6. Condition of Living Resources

Background

In previous chapters, the assessment has emphasized physical and chemical conditions in the water and sediments. In this chapter, we look to the organisms themselves for an indication of the environmental condition of the estuaries. Living resources (i.e., biological communities) are ideal indicators, as they reflect long-term conditions that are averaged over all seasons and many annual cycles. The effects of exceptional events, such as storms or droughts, are included in the assessment as well. Importantly, all parties in environmental actions (i.e., ecologists, environmental as well as industrial managers, regulators, etc.) tend to agree that the condition of living resources is a fair judge of environmental condition. For all these reasons, it is likely that future environmental regulations will include measurable biological indicators in addition to the more familiar indicators of sediment and water quality.

The worms, shellfish, and crustaceans that live in or on the bottom surfaces of estuaries are collectively called the benthos. They play a central role in the estuarine food web and in maintaining the quality of the water and sediments in estuaries. Most healthy benthic communities maintain an abundant and diverse mix of native organisms. A shift away from native species toward a more limited community dominated by pollution-tolerant taxa is a likely indication of an impaired ecosystem.

In this chapter, we review a benthic index which reflects diversity in the benthic community and the abundance of pollution-tolerant species.

We also examine two simple measures of fish communities to gauge estuarine condition: the number of fish species in an estuary, and the incidence of abnormalities in fish. And finally, because humans consume copious amounts of fish and shellfish, we examine the residue of toxic substances in the edible parts of fish and shellfish.

Condition of the Benthic Community (Benthic Index)

Benthic communities are sensitive to many environmental stresses such as salinity fluctuations, oxygen deprivation, and poisoning by toxic substances. Biologists often combine several measures of stress into a single, easily understandable index of community condition. These measures are analogous to financial indicators, such as the Dow Jones Index that characterizes the condition of the economy.

Paul, et al. (1999) developed such an index to evaluate the benthic condition of mid-Atlantic estuaries. This index is based on a measure of diversity and the abundance of pollution tolerant taxa, and has been used to successfully identify sites that are degraded throughout the region.

Figures 6-1 and 6-2 show the distribution of benthic conditions throughout the region and in intensively-sampled systems. Appendix D displays the benthic index scores in comparison with contaminant concentrations in sediments and other parameters.

About 40% of the MAIA region has degraded sediments as is reflected by benthic index scores of zero or less. Index scores range from about -9 to +4 in the mid-Atlantic region. Positive values of the index signify healthy community conditions, and negative values indicate degraded communities.

About a third of the sediments in the Delaware Bay and the Delaware, Schuylkill, and Salem Rivers receives a poor rating by the benthic index.

