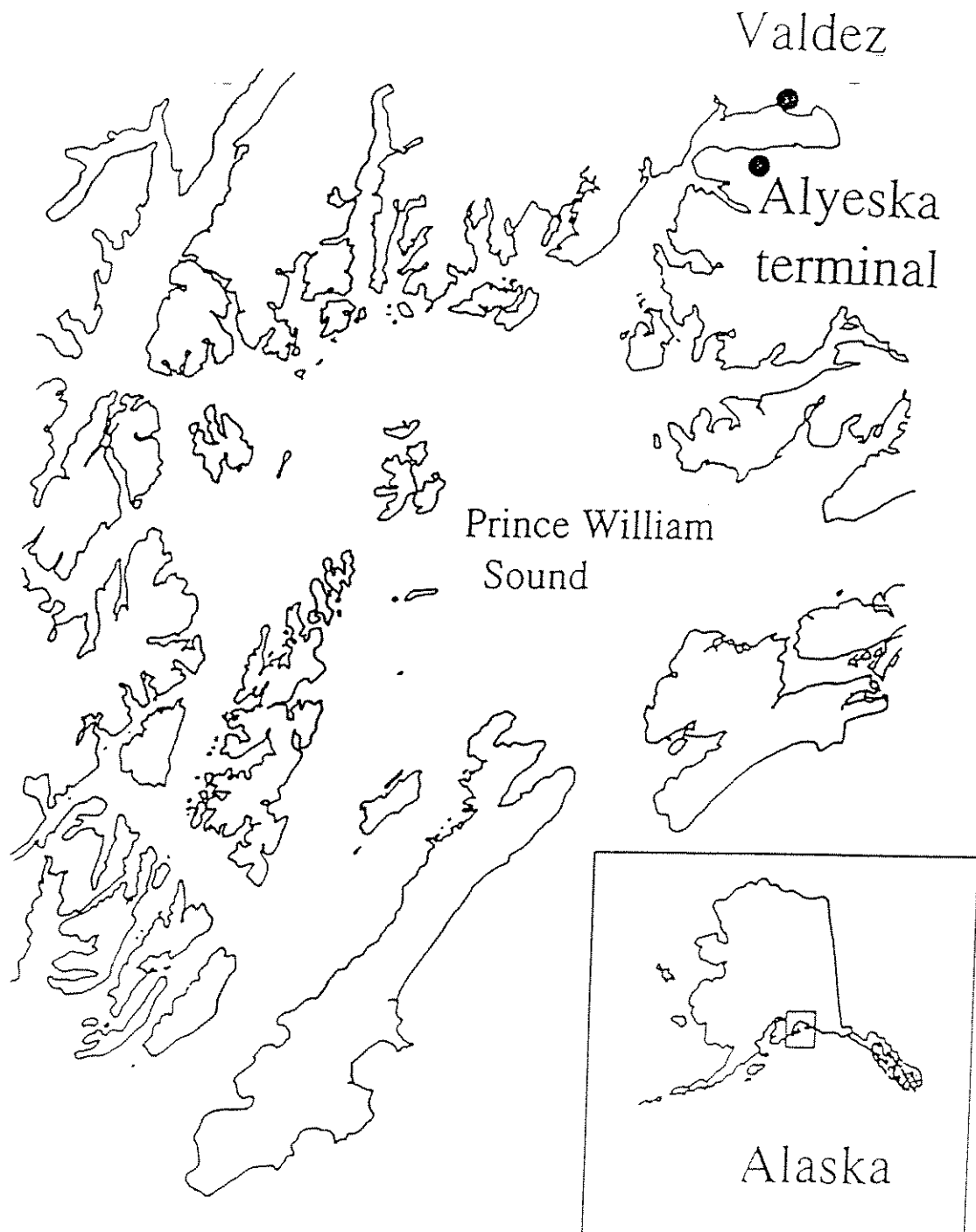


Figure A-1 Map of Prince William Sound showing locations of Valdez and Alyeska Terminal.



*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.

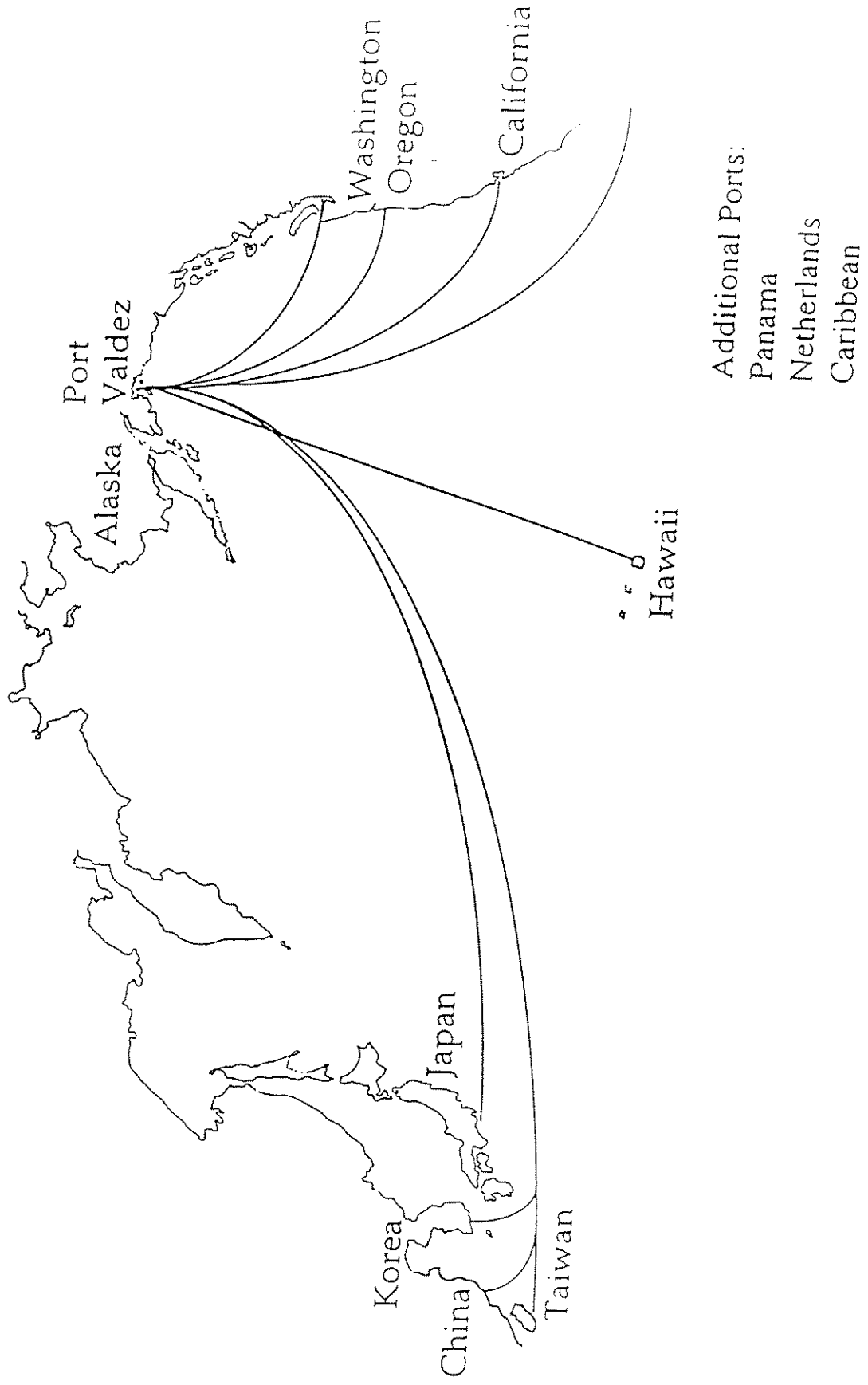


Figure A-3. Regional distribution of last port of call for oil tankers arriving to Prince William Sound during 1996. Shown are the percentage of all tanker arrivals (n=629) that originated in the respective regions for that year. (Source: RCAC, unpubl. data).

