medium with minimum requirements of water quality. The major consideration is that the water acidity be relatively low to prevent corrosion of equipment.

However, many operations require use of large quantities of water with quality requirements relating to impurity, type, and level. These operations are froth flotation, mine dump leaching, and secondary oil recovery.

Water quality requirements needed for the manufacture of cement are minimal, the document said. The major consideration is the alkali content of process water.

Water Resources

## NAS SAYS KNOWLEDGE OF LOCALITIES ESSENTIAL TO APPLICATION OF STANDARDS

Knowledge of local environmental conditions is essential prior to application of any water quality recommendations for marine aquatic life and wildlife, according to a National Academy of Sciences' draft of "Water Quality Criteria – 1972" (Environment Reporter, August 10, p. 588 and August 17, p. 669).

The NAS document dealt with maintenance of the marine ecosystem, fisheries, aquaculture, wildlife protection, and waste disposal. In developing recommendations, NAS also considered the effects of transportation, harbor development, dredging, and dumping of spoils.

NAS said application of recommendations to a local situation is unique, because it requires an understanding of the circulation of water and the resultant mixing and dilution of pollutants, a knowledge of biological species, and determination of the most sensitive species, and an evaluation of the transport of materials through the food web.

### Water Quality Change

The introduction of a chemical compound or a change in the physical environment can affect a natural marine ecosystem in several ways, the report said. These changes include a reduction in the input of solar energy into the ecosystem, an increase in the input of organic matter and nutrients that might stimulate growth of undesirable species, and a reduction in the availability of nutrients by increased sorption and sedimentation.

Changes also can create intolerable physical extremes for some organisms, kill or reduce the success of individual organisms, eliminate species, reduce species diversity, decrease biomass, or increase biomass.

### Fisheries

General requirements for water quality in relation to successful fisheries include favorable environmental conditions at every location, which is required in the life history of each species; freedom from tainting substances; absence of toxic conditions or substances; and absence of sublethal deleterious conditions.

Further, there should be water sufficient to maintain the health of the biological systems, which support useful species, and absence of environmental conditions, which are exceptionally favorable to parasites, predators, and competitors of useful species.

### Aquaculture

Aquaculture is heavily dependent on high water quality, according to the NAS report.

General recommendations for the quality of water for use in culture include continuously adequate control of those materials and conditions, which are required for good health and efficient production of the species and absence of deleterious chemical and physical conditions.

Other recommendations included environmental stability and prevention of introduction of diseases. NAS said specific requirements for each culture effort must be with reference to the species involved, the densities desired, and the operational design of the culture system.

NAS said it is difficult to assess the potential yield from marine aquaculture, dependent as it is on a primitive art undergoing rapid technological development. However, introduction of present methods into new, undeveloped parts of the world could at least double the present harvest within the next 10 years, the report said.

### Marine Wildlife

NAS said its recommendations for marine wildlife include all criteria formulated to protect fish, invertebrate, and plant communities because wildlife can only be adequately protected, if the diversity and integrity of food webs are maintained. Further, these recommendations must protect wildlife from pollutants that are relatively persistent in the environment, transported by wind or water currents, and concentrated or recycled in food webs.

The report said the recommendations to protect wildlife dependent on fresh water ecosystems also may apply to estuaries.

NAS said it is not practical to make recommendations for the relatively persistent organic pollutants based on water concentrations, especially when partition coefficients are unknown. Therefore, recommendations for the toxic organic compounds that are trophically accumulated by marine wildlife are based on concentrations in fish.

NAS recommendations for marine wildlife are as follows:

In the absence of data indicating that radionuclides released by human activities are accumulated by wildlife species, recommendations established for marine fish and invertebrates also should apply to wildlife.

In the absence of data indicating that heavy metals are present in marine wildlife in concentrations above natural levels, recommendations formulated to protect other marine organisms should apply.

Polychlorinated biphenyl concentrations in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the same size range as the fish consumed, should be no greater than .5 milligram per kilogram (mg/kg) of the wet weight.

DDT concentrations in any sample consisting of a homogenate of 25 or more fish of any species that is consumed by fish-eating birds and mammals, within the same size range as the fish consumed, should be no greater than 50 micrograms/kg of the wet weight.

The sum of the concentrations of aldrin, dieldrin,



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endrin, and heptachlor in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the size range consumed by any bird or mammal, should be no greater than five micrograms/kg of the wet weight.

