Marine Resources of Kouchibouguak Park
Extended Summary

Report to Parks Canada, April 15, 1976

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INTRODUCTION

Kouchibouguac National Park is located on the east coast of New Brunswick, Canada It includes 25 kilometers of barrier islands/sand dunes which shelter three lagoons and face the Gulf of St. Lawrence on their seaward side. Three rivers and five main streams flow into these lagoons within the park boundaries. This report is intended to provide a broad scientific basis for managing the marine/estuarine resources of the park, as well as baseline data for monitoring purposes. It includes reviews of related literature.

METHODS

An intensive sampling program was conducted over the months of June, July and August of 1975, with some additional sampling of fish in November. It included observations on bathymetry, tides, currents, temperature, salinity, sediment grain size, infauna and epifauna, small fish, algal flora, submerged angiosperms (eelgrass and widgeon grass), nutrients, dissolved oxygen. shellfish (clams, blue mussels, periwinkles, oysters, crab, lobster) and exploitable fish (alewife, striped bass, Atlantic salmon, trout, smelt, tomcod, flounder, eel, sucker). The basic program for sampling immobile biotia (e.g. seaweeds) and biota with relatively limited movement (e.g., clams, mussels) consisted of sampling and observations at 61 lagoon stations pinpointed on a map before the field trips and distributed to give representation of the lagoon as a whole but without reference to special features or sub-environments, and at ten additional stations chosen to provide some representation of the channels leading from the rivers (which occupy only a small fraction of the total lagoon area) and of the rivers above the lagoon. Additional or separate studies were conducted on several species, e.g., soft shelled clams. Fish were sampled using a beach seine, nets and eel traps and crab and lobster with traps. Ages at length of selected fish species were determined by counts of annual rings on otoliths or or by separation of polymodal length frequencies.

The original data are included in the report as well as interpretive statistics and charts and maps showing locations of sampling stations and species distributions.