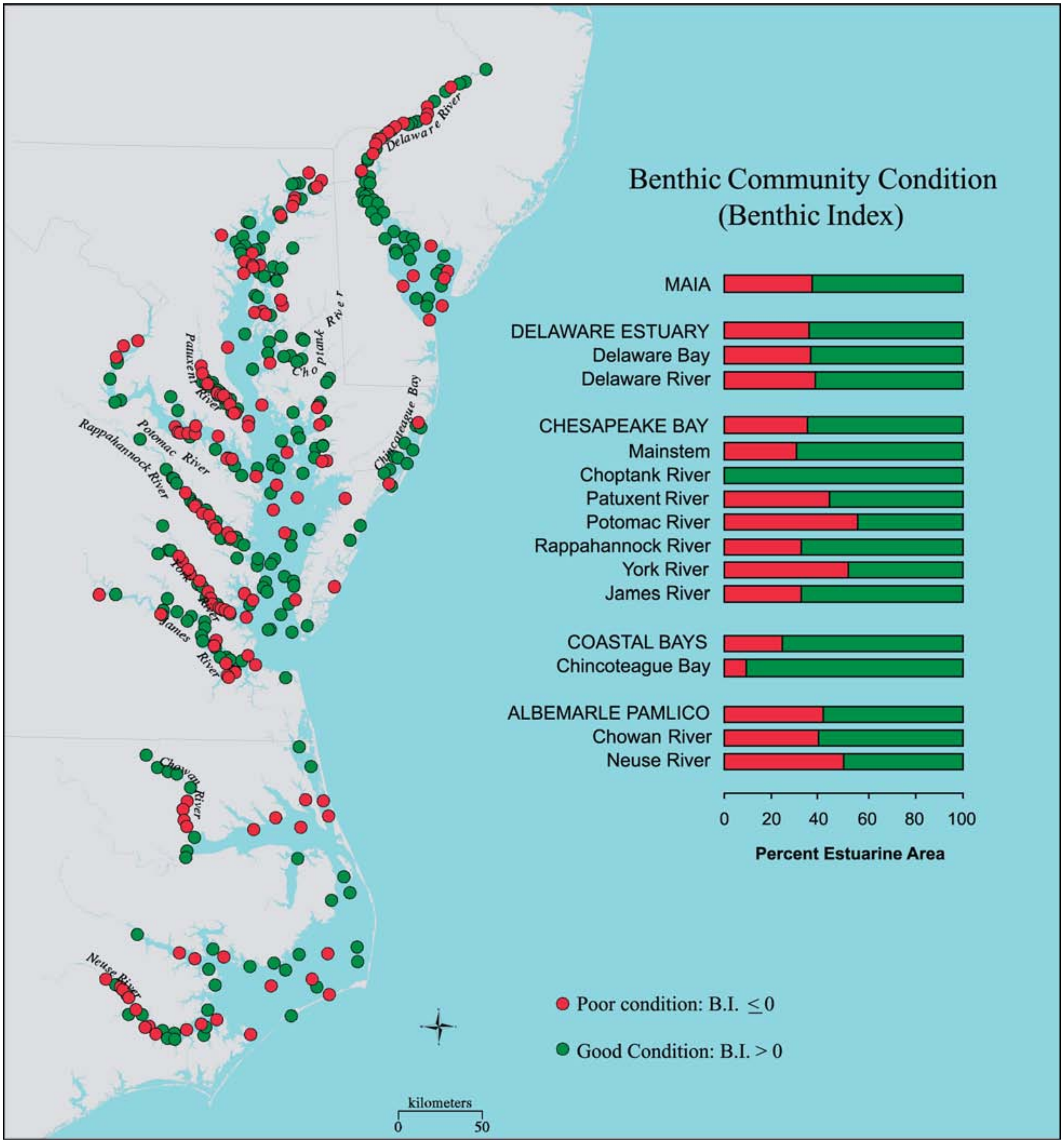

Figure 6-1. Index of Benthic Community Condition (Benthic Index).