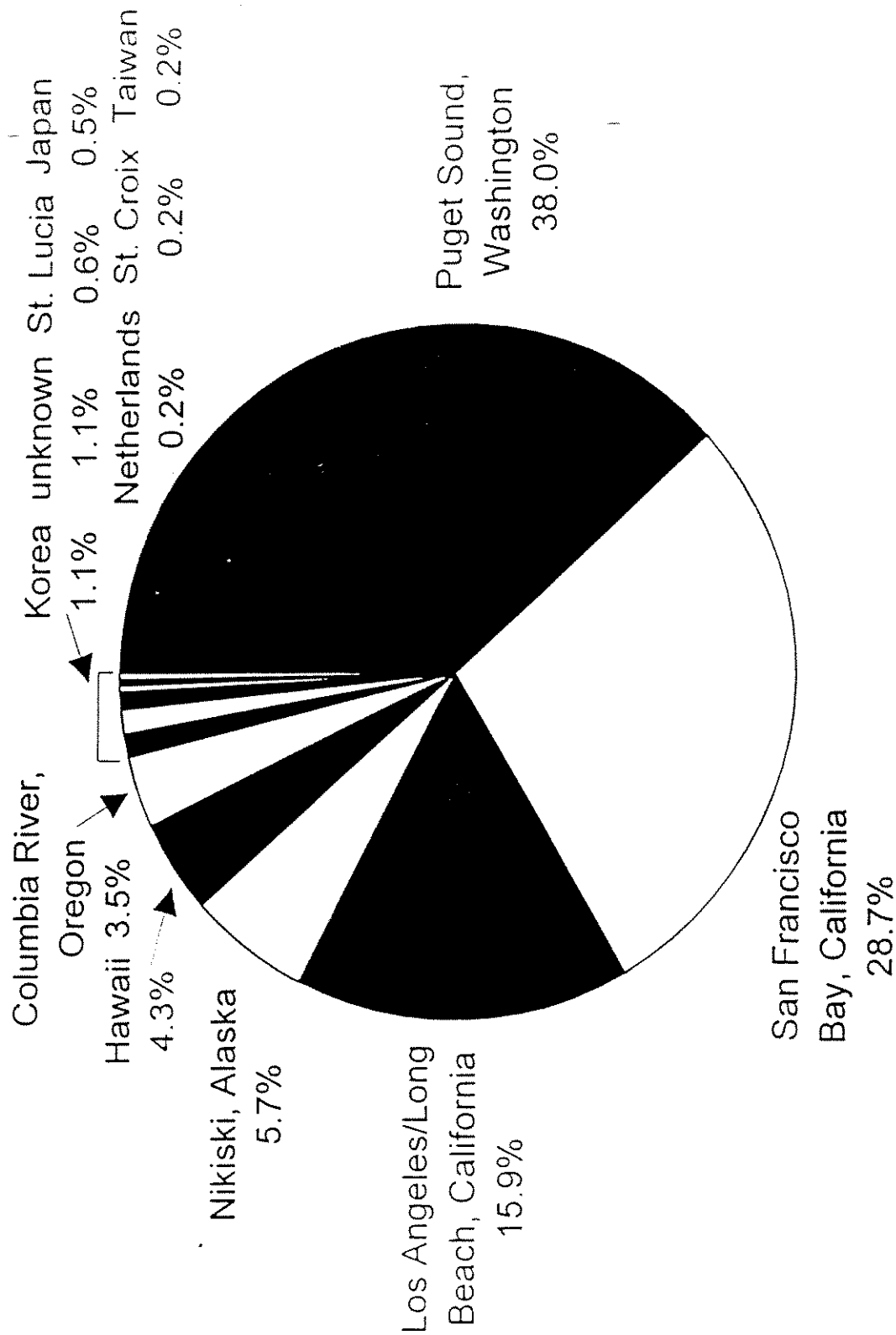


Figure A-4. Characteristics of Oil Tanker traffic arriving to Port Valdez for 1987-1994. Shown are the number of tankers that visit the port each year and the cumulative number of arrivals for these vessels each year. (Source: Wiegers et al. 1997.)

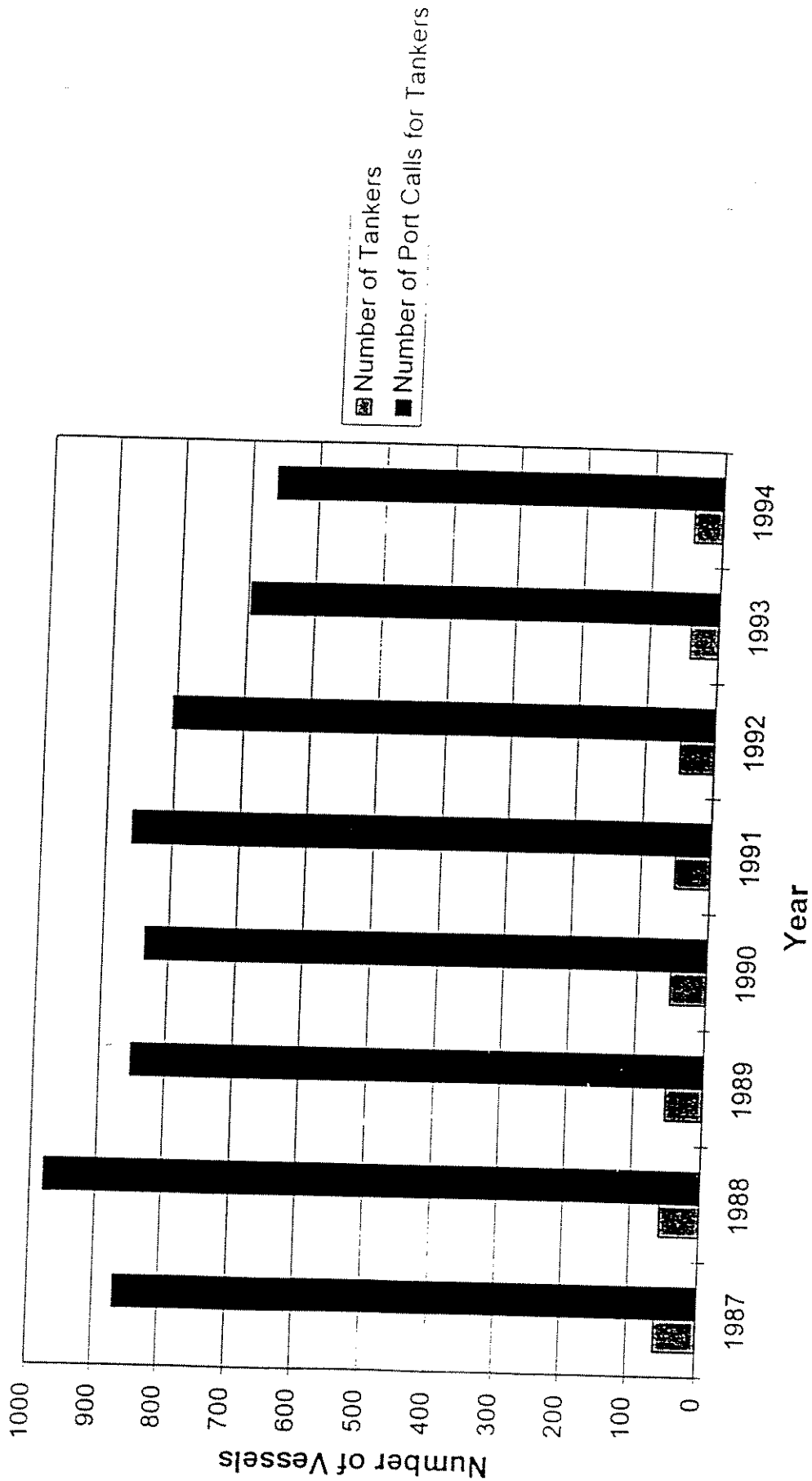
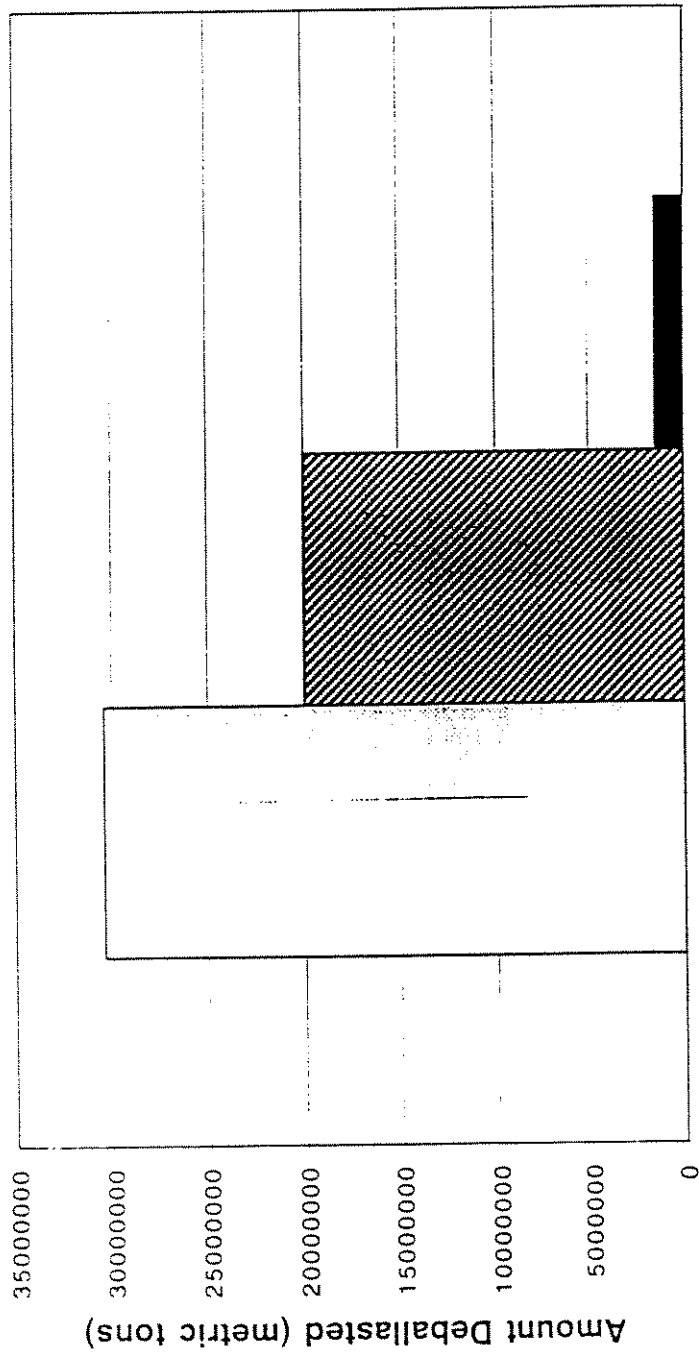