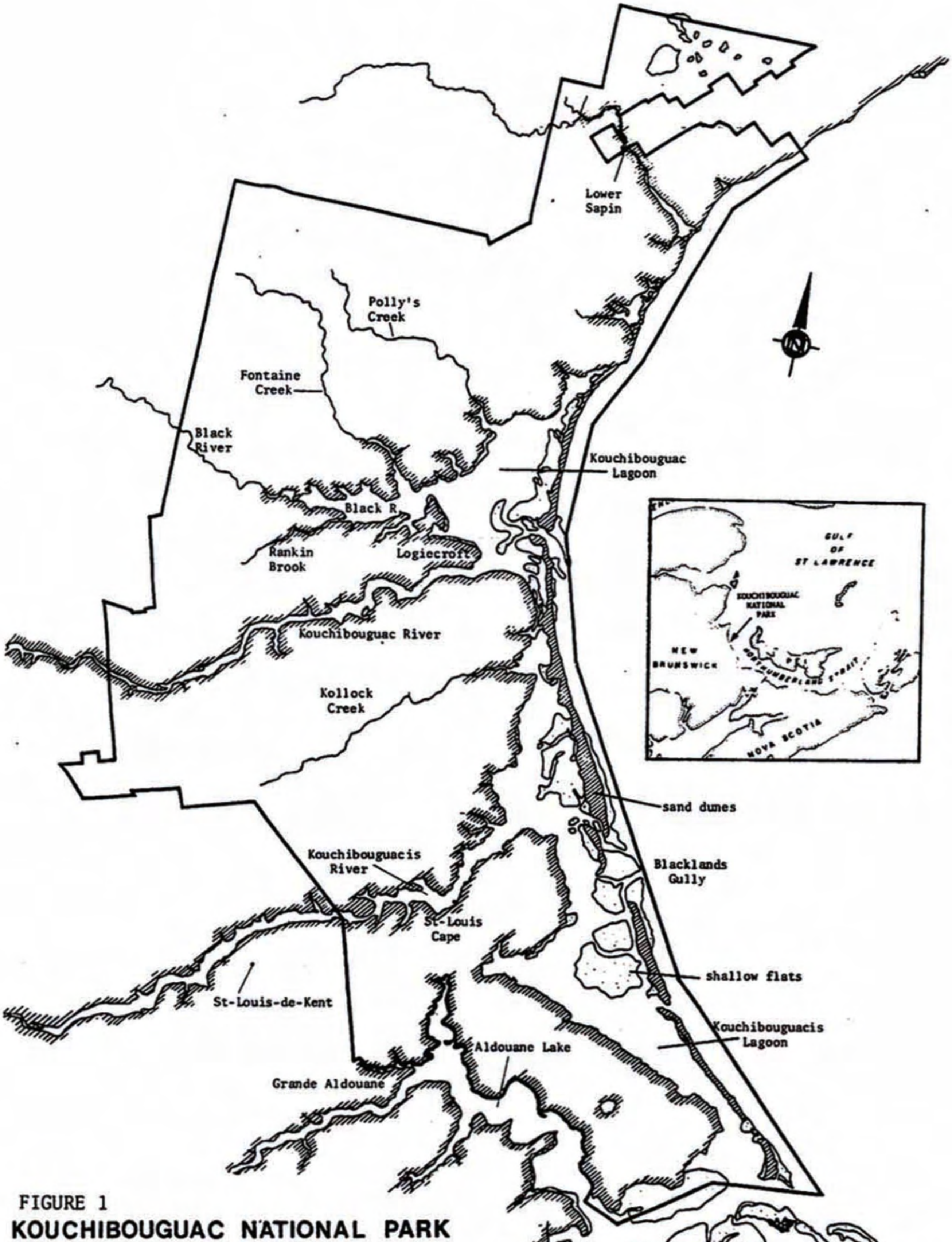

FIGURE 1
KOUCHIBOUGUAC NATIONAL PARK
NEW BRUNSWICK

SUMMARY OF RESULTS

Tides

Tides at Logiecroft were of the mixed, semi-diurnal type similar to Rustico. Time of high water of the major mode lagged behind Rustico by varying periods, usually between one and two hours. The magnitude of the major mode also varied in relation to the Rustico tides, varying between 0.39 and 0.97 times the Rustico magnitude. Current observations at the narrows between the two lagoons suggests the southern lagoon flushes faster than the northern lagoon.

Bathymetry

The lagoons are characterized as being generally shallow (less than 1 m depth) except in channels which in the lagoons are mostly between 2 and 3 m depth. The "mud flats" adjacent to the dunes have an average depth of about 30 cm (referred to lowest low water observed in July, 1975).

Salinity, Temperature and Currents

The degree of salinity stratification in the three major rivers increased in the order Black River - Kouchibouguacis River - Kouchibouguac River; the Black River had a salinity structure tending toward the "partially mixed estuary" type, while the Kouchibouguacis structure had features characteristic of the "salt wedge" circulation type. Differences in the degrees of stratification are probably related to differences in river discharge, this being greatest (per unit cross-sectional area) for the Kouchibouguac River.

The degree of salinity stratification decreases down the rivers and the channels towards the sea; this must be accompanied by increased mass flow past any point of land as the sea is approached.

Within the lagoon, away from the channels, there is little if any stratification; salinities in the lagoonal area were generally in the range 20-30 ‰ during the summer.

Within the Kouchibouguac estuarine system, almost the full range of estuarine circulation patterns is present, from vertically homogeneous in the lagoonal waters to the salt wedge type in the Kouchibouguac River. The exact structures within the river changes with the tide, and seasonally. During the summer of 1965, minimum surface water salinities in the rivers (within the Park) increased from less than 3 ‰ in June and early July and early

July to 11.5 ‰ in late August.

Temperature profiles were complementary to the salinity profiles, with high temperatures in the lower salinity waters; thermoclines and heloclines, when they were distinct occurred between 2 and 6 ft. (0.6 and 1.8 m). Surface water temperatures increased from a mean of about 7 1/2° C on June 10 to a maximum average of about 24.5° C on August 6, then declined to about 20° C on August 29.