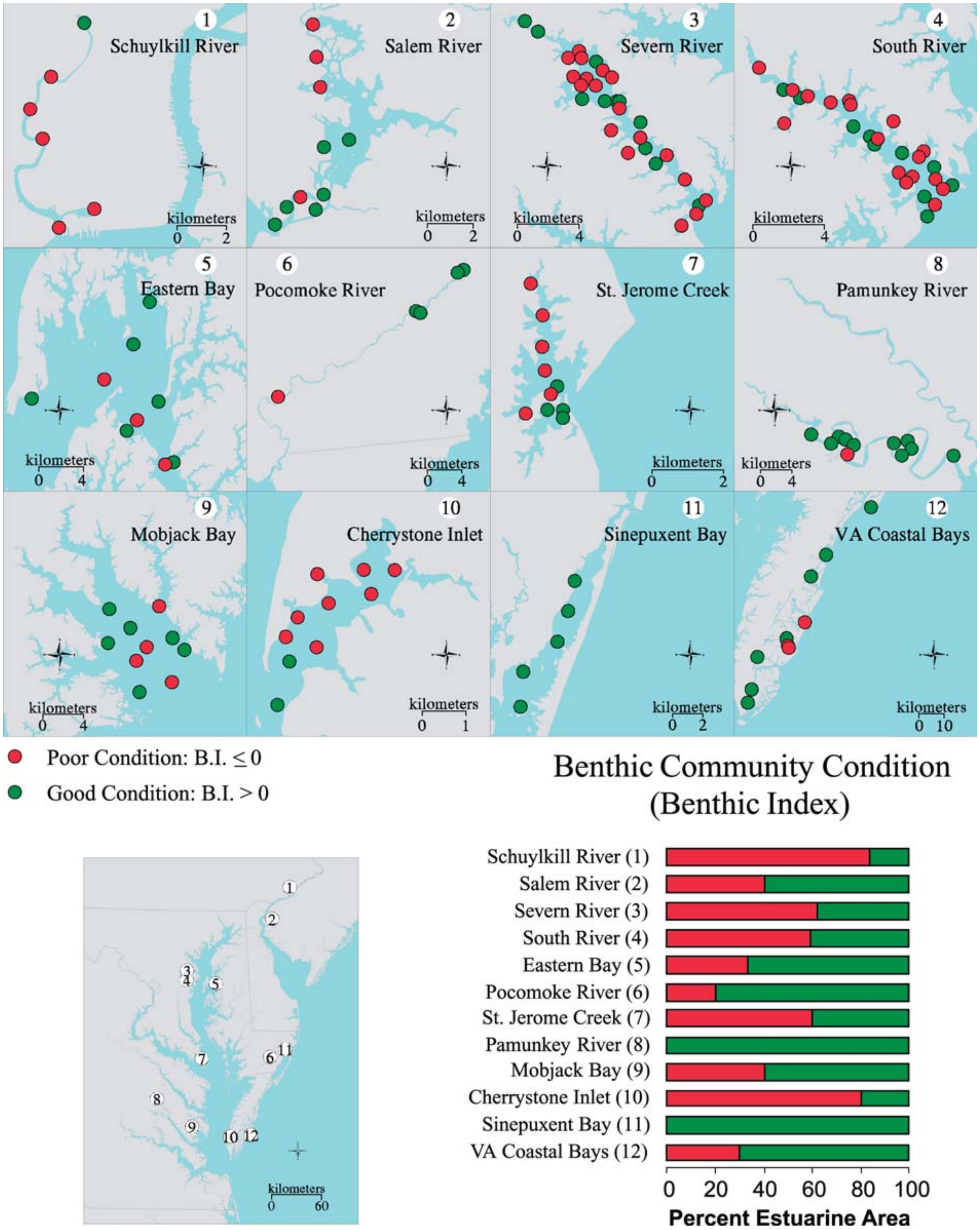

Figure 6-2. Index of Benthic Community Condition in Intensively-Sampled Systems.

The lowest scores in the mid-Atlantic region are reported for the Schuylkill and Salem Rivers.

Overall, about a third of the Chesapeake Bay is also rated as degraded by the benthic index. Generally, the mainstem fares better than the tributaries. Over half of Potomac and York Rivers have negative indices. The Choptank and Pamunkey Rivers are rated more positively.

The Maryland and Virginia coastal bays show the best index scores in the study. Chincoteague and Sinepuxent Bays and most of the Virginia coastal bays merit positive scores.

Forty percent of the sediments in the APES has degraded benthos. Forty to fifty percent of the Neuse and Chowan Rivers is impaired.

When the benthic community index is compared with other measures of water and sediment quality, several statistically-valid relationships are evident (see Appendix F). For instance, the benthic index decreases in value as the DO concentration decreases and as the degree of sediment contamination increases. These correlations demonstrate that the benthic index responds to pollution gradients in the expected manner and is a useful measure of benthic condition.

Condition of Benthic Community

Method: A benthic index score was calculated by an algorithm developed by Paul, et al. (1999) in the EMAP-VP study to evaluate the condition of benthic communities in mid-Atlantic estuaries. This index is based on a measure of diversity and the abundance of pollution tolerant taxa (see Appendix B). Positive values signify healthy community conditions, and negative values indicate degraded communities.
Units: The index has no units
Assessment categories:
Good: > zero
Poor: ≤ zero
Range of data: -8.9 to 4.1
A benthic index for the Albemarle-Pamlico Estuarine System is calculated using a separate algorithm developed for that region (Jeff Hyland, personal communication). Those data are categorized as good or poor, equivalently to EMAP-VP index. Also, a slight adjustment to the scores of the Delaware Estuary is made (+ 0.3 added) to account for a difference in analysis methods used for that system. See Appendix B for details.

Number of Fish Species

Ecologists tell us that diversity of fish communities is also an informative indicator of overall conditions in an estuary. In the summer of 1998, the MAIA program performed uniform fish trawls in the Chesapeake Bay, Delaware Bay, and the coastal bays.

