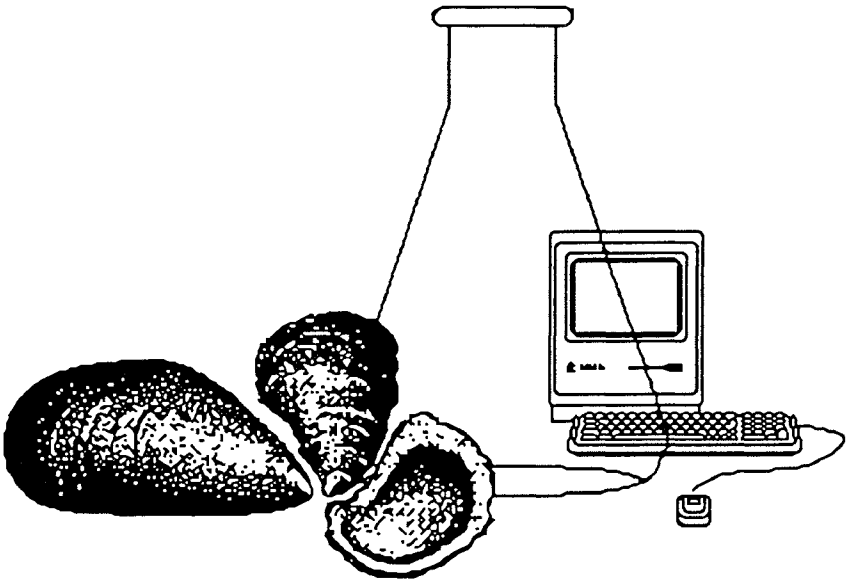
NOAA Technical Memorandum NOS ORCA 63

National Status and Trends Program
for Marine Environmental Quality

Mussel Watch Worldwide Literature Survey - 1991



Rockville, Maryland
November, 1991

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National Ocean Service
U.S. Department of Commerce

Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
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Rockville, Maryland

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Mussel Watch Worldwide Literature Survey - 1991

Adriana Y. Cantillo

Rockville, Maryland
November, 1991

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Mussel Watch Worldwide Literature Survey - 1991

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ABSTRACT

The NOAA National Status and Trends Program includes the Mussel Watch Project in which mussels or oysters and sediments are collected from more than 240 sites in U. S. coastal waters. The bivalves and sediments are analyzed for more than 70 analytes including organic chemicals, selected major and minor elements, and ancillary parameters. This bibliography is the result of the compilation of a comprehensive collection of worldwide literature on the use of marine mussels or oysters as sentinel organisms for the study of coastal contamination. Information gathered will be used to compare results with those of the NS&T Mussel Watch Project. Five electronic bibliographical databases were searched and extensive manual searching was done to compile more than 1200 citations. An extensive index of species name, geographical location and analytes is included.

I. INTRODUCTION

One of the principal components of the NOAA National Status and Trends (NS&T) Program is the Mussel Watch Project in which mussels or oysters and sediments are collected from more than 240 sites in U. S. coastal waters. The bivalves and sediments are analyzed for a large suite of organic chemicals, selected major and minor elements, and ancillary parameters. The more than 70 analytes are listed in Table 1. The Mussel Watch Project is currently in its 6th year of operation. Descriptions of the program, sampling sites, and analytical results have been published. Current information on the NS&T Program can be obtained by writing the National Status and Trends Program.

The purpose of this bibliographic search is to compile a comprehensive collection of worldwide literature on the use of marine mussels or oysters as sentinel organisms for the study of coastal contamination. This compilation will be used to compare the results of such studies to those of the NS&T Mussel Watch Project.

II. DESCRIPTION OF LITERATURE SEARCH

Five electronic bibliographical databases in the DIALOG[1] system were searched in March of 1991 (Table 2). They were: BIOSIS PREVIEWS, CA SEARCH, NTIS, OCEANIC ABSTRACTS and AQUATIC SCIENCE ABSTRACTS. The complete description of these databases, including the journals and other types of publications abstracted, as well as time coverage, can be found in the DIALOG "blue sheets" and chapter descriptions. CA SEARCH is the electronic equivalent of Chemical Abstracts, while AQUATIC SCIENCE ABSTRACTS is that of Aquatic Science Abstracts, and BIOSIS PREVIEWS is that of

[1] DIALOG is available worldwide. In the United States, contact Dialog Information Services, Inc., 800 334 2564. Outside the United States, contact Dialog International Marketing, telex 334499, fax 415 858 7069.