Currents were generally strong and regularly reversing with the tide in the rivers and channels, while in the broad lagoonal expanse areas from the channels they were weak and less regular. Currents recorded from river-channel areas reached values as high as 1.25 m/sec; in the lagoonal expanses they were generally between 5 and 25 cm/sec.

Sediments

Within the channels, soft "sandy muds" predominate; these are generally stabilized by a surface mat, possibly diatomaceous in nature. In areas of channels subject to strong currents, highly compacted "gravelly sands" occur, and in the region of the passages through the sand dunes, the compacted gravelly sands are overlain by transitory well-suited coarse sands.

"Sandy muds" predominate in the broad lagoonal expanses of the northern lagoon, and "gravelly sands" in the southern lagoon. It is suggested that this difference is associated with the recent recolonization (within the last 15 years) of the lagoonal expanses by eelgrass, and the greater fresh water input and associated sediment load going into the northern lagoon. On this basis, it is predicted that the sediments of the southern lagoon will become increasingly "muddy". This has important biological implications.

The Major Biofacies

Five major "biofacies" which are discretely distributed were defined. These are (1) Ruppia-mud, (2) Ruppia-Zostera-mud, (3) Zostera, (4) Channels, and (5) Beaches. The Ruppia-mud biofacies occurs towards the heads of the rivers (within the Park). The Zostera biofacies occurs over the broad lagoonal expanses, excluding the channels and extending up the rivers in a wedge shape; between the Ruppia-mud and Zostera biofacies, the zone of overlap of Ruppia and Zostera is delineated as the Ruppia-Zostera-mud biofacies.

The upstream limits of Zostera distribution (and the corresponding downstream limit of the Ruppia-mud biofacies) is believed to occur at a point where salinities go below 4-5 ‰ for prolonged periods.

The Zostera biofacies covers more than 90% of the estuarine system. Three subdivisions of this biofacies were defined: Zostera-mud, Zostera-sand and Bare sand; these occur in a patchwork type distribution within the Zostera biofacies. The beach biofacies includes the sandy intertidal beaches. These are areas of high clam production.

Infauna, Epifauna and Small Fish

There were some important differences between the various biofacies or their subdivisions with respect to the associated fauna, notably:

1. Observed (from stomach contents) major prey species (sand shrimp, silversides, sand lances) occurred mainly in the Zostera-sand and bare sand biofacies, or were species which leave the dense Zostera stands at hight for more open areas. The implication is that the predators (tomcod, trout, bass, smelt) do not feed in the dense eelgrass stand. It is suggested that the physical structure of these stands and the large diurnal fluctuations in oxygen within the stands to make them inhospitable to the predator species. Because Zostera and associated fine sediment accumulation are still increasing, it is suggested that the possible feeding areas for these predators will decrease in the future.
2. Crabs and mussels occurred in greatest numbers in channel biofacies. These species do not do well in Zostera biofacies because of space limitation (crabs) and smothering by fine sediments (mussels).
3. Clams were generally abundant only in the beach biofacies.

Some species were widely distributed and commonly abundant in the shallow submerged biofacies, notably Littorina littorea (edible periwinkle), Mytilus edulis (mussel), Macoma balthica (infaunal bivalve), Nereis virens and Glycera dibranchiata (polychaete worms), and various gastropods. Several crustaceans were observed only in the Zostera biofacies, although they may leave this at night. The predatory (on bivalves) species, Lunatia heros (moon snail) and the star fish, Asterias vulgaris, were most abundant in channels. The region of Little Gulley - the "Marine sandy zone" of the channel biofacies - is a unique area with high concentrations of mussels, crabs, and lobsters.

The Algal Flora

Ten species of brown and red "seaweeds" excluding P. subtilissima were encountered in the lagoon. Overall, Fucus distichus is the most common of these species. None make up a major portion of the plant biomass in the lagoons. The discovery of Gracilaria foliifera in the lagoonal waters is the first record for this species in New Brunswick. The red and brown algae exhibited some interesting distribution of patterns; G. foliifera, for example was common in the southern part of the southern lagoon, but not elsewhere, while Ahnfeltia plicata was common in the northern lagoon, but was not found in the southern lagoon. Many of the red and brown algal species were commonly unattached, lying motionless between the blades of Zostera. With two exceptions, however, they all appeared to be normal inhabitants of the lagoon (i.e. not drifting from the sea).