The species count ranged from 0 to 13, with an average of 4.6 species per site. The fish trawls almost certainly underestimate the actual number of fish species in an estuary because not all fish habitats were sampled, and many fish can easily avoid the trawl nets. Still, the estimates provide a comparison of the relative fish diversity among estuaries.

Figure 6-3 indicates the results of the fish species count. The following ranges were observed:

System	Number
Delaware Estuary	5-6
Sinepuxent Bay	4-8
Chincoteague Bay	2-6
VA coastal bays	3-13
Upper Chesapeake Bay	5-6
Severn & South Rivers	0-3
Patuxent River	2-5
Potomac River	0-7
Rappahannock River	1-5
York River	4-8
James River	3-9

Relatively more fish species were found in the upper Delaware Bay, the coastal bays, and in the upper portions of tributaries. Fewer species were evident in the Chesapeake mainstem and lower tributaries.

Number of Fish Species

Method: Standard trawls were conducted: 10 ± 2 minutes in duration with a towing speed of 2-3 knots through the water against the prevailing current. Fish were identified in the field.
Units: This parameter has no units.
Map categories:
Low: Zero to three species
High: More than three species

Fish Abnormalities

As an additional check on the health of the fish community, fish caught in the trawls were examined for external abnormalities (ulcers, growths, and abnormal backbones). The site was designated "poor" if any abnormality was found in any fish. Figure 6-4 shows the incidence of abnormalities in the Chesapeake and Delaware estuaries.

The overall incidence of abnormalities was low. The only pathologies found were ulcers on five fish, a rate of less than two abnormalities per thousand fish. These results are comparable to the rate of abnormalities observed in the 1990-1993 EMAP-VP study, in which the incidence was less than three abnormalities per thousand fish.

Fish Abnormalities

Method: 3286 fish from 76 trawls were examined in the field for signs of external pathology (lumps, growths, ulcers, or finrot). Diagnoses of pathology were confirmed by expert pathologists.
Units: This parameter has no units.
Map categories:
Low: No abnormalities
High: One or more abnormalities

Contamination of Fish and Shellfish Tissue

In estuaries with contaminated sediments, there is additional concern that the metallic and organic pollutants may be concentrated in secondary and tertiary consumers such as shellfish and fish. Such bioaccumulation arises because the predator retains most of the contaminants from the prey organism. These contaminants are stored in the edible tissue of the fish and shellfish, and, therefore, pose a risk to humans who consume the contaminated organisms.

In the MAIA study, representative samples of edible tissue from summer flounder and blue crabs were analyzed for metallic and organic toxicants. Table 6-1 lists the analytes and concentration limits considered by USEPA to present risks to human consumers (USEPA 2000c). The limits are based on human health risk assessment and are considered to be protective of recreational, tribal, ethnic, and subsistence fishers who are likely to consume more fish than the general population.

