THE ROLE OF ESTUARIES IN THE LIFE CYCLES OF FISHES IN NEW ZEALAND

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SUMMARY: Examination of the fish faunas of estuaries in New Zealand suggests that they have resident faunas of low diversity. However the estuaries serve as pathways in the migrations of a few marine fish species and a wide range of freshwater fish species. For this reason it is important that estuaries remain free from pollution and habitat modification.

Introduction

Estuaries are known in many parts of the world as breeding and nursery grounds for a wide variety of fishes. Although estuaries provide a rather harsh environment because of changes in salinity, many species of fish have found them to be highly advantageous areas in which to spawn, develop, and grow during early life; productivity tends to be high.

Whether an estuary is defined as a semi-enclosed body of coastal water opening to the sea, with salinity variation resulting from the entry of river water, or is seen in a much more restricted sense as that area of a river mouth where fresh and salt water confront each other under the influence of tides, it is true to say that knowledge of fishes in New Zealand estuaries is meagre. In this account I have used a restricted definition of an estuary to focus attention on the role of the waters at river mouths in the lives of fish species.

Marine Fishes Resident in River Estuaries

Few species of New Zealand marine fish are regarded as having populations that are primarily resident in river estuaries. When taxonomic problems have been resolved, possibly one species of *Tripterygion* may be classified as an estuarine resident.

I know of no species that spawns solely or primarily in river estuaries. Substantial numbers of the young of some species, particularly flatfish (*Rhombosolea* spp), are found in estuarine waters but it is not known that their chief concentrations occur there (Colman, 1973, 1974).

Several marine fish species migrate in and out of river estuaries each day with changes of the tide, notably the kahawai [*Arripis trutta* (Forster *in* Bloch and Schneider)], yellow-eyed mullet [*Aldrichetta forsteri* (Valenciennes *in* Cuvier and Valenciennes)], grey mullet [*Mugil cephalus* Linnaeus], and yellow-belly flounder [*Rhombosolea leporina* Günther] (Graham, 1953). Possibly there are many more such species that are less well-known. Webb (1972, 1973 a, b) recorded the following as regular, if seasonal, residents of the Avon-Heathcote estuary in Canterbury: spotty [*Pseudolabrus celidotus* (Forster *in* Bloch and Schneider)], globefish [*Spheroides richei* (Freminville)], stargazer [*Leptoscopus macropygus* (Richardson)], common sole [*Peltorhamphus novaezealandiae* Günther] and sand flounder [*Rhombosolea plebeia* (Richardson)]. A further 12 marine species were listed as "scarce or of irregular occurrence" by Webb (1973b) who also noted, however, that for some of these species he had made no concerted effort to determine abundance and distribution, e.g., Webb (1973b) wrote that the clingfish [*Trachelochismus pinnulatus* (Forster *in* Bloch and Schneider)] "was not specifically searched for, being small in size and confined to deep water".

There is no doubt that further studies will reveal additional marine fishes in New Zealand river estuaries. The skipjack [*Katsuwonis pelamis* (Linnaeus)] has recently been taken some kilometres up the Whakatane River (A. G. York, *pers. comm.*).

All the fishes discussed above, including those listed by Webb (1972, and 1973a, b) are marine spawners, but possibly, some also spawn in the more consistently saline areas of river estuaries, e.g. Webb (1973b) suggested that this may be true of the clingfish, and the rockfish [*Acanthoclinus quadridactylus* (Forster *in* Bloch and Schneider)].

It is apparent that although river estuaries are used by a variety of marine fishes these waters are not known to constitute a marine fish habitat of