Polysiphonia subtilissima (red algae) was a common epiphyte on eelgrass, and may contribute substantially to primary production. This was the only red algal species penetrating the estuarine sectors of the rivers.

Some green algal species made up a substantial portion of the plant biomass. Enteromorpha intestinalis occurred in large quantities in the rivers and Chaetomorpha linum, in the lagoon.

No substantial quantities of Irish Moss, Chondrus crispus were found in the lagoon.

The Submerged Angiosperms

The most important biological feature of the estuarine system as a whole is the occurrence of submerged angiosperms throughout the system, except in channels. Except in the upper, less saline reaches of the rivers where Ruppia maritima occurs, eelgrass (Zostera marina) predominates. This plant increases greatly in biomass during the month of June; in mid-July anthesis occurred and by the end of July, seeds were found in the water column. During its initial growth in June it seems to be easily eroded and masses of fresh eelgrass, and also Enteromorpha which increases greatly in biomass during the same period, were observed in the water column. These drifting masses catch in nets, making fishing very difficult during June and July. Eelgrass began regrowing in this system about 15 years ago, presumably following its near absence there since the general decimation of Zostera in the '30's.

Eelgrass stands over most of the northern lagoon were judged to be mature; i.e., fully developed, while it appears that eelgrass may still increase in abundance in the southern lagoon. It is suggested that while the eelgrass forms a major food base for the system, it is "counterproductive" for many desirable species because of adverse physical, chemical and sedimentary conditions associated with the eelgrass stands.

Nutrients and Oxygen

Lagoon and river mouth waters sampled during the daytime between July 17 and August 28 were generally supersaturated with oxygen, reflecting the high primary production associated with macrophytes. It appears that in dense eelgrass stands, oxygen levels at night may fall below critical values for desirable fish species.

Concentrations of inorganic nitrogen (NO_3^-, NO_2^-, NH_4^+) and phosphate were generally low. Nitrate was undetectable in most samples. Phosphate concentrations were generally above the level considered limiting for marine plant growth. A low N:P ratio suggests nitrogen was the limiting nutrient for plant growth. Roots of _Zostera marina_ exhibited nitrogen-fixing activity, and it is suggested that the high productivity of _Zostera_ in this system is associated with uptake of nitrogen and phosporus from the sediments.

Irish Moss

We could find no basis for the claims of local fishermen that harvestable quantities of Irish Moss occur in the lagoon waters.

Clams

Population dynamics of the beach clam populations were examined, and rates of growth and mortality estimated for exploited and unexploited populations. It appears that the clam population as a whole is intensively exploited. Quantitative estimates of total yields and catch per unit effort were made for different rotation harvest schemes. A three year rotation harvest appears optimal. According to our calculation, it would result in a doubling of yield for the Park as a whole, and an increase in catch per unit effort by a factor of 5.

Mussels

While mussels are widely distributed and generally abundant in the Park waters, mussel "beds" are not extensive. Further, there are few with many mussels of length greater that 50 mm, the size generally harvested. The mussels are loosely attached in these beds, and could be easily harvested. Recovery of intensively exploited beds might be very slow or might not occur.

Periwinkles

Common periwinkles are present in high numbers in the lagoonal system, but are generally small (less than 15 mm height).

Oysters

Although it is evident that oyster beds were once reasonably extensive in the Park waters, notably in the Logiecroft area, only a few beds are now to be found. The decrease may have been associated with Melpeque disease, or with renewed eelgrass growth or both. Whatever the cause, it is evident that conditions will become progressively less favorable for establishment of oyster beds in the future, because of increasing eelgrass growth and associated accumulation of fine sediments.

Lobster

Substantial numbers of lobster were found only in the Little Gulley region. Low numbers were taken in traps set in channels within the Park. This limited distribution is related to the limited availability of suitably stable bottom for burrowing.

