Canadian Water Quality Guidelines for the Protection of Aquatic Life

SALINITY
(Marine)

The salinity of water is an expression of, although not numerically identical to, the concentration of total dissolved solids. The salinity of the world's oceans ranges from 32–38‰ with an average of 35‰ (Kalle 1971). Salinity levels in coastal waters vary because of river inputs, influx of groundwater, variable evaporation rates, freshwater runoff with rainfall, and tidal and ocean currents. In most Canadian coastal areas, salinities are lower than the oceanic average because freshwater inputs are plentiful and evaporation rates are relatively low due to the cooler climate (Harrison et al. 1983). At higher latitudes, surface salinities of coastal waters are reduced by high river flow in the summer and, to some extent, by drainage and sinking of brine from ice during the freezing period (Nicol 1967; Anderson and Dryssen 1989; MacDonald et al. 1990; Myers et al. 1990).

Many semi-enclosed areas, fjords, embayments, and estuaries show extreme salinity variability in time and space. Temporal variations in salinity result from diurnal, seasonal, and annual cycles, as well as episodic changes, while spatial variation may be horizontal and/or vertical (Krauel 1975; Thomson 1981; Dickie and Trites 1983; Prinsenberg 1986; Smith 1989; Hopky et al. 1990). At the mouth of the Fraser River estuary, for example, the isohalines (lines connecting points of equal salinity) are closer to shore in winter during low river flow than during high river flow in late spring/early summer, when they are pushed seaward (Ages and Woollard 1994). A similar pattern has been observed at the head of the upper St. Lawrence estuary (Silverberg and Sundby 1979) and in the lower St. Lawrence estuary (Petrie 1990). Anthropogenic factors, such as freshwater diversions, large volume industrial and municipal effluent discharges, and barriers to existing flow patterns, can change the salinity regimes of estuaries and other coastal water bodies and affect biota (Thomson 1981; Dickie and Trites 1983).

Biological Effects

The salinity of coastal waters affects several important physical and chemical properties of water, such as the freezing point, specific gravity, and osmotic pressure; this can have biological implications. A relationship appears to exist, in some cases, between adverse effects on marine and estuarine organisms and the length of exposure to extreme salinities (Voyer and Modica 1990; Voyer and McGovern 1991). Saline water is a composite of many different solutes and, as such, its density is variable and greater than that of freshwater (Moore 1966). The specific gravity of most animal tissue is comparable to that of seawater (Moore 1966; Giancoli 1991). For those organisms that can control their buoyancy (e.g., teleost fish), alterations in surrounding saline concentrations and, consequently, specific gravities have fewer consequences (Moore 1966). Other organisms, however, rely on constant specific gravities for mobility. Marine diatoms, for example, are immobile and yet, because their specific gravities are the same as the surrounding water, they are able to float. A decrease in the surrounding salinity could result in these diatoms sinking to levels that impede efficient photosynthesis.

Salinity is a limiting factor in the distribution of aquatic organisms. The distribution of stenohaline organisms (i.e., those that cannot tolerate fluctuations in salinity) is usually limited to true marine waters or freshwater habitats. Euryhaline organisms (i.e., those that can inhabit environments with variable salinity) can withstand salinity fluctuations, either by tolerating changes in internal osmotic pressure or by maintaining a constant internal osmotic pressure through osmoregulation (Nicol 1967). In the St. Lawrence estuary, for example, the species composition of copepods varies between the upper freshwater reaches of the estuary and the brackish middle reaches. Similarly, different stenohaline marine species are found in the outer or lower portions of the estuary (Bousfield et al. 1975). Freshwater and brackish water

Table 1. Water quality guidelines for salinity for the protection of aquatic life (CCME 1996).

Aquatic life — Estuarine and marine
Salinity[*]
Human activities should not cause the salinity (expressed as parts per thousand [‰]) of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth.

[*] Interim guideline.

macrophytes predominate in the low-salinity Fraser River estuary (Kistritz 1978), but stenohaline marine species, such as eelgrass and shellfish, are found in the adjacent, more saline area that is isolated from the river flow behind the two long jetties to the south of the river. In many coastal areas, salinity fluctuations limit the distributions of organisms that require stable salinities for survival. In other cases, however, natural diurnal changes in salinity, which occur in many coastal waters, are critical to the biota. For example, naturally occurring salinity fluctuations may reduce the adverse effects of low salinities on some organisms (Davenport et al. 1975; Rijstenbil et al. 1989; Voyer et al. 1989).

The salinity of coastal waters is also important because of the physical and chemical interactions that may occur with other stress factors and toxicants. Physical interactions include the effects of salinity on the solubility, uptake, and bioavailability of certain compounds in aqueous media (Whitehouse 1984; Nugegoda and Rainbow 1989), while chemical interactions include the modification of the chemical speciation of trace metals (Hong and Kester 1985). In addition, salinity affects many organism responses (e.g., survival, reproduction, behaviour, and other sublethal effects) to a variety of substances (Sprague 1985; De Lisle and Roberts 1988).

Interim Guideline

Human activities should not cause the salinity (expressed as, parts per thousand [‰]) of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth (CCME 1996).

Rationale

The recommended interim salinity guideline, which is similar to that recommended by the NTAC (1968), is designed to protect marine and estuarine organisms by avoiding or limiting human-induced fluctuations in both the magnitude and temporal scale of the salinity regime. It is also assumed that this guideline will protect natural circulation and mixing patterns of coastal water bodies and thereby limit effects on the physiology and distribution of marine and estuarine organisms associated with such patterns.

Additional research is required on the effects of changes from the natural salinity level on marine and estuarine organisms, on the availability and toxicity of pollutants to these organisms, and on the effects of salinity-induced circulation and mixing patterns of coastal water bodies on the distribution of aquatic organisms.

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