Biological Abstracts. NTIS is prepared by the U. S. Dept. of Commerce and has no equivalent printed form. In addition, manual searching of Chemical Abstracts was done covering volumes 1 (1907) through 115 (issue 10) (1991). Major investigators in the field of marine mussel watch studies worldwide have been contacted for comments and suggestions.

The search strategy was designed to select citations mentioning mussels or oysters and any of the chemicals found in Table 1. The name and Chemical Abstracts Registry numbers of all the chemicals were used in the search strategy. The search was limited to citations in English. The major and trace element search was limited to citations published after 1976 due to the large number of entries found. As the compilation progressed, however, papers on other environmentally significant chemicals (such as dioxins), papers and reports in languages other than English, and older citations, were

Table 1. Chemicals determined as part of the NOAA National Status and Trends Program

Polycyclic aromatic hydrocarbons

Biphenyl
Naphthalene
1-Methylnaphthalene
2-Methylnaphthalene
2,6-Dimethylnaphthalene
Acenaphthene
Acenaphthylene
1,6,7-Trimethylnaphthalene
Fluorene
Phenanthrene
1-Methylphenanthrene
Anthracene
Fluoranthene
Pyrene
Benz(a)anthracene
Chrysene
Benzo[a]pyrene
Benzo[e]pyrene
Perylene
Dibenz[a,h]anthracene
Benzo[b]fluoranthene
Benzo[k]fluoranthene
Indeno[1,2,3-cd]pyrene
Benzo[g,h,i]perylene

DDT and metabolites

2,4'-DDD	4,4'-DDD
2,4'-DDE	4,4'-DDE
2,4'-DDT	4,4'-DDT

Chlorinated pesticides other than DDT

Aldrin	Dieldrin
cis-Chlordane	trans-Nonachlor
Heptachlor	Lindane
Heptachlor epoxide	Mirex
Hexachlorobenzene	

Polychlorinated biphenyls

PCB-8	PCB-18	PCB-28
PCB-44	PCB-52	PCB-66
PCB-101	PCB-105	PCB-118
PCB-128	PCB-138	PCB-153
PCB-179	PCB-180	PCB-187
PCB-195	PCB-206	PCB-209

Elements

Ag	As	Cd	Cr	Cu
Hg	Ni	Pb	Sb	Se
Sn	Zn			

Tributyltin species

Tributyltin [bis(tri-n-butyltin)oxide]
Dibutyltin (degradation product)
Monobutyltin (degradation product)

Table 2. Databases searched

Database	Time coverage	Producer
AQUATIC SCIENCE ABSTRACTS	1978-1991	Cambridge Scientific Abstracts
BIOSIS PREVIEWS	1969-1991	BIOSIS, Inc.
CA SEARCH	1967-1991	American Chemical Society
NTIS	1983-1991	National Technical Information Services
OCEANIC ABSTRACTS	1964-1991	Cambridge Scientific Abstracts

added to the database. Extensive use was made of the Mussel Watch studies literature compilation of Kidder (1977). Future updates of the search will include non-English citations and searches of other electronic databases.

III. NOAA MUSSEL WATCH BIBLIOGRAPHIC DATABASE

The results of the electronic search were edited for relevancy to the Mussel Watch concept and entered into the Apple Macintosh version of PRO-CITE[2], a bibliographic software system. The database resides at the NOAA National Ocean Service/Office of Ocean Resources Conservation and Assessment/Coastal Monitoring and Bioeffects Assessment Division (CMBAD), and will be updated on an ongoing basis.

When available, scientific species name, geographical location of the study, and chemicals have been added to the citation as index terms. In many instances, the bivalve species is not available either in the abstract or the key words stored in the electronic database. In such cases, only the generic terms "mussel" or "oyster" are found. The citation information has been checked against a printed source whenever possible to correct errors resulting from limitations of the electronic databases,[3] and refine index terms. Organometallic species are listed as families. All the tributyltin compounds, for example, are indexed under organotins. If a paper covers a specific geographical area, then the location name, state/province and country were used in the index. For example, papers on Port Phillip Bay are indexed under the Bay name, Victoria and Australia. Papers covering large geographical areas such as synthesis papers of French or U. S. Mussel Watch Programs, are indexed using only the name of the country.