Crabs

Crabs of exploitable sizes occur within the lagoon; only in channels are they present in any abundance. We are uncertain how or when the stock is recruited (as larvae or small crabs from outside of the lagoon). The crabs move rapidly towards bait, and it suggested that a much simpler method of fishing that the use of traps could be utilized.

Fish

Fishing was conducted through the summer (June 6 - August 28) using gill nets (1 1/2" - 6 1/2" mesh). Catches in eel traps were also examined. The fishing is an ongoing program, and more information is required for most species. The following is a summary of conclusions or results from the summer fishing.

Salmon - smolt were taken from traps in June. Only one salmon was caught, this on June 9. This individual was bright. Absense of salmon later in the summer may have been related to the unusually dry summer and consequent lack of appropriate signals for salmon outside to move into the rivers.

Gaspereau - Gaspereau were taken in abundance during their spawning run in June.

Striped Bass - Small bass, presumably 1 and 2 years of age were caught in eel traps in early June. Occasional bass were taken through the summer; all were small, less than 34 cm in length. Stomach contents consisted mainly of sand shrimp, sand lances and silversides, all fauna characteristic of bare sand and Zostera-sand biofacies.

Brook Trout - Small trout were caught in eel traps in early June. Occasional trout were taken up until July 31, the largest individual was 1.1 kg in weight.

Smelt - Post spawning smelt were taken in traps and nets between June 5 and June 23. Stomach contents included sand lances.

Tomcod - Large numbers of tomcod were taken in eel traps in early June. These appeared to include mainly 1, 2, or 3 year old fish. Occasional individuals were taken after this up to July 28. We were surprised to observe large numbers in January in the Miramichi.

Smooth Flounder - Large numbers of smooth flounder were taken in traps in early June and they were observed in lagoonal waters throughout the summer, both in channels and in eel-grass beds. Size-frequency distributions suggest 9 age groups were present and indicate a growth rate of about 3 cm/ annum.

Eels - Yellow eels were caught in large numbers in eel traps in early June. This may represent a minor spring migration of yellow eels towards the lagoon. Eels were observed in eel-grass beds throughout the summer.

White Sucker - Suckers were caught in the Kouchibouguac River near the Park boundary in July. This area is within the zone of marine influence.

General Comments - In general, the seasonal occurrence of the various species was as expected. We did not catch shad, white perch, winter flounder, mackerel or capelin which have previously been reported in Park waters.

The occurrence of significant numbers of small trout, bass and salmon in eel traps points to the need to examine this fishing further for its possible influence on other species.

Other Species of Possible Exploitable Value

Gracilaria foliifera is an "agarophyte". It is not presently commercially exploited in Canadian waters. The southern part of the Kouchibouguacis Lagoon appears to be a favorable environment for this species and this area might at some time be suitable for cultivation of this species.

Moon snails are mentioned by Caddy et al (1974) under the category "miscellaneous unexploited species". They are present in the Park waters in fairly large numbers and might be utilized by tourists.

Seeds of Zostera marina were utilized at one time by California industries to make flour (Felger and Moser, 1973). Such a use might appeal to tourists.

DISCUSSION: AN OVERVIEW

We have provided up to this point in the report detailed information concerning individually identifiable processes or objects, integrating the information best we could along the way. In this section, we present our view of the system as a whole, in the context general management considerations.

There are no comparable studies to this one on the sort of system that exists in the marine sector of Kouchibouguac Park. While some of its properties might have been predicted *a priori*, the impression we have of the system after one season's intensive field work is far different from that we had anticipated. Viewing the lagoons from the boardwalk at Kelly's Beach, one gets the impression of broad expanses of lagoon teeming with life. One only has to look down beside the boardwalk to see schools of silversides and occasional and bass; clumps of Zostera are viewed round and about, and clams are taken in seemingly unendless quantities from the nearby beach.

This situation does not prevail throughout the lagoons however. The shallows of the Kelly's Beach area are unusual in being a region of moderate currents - these resulting from tide induced differences. in water levels between the lagoons, and spillovers through this narrow neck. The bottom is sandy with only scattered eelgrass, thus allowing free movement of fish, which congregate around the boardwalk to avoid the glare of the mid-day sun. The constant current brings with it a continual supply of small invertebrates, and maintains oxygen at favorable levels. The clam population of the beach area, as it turns out is one of the most productive ones, at least potentially, the density of small clams ranking 6th of 38 areas examined. This in turn is associated with a favorable substratum and consistent currents bringing food and young to settle.