The concentration of any chlorinated hydrocarbons, including lindane, chlordane, endosulfan, methoxychlor, mirex, toxaphene, and hexachlorobenzene, in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the size range that is consumed by any bird or mammal, should be no greater than 50 micrograms/kg of the wet weight.

To reduce the incidence of lead poisoning fresh water and marine waterfowl, NAS recommended that nontoxic shot be used or that no further lead shot be introduced into zones of shot deposition if lead shot concentrations exceed one shot per four square feet in the top two inches of sediment.

NAS said the characteristics of a receiving body of water must be considered when evaluating the effects of any pollutant upon the environment.

### Mixing Zones

The report said that mixing zones should be considered on a case-by-case basis, because each proposed site involves a unique set of pertinent considerations. These include the nature, quantity, and concentration of effluent material; the physical, chemical, and biological characteristics of the mixing area and receiving waters; and the desired uses of the waters.

However, the academy's general recommendation was that the total time-toxicity exposure history should not cause deleterious effects in affected populations of important species, including the post-exposure effects.

### Categories of Pollutants

For temperature, NAS said the recommendations included in the report on fresh water appear to be valid for estuarine and marine waters as well. However, additional studies are needed on the temperature tolerances of species directly involved.

### Inorganics

The NAS recommendations for inorganic chemicals, including heavy metals and pH are as follows:

The normal range of pH in either direction should not be extended by more than .2 units. Within the normal range, the pH should not vary by more than .5 unit. Addition of foreign material should not drop the pH below 6.5 or raise it above 8.5.

An application factor of .01 should be applied to marine 96-hour lethal concentration ($LC_{50}$, median) data for the appropriate organisms most sensitive to aluminum. Concentrations of aluminum exceeding 1.5 milligrams per liter (mg/l) constitute a hazard and concentrations less than .2 mg/l present minimal risk of deleterious effects.

An application factor of .1 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to ammonia. Concentrations of un-ioned ammonia equal to or exceeding .4 mg/l constitute a hazard and concentrations less than .01 mg/l present minimal risk of deleterious effects.

An application factor of .02 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to antimony. Concentrations of antimony equal to or exceeding .2 mg/l constitute a hazard. Data are not available for recommending a concentration which would present minimal risk of deleterious effects.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to arsenic. Concentrations of arsenic equal to or exceeding .05 mg/l constitute a hazard and concentrations less than .01 mg/l present minimal risk of deleterious effects.

An application factor of .05 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to barium. Concentrations of barium equal to or exceeding one mg/l constitute a hazard and concentrations less than .5 mg/l present minimal risk of deleterious effects.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to beryllium. Concentrations of beryllium equal to or exceeding 1.5 mg/l constitute a hazard and concentrations less than .1 mg/l present minimal risk of deleterious effects.

Concentrations of boron equal to or exceeding five mg/l constitute a hazard and concentrations less than five mg/l present minimal risk of deleterious effects. An application factor of .1 was recommended for boron compounds applied to marine 96-hour $LC_{50}$ data for sea water.

Free bromine in the marine environment should not exceed .1 mg/l and ionic bromine in the form of bromate should not exceed 100 mg/l.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for appropriate organisms most sensitive to cadmium. Concentrations of cadmium equal to or exceeding .01 mg/l constitute a hazard and concentrations less than .2 microgram per liter present minimal risk of deleterious effects. In the presence of copper and/or zinc at one mg/l, the application factor for cadmium should be lower by at least one order of magnitude. Cadmium criteria for aquatic life should also apply to wildlife.

An application factor of .1 should be applied to marine 96-hour $LC_{50}$ data from sea water bioassays for the most sensitive species to be protected from chlorine. Free residual chlorine in sea water in excess of .01 mg/l can be hazardous to marine life. However, in the absence of data, it is premature to advance recommendations.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to chromium. Concentrations of chromium equal to or exceeding .1 mg/l constitute a hazard and concentrations less than .05 mg/l present minimal risk of deleterious effects. In oyster areas, concentrations should be maintained at less than .01 mg/l.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to copper. Concentrations of copper equal to or exceeding .05 mg/l constitute a hazard and concentrations less than .01 micrograms per liter present minimal risk of deleterious effects.

### Cyanides

An application factor of .1 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to cyanide. Concentrations of cyanide equal to or exceeding .01 mg/l constitute a hazard and concentrations less than .005 mg/l present minimal risk of deleterious effects.

An application factor of .1 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to fluoride. Concentrations of fluoride equal to or exceeding 1.5 mg/l constitute a hazard and concentrations less than .5 mg/l present minimal risk of deleterious effects.