Figure A-5. Estimated annual quantity of segregated ballast water discharged into Chesapeake Bay, Prince William Sound, and San Francisco Bay from commercial vessels. Estimates were based upon information from the following sources: Smith et al., 1996 and Ruiz et al., unpubl. data (Chesapeake Bay); Wieggers 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                |
|---------------------|--|------------------------|-----------------------|
| <b>Planta</b>       |  |                        |                       |
| 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            |
| <b>Invertebrata</b> |  |                        |                       |
| <b>Cnidaria</b>     |  |                        |                       |
| Hydrozoa            | <i>Cordytophora caspia</i>                   | freshwater hydroid     | Black & Caspian Seas  |
| <b>Annelida</b>     |  |                        |                       |
| Polychaeta          | <i>Polydora redeki</i>                       |                        | W. Europe             |
|                     | <i>Marenzelleria viridis</i>                 |                        | N. America            |
| <b>Mollusca</b>     |  |                        |                       |
| 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           |
| <b>Arthropoda</b>   |  |                        |                       |
| 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           |
| <b>Bryozoa</b>      |  |                        |                       |
| Cheilostomata       | <i>Victorella pavidia</i>                    |                        | Black & Caspian Seas? |
| <b>Chordata</b>     |  |                        |                       |
| <b>Fish</b>         |  |                        |                       |
|                     | <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>Asciidiella 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                 |
|----------------------------|---|-----------------------------|------------------------|
| <b>Planta</b>              |   |                             |                        |
| 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>                           |                             |                        |
| <b>Invertebrata</b>        |   |                             |                        |
| <b>Cnidaria</b>            |   |                             |                        |
| Hydrozoa                   | <i>Gonionemus vertens</i>                         |                             | IndoPacific? Europe?   |
|                            | <i>Rhizogeton nudum</i>                           |                             |                        |
|                            | <i>Clavopsella navis</i>                          |                             |                        |
| Anthozoa                   | <i>Haliplanella lineata</i>                       | striped anemone             | Japan, Korea           |
| <b>Annelida</b>            |   |                             |                        |
| 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           |
| <b>Arthropoda</b>          |   |                             |                        |
| 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            |
| <b>Mollusca</b>            |   |                             |                        |
| 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                   |
| <b>Nematoda</b>            |   |                             |                        |
| Dracunculoidea             | <i>Anguillicola crassus</i>                       |                             | IndoPacific? Europe?   |
| <b>Chordata</b>            |   |                             |                        |
| 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  |     |     |    |    |    |
|                           | <i>Spartina alterniflora</i>                           | English cordgrass            | nwAtlantic         | X  | X   |     |    | X  |    |
|                           | <i>Spartina anglica</i>                                | dense-flowered cordgrass     | Chile              | X  |     |     |    |    |    |
|                           | <i>Spartina densiflora</i>                             | saltmeadow cordgrass         | seUS               | X  |     |     |    |    |    |
|                           | <i>Spartina patens</i>                                 | narrow-leaf cattail          | Eurasia            | X  |     |     |    |    |    |
|                           | <i>Typha angustifolia</i>                              | Japanese eelgrass            | Japan              |    |     | X   |    | X  |    |
|                           | <i>Zostera japonica</i>                                |                              | Japan              | X  |     |     |    |    |    |
| Protozoa(Foraminifera)    | <i>Trochammmina hadai</i>                              |                              | Europe             | X  |     |     |    |    |    |
| Protozoa(Mollusc host)    | <i>Ancistrocoma pelseneeri</i>                         |                              | Europe             | X  |     |     |    |    |    |
|                           | <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>                             |                              | ?                  | X  |     |     |    |    |    |
|                           | <i>Lobochona prorates</i>                              |                              | ?                  | X  |     |     | X  |    |    |
|                           | <i>Mirofolliculina</i> sp.                             |                              | ?                  | X  |     |     |    |    |    |
| Porifera                  | <i>Citona</i> sp.                                      | boring sponge                | nAtlantic?         | X  |     |     |    | #  |    |
|                           | <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>                               | club hydroid                 | Japan              | X  |     |     |    |    |    |
|                           | <i>Clava multicornis</i>                               | club hydroid                 | nAtlantic          | X  |     |     | X  | X  |    |
|                           | <i>Cordylophora caspia</i>                             | freshwater hydroid           | Black&Caspian Seas | X  |     | X   | 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>Zanclus 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  | X  |    |
|                           | <i>Haliplanella luciae</i>                             | orange-striped green anemone | Japan              | X  |     |     | X  | X  |    |
| Platyhelm(Turbellaria)    | <i>Pseudostylochus ostreophagus</i>                    |                              | Japan              | X  |     |     |    |    |    |
|                           | <i>Leptoplana limnorica</i>                            |                              | Japan              | 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 takanosisis</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           | Japan                     | x  | x   | x   |    |    |    |
|                          | <i>Sakuraeolus enosimensis</i>          | white-tentacled Jap.snail  | N.Zealand; Australia?     | x  |     |     |    |    |    |
|                          | <i>Tenellia adpersa</i>                 | miniature aeolis           | Japan                     | x  |     |     |    |    |    |
| Mollusca(Gastropoda-pul) | <i>Myosotella myosotis (= Ovatella)</i> |                            | Europe?                   | x  | x   | x   |    | x  |    |
| Mollusca(Bivalvia)       | <i>Arcuatula clemissa</i>               | ribbed mussel              | nwAtlantic                | x  |     |     |    |    |    |
|                          | <i>Anomia chinensis</i>                 | Chinese jingle             | nwPacific                 |    |     | x   | x  | x  |    |
|                          | <i>Corbicula fluminea</i>               | Asian clam                 | China, Korea, Japan       | x  |     |     |    |    |    |
|                          | <i>Crassostrea gigas</i>                | Japanese oyster            | Japan                     |    |     | x   | x  | x  |    |
|                          | <i>Crassostrea virginica</i>            | Eastern oyster             | nwAtlantic                |    |     |     |    |    | x  |
|                          | <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  | x  |
|                          | <i>Mya arenaria</i>                     | softshell clam             | nAtlantic                 | x  |     | x   | x  | x  | x  |
|                          | <i>Mytilus galloprovincialis</i>        | Mediterran. mussel         | Med. Sea                  | 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 sSiberia, 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 |
|----------------------|----------------------------------|------------------------|---------------------|----|-----|-----|----|----|----|
|                      | <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  |    |    |
|                      | <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>        | cordgrass bug          | e&midwU.S.          | X  |     |     |    |    |    |
|                      | <i>Acyonidium sp.</i>            |                        | wPacific?           |    | X   |     | X  |    |    |
| Bryozoa              | <i>Anguilla palmata</i>          | ambiguous bryozoan     | nAtlantic           | X  | X   |     |    |    |    |
|                      | <i>Bowerbankia gracilis</i>      | creeping bryozoan      | nAtlantic?          | 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<br>(= <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<br>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<br>carp                        | wn,Atlantic<br>Eurasia                    | x                      |     | x   |    |    |    |
| <i>Dorosoma petenense</i>    |                                   | threadfin shad                                   | midw U.S., Florida-Guat                   | x                      |     |     |    |    |    |
| <i>Gambusia affinis</i>      |                                   | mosquitofish                                     | midw/seU.S., Mexico                       | x                      |     |     |    |    |    |
| <i>Ictalurus furcatus</i>    |                                   | blue catfish                                     | midw/seU.S., RioGrand,Mex                 | x                      |     |     | x  |    |    |
| <i>Lepomis cyanellus</i>     |                                   | green sunfish                                    | midw/seU.S., nMex                         | x                      |     |     |    |    |    |
| <i>Lepomis gulosus</i>       |                                   | warmouth   | midw/seU.S., RioGrande                    | x                      |     |     |    |    |    |
| <i>Lepomis macrochirus</i>   |                                   | bluegill   | midw/seU.S., Mex,RioGR                    | x                      |     |     |    |    |    |
| <i>Lepomis microlophus</i>   |                                   | redear sunfish                                   | midw/seU.S.                               | x                      |     |     |    |    |    |
| <i>Lucania parva</i>         |                                   | rainwater killifish                              | Mass.toMex, RioGR                         | x                      |     |     |    |    |    |
| <i>Menidia beryllina</i>     |                                   | inland silverside                                | midw/seUS, RioGR                          | x                      |     |     |    |    |    |
| <i>Micropterus dolomieu</i>  |                                   | smallmouth bass                                  | central N.Am                              | x                      |     |     |    |    |    |
| <i>Micropterus salmoides</i> |                                   | largemouth bass                                  | 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             |
|---------------------------------------|--------|-------|--------|------------------------------|
| <b>Cnidaria</b>                       |        |       |        |                              |
| <i>Anthopleura artemesia</i>          | W      | C     | N      |                              |
| <b>Nemertea</b>                       |        |       |        |                              |
| <i>Paranemertea</i> sp.               | B      | C     | N      |                              |
| <b>Aschelminthes</b>                  |        |       |        |                              |
| <i>Priapulius caudatus</i>            | B      | C     | N      |                              |
| <b>Echiurida</b>                      |        |       |        |                              |
| <i>Echiurus echiurus alaskensis</i>   | B      | WA    | N      |                              |
| <b>Oligochaeta</b>                    |        |       |        |                              |
| Unidentified spp.                     | B      |       |        |                              |
| <b>Polychaeta</b>                     |        |       |        |                              |
| <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>Glycinde 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      |                              |
| <b>Copepoda</b>                       |        |       |        |                              |
| <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      |       |        |                               |
| <b>Balanomorpha</b>                 |        |       |        |                               |
| <i>Balanus gladula</i>              | B      | C     | N      |                               |
| <i>Semibalanus balanoides</i>       | B      | C     | N      |                               |
| <b>Cumacea</b>                      |        |       |        |                               |
| <i>Cumella vulgaris</i>             | B      | C     | N      |                               |
| <i>Eudorella</i> sp.                | W      |       |        |                               |
| <i>Leptocuma</i> sp.                | W      |       |        |                               |
| <b>Isopoda</b>                      |        |       |        |                               |
| <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      |                               |
| <b>Amphipoda</b>                    |        |       |        |                               |
| <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      |                               |
| <b>Decapoda</b>                     |        |       |        |                               |
| <i>Pagurus hirsutiusculus</i>       | W      | SC    | N      |                               |
| <i>Hemigrapsus oregonensis</i>      | W      | BJC   | N      |                               |
| <i>Hemigrapsus nudis</i>            | S      | BJC   | N      |                               |
| <b>Arachnida</b>                    |        |       |        |                               |
| <i>Halobisium occidentale</i>       | B      | C     | N      |                               |
| <b>Gastropoda</b>                   |        |       |        |                               |
| <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      |                               |
| <b>Bivalvia</b>                     |        |       |        |                               |
| <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 |    |    |    |        |                      |
|---|--------|-----|-----|-----|-----|--------|----|----|-----|----|------------------|----|----|-----|----|----|----|----|----|----|---------------------------|----|----|----|--------|----------------------|
|   | CAL    |     |     |     |     | Survey |    |    |     |    | Unatt. Surv.     | AU | JA | C-R | VA | SA | BC | WA | OR | CA |                           | AR | EC | NO | GB     |                      |
|   | WEI    | CHA | HAN | WEI | CHA | HAN    |    |    |     |    |                  |    |    |     |    |    |    |    |    |    |                           |    |    |    |        |                      |
| <i>Palmaria hecatensis</i>                            |        |     |     |     |     |        |    |    |     |    |                  |    |    |     |    |    |    |    |    |    |                           |    |    |    | NE Pac |                      |
| <i>Palmaria palmata</i>                               | X      | X   |     |     |     | X      |    |    |     |    | X                |    |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, N All         |
| <i>Phycodrys rigidi</i>                               | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac                |
| <i>Polysiphonia brodiaei</i>                          |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | widespread           |
| <i>Polysiphonia hendryi v. deliquescens</i>           |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | NE Pac               |
| <i>Polysiphonia hendryi v. hendryi</i>                |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | NE Pac               |
| <i>Polysiphonia hendryi v. luxurians</i>              |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | NE Pac               |
| <i>Polysiphonia pacifica v. pacifica</i>              |        | 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   |     |     |     |        |    |    |     |    | O                |    |    |     |    |    |    |    |    |    |                           |    |    |    |        |                      |
| <i>Pterosiphonia bipinnata</i>                        | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, Arctic        |
| <i>Ptilota filicina</i>                               | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac                |
| <i>Ptilota serrata</i> (incl. <i>pectinata</i> )      | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, Arctic        |
| <i>Rhodomela lycopodioides</i>                        | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, Arctic, N All |
| <i>Scagelia occidentale</i> (incl. <i>pylaisaei</i> ) | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, Arctic, N All |
| <i>Tokidodendron kurilensis</i>                       | X      | X   |     |     |     | X      |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac                |
| <b>SEAGRASSES</b>                                     |        |     |     |     |     |        |    |    |     |    |                  |    |    |     |    |    |    |    |    |    |                           |    |    |    |        |                      |
| <i>Zostera marina</i>                                 |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, Arctic, N All |
| <b>LICHENS</b>  |        |     |     |     |     |        |    |    |     |    |                  |    |    |     |    |    |    |    |    |    |                           |    |    |    |        |                      |
| <i>Verrucaria maura</i>                               |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, N All         |
| <i>Verrucaria mucosa</i>                              |        | X   |     |     |     |        |    |    |     |    | X                | X  |    |     |    |    |    |    |    |    |                           |    |    |    |        | N Pac, N All         |
| <b>TOTAL "X"</b>                                      | 68     | 81  | 20  | 24  | 29  | 24     | 60 | 46 | 101 | 91 | 90               | 85 | 76 | 70  | 42 | 46 | 43 | 42 | 42 | 43 | 42                        | 43 | 42 | 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   |
|----------------------------------|--------------|---------|-----------|------------------|---|
| <b>Protozoa</b>                  |              |         |           |                  |   |
| <i>Trochammina hadai</i>         | Japan        | 1990s   | B         | SFB              | Cohen and Carlton 1995  |
| <b>Coelenterata</b>              |              |         |           |                  |   |
| <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  |
| <b>Polychaeta</b>                |              |         |           |                  |   |
| <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,<br>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  |
| <b>Crustacea</b>                 |              |         |           |                  |   |
| <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 Region | Reference                                    |
|----------------------------------|--------------|---------|-----------|------------------|--|
| <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                          |
| <b>Mollusca</b>                  |              |         |           |                  |  |
| <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                       |
| <b>Mollusca</b>                  |              |         |           |                  |  |
| <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                                 |
| <b>Ectoprocta</b>                |              |         |           |                  |  |
| <i>Membranipora membranacea</i>  | EUR          | 1987    | B         | NWA              | Carlton and Geller 1993                      |
| <b>Urochordata</b>               |              |         |           |                  |  |
| <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                   |
| <b>Vertebrata</b>                |              |         |           |                  |  |
| <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=oystersAtlantic, OJ=oystersJapan, OBC=oysters British Columbia, ROK=roe-on-kelp, S=scientific research, ?=unknown vector or date