Such conditions are unusual. Over broad expanses of the lagoons, more so in the northern lagoon then in the southern, currents are almost non-existent. Thickets of eelgrass growth extend to the surface damping the slight water motion that exists. Fine sediments fall out of suspension and when they are stirred up, smother invertebrates or cause them to cease feeding. Even though some mussels and clams may occur there, their growth rates are low. The high density of the eelgrass turions prevents free movement of larger fish and of burrowing activities by crabs. Because the thickets extend to the water surface, the fish do not have access from above. Dead leaves accumulate on the sediments consuming oxygen and stimulating sulfate reduction and production of sulfide below. During the daytime, oxygen is produced in abundance, at least in the upper levels of the canopy, but at night falls to levels critical for many "desirable" species. The large expanses of dense eelgrass stands are in one sense comparable to the aquatic weeds associated with lake eutrophication.

Thus, for many of the "desirable" (harvestable) species, e.g. clams, mussels, crabs and the larger predatory fish, these areas are inhospitable. In the winter when ice cover further restricts gas exchange with the atmosphere and the macrophyte production of the previous season consumes the oxygen present, probably leading to widespread and continuous low oxygen conditions and perhaps anaerobesis and sulfide in the water column.

This does not mean, however, that the eelgrass beds do not in some way support desirable species. Crustaceans and worms move out of the eelgrass beds at night, en masse, into the more open areas or descend into channels. For these species (e.g. <u>Nereis</u>, <u>Mysis</u>, <u>Gemmarus</u>, <u>Idotea</u>) the eelgrass beds are a protective habitat during the day, but at night when they move away, they are subject to predation. Further, a constant stream of detritus and its associated organisms from the eelgrass beds provides food for filter-feeding organisms in the more open areas. The important point is that the desirable species occur outside of the dense eelgrass stands and that these open areas are of relatively restricted extent. Accordingly, the species which occupy the open areas are not on the whole abundant in the Park waters, at least not in comparison to the total area of the lagoons. These species include the mussels, oysters, the quahaug (hard shelled clam), crabs and lobsters. Perhaps potential seasonal visitors; e.g., winter flounder and mackerel, should also be included in this category.

The channels through the lagoon are particularly vital areas, because they are eelgrass free. Currents maintain favorable oxygen conditions and bring continuous supplies of suspended particles for the filter feeders. Surrounded by eelgrass beds they must be sites of intense activity at night and it is here that much of the feeding activity of the nekton must take place.[1] It is only in the channels that high concentrations of mussels, crabs, lobsters and flounder occur. An important consequence of this is that because the only major populations do occur here they might be quickly fished out. This is particularly so of the mussels and lobster. The mussel beds are loosely attached and are easily removed. If a bed was completely removed, it might be a long time (if at all) before conditions would be suitable for re-establishment of the mussel bed. Further, in the channel mussel beds the population structure indicated that recruitment is not continuous - older mussels seem to prevent settlement of young and growth is slow. Thus non-complete, but intensive harvesting could not be sustained. Lobsters are abundant only in the Little Gully region, and the area could be rapidly fished out. Crabs and flounder do occur in the eelgrass stands and these might form a reservoir to replace those taken from channels where they are most efficiently harvested.

The extent to which the larger fishes are affected by the eelgrass situation is somewhat uncertain. The salmon do not normally feed extensively in the estuarine sector in any case, and their numbers are dependent more on the stream conditions above the head of the tide. might also be considered in the same category although juveniles may spend limited time in the lower part of the estuary. For these species, the broad expanse of the lagoons is of little consequence one way or the other. It <u>is</u> important to realize in this respect that the rivers of the Park are not major rivers and that while these fish may be locally abundant, it is unlikely that their populations would sustain intensive commercial fishing.

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1. It should be mentioned also that two seals, presumably harbour seals, were observed in channels during July, 1975. These may feed extensively on the benthos.