Concentrations of iron equal to or exceeding .3 mg/l constitute a hazard and concentrations less than .05 present minimal risk of deleterious effects.

Concentrations of lead in sea water should not exceed .02 of the 96-hour $LC_{50}$ for the most sensitive species and the 24-hour average concentration should not exceed .01 or the 96-hour $LC_{50}$. Concentrations of lead equal to or exceeding .05 mg/l constitute a hazard and concentrations less than .01 mg/l present minimal risk of deleterious effects. Special efforts should be made to reduce lead concentrations even further in oyster-growing areas.

An application factor of .02 of the 96-hour $LC_{50}$ for the organisms most sensitive to manganese was recommended. Concentrations of .1 mg/l may constitute a hazard and concentrations of less than .02 mg/l present minimal risk.

Concentrations of mercury equal to or exceeding .10 micrograms per liter constitute a hazard. Recommendations established to protect aquatic life and public water supplies also should apply to wildlife.

Concentrations of molybdenum in sea water should not exceed .05 of the 96-hour $LC_{50}$ for the most sensitive species and the 24-hour average should not exceed .02 of the 96-hour $LC_{50}$.

An application factor of .02 should be applied to 96-hour $LC_{50}$ data on the organisms most sensitive to nickel. Concentrations of nickel in excess of .1 mg/l would pose a hazard and concentrations of .002 mg/l would pose minimal risk.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to elemental phosphorus. Concentrations equal to or exceeding one microgram per liter constitute a hazard.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for appropriate organisms most sensitive to selenium. Concentrations equal to or exceeding .01 mg/l constitute a hazard and concentrations less than .005 mg/l present minimal risk of deleterious effects.

Concentrations of silver in marine water should not exceed .05 of the 96-hour $LC_{50}$ for the most sensitive species. Concentrations equal to or exceeding five micrograms per liter constitute a hazard and concentrations less than one microgram per liter present minimal risk.

An application factor of .1 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to sulfide. Concentrations equal to or exceeding .01 mg/l constitute a hazard and concentrations less than .005 mg/l present minimal risk, if the pH is maintained within a range of 6.5 to 8.5.

Because of the chronic effect of long-term exposure of fish to thallium, tests should be conducted for at least 20 days on sensitive species. Techniques should measure circulatory disturbances and other sublethal effects. Concentrations equal to or exceeding .1 mg/l constitute a hazard and concentrations less than .05 mg/l present minimal risk.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to uranium. Concentrations equal to or exceeding .5 mg/l constitute a hazard and concentrations less than .1 mg/l present minimal risk.

Concentrations of vanadium in sea water should not exceed .05 of the 96-hour $LC_{50}$ for the most sensitive species.

An application factor of .01 should be applied to marine 96-hour $LC_{50}$ data for the appropriate organisms most sensitive to zinc. Concentrations equal to or exceeding .1 mg/l constitute a hazard and concentrations less than .02 mg/l present minimal risk.

### Oil in Sea Water

NAS said no oil or petroleum products that can be detected as a visible film, sheen, or discoloration of the surface, that can be detected by odor, that can cause tainting of fish or edible invertebrates or damage the biota, or that can form an oil deposit on the shores or bottom of the receiving body of water should be discharged into estuarine or coastal waters.

Accidental releases of oil to the marine environment should be reclaimed or treated as expeditiously as possible using procedures at least equivalent to those provided in the 1970 National Contingency Plan.

To protect marine wildlife, a monitoring program should follow long-term trends in petroleum tar accumulation in selected areas of the oceans, no oil exploration or drilling should be permitted within existing or proposed sanctuaries, parks, reserves or other protected areas, and oil exploration or drilling should not be conducted in a manner which could deleteriously affect species subject to interstate or international agreements.

To minimize damage to the marine biota, oil on the sea surface should be contained by booms and recovered by use of surface skimmers or similar techniques and oil on beaches should be mechanically removed using straw, peat moss, or other appropriate techniques that will produce minimal adverse effects on the biota. In the event of a tanker wreck, oil remaining in the hulk should be off-loaded.

Failing recovery of oil from the sea surface or from a wrecked tanker, efforts should be made to burn it in place. Dispersants of minimal possible toxicity should be used only when necessary to avoid even greater hazard to the environment. NAS did not recommend sinking of oil.