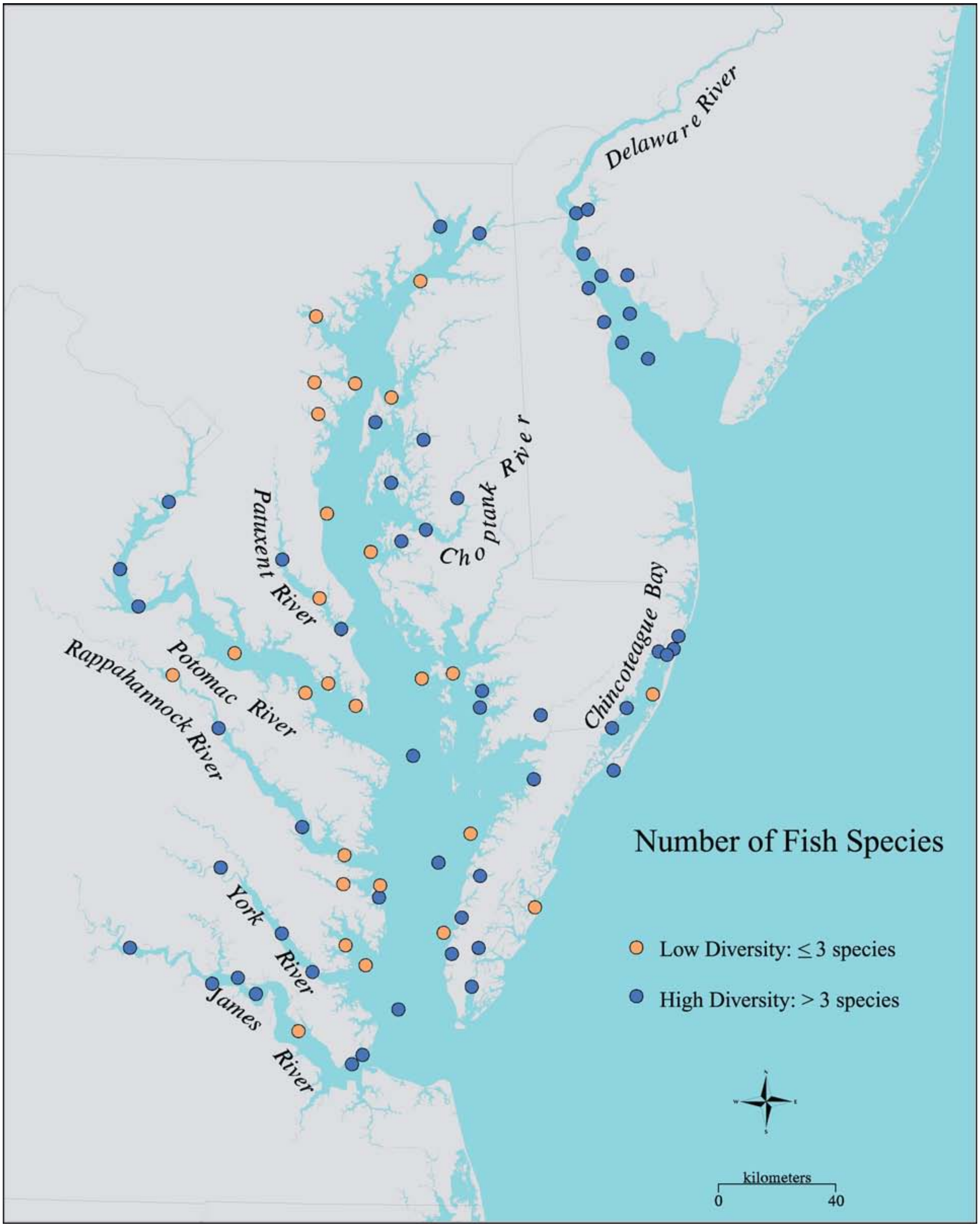

Figure 6-3. Number of Fish Species.