Other migratory species - trout, striped bass, smelt and tomcod do normally feed in the lower estuary at some time. Smelt, which generally leave the estuary before the maximum biomass of Zostera is reached, may not be adversely affected by the Zostera, in fact conditions then may be ideal in the spring when Zostera is just beginning to grow. Tomcod occurring in the estuary in the spring may also find feeding conditions favorable. However spawning areas for the tomcod (over sandy or gravelly bottoms, under the ice in winter) in the Park are probably relatively restricted.

Foraging sites for trout and striped bass are undoubtedly restricted by the dense eelgrass growth. Thus we found species characteristic of the open sandy areas or of sandy areas interspearsed with Zostera stands in their stomachs, but not the mummichog which is most abundant in the eelgrass beds (it is a major prey species elsewhere). If, as we have predicted, eelgrass growth increases further in the southern lagoon, the feeding areas for these species will become more restricted

A few species are abundant in the eelgrass stands, and large populations do occur in the Park. These include periwinkles and eels and mussels. The mussels are generally small however, are irregularly distributed and could not be easily harvested without mass upheaval of the Zostera beds. The same applies for periwinkles. Certainly there need be no restriction on harvesting of the periwinkles providing non-destructive methods are used. The eelgrass beds are a prime site for eels and this species is certainly abundant in the Park system as a whole. As mentioned above crabs are common in the eelgrass beds and while they might not be easily harvested there, they might form an important reservoir to restock populations exploited from the channels.

The prime habitat of soft-shelled clams occurs above the level of eelgrass growth, thus they are relatively unaffected by the eelgrass, and are correspondingly abundant in proportion to the occurrence of suitable beaches. However, the areas of highest abundance seem to be in beaches adjacent to sandy sublittoral sediments. Thus some decrease in general abundance might be expected in the future in the southern lagoon if as we have suggested, eelgrass and muddy bottoms become more widespread there.

Aside from their importance as feeding grounds and habitats, the channels through the lagoon constitute vital "canals" or roadways through the lagoonal system. For the majority of species there are no alternate pathways to the spawning grounds. Boat traffic also is limited to the channels. In a generally shallow system in particular it is in the channels that key sedimentary and water exchange processes occur. The channels may be viewed as the heart of the estuarine system, biologically and physically. The lagoonal channels are few, narrow and short. Together with the region at the head of the tide, so for the anadramous fishes, the channels must be given the status *Areas of Particular Concern* within the Park, and afforded appropriate protection. For this reason on its own, intensive fishing activities in the channels must be avoided.

On the whole, it is our impression that the Kouchibouguac estuarine system is a rather delicate one, with high production of only a few species with the possible exception of clams and smelt. Intensive fishing of other species is likely to have some effects beyond that on the desired species itself. The spring months, for example, are a period of multiple species activity, and fishing for one species will almost certainly take others as well. Intensive fishing activity in the lagoon channels by any methods involving dragging devices or even constant setting and removal of heavy traps may cause extensive disruption of the soft, feebly stabilized sediments. Such disruptions might lead to extensive erosion and smothering of mussel populations as well as causing upheaval of crab habitats. Species within the eelgrass canopies are dispersed and not easily collected by non-destructive means. Even traversing these areas in a power boat causes some upheaval and redistribution of sediments which, if conducted on a large scale, might have widespread adverse effects. No species at the moment appears to be in danger from overfishing. However, by appropriate management, yields of a number of species might be substantially increased. Further limited commercial fishing of some species could be done without adverse effects.

We do not mean to give the impression, as we may have done, that this system is one suffocated by an aquatic weed problem and "eutrophication" in its ugliest sense. The growth of eelgrass as we observe it in this type of system is a natural phenomenon simply interrupted for a brief period in recent history by some sort of natural catastrophic event. The changes that have occurred with regrowth of eelgrass are mainly quantitative ones rather than the qualitative ones, and even though they may have led to somewhat lower production of desirable species than might be the case in the absence of eelgrass, there is no question of attempting to reverse this natural phenomenon. The system remains rich in its diversity and highly productive of some species. In the end, the greatest value of the system lies in its near pristine state. With appropriate care, this need not be altered greatly by harvesting of its resources.