| SPECIES                             | DONOR    | RECIPIENT        | DATE       | VECTOR  | REFERENCE   |
|-------------------------------------|----------|------------------|------------|---------|---|
| <b>Chlorophyta</b>                  |          |                  |            |         |   |
| <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>         |          |                  |            |         |   |
| <b>Chrysophyta, Phaeophyceae</b>    |          |                  |            |         |   |
| <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<br>FR-BRIT<br>NZ<br>AUS-TAS<br>GB<br>BC, O<br>AUS<br>N-ATL, J<br>J, CH<br>R-SIB<br>GB<br>J | 1971<br>1983<br>1987<br>1982<br>1995<br><1978<br>1971<br>?<br>?<br>1983<br>1983 | OJ<br>A<br>F, B<br>B<br>F<br>?<br>F<br>?<br>?<br>F<br>? | Floch et al., 1991<br>Castric-Fey et al., 1993<br>Hay and Luckens, 1987; Hay, 1990; Nelson, 1995<br>Sanderson and Barrett, 1989; Sanderson, 1990<br>Fletcher and Manfredi, 1995<br>Peters and Bremen, 1992<br>Womersley, 1987<br>Peters et al., 1993<br>Peters et al., 1993<br>Skinner and Womersley, 1983; Adams, 1994<br>Skinner and Womersley, 1983 |
| <i>Scytothamnus</i> sp.                           |         |   |   |   |  |
| <i>Sorocarpus micromorus</i>                      |         |   |   |   |  |
| <i>Sphaerotrichia divaricata</i>                  |         | BC, NS, GB, MED<br>SCAN, R-ARC<br>AUS-TAS, NZ<br>S-AUS  |   |   |  |
| <i>Strania attenuata</i>                          |         |   |   |   |  |
| <i>Stictyosiphon soriferous</i>                   |         |   |   |   |  |
| <b>Rhodophyta</b>                                 |         |   |   |   |  |
| <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>Bonnemaisiona 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  |
| <b>Seagrasses</b>                                 |         |   |   |   |  |
| <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=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   |
|---------------------------------------|---------------|--------------|--------|---------|---|
| <b>Chlorophyta</b>                    |               |              |        |         |   |
| <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                         |
| <b>Chrysophyceae-Phaeophyta</b>       |               |              |        |         |   |
| <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>           |               |              |        |         |   |
| <b>Rhodophyta</b>                     |               |              |        |         |   |
| <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, Britany, 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=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:

|   |                      |             |            |  |
|---|----------------------|-------------|------------|--|
| <b>Pyrophyta (Dinoflagellates)</b>                        |                      |             |            |  |
| <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 |
| <b>Bacillariophyta (Diatoms)</b>                          |                      |             |            |  |
| <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> | CAN-NS, W, O, C      | 1987        | ASP        | Wekell et al., 1994; Postel and Horner, 1993                                       |
| <b>Chrysophyta</b>  |                      |             |            |  |
| <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:

|                                    |           |      |                        |  |
|------------------------------------|-----------|------|------------------------|--|
| <b>Chrysophyta</b>                 |           |      |                        |  |
| <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                  |
| <b>Cyanophyta (Bluegreens)</b>     |           |      |                        |  |
| <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).