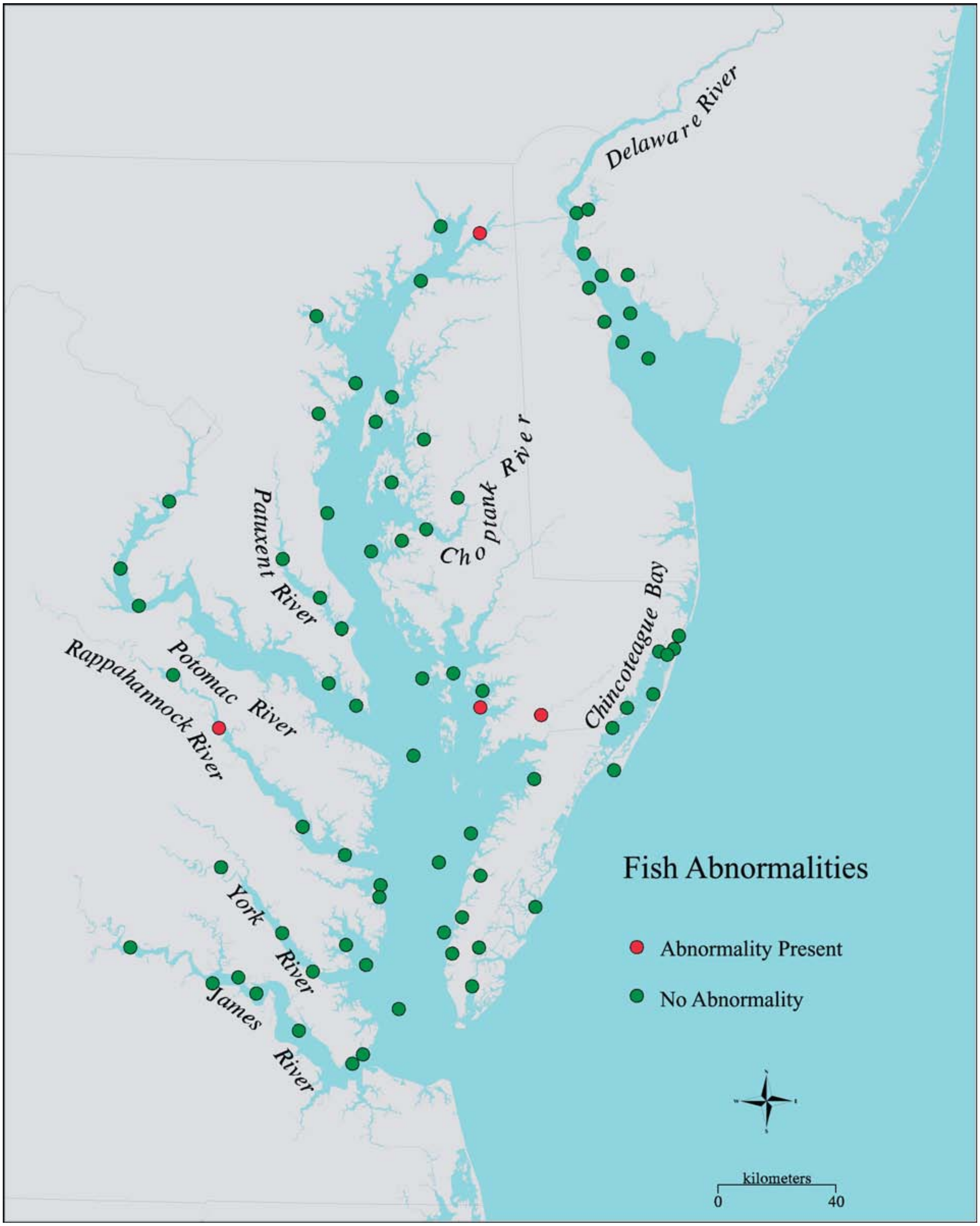

Figure 6-4. Occurrence of Abnormalities in Fish.

Only a limited number of sites in the Chesapeake Bay, Delaware Bay, and the coastal bays were investigated for tissue contamination. Figure 6-5 shows that most fish sampled had at least one exceedance to the consumption guidelines. Thirty stations (65% of all stations) are out of compliance. Of these, 23 exceed the arsenic limit, with an average tissue concentration of 2.5 ppm (and a maximum of 4.9 ppm). Thirteen of the stations exceed the PCB limit, with an average concentration of 40 ppm (and maximum of 81 ppm). No other analyte is responsible for an exceedance in this limited study.

Table 6-1. USEPA Chemical Analytes and Consumption Limits Used in Issuing Fish Advisories.

Fish/Shellfish Tissue Contaminants

Analyte	limit (ppm)
Arsenic	1.2
Cadmium	4
Mercury	0.4
Selenium	20
Chloropyrifos	123000
Dieldrin	2.5
Endosulfan	24000
Endrin	1200
Heptachlor epoxide	4
Hexachlorobenzene	25
Lindane	30
Total Chlordane	110
Total DDT	120
Total PAH	6
Total PCB	20

Contamination in Fish and Shellfish Tissue

Method: Edible portions of summer flounder or blue crab were composited, homogenized, and analyzed for concentrations of metals and organic compounds. The concentrations of analytes were compared to consumption limits for fish, as recommended by USEPA (2000). The condition at a site was determined by the number of exceedances.
Units: None are applicable.
Map categories:
Low: No exceedances
High: > 1 exceedance

Summary: Conditions of the Living Resources

38 ± 8% of the mid-Atlantic estuaries overall have benthic communities that are degraded, as is indicated by the benthic community index.

The benthic communities in the poorest condition are located in the Delaware, Schuylkill, and Salem Rivers, and in the Potomac, South, and Severn Rivers. These systems show extensive signs of eutrophication and/or sediment contamination. However, the benthic community index also indicated extensive poor conditions in a number of systems that were not otherwise afflicted with environmental problems. These include the York and Neuse Rivers and the St. Jerome Creek and Cherrystone Inlet.