Regulations for exploitation of biological resources vary from simple to detailed according to the information on the resource available and the exploitation pressure. At the simplest level, the only regulation concerns closed seasons. These are considered in relation to seasonal activities of the species concerned. Specifying fishing gear, mesh sizes and specific areas for fishing requires more information on the species concerned. Limiting numbers taken require (or should be based on) some information of the population structure and abundance. In only a few fisheries is sufficient information available to objectively set limits for the total catch; the seal population is an example. Gathering of such information is a formidable task as is also the monitoring of catches and although desirable, it is quite obviously impossible to obtain such information for every species that is subject to intensive harvesting.

A practical alternative to this, and more sophisticated than "simple" regulations, is suggested by our studies on the clam population. For this intensively exploited population, only one regulation exists (other than banning fishing in polluted areas) - that being a minimum size limit. This is certainly inadequate, both from the biological point of view and from the point of view of envorcing the regulations. Given detailed knowledge of the population dynamics, appropriate maximum "sustainable yields" could be calculated. However, implementation of regulations to ensure that such yields are not exceeded presents practical problems. The alternative suggested by our very simple calculations is implementation of ROTATION HARVEST schemes.

For three year rotation harvests, we calculated yield for the system as a whole would double. Further, catch per unit effort would go up by a factor of 5 - certainly a benefit to the exploiters. Thus it would be expected to catch twice the previous number of clams with 1/5 of the previous effort. This system also has the biological advantage of ensuring existence of large stocks to maintain adequate recruitment and has the practical advantage that it is easy to enforce. A three year rotation harvest appears optimal for this species which becomes of harvestable size at 3 to 4 years of age. By analogy, it can be reasonably guessed that for other invertebrate species, a rotation harvest at intervals corresponding to the age at which the species becomes harvestable would likewise be optimal.

Could a rotation harvest scheme be utilized for anadramous fish populations? For invertebrates with pelagic larval stages, recruitment seems to be determined by factors other than the size of the reproductive stock or population fecundity, at least within fairly wide limits. Further, one population may be recruited largely from larvae produced by other populations. For anadramous fish populations, however, population fecundity does have a major influence on recruitment - if a fish is not in the stream to lay eggs, none will develop there. Further for those species with strong homing tendencies, local populations are entirely dependent on their own population for recruitment. A rotation harvest scheme applied to such a population might be expected to have even greater benefits than for marine invertebrates because recruitment would be enhanced. Further, by taking into consideration the interval between birth and return to the stream, competition between young year classes (parr for example), etc., it may be possible to increase yields substantially with relatively short interharvest intervals or with longer harvest intervals and thereby allow a good fraction of the streams to be fished at any one time.

Rotation harvest schemes do not seem to be in common use, perhaps because of the local nature of fisheries - although banning fishing in some areas for a period because of overexploitation is in principal the same idea. For a relatively small system such as the Park, in which it is not of great inconvenience to fishermen to restrict fishing to a few locales, it would seem to be practical. For species for which it is uncertain to what extent they are exploited, and for which more time is required to obtain the appropriate information, rotation harvests would provide a sensible alternative to either banning fishing, or simply continuing the *status quo*. Where a number of species are involved, the interval for the rotation harvest could be a compromise or mean between the intervals appropriate for the various individual species. Further, since any interval (except for an annual interval) below the optimum harvest interval would have some beneficial effect, the interval selected could be biased somewhat by considerations of how many different areas can be practically delineated.

In the recommendations, we have attempted to present possible alterantives with respect to management of resources. It is realized that the most desirable management schemes may be the most expensive and difficult to carry out. To say that some commercial fishing of a resource could be conducted does not mean we recommend that it be done - this is a matter of Parks policy. We have attempted to accommodate, however, within the recommendations, the multiple demands on this system and the need for frugality in these times.

Other recommendations or management schemes might be conceived. If the main body of our report provides the basis for this, then it has achieved its primary aim - to provide a broad scientific basis for management considerations.