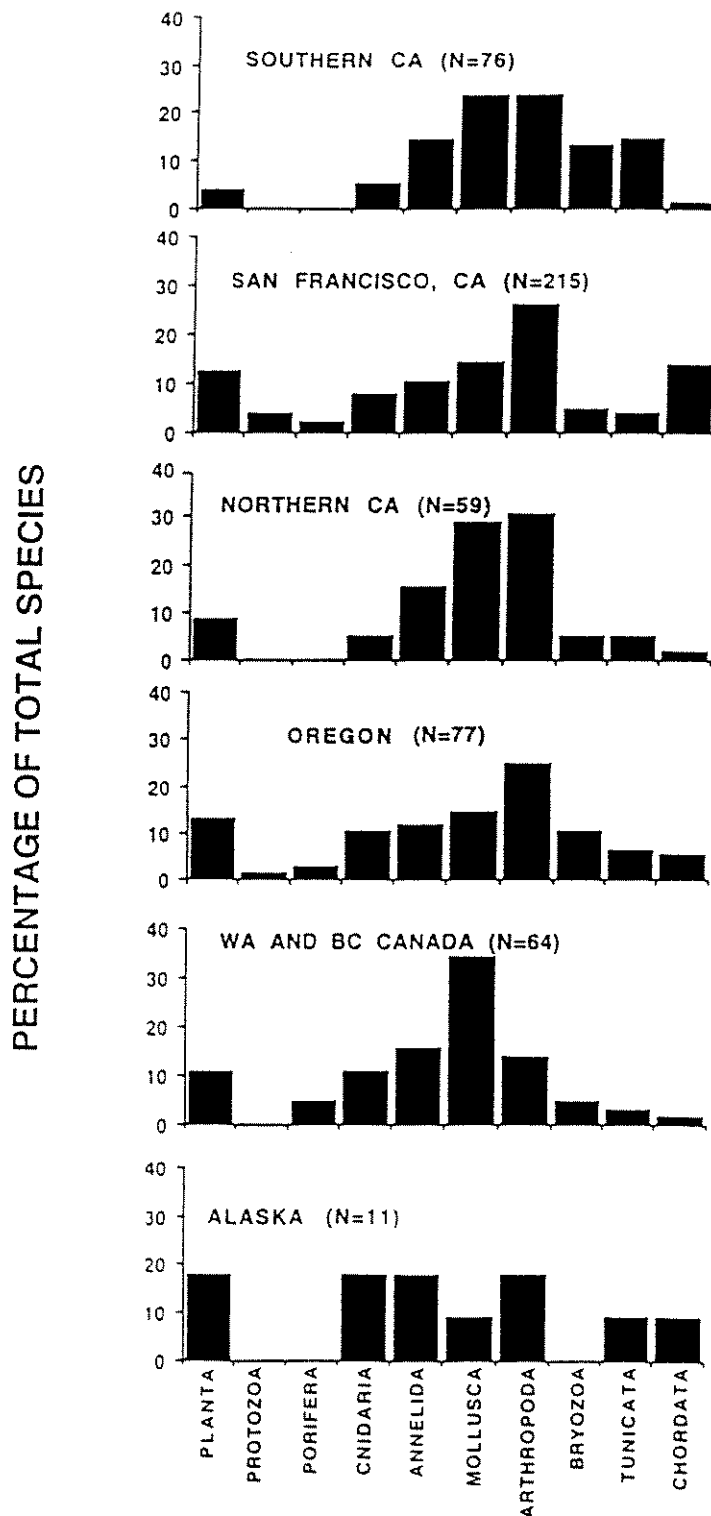




Table C-1. Characteristics of segregated ballast water arriving to Port Valdez, Alaska for each of the 16 oil tankers sampled between 23 May and 6 June 1997. Shown are date of arrival, ballast water source, total ballast water capacity, amount of ballast water on board (as volume and percent capacity) 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<br>BW Exchange<br>(# tanks) | Total BW<br>Capacity (m3) | Total BWOB<br>(m3) | % Total<br>BW<br>Capacity | Age<br>(days) | Temperature<br>(C°) | Salinity<br>(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 <sup>o</sup> ) | Shipside Temperature @ 10 meters (C <sup>o</sup> ) |
|----------------------|-----------------------------------|-------------------------------------|--|--|
| ARCO Spirit          | 29                                | 30                                  | 14   | 9  |
| ARCO Anchorage       | 27                                | 32                                  | 10   | 5  |
| Baton Rouge          | 23                                | 29                                  | 10   | 6  |
| S/R Long Beach       | 20                                | 32                                  | 12   | 5  |
| Chevron Mississippi  | 27                                | 32                                  | 14   | 8  |
| Potomac Trader       | 25                                | 31                                  | 14   | 9  |
| ARCO Fairbanks       | 22                                | 31                                  | 11   | 9  |
| O/S Washington       | no sample                         | no sample                           | no sample  | no sample  |
| BT Alaska            | 21                                | 31                                  | 13   | 9  |
| S/R North Slope      | 21                                | 31                                  | 13   | 9  |
| S/R San Francisco    | 21                                | 31                                  | 13   | 9  |
| ARCO Juneau          | 21                                | 31                                  | 13   | 9  |
| ARCO Independence    | 21                                | 31                                  | 13   | 9  |
| OMI Columbia         | 20                                | 31                                  | 12   | 5  |
| Prince William Sound | no sample                         | no sample                           | no sample  | no sample  |
| S/R Benecia          | no sample                         | no sample                           | no sample  | no sample  |





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/m<sup>3</sup>) 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 <sup>3</sup> | TOTAL VOLUME (M <sup>3</sup> ) | 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          |
| <b>MEAN</b>         |       | <b>19.13</b>      | <b>7,000.55</b>                     | <b>31,755.41</b>               | <b>244,427,243</b>   |
| <b>SE</b>           |       | <b>1.66</b>       | <b>1,355.89</b>                     | <b>4,026.34</b>                | <b>63,878,556.94</b> |

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/m<sup>3</sup>); mean and standard errors for two tanks) by taxonomic group obtained from a single foreign arrival compared to the mean density measures (number/m<sup>3</sup>) 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<br>(n=14) |        | Exchange Ship<br>(n=1) |        |
|--------------------------|-----------------------------|--------|------------------------|--------|
|                          | Mean                        | SE     | Mean                   | SE     |
| <b>DINOFAGELLATA</b>     |                             |        |                        |        |
| Ceratium                 | 4.40                        | 3.80   | 1.60                   | 0.17   |
| Peridinium sp.           | 59.68                       | 29.55  | 3.59                   | 3.59   |
| <b>DIATOMACEA</b>        |                             |        |                        |        |
| Discooid                 | 722.16                      | 255.25 | 91.64                  | 54.86  |
| Centrale                 | 186.87                      | 103.47 | 29.95                  | 1.65   |
| Pennate                  | 40.80                       | 27.20  | -                      | -      |
| <b>"PROTOZOA"</b>        |                             |        |                        |        |
| Foraminifera             | 3.31                        | 2.08   | 2.87                   | 2.87   |
| Tintinnida               | 0.96                        | 0.40   | 95.70                  | 26.38  |
| <b>CNIDARIA</b>          |                             |        |                        |        |
| unid. medusa             | 22.68                       | 13.63  | -                      | -      |
| <b>CTENOPHORA</b>        |                             |        |                        |        |
| PLATYHELMINTHES          | 0.03                        | 0.03   | -                      | -      |
| Turbellaria              | 5.86                        | 3.34   | -                      | -      |
| Müller's/Götte's larvae  | 5.41                        | 4.60   | -                      | -      |
| <b>NEMERTEA</b>          |                             |        |                        |        |
| pillidium larvae         | 0.87                        | 0.82   | -                      | -      |
| <b>ANNELIDA</b>          |                             |        |                        |        |
| 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  | -                      | -      |
| <b>MOLLUSCA</b>          |                             |        |                        |        |
| 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   | -                      | -      |
| <b>CRUSTACEA</b>         |                             |        |                        |        |
| Cirripedia               |                             |        |                        |        |
| nauplii                  | 627.67                      | 323.55 | 8.57                   | 2.92   |
| cyprids                  | 83.44                       | 25.17  | 6.40                   | 2.09   |
| Copepoda                 | 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 |
| Limnithona sp.           | 72.91                       | 66.46  | -                      | -      |
| Cyclopina sp.            | 33.40                       | 32.88  | -                      | -      |
| <b>Copepoda, cont.</b>   |                             |        |                        |        |
| <b>Copepoda, cont...</b> |                             |        |                        |        |
| <b>Calanoida</b>         |                             |        |                        |        |
| 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   | -                      | -      |
| <b>Poecilostoma</b>      |                             |        |                        |        |
| Corycaeid                | 63.24                       | 40.09  | -                      | -      |
| Hemicyclops sp.          | 0.65                        | 0.62   | -                      | -      |
| "Rudolph"                | 1.75                        | 1.41   | -                      | -      |
| <b>Amphipoda</b>         |                             |        |                        |        |
| Gammaridea               | 0.03                        | 0.02   | -                      | -      |
| Hyperidea                | 0.15                        | 0.10   | -                      | -      |
| Isopoda                  | 0.19                        | 0.07   | 0.71                   | 0.71   |
| Decapoda                 | 0.43                        | 0.15   | -                      | -      |
| zoa                      | 25.10                       | 18.36  | 0.71                   | 0.71   |
| megalopa                 | 0.41                        | 0.19   | -                      | -      |
| <b>Caridea</b>           |                             |        |                        |        |
| Cladoceran               | 0.02                        | 0.01   | -                      | -      |
| Anomura                  | 2.96                        | 2.24   | -                      | -      |
| <b>Porcellanid zoa</b>   |                             |        |                        |        |
| 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                        | -      | -                      |        |
| <b>BRYOZOA</b>           |                             |        |                        |        |
| 0.06                     | 0.06                        | -      | -                      |        |
| 10.51                    | 4.38                        | 28.56  | 7.34                   |        |
| 5.46                     | 3.37                        | -      | -                      |        |
| 9.66                     | 4.46                        | 0.71   | 0.71                   |        |
| 16.70                    | 15.52                       | 1.44   | 1.44                   |        |
| 1.02                     | 0.87                        | -      | -                      |        |
| 17.59                    | 8.12                        | 3.58   | 2.17                   |        |
| 0.08                     | 0.07                        | -      | -                      |        |
| 0.06                     | 0.06                        | -      | -                      |        |
| <b>OTHER</b>             |                             |        |                        |        |
| 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.