Over 3,000 fish were examined for signs of external pathology. Less than two abnormalities per thousand fish were noted — a positive indication of condition.

In 65% of the analyses performed, the edible portions of fish and shellfish contained metals and/or organic toxicants at levels large enough to present risk to human consumers. Arsenic and PCBs were the only toxicants that exceeded EPA guidelines.

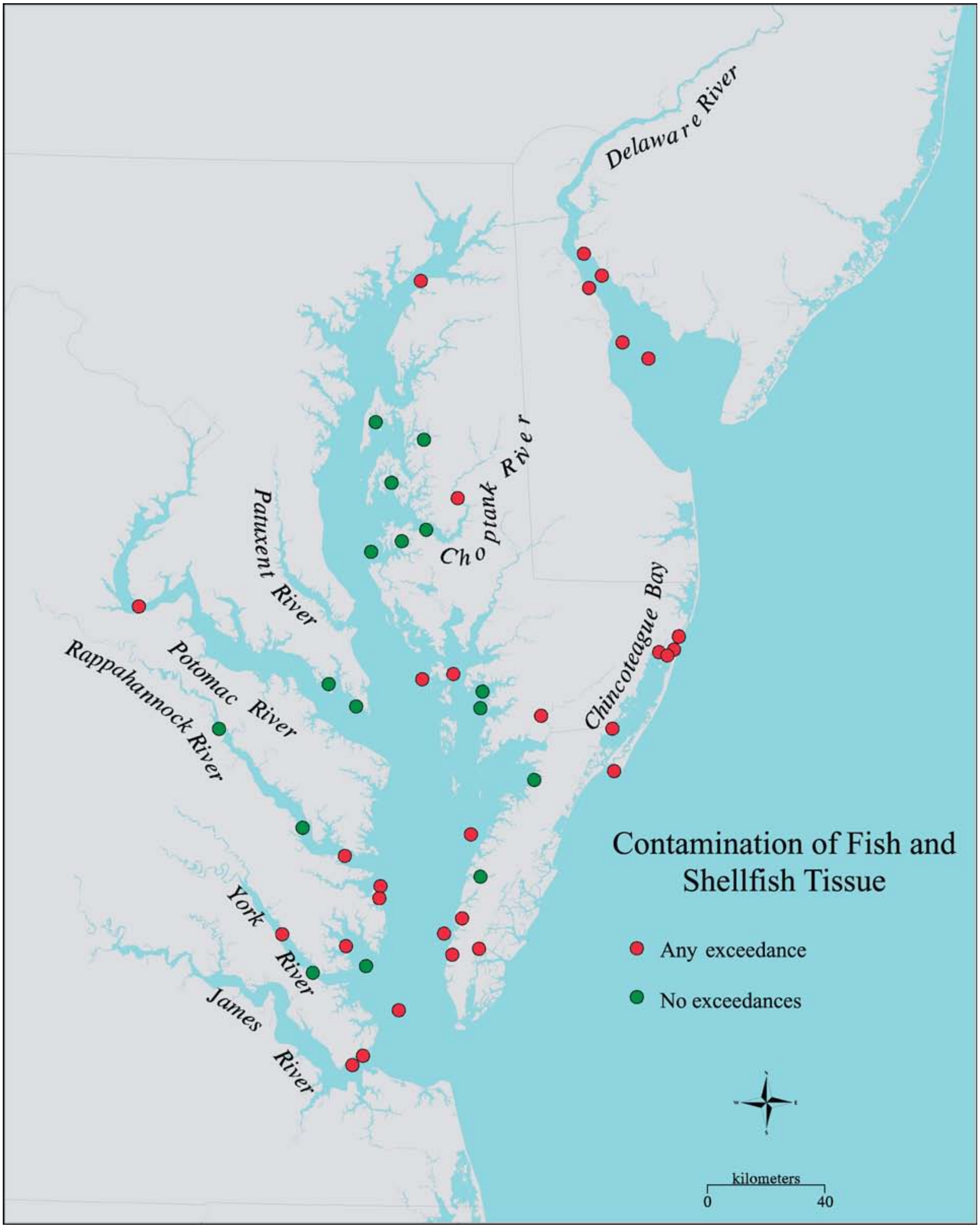

Figure 6-5. Contaminant Exceedances in Fish and Shellfish Tissue.