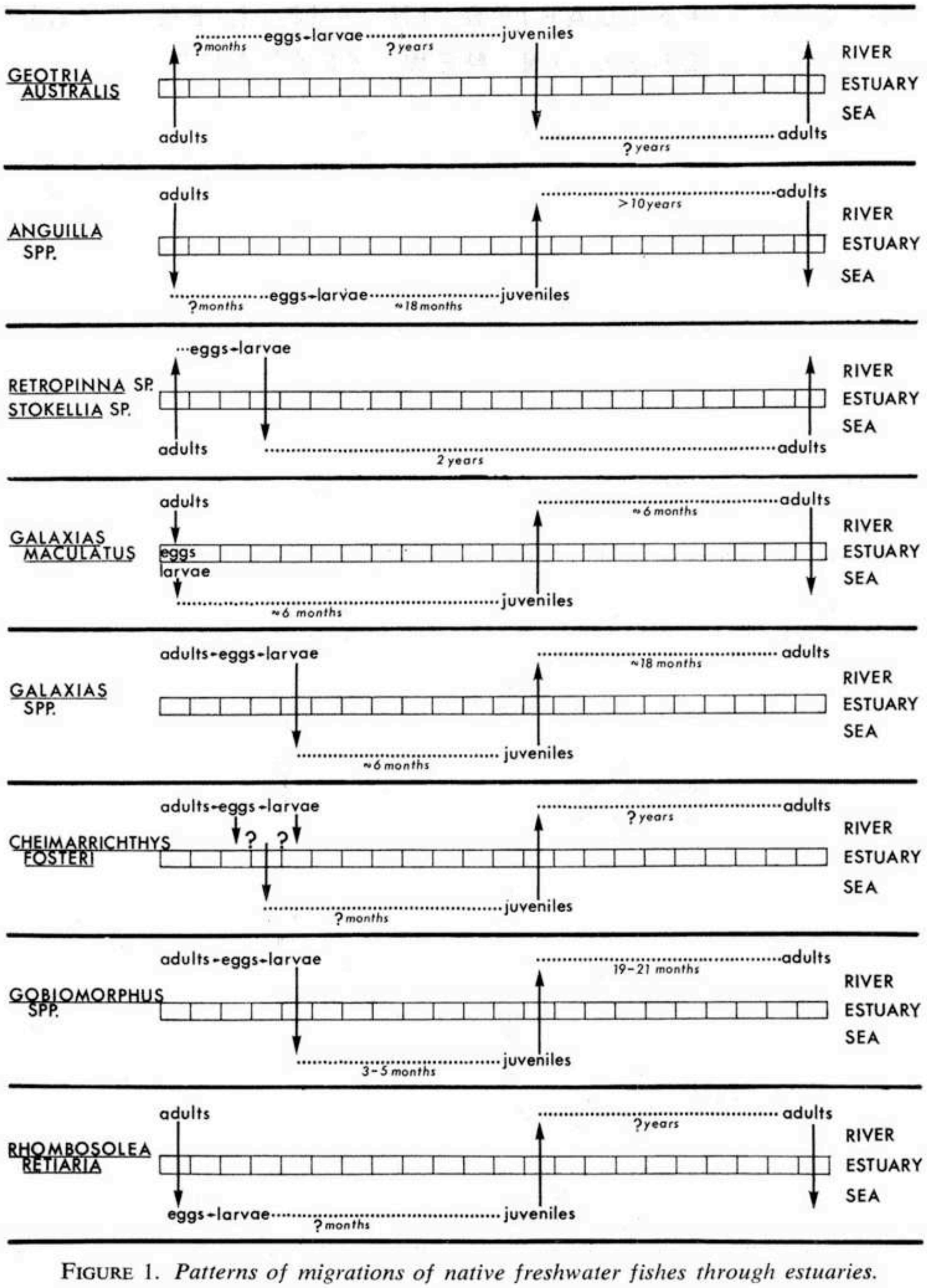

FIGURE 1. *Patterns of migrations of native freshwater fishes through estuaries.*

major importance—certainly not as important as might be imagined. Possibly this is due to the fact that New Zealand rivers are relatively small, and have steep estuarine gradients; these combine to make the river estuaries small, and subject to extensive tidal flushing. However, estuaries are areas

of high productivity and may serve as feeding grounds for marine fish stocks.

Freshwater Fishes Resident in River Estuaries

Examination of the freshwater fish fauna, reveals that only a small part of it, also, is resident in river estuaries. None of the species is known to be primarily, or even significantly estuarine dwelling. Possibly, the giant bully [*Gobiomorphus gobioides* (Valenciennes *in* Cuvier and Valenciennes)] will eventually be shown to live in substantial concentrations in estuaries. The black flounder [*Rhombosolea retiaria* Hutton], inanga [*Galaxias maculatus* (Jenyns)], and common smelt [*Retropinna retropinna* (Richardson)] do occur in estuaries, but at present it seems clear that the main concentrations of these species do not occur there.

If the giant bully lives primarily in estuaries, it probably also spawns there. Certainly, river estuaries are the chief spawning grounds of the inanga (McDowall, 1968) which lays its eggs on supra-tidal, grassy, estuarine river flats that are inundated by water only at the high spring tides.

On existing information it appears that the importance of river estuaries to freshwater fish life in New Zealand is relatively slight. Few of our freshwater fishes seem to be resident in estuaries.