This compilation contains more than 1200 citations. Printed copies of the citations in the database are being collected at the Coastal Monitoring and Bioeffects Assessment Division office in Rockville, MD.

IV. RESULTS AND OBSERVATIONS

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[2] PRO-CITE, Personal Bibliographic Software, Inc., PO Box 4250, Ann Arbor, MI 48106.

[3] BIOSIS, one of the electronic databases covering the field of biology, lists some older citations in capital letters, omitting the use of italics or underlining for species names, and adding or omitting words in the titles.

The "classic" Mussel Watch studies of the 1970's in the United States were performed using the common blue mussel, *Mytilus edulis*, or the American oyster, *Crassostrea virginica*. These species are not available worldwide or indeed U. S.-wide. Therefore, other sentinnel organisms, including various species of mussels (i.e., *Mytilus galloprovincialis, Mytilus californianus, Modiolus modiolus, Perna viridis*, and others), and oysters (i.e., *Crassostrea edulis, Crassostrea gigas*, and others) have been used. In cases where these mussels or oysters were not available, other molluscan species have been sampled but papers based on such samples have not been included in this bibliographic database. An exception is the case of the use of *Arca zebra* (commonly known as the turkey wing) in tropical waters since mussels and oysters are not found in large populations in some of these areas. The species cited in the bibliographic database are listed in Table 3.

Mussel Watch studies in freshwater bodies, such as those in the Great Lakes (North America), Lake Balaton (Hungary), and other locations, have not been included in the bibliographic database.

Complete citation information and citation number are listed in Appendix I in alphabetical order of the first author. The citation number is listed to the left of the entry. The subject indices are cross referenced to citation number in Appendix II.

Citations relevant to Mussel Watch studies but covering species other than mussels or oysters, and chemicals other than those listed in Table 1 are listed in Appendix III and are not included in the indices.

V. REFERENCES

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Keen, A. M. (1971) Sea Shells of Tropical West America: Marine Mollusks from Baja California to Peru. Stanford University Press, Stanford, CA. 1064 pp.

Kidder, G. M. (1977) Pollutant levels in bivalves - a data bibliography. Report, EPA contract R-80421501, Scripps Institute of Oceanography, La Jolla, CA.

Table 3. Bivalve species cited in the Mussel Watch Bibliographic Database

Species	Common name	Length (mm)	Range
Arca zebra (Swainson 1833)[1,2]	Turkey wing	70	Southeastern U. S. to Brazil, Bermuda
Aulacomya ater (Molina 1782)[1]	Black ribbed mussel	150	Southeastern and southwestern South America
Aulacomya maoriana (Iredale 1915)[3] ✶	Maori mussel	80	New Zealand
Brachydontes demissus plicatulus ✢	Ribbed mussel	-	Eastern and Pacific U. S.
Brachydontes variabilis	Mussel	-	Lebanon
Choromytilus meridionalis (Krauss 1848)[4] ✤	Mussel	150	South Africa
Crassostrea angulata (Lamarck 1819)[5]	Portuguese oyster	180	Portugal and introduced elsewhere
Crassostrea brasiliana (Lamarck 1819)[6] ✖	Oyster	-	Brazil
Crassostrea commercialis ❖	Rock oyster	-	Pacific
Crassostrea corteziensis (Hertlein 1951)[7] ✧	Oyster	90	California to Panama
Crassostrea cucullata ❖	Rock oyster	-	Pacific
Crassostrea edulis ☆	Edible oyster	-	Eastern U. S., Western Europe and Mediterranean
Crassostrea gasar (Adonson)[8] ✦	Oyster	80-120	West Africa
Crassostrea gigas (Thunberg 1793)[1,2]	Pacific oyster	150	Western Canada to California, Japan and introduced elsewhere
Crassostrea glomerata (Gould 1850)[1]	Auckland rock oyster	90	New Zealand
Crassostrea laperousei (Schrencki 1861)[9] ▲	Oyster	350	Pacific
Crassostrea lugubris	Oyster	-	Thailand
Crassostrea madrasensis	Oyster	-	India
Crassostrea margaritacea (Lamarck 1819)[4]	Cape rock oyster	180	South Africa to Mozambique
Crassostrea rhizophorae (Guilding 1828)[1] ✖	Caribbean edible oyster	75	West Indies to Brazil
Crassostrea rivularis (Gould 1850)[10]	Oyster	-	Indo-Pacific
Crassostrea virginica (Gmelin 1791)[1,2]	Eastern oyster	85	Gulf of St. Lawrence to Caribbean, Gulf of Mexico and introduced elsewhere
Geukensia demissa (Dillwyn 1817)[2] ✢	Ribbed mussel	-	Eastern and Pacific U. S.