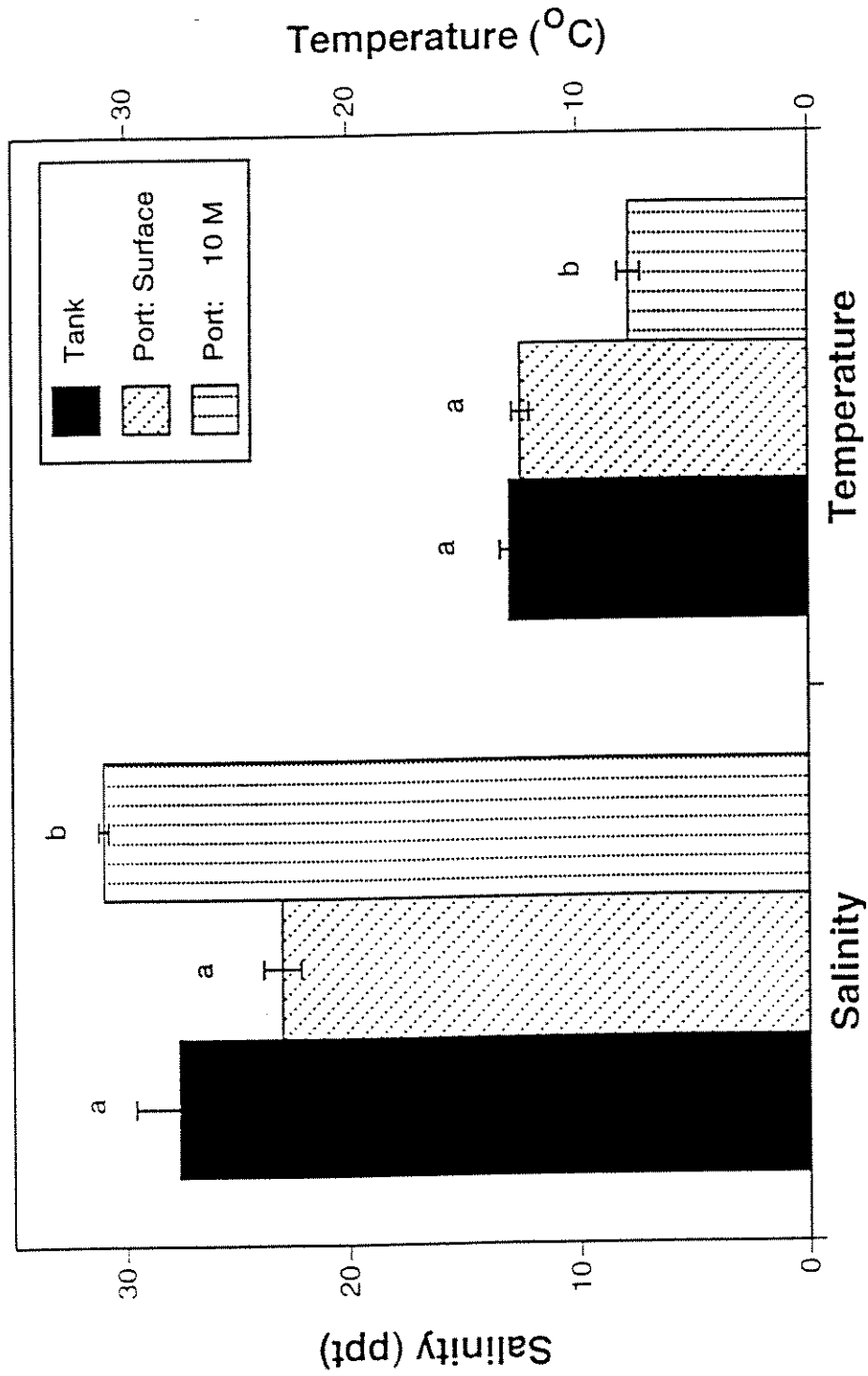


Figure C-2. Relationship between density of organisms in segregated ballast water arriving to Port Valdez, Alaska in oil tankers from domestic ports and age of ballast water. Density measures were those derived from quantitative analysis of plankton samples, and age indicates the number of days since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

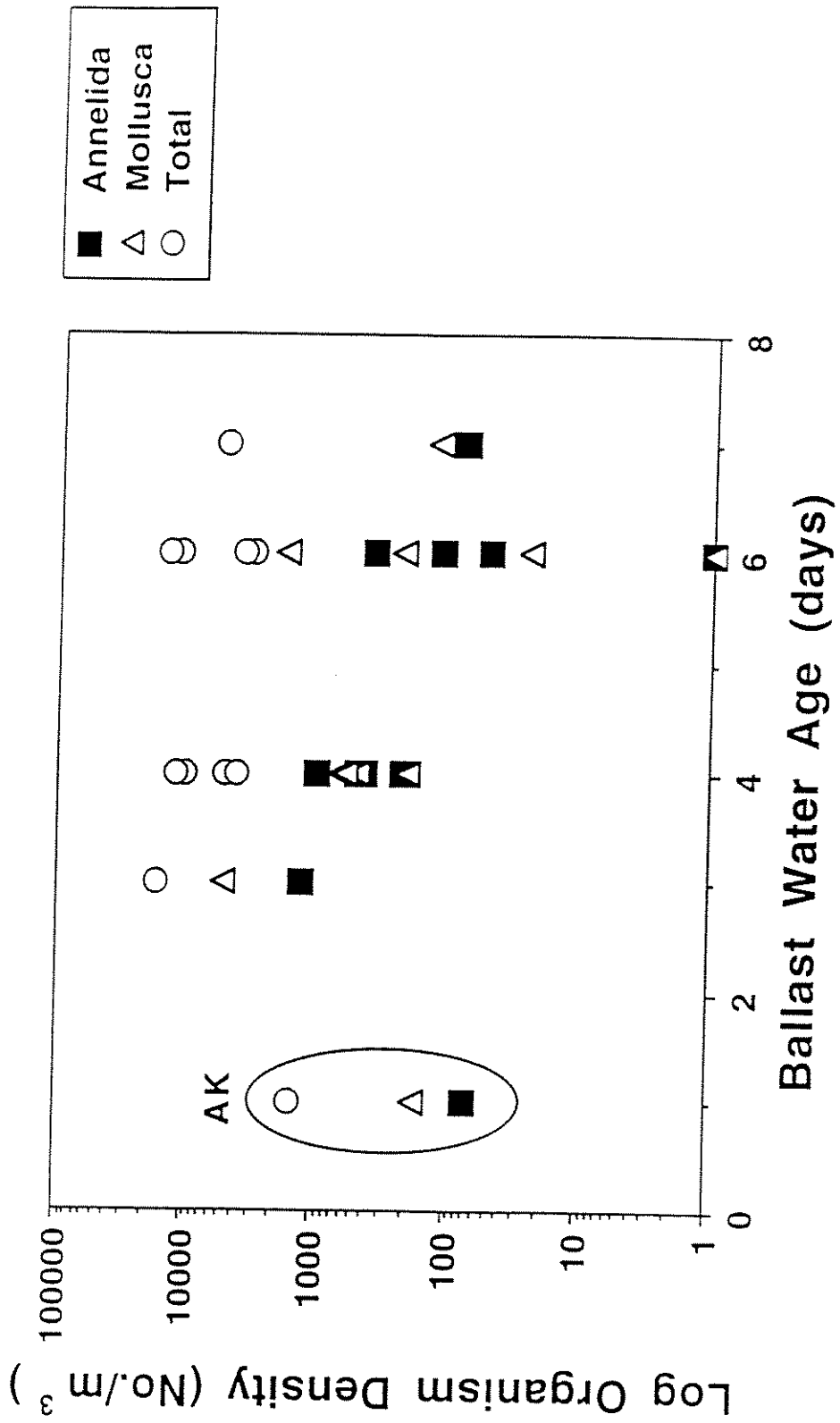




Figure C-3. Comparison of densities for planktonic organisms measured in non-exchanged ballast water of ships from domestic ports versus exchanged ballast water of a single ship from a foreign port. Shown are means and 95% confidence intervals of all non-exchanged ballast samples for the respective taxa.