Migration of Native Freshwater Fishes Through River Estuaries

Contrasting with the apparently minor importance of river estuaries for residential fish, is the highly significant role they play in the lives of migratory freshwater fishes (Fig. 1). River estuaries are pathways—or bottlenecks—through which most New Zealand freshwater fishes must pass during their upstream and downstream migrations. Although the estuaries may play only a minor and temporary role in the lives of these fishes, they are an essential link in the life histories that must not be interfered with.

Existing data show that there is some movement of fishes upstream and downstream through our river estuaries at all times of the year. However, it is very clear that there are major peaks, both in fish numbers and species diversity, in the spring and autumn, a major trough in winter, and a lesser trough in the summer. In the account that follows I have included all New Zealand migratory freshwater fish species, even though the data for some of them are very limited.

Of 27 native species of freshwater fish 17, or about 63%, are *diadromous,* i.e., they migrate between fresh and salt water at some stage of the life history (listed in Table 1). (It should be obvious that in all species, both an upstream and a downstream migration occurs.) Four species are *anadromous* (migrate upstream *to spawn*), two are catadromous (migrate downstream *to spawn*), one is marginally catadromous (i.e., it scarcely reaches the sea in its downstream migration) and the remaining 10 species are neither anadromous nor catadromous, i.e., their migration is not related to spawning.

The migrants fall into four distinct types:

1. mature to ripe spawning adults;

Table 1. *Direction and periodicity of migration in New Zealand freshwater fishes.*

	UPSTREAM		*DOWNSTREAM*	
SPECIES	STAGE	PERIOD	STAGE	PERIOD
Geotria australis	adult	spring	juvenile	autumn?
Anguilla dieffenbachii	juvenile	spring	adult	autumn
Anguilla australis	juvenile	spring	adult	autumn
Retropinna retropinna	adult	spring/summer	larva	spring/summer
Stokellia anisodon	adult	spring/summer	larva	spring/summer
Prototroctes oxyrhynchus	adult?	autumn?	?	?
Galaxias argenteus	juvenile	spring	larva	autumn
Galaxias fasciatus	juvenile	spring	larva	autumn
Galaxias postvectis	juvenile	spring	larva	autumn
Galaxias brevipinnis	juvenile	spring	larva	autumn
Galaxias maculatus	juvenile	spring	larva	autumn
Gobiomorphus huttoni	juvenile	spring/summer	larva	late winter/spring
Gobiomorphus cotidianus	juvenile	spring/summer	larva	late winter/spring
Gobiomorphus hubbsi	juvenile	spring/summer	larva	late winter/spring
Gobiomorphus gobioides	juvenile	spring/summer	larva	late winter/spring
Cheimarrichthys fosteri	juvenile	?	egg/larva?	summer/autumn
Rhombosolea retiaria	juvenile	?	adult?	?

2. freshly hatched larvae;
3. juveniles;
4. eggs.

1. The mature to ripe adults of the lamprey [*Geotria australis* Gray], the common smelt and Stokell's smelt [*Stokellia anisodon* (Stokell)] are anadromous, and the grayling [*Prototroctes oxyrhynchus* Günther] may have been too. Mature adult lampreys enter freshwater from the sea during the spring, as far as we know, and probably spend some months reaching spawning condition as they migrate upstream to the spawning grounds. Ripe adults of both the common smelt and Stokell's smelt enter estuaries during the late spring and in summer, and spawn in the lowland reaches during this period (McMillan, 1961; Woods, 1968; McDowall, 1972). It is suspected that the now extinct grayling was also anadromous, because ripe adults were found in freshwater apparently moving upstream. The migration may have been during the autumn.

Downstream migrations of adults include those of the two eel species [*Anguilla australis* Richardson and *A. dieffenbachii* Gray] in the autumn and early winter (Cairns, 1941), and of the inanga in autumn. The eels go to sea to spawn in as yet uncertain but probably sub-tropical western-Pacific waters (Castle, 1963). Contrary to assertations still being made, the inanga migrations end in the estuaries—they do not go to sea. Spawning is estuarine (McDowall, 1968).

It seems likely that the black flounder [*Rhombosolea retiaria* Hutton], although it is occasionally found very great distances upstream, migrates downstream and spawns in the sea like other flatfishes. Certainly, the larvae are marine and very small juveniles are rarely taken in freshwater.