Table 3 (cont.)

Species	Common name	Length (mm)	Range
Gryphaea angulata	Portuguese oyster	-	Europe
Isognomon alatus (Gmelin 1791)[1,2]	Flat tree-oyster	75	Southeastern Atlantic U. S., Caribbean to Brazil, Bermuda
Isognomon isognomon (Linné 1758)[11]	Tree oyster	150	Tropics
Malleus meridianus (Cotton 1930)[11]	Hammer oyster	150	Australia
Modiolus auriculatus (Krauss 1848)[4]	Mussel	50	Indo-Pacific to South Africa
Modiolus barbatus (Linné 1758)[5]	Bearded horsemussel	60	Britain and Mediterranean
Modiolus capax (Conrad 1837)[2,7]	Fat horsemussel	80	California to Peru
Modiolus demissus +	Ribbed mussel	-	Eastern and Pacific U. S.
Modiolus modiolus (Linné 1758)[1,2]	Northern horsemussel	130	Arctic to mid latitudes
Modiolus neozelanicus	Mussel	-	New Zealand
Mytella falcata (d'Orbigny 1846)[1]	Falcate swamp mussel	70	Western Mexico to Ecuador, Venezuela to Uruguay
Mytella strigata (Hanley 1843)[12]	Mussel	40	Mexico to El Salvador, Venezuela to Argentina
Mytilus afer	Mussel	-	Atlantic and Mediterranean
Mytilus californianus (Conrad 1837)[1]	California mussel	200	Alaska to Mexico
Mytilus coruscus (Goud 1861)[10]	Hard shell mussel	130	Japan
Mytilus demissus (Dillwyn 1817)[13] +	Ribbed mussel	50-100	Gulf of St. Lawrence to Southeast Florida
Mytilus demissus plicatus +	Ribbed mussel	-	-
Mytilus edulis (Linné 1758)[1]	Blue mussel	75	Subartic seas worldwide
Mytilus edulis aoteanus (Powell 1958)[3]	Mussel	60-120	New Zealand
Mytilus edulis chilensis	Mussel	-	Chile
Mytilus edulis planulatus (Lamarck 1819?)[3]	Mussel	120	New Zealand and Australia
Mytilus galloprovincialis (Lamarck 1819)[1]	Mediterranean blue mussel	100	Western Europe and Mediterranean
Mytilus magellanicus	Mussel	-	Peru
Mytilus minimus	Mussel	-	Egypt
Mytilus obscurus	Mussel	-	Australia

Table 3 (cont.)

Species	Common name	Length (mm)	Range
Mytilus platensis (Orbigny 1846)[6] ●	Mussel	60	Southern Brazil to Argentina
Mytilus smaradignus ▼	Mussel	-	-
Mytilus striagata	Mussel	-	Mazatlan
Mytilus trossulus	Mussel	-	Russia
Mytilus viridis (Linné 1758)[1]	Green mussel	50	Indo-Pacific
Ostrea angasi (Sowerby 1871)[11] ✿	Oyster	200	Australia and Tasmania
Ostrea angulata	Oyster	-	Mediterranean
Ostrea circumpicta	Oyster	-	Japan
Ostrea edulis (Linné 1758)[1,2]	Edible oyster	80	Eastern U. S., Western Europe and Mediterranean
Ostrea equestris (Say 1834)[2,6] ★	Crested oyster	50	Virginia to Caribbean to Brazil
Ostrea gigas ▲	Pacific yster		-
Ostrea heffordi (Finlay 1928)[3]	Oyster	40-50	New Zealand
Ostrea lurida (Carpenter 1864)[1,2]	Native Pacific oyster	60	Alaska to Baja California
Ostrea lutaria (Hutton 1873)[3]	Bluff oyster	70-100	New Zealand
Ostrea pliculata	Oyster	-	Thailand
Ostrea sandvicensis (Sowerby 1871)[14]	Hawaiian oyster	50	Hawaii
Ostrea sinuata (Lamarck 1819)[15] ✿	Pt. Lincoln oyster	150	New Zealand, South Australia
Ostrea spinosa	Oyster	-	Japan
Perna canaliculus (Gmelin 1791)[1]	Channel mussel	150	New Zealand
Perna indica	Mussel	-	India
Perna perna (Linné 1758)[1]	Brown mussel	70	West Africa and southern Caribbean
Perna viridis (Linné 1758)	Green-lipped mussel	-	Phillipines
Pinctada carchariarium (Jamieson 1901)[15]	Shark Bay pearl oyster	120?	South Australia
Pinctada fucata martensii (Dunker)[10] ♦	Japanese pearl oyster	-	Japan
Pinctada margaritifera (Linné 1758)[16]	Black lipped pearl oyster	300	Kuwait and Oman
Pinctada vulgans	Oyster	-	Malaysia
Saccostrea commercialis	Sydney rock oyster	-	Australia
Saccostrea cucullata ❖	Rock oyster	-	Indo-Pacific