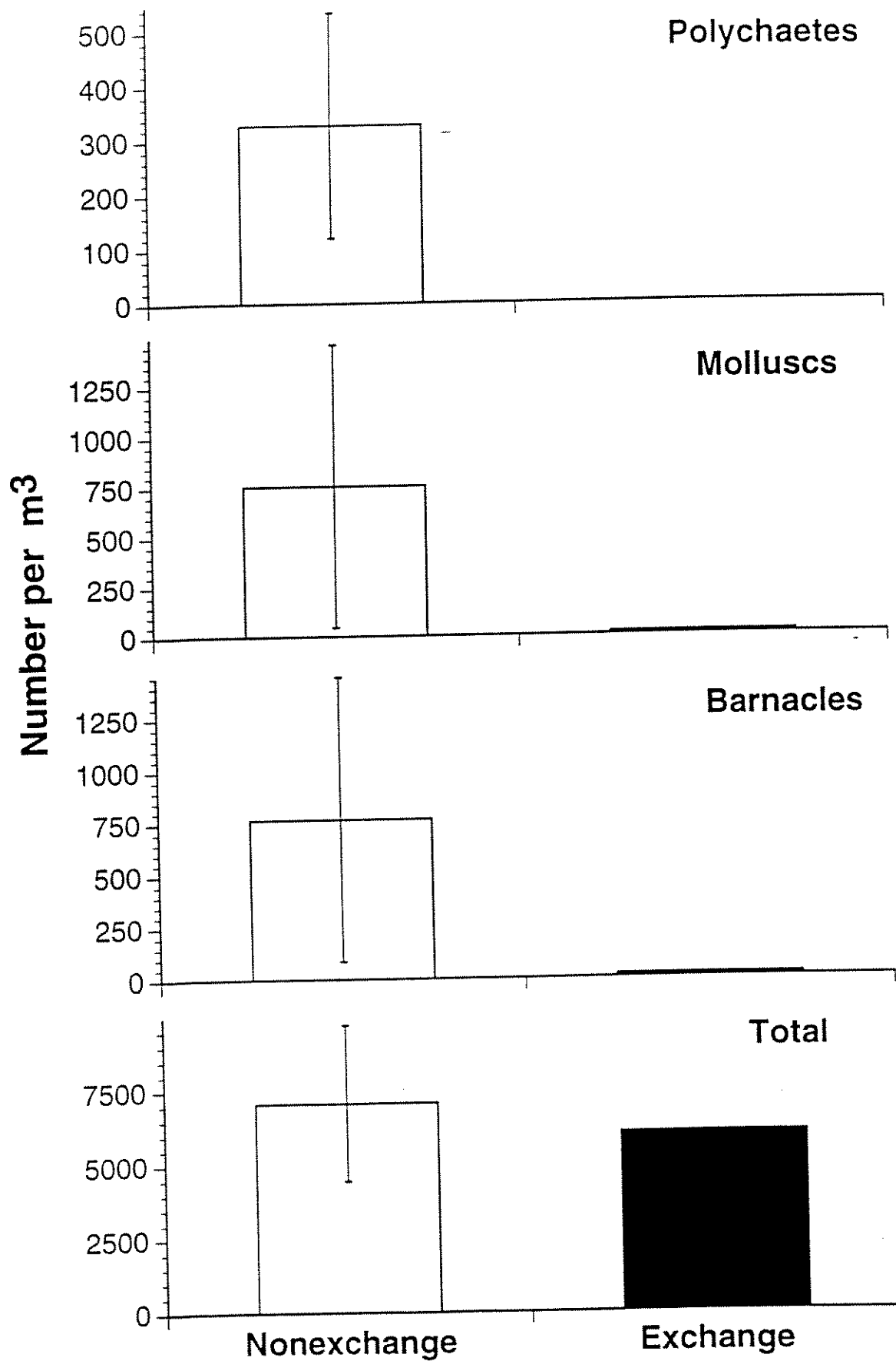


Table D-1. Characteristics of ballast water sampled on two oil tankers that conducted experimental ballast water exchange with segregated ballast water en route to Port Valdez from San Francisco Bay. Shown are the sources of ballast water, location of ballast water exchange, amount (%) of ballast water 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   | -            | -       | -               | -      |
| trocophore           | 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   |        |         |        |        |     |
|                 |        |        |        |        |        |         |        |        |        |         |        |        |     |
| DIATOMACEA      |        |        |        |        |        |         |        |        |        |         |        |        |     |
|                 |        |        | 4.39   | 4.39   | 2.87   | 2.87    |        |        | 8.28   | 8.28    | 1.44   | 8      |     |
|                 |        |        |        |        |        |         |        |        |        |         |        |        |     |
|                 |        | 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   | 88.96  | 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  | 291.36 | 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  | 366.15 | 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  | 6.62   | 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   | 1.60    | 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).

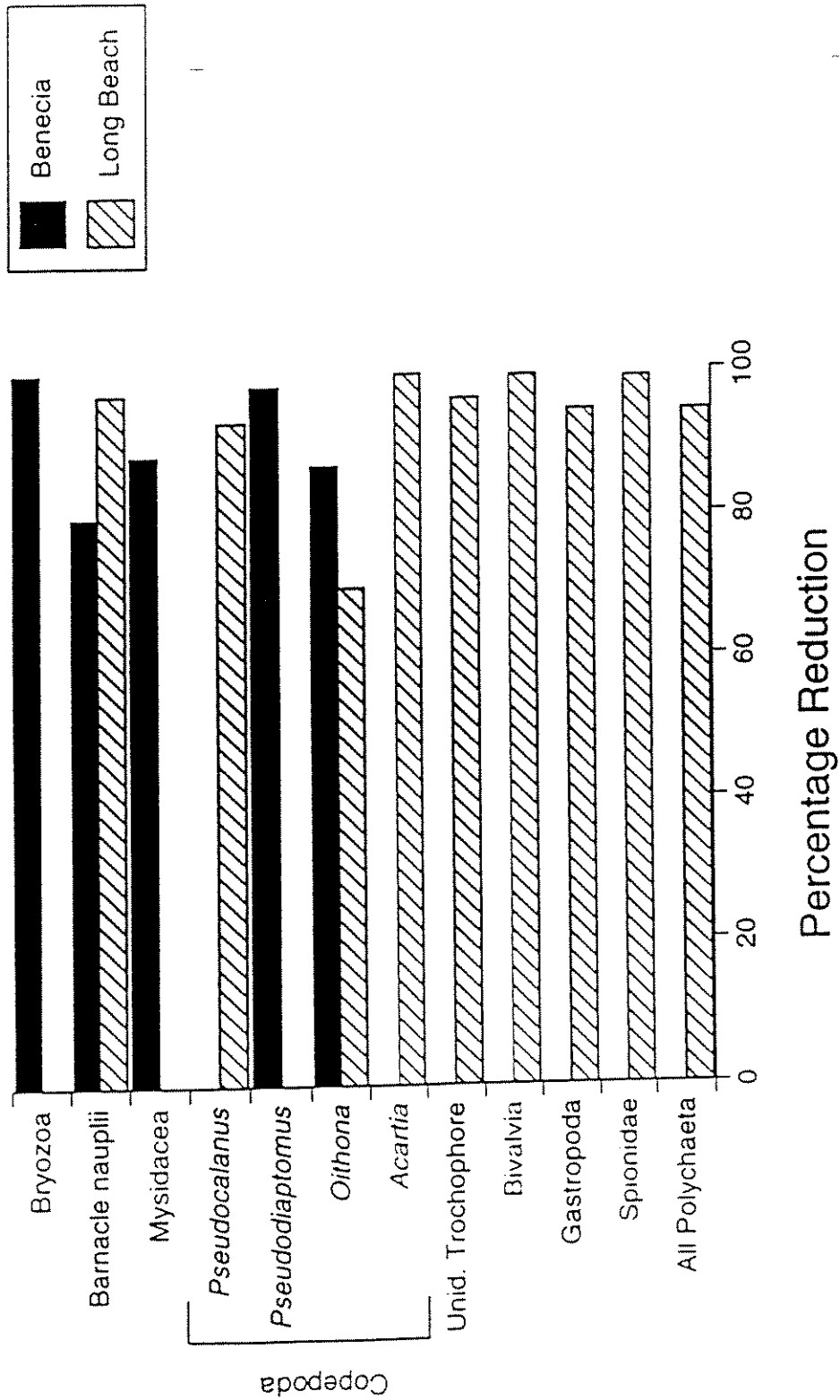


Figure D-2. Percent increase during ballast water exchange experiment of taxa that derived from oceanic waters and were relatively abundant in exchanged tanks. Shown is the percent increase for each taxonomic group by ship, as calculated from mean densities in Table D-2. Missing bars indicate that the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