2. Freshly hatched larvae. Movements of freshly hatched larvae are, for obvious reasons, downstream ones. The following species are involved: The larvae of both the common smelt and Stokell's smelt move to sea in the late spring and through the summer, from their lowland spawning grounds. The larvae of the inanga, although moving to sea through most of the year (spawning is known from at least September to June) do so predominantly during the autumn, from about March onwards (McDowall, 1968). Larvae of the other galaxiid whitebait are also likely to be going to sea during this period, some species from habitats in lowland streams, and others from forested streams at moderate to considerable altitudes and distances inland (Ots and Eldon, 1975).

The bullies spawn primarily in the winter and spring, and to some extent into the summer, and mostly in the lowlands. Their larvae go to sea probably from about August onwards through into the summer (McDowall, 1965a).

3. Juveniles. Most of the fishes migrating upstream from the sea through estuaries, are juveniles.

Immense migrations of glass eels take place during the spring (Cairns, 1941, Jellyman, 1974) when the estuary has an important, if temporary, role as the young glass eels tend to settle in the river estuaries for some time before moving on upstream.

Huge numbers of juveniles of the five whitebait species also migrate during the spring, varying somewhat in seasonality, with the koaro [*Galaxias brevipinnis* Günther] being an early migrant, the banded kokopu [*G. fasciatus* Gray] somewhat later, and the giant kokopu [*G. argenteus* (Gmelin)] very late, some time in early November (McDowall and Eldon, In Prep.). The young of four species of bully [*Gobiomorphus huttoni* (Ogilby), *G. cotidianus* McDowall, *G. hubbsi* (Stokell), and probably *G. gobioides*] migrate upstream during the spring and summer, partly overlapping with the eels and whitebait (McDowall, 1965b). Thus the spring and early summer is a time of immense activity in New Zealand river estuaries as these three groups of fishes (eels, whitebait and bullies) make their way in from the sea.

Small, juvenile torrentfish [*Cheimarrichthys fosteri* Haast] also migrate from the sea, but the period of migration is not yet clearly determined.

Downstream movement of juveniles appears to be limited to the macrophthalmia of the lamprey, probably during the autumn, but this is still far from clearly defined.

4. Eggs. The proposal that there are "migrant" eggs depends wholly on inference. The torrentfish has large numbers of very small eggs, and the species lives in very swiftly flowing waters. Spawning is undescribed, but is probably in summer or autumn. Larval life is not known to be in freshwater (McDowall, 1973). It seems possible that the eggs are laid in freshwater and are carried downstream to hatch in the sea. Certainly the eggs of the related blue cod [*Parapercis colias* (Forster *in* Bloch and Schneider)] are pelagic (D. A. Robertson, *pers. comm.*). If the eggs of the torrentfish do go to sea, then this is a most unusual life cycle. If not, then the eggs presumably hatch upstream and the larvae are carried to sea.

INTRODUCED FRESHWATER FISHES

Of the seven species of salmonid introduced into New Zealand, six are known to be marine migratory in Europe or North America from where they came.

Only the mackinaw [*Salvelinus namaycush* (Walbaum)] confines its life history to fresh water. Sea run stocks of the Atlantic salmon [*Salmo salar* Linnaeus], brook char [*Salvelinus fontinalis* (Mitchill)] and sockeye salmon [*Oncorhynchus nerka* (Walbaum)] have never developed in New Zealand—all are landlocked. Efforts to establish sea run stocks of the rainbow trout [*Salmo gairdnerii* (Richardson)] are currently being made, but their success remains uncertain (Lally, 1973). Sea run stocks of brown trout [*Salmo trutta* Linnaeus] are well-known in New Zealand, although knowledge of the nature of their migrations is very limited (Stokell, 1955).

The migrations of the quinnat salmon [*Oncorhynchus tshawytscha* (Walbaum)] are much better documented. Movements upstream of mature adults begin in January and reach a peak during April. The spawned eggs are in the gravel redds for two or three months, and the young emerge and move downstream to the sea, some soon after hatching, others after weeks to several months in freshwater (Flain, 1972).

DISCUSSION

The river estuaries of New Zealand, although not habitats that are of obvious importance to the natural history and ecology of New Zealand fishes are important to a few migratory marine fishes and play a very significant role in transitory phases in the life histories of our freshwater fishes, particularly during the spring when very intensive migrations of a wide range of species are occurring.

If the species that depend on migration of these various life history stages through estuaries are to remain viable, it is of the utmost importance that hydrological values in the estuaries be maintained at the highest levels so that migration is not hindered, or even prevented. Pollution and habitat modifications which would affect the movements of fishes must be kept to a minimum.

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