Table 3 (cont.)

Species	Common name	Length (mm)	Range
Saccostrea echinata (Quoy and Gaimard 1835)[9]	Spiny oyster	-	Australia, Japan (Pacific?)
Saccostrea glomerata ■	Oyster	-	-
Saccostrea iridescens (Gray in Hanley 1854)[7]	Iridescent oyster	250	Mexico to Peru
Septifer bilocularis (Linné 1758)[1]	Box mussel	250	Indo-Pacific
Stavelia horrida (Dunker 1856)[11]	Hairy mussel	250	Australia
Tiostria lutaria ✱	Oyster	-	-

✶ *Aulacomya ater maoriana* (Iredale 1915) listed in Powell (1979) may be the same as *A. maoriana*.
✢ *Mytilus demissus*, *Mytilus demissus plicatus*, *Modiolus demissus* and *Brachydontes demissus plicatulus* are junior synonyms of *Geukensia demissa*. *Brachidontes* is the currently accepted spelling of *Brachydontes* (Turgeon *et al.*, 1988).
✤ Form of *Aulacomya ater* (Kilburn and Rippey, 1982).
✖ *Crassostrea brasiliana* and *Crassostrea rhizophorae* are probably the same species.
❖ *Crassostrea commercialis*, *Crassostrea cucullata*, and *Saccostrea cucullata* are the same species.
✧ Probably the same as *Ostrea corteziensis*.
☆ Same as *Ostrea edulis* (Turgeon *et al.*, 1988).
✦ Same as *Ostrea tulipa* Lamarck 1819 (Nicklès, 1950).
▲ Junior synonym for *Crassostrea gigas* (Turgeon *et al.*, 1988).
● Probably same as *Mytilus edulis platensis*.
▼ Probably same as *Mytilus viridis* (Abbott and Dance, 1982).
✿ Same as *Ostrea sinuata* (Cotton and Godfrey, 1938).
★ Junior synonym of *Ostreola equestris* (Turgeon *et al.*, 1988).
♦ Same as *Pinctada martensii* (Kira, 1965).
■ Same as *Crassostrea glomerata* (Powell, 1979).
✱ Same as *Ostrea lutaria*.

1, Abbott and Dance (1982); 2, Turgeon *et al.*, 1988); 3, Powell (1979); 4, Kilburn and Rippey (1982); 5, Tebble (1976); 6, Rios (1985); 7, Olsson (1961); 8, Nicklès (1950); 9, Habe and Ito (1970); 10, Kira (1965); 11, Wells and Bryce (1986); 12, Keen (1971); 13, Abbott (1974); 14, Morris (1966); 15, Cotton and Godfrey (1938); 16, Bosch (1982).

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VI. ACKNOWLEDGEMENTS

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APPENDIX I

Mussel Watch Worlwide Literature

(Chem. Abs. information included for older citations.)

1 **Abbe, G. R.** (1982) Growth, mortality, and copper-nickel accumulation by oysters, *Crassostrea virginica*, at the Morgantown steam electric station on the Potomac river, Maryland. J. Shellfish Res., 2(-):3-13.

2 **Abbe, G. R., and J. G. Sanders** (1986) Condenser replacement in a coastal power plant: copper uptake and incorporation in the American oyster, *Crassostrea virginica*. Mar. Environ. Res., 19(-):93-113.

3 **Abbe, G. R., and J. G. Sanders** (1990) Pathways of silver uptake and accumulation by the American oyster (*Crassotrea virginica*) in Chesapeake Bay. Est. Coastal Shelf Sci., 31(2):113-23.