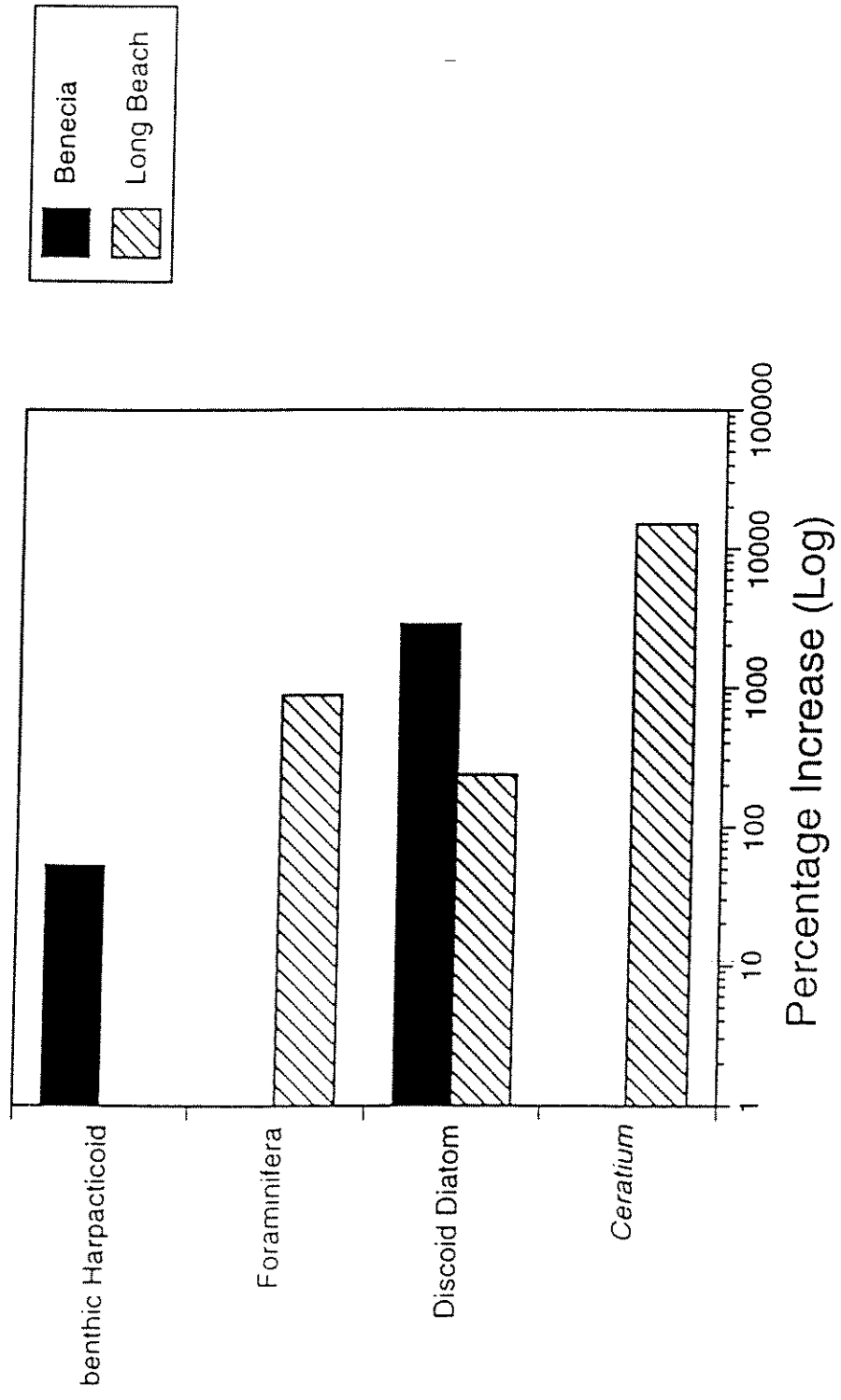


Table E-1. Characteristics of all ballast water arriving to Port Valdez, Alaska for each of 16 oil tankers. Shown are the sources and volumes of clean (segregated) and oily (nonsegregated) ballast water, percent of total ballast water that is nonsegregated, and date of arrival for each vessel. Mean and 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<br>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<br>(°C) | SALINITY<br>(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 ( $\#/m^3$ ) 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  | 0.00    | 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  |

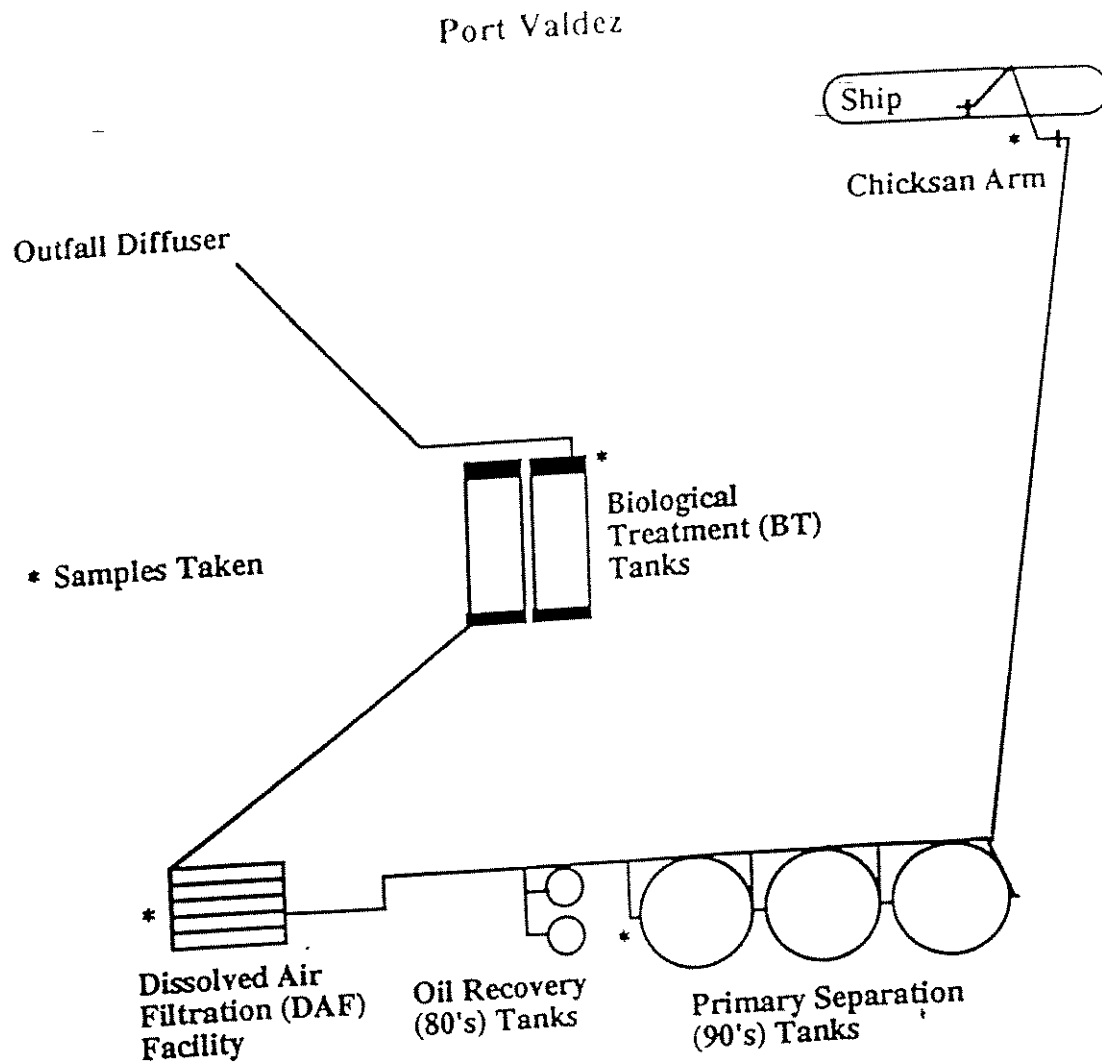


Figure E-1. Diagram of the Ballast Water Treatment Facility in Port Valdez, Alaska. Asterisks (\*) indicate the four locations of sample collections in the treatment process: Chicksan Arm, 90s Tanks, DAF Tanks, and BT Tanks.

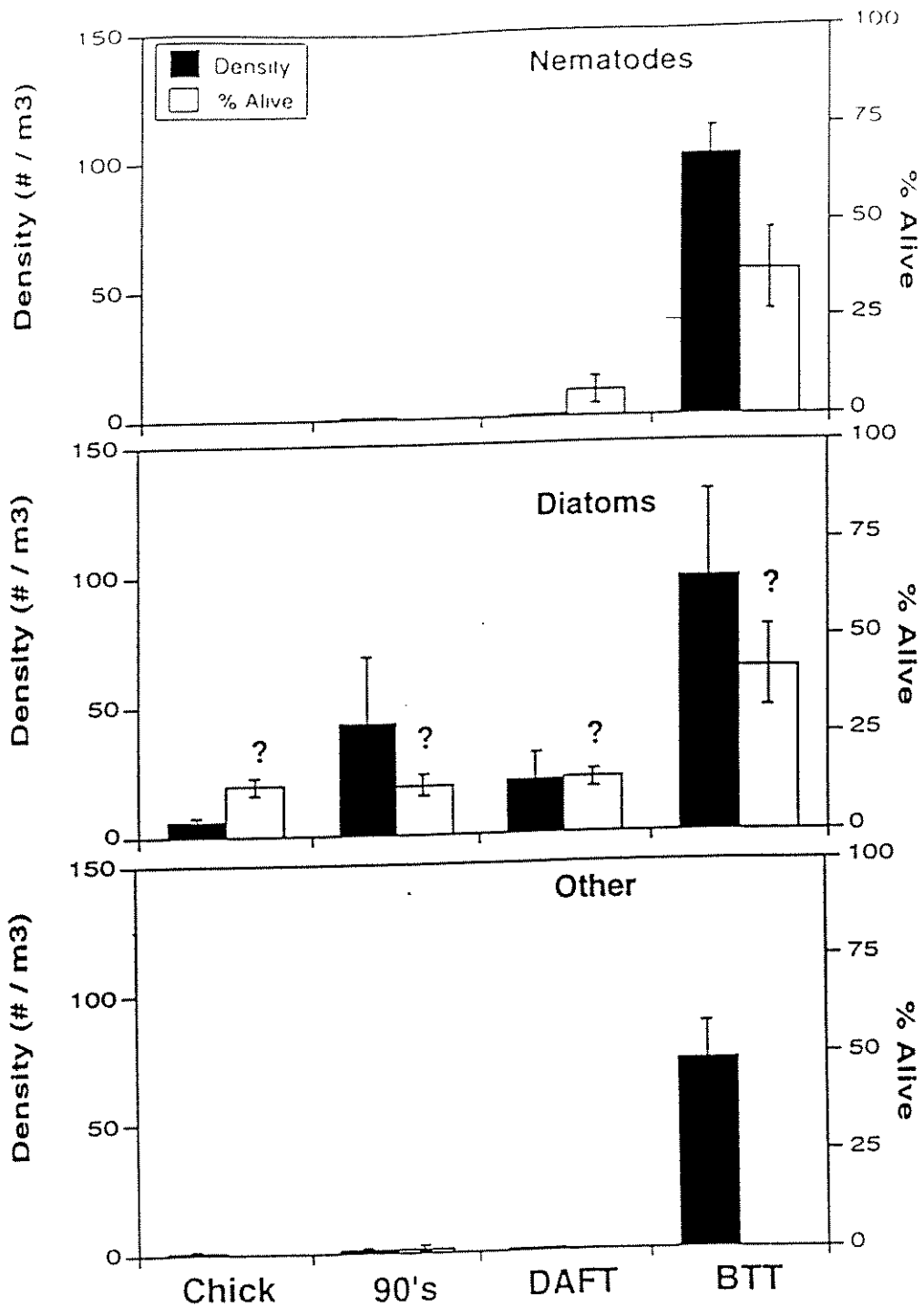


Figure E-2. Total density of organisms and percent alive in samples collected from the Ballast Water Treatment Facility in Valdez, Alaska. Shown are means (+s.e.) for density and % alive for each of three taxonomic groups at the four different stages of treatment. Taxonomic groups include nematodes, 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. ]