NAS said the concentration of radioisotopes in sea water should be low enough so that the concentration in any marine species will not exceed the Federal Radiation Council's radiation protection guides for organisms harvested for use as human food. This recommendation is based on the assumption that radiation concentrations, which are acceptable as human food, will not injure aquatic organisms, including wildlife.

### Sewage and Nutrients

NAS said untreated or treated municipal sewage discharges should be recognized as a major source of toxic substances. Recommendations for these pollutants will limit the amount of sewage affluent that can be dispersed into estuaries. Reduced degradation rates of highly dispersed materials should be considered if the effluent contains refractory organic material.

NAS said that while undegradable synthetic organic compounds do not cause oxygen depletion, they can adversely affect an ecosystem. Specific quantitative analyses should be done to identify and assess the abundance of these compounds.

The addition of any organic waste to the marine environment should be controlled to avoid decomposition which would reduce the oxygen content of the water below limits recommended for oxygen. Further, neither organic matter nor fertilizers should be added that will induce production of organic matter by normal biota to an extent causing an increase in the size of any natural anoxic zone in the deeper waters of an estuary.

NAS said the natural ratios of available nitrogen to total phosphorus should be evaluated under each condition and the element actually limiting plant production should be determined.

Disposal of sludge into coastal waters should be recognized as a temporary practice, because such dumping can adversely affect aquatic organisms. NAS said disposal of organic wastes into the deep sea is not recommended until further studies on their fate, on their effect on fauna, and on the controllability of such a procedure have been conducted.

The study said that disposal of waste materials at sea should be controlled. Disposal should be permitted only when reasonable evidence is presented that the proposed action will not seriously damage the marine biota, interfere with fisheries operations or other uses of the marine environment, or cause hazards to human health and welfare.

### Dredging

In connection with dredging operations or other physical modification of harbors and estuaries which would increase the suspended sediment load, NAS made several recommendations. These included evaluation of the range and types of particles to be resuspended and transported, where they will settle, and what substratum changes or modifications could be created by proposed activities in both the dredged and disposal areas.

NAS also recommended determination of the biological activity of the water column, the sediment-water interface, and the substrate material to depths which contain burrowing organisms; estimation of the potential release into the water column of sediments; and establishment of the expected relationship between properties of the suspended load and the permanent resident species of the area and their ability to repopulate the area and the transitory species which use the area only at certain seasons of the year.

Water Resources

## NAS REPORT URGES STRINGENT METHODS TO CONTROL WASTE INPUTS, LAND DRAINAGE

More stringent methods to control and/or treat waste inputs and land drainage should be applied to improve water quality as demand for use increases, according to the National Academy of Sciences' draft of "Water Quality Criteria – 1972."

NAS said that another general recommendation, which would apply to a wide variety of receiving systems and pollutants, is that consideration should be given to providing reserve capacity in recognition of the limitations of water quality management programs.

Further, bioassays and other appropriate tests should be made to obtain scientific evidence on the effect of waste water discharges on the environment and a survey of receiving systems should be made on a regular basis to assess the impact of discharges on the biological community.

### Fresh Water Life

NAS said that an essential objective of fresh water quality is the protection of fish and other aquatic organisms for sport or commercial harvesting.

Although water quality characteristics in mixing zones can differ from those in receiving systems, to protect uses in both regions mixing zones should be free of materials which form objectionable deposits; floating debris, scum, oil and other matter; substances producing objectionable color, odor, taste, or turbidity; and conditions which produce objectionable growth of nuisance plants and animals.

NAS said mixing zone characteristics should be defined on a case-by-case basis to avoid potential biological damage or interference with other uses of a receiving system. This action should be taken only after determination that the assimilative capacity of the receiving system can safely accommodate the discharges.

To protect populations of nonmobile benthic and sessile organisms in mixing zones, NAS recommended that the area of their habitat exposed to water quality poorer than recommended receiving system quality be minimized by discharge design. An alternative would be to define intermittent time exposure history relationships for the organisms' well-being.

To protect drifting and both weak and strong swimming organisms in mixing zones, NAS recommended that scientifically valid data be developed to demonstrate that the organisms can survive the integrated time exposure history based on maximum expected residence time.

NAS said application factors should be incorporated into bioassay extrapolation procedures to provide an adequate margin of safety when summations of short-term exposure are developed.

When two plumes are contiguous or overlap and synergistic effects do not occur, NAS said aquatic life should be protected if the sum of the fractions of integrated time exposure effects for each plume if the total is equal to or less than .5. Alternatively, protection should be provided if the sum of the fractions for both plumes is equal to or less than one.