4 **Abdel-Moati, A., and M. M. Atta** (1991) *Patella vulgata*, *Mytilus minimus* and *Hyale prevosti* as bioindicators for Pb and Se enrichment in Alexandria coastal waters. Mar. Pollut. Bull., 22(3):148-10.

5 **Abdullah, M. I., and I. Steffenak** (1988) The GEEP Workshop: trace metal analyses. Mar. Ecol., 46(1-3):27-30.

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8 **Adachi, K.** (1980) Mass fragmentographic determination of polymethylnaphthalene and polymethylphenanthrene in a crude oil and in marine organisms. Bull. Environ. Contam. Toxicol., 25(3):416-23.

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10 **Aftab, N.** (1987) Seasonal variation in biochemical composition of oysters, *Crassostrea madrasensis*, from Karachi coast. Karachi Univ. J. Sci., 15(1-2): 71-7.

11 **Ahmed, M.** (1975) Speciation in living oysters. Adv. Mar. Biol., 13(-): 357-97.

12 **Aissi, A., and D. Siblot** (1980) Etude du lac El-Mellah (Wilaya d'Annaba): les métaux lourds dans certains organismes. Ves Journess Etud. Pollutions, -(-):151-4 (French).

13 **Albright, L., T. G. Northcote, P. C. Olaffs, and S. Y. Szeto** (1975) Chlorinated hydrocarbon residues in fish, crabs, and shellfish of the Lower Fraser River, its estuary, and selected locations in Georgia Strait, British Columbia -1972-73. Pest. Monit. J., 9(-):134-40.

14 **Al-Dabbas, M. A. M., F. H. Hubbard, and J. McManus** (1984) The shell of *Mytilus* as an indicator of zonal variations of water quality within an estuary. Est. Coastal Shelf Sci., 18(3):263-70.

15 **Alexander, G. V., and D. R. Young** (1976) Trace metals in southern California mussels. Mar. Pollut. Bull., 7(1):7-9.

16 **Alexander, R., M. Cumbers, R. Kagi, M. Offer, and R. Taylor** (1982) Petroleum contamination of Cockburn Sound, Western Australia. Toxicol. Environ. Chem., 5(3-4):251-75.

17 **Al-Sabti, K., and B. Kurelec** (1985) Induction of chromosomal aberrations in the Mussel *Mytilus galloprovincialis* Watch. Bull. Environ. Contam. Toxicol., 35(-):660-5.

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Port de Minimes
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Port-Cartier
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Prince Edward Isl.
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Princess Harbor
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Saccostrea cucullata
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Saccostrea echinata
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Saccostrea glomerata
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Saccostrea iridescens
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Sado Est.
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Sepetiba Bay
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Septifer bilocularis
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Sequim Bay
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Severn Est.
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St. Croix
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St. John
862

St. Lawrence Est.
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St. Louis Bay
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Stavelia horrida
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Strait of Hormuz
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Strunjan
913

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143

Sullon Voe
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Svardsfjarden
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Swansea
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Thailand
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Thames Est.
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Thermaikos Gulf
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Tianjin Harbor
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Tigris Est.
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Timbalier Bay
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Tiostrea lutaria
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Tiostria lutaria
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Valencia
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Vellar Est.
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Velsao
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Venezuela
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Victoria
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Virginia
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Waitemaka Harbor
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Wales
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Washington
131, 173, 317, 623, 710, 720, 856, 897, 1103

Weser Est.
931

Western Australia
666, 996, 997, 1000, 1002, 1091

Western Port Bay
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Westerschelde
453

White Sea
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Whitsand Bay
781, 1102

Willapa Bay
720

Wyre Est.
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Yaquina Bay
563, 699, 700

Yeosu
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Yugoslavia
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804, 805, 807, 808, 809, 811,
838, 826, 812, 820, 816, 817,
833, 835, 834, 837, 841, 843,
853, 884, 857, 859, 895, 880,
896, 897, 888, 882, 893, 908,
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964, 981, 979, 994, 1001, 1000,
970, 997, 971, 992, 995, 1002,
1010, 1028, 1022, 1023, 1027,
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1080, 1081, 1084, 1094, 1098,
1101, 1106, 1115, 1109, 1110,
1122, 1117, 1123

APPENDIX III

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