The DERBY TIDAL POWER PROJECT: An Examination of the 1997 Consultative Environmental Review for Environmental Effects that might necessitate abandonment of the Project

by

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Introduction

This examination of the Consultative Environmental Review (CER) of the proposed Derby Tidal Power Project in Doctors Creek, Kimberley, Australia, was undertaken at the request of private citizens from the Derby region. Its purpose was to identify areas of significant uncertainty in the information presented in the CER on potential environmental effects of the Project, and to assess the prospects that these might have for producing unacceptable environmental effects or of diminishing the expected benefits to be derived from the Project.

I and my colleagues from the Estuarine Centre have never visited northern Australia, and have no direct knowledge of the Kings Sound and Doctors Creek ecosystem. We have, however, been conducting research on estuaries — especially macrotidal ones — for the last 22 years, and much of that research has been aimed at understanding the ecology and ecosystem properties of coastal systems that have been investigated for their potential to support tidal power development.

The Acadia Centre for Estuarine Research (ACER) was established in 1985 to continue and co-ordinate multidisciplinary research that had begun a decade earlier on the macrotidal estuaries of the Bay of Fundy system. Since that time ACER has been the centre for research on tidal power effects in the Bay of Fundy, investigating ecosystem properties, sediment dynamics, biophysical relationships, and the effects of causeways on the biotic characteristics of the system. We have as a practical experiment the Annapolis Royal tidal power station: a 20 MW generator that has been operating on the Annapolis River since 1985, and have conducted a number of research projects related to fish passage, sediment dynamics, and shoreline stability in relation to that facility..

The multidisciplinary, ecosystem-based approach that we have taken has been and is being adopted by other research groups around the world. ACER personnel have been involved in planning such projects in the United Kingdom, Argentina, Uruguay, Italy, and other estuarine systems in Canada.

Overall Assessment of the Derby Tidal Power Project.

Tidal power is a potentially valuable alternative to the combustion of fossil fuels for energy supply. It is a renewable and predictable energy source that may be easily integrated into power supply networks, and used to displace various other forms of energy. Given present technologies, however, there are few places in the world where tidal power offers a realistic option: situations where a large tidal range occurs in a region of significant demand. Consequently, many proposals have been abandoned for economic reasons after preliminary investigations: either there is insufficient demand in the immediate area, or the costs of construction and transmission to market combine to make the project too expensive.

Cost benefit analyses are based upon a wide array of assumptions, all of which need to be evaluated for each potential site, and at each *time* when a proposal is being considered. Two significant variables represent the major economic challenges to initiation of tidal power development: the cost of oil, and the techniques for power generation. Usually, cost benefit analyses look more favourable when the cost of fossil fuels such as oil is high, because tidal power is seen as replacing a highly valued commodity. In fact, construction of any tidal generating facility requires the expenditure of vast quantities of fossil fuel; consequently, the best time to invest in building such a facility is when oil prices are low.

The technique for tidal power generation for all existing plants, and for most of the proposals considered in recent years, including the Derby Proposal, is the same: turbines are driven by a head of water that is built up behind a dam constructed in a tidal inlet. The design allows for capturing of a large proportion of the potential energy represented by the retained water, and the considerable amount of power generated yields a favourable generation cost per kwh. However, dependence on the presence of a tidal dam produces two strongly negative effects. Most of the cost of a tidal generating station of this kind is associated with building of the dam itself. If, instead of the traditional low-head turbines proposed for such installations some of the more recent run-of-the-river or in-stream turbines were to be used, tidal power generation would be much less costly to initiate. Such systems operate on tidal streams in a way analogous to a windmill. They can thus only capture a small amount of the total available energy, although they do so without greatly changing the nature of the river or estuary flow.

As vertical axis turbines and other designs become more well known, the prospects for tidal power should improve tremendously, because in addition to the great cost of constructing tidal dams, **<u>it is the dam itself which produces many of the most significant environmental changes that make tidal power unacceptable in most instances</u>**.

A third variable of importance in cost-benefit analyses is the estimate of the lifetime of the facility. Return on investment estimates depend upon the length of the operating life that can be assumed. In the case of the Derby Tidal Power Project, the proponents estimate a design life of 120 years (P. 26), a value which seems to me to be highly improbable, given the turbid nature of the ecosystem being modified. Many hydroelectric facilities have proved to have far less working life than initially anticipated, primarily because sedimentation effects reduced the working volume of the reservoir. Although this statement reflects the experience of many river-based hydro developments, it is a salutary reminder of the inadequate knowledge upon which decisions have been made even in an industry (i.e. river based hydro) with more than a century of experience.

<u>Environmental Effects</u>

The principal areas of concern from an environmental viewpoint relate to the following:

1. **The probable fate of suspended and deposited sediments under the changed current regime of the two creeks.**
2. **The effects on fish and reptiles inhabiting the estuaries and King Sound.**

3. The effects on birds.

The Consultative Environmental Report appears to pay considerable attention to the effects on mangroves, about which I have little comment to make. I have no direct experience in mangrove-based systems[1], and it appears from the CER that there is a reasonable degree of background knowledge available for an assessment. It is worth noting, however, that mangroves are recognised around the world for the important roles that they play in supporting a variety of terrestrial and aquatic vertebrates, particularly as nurseries for marine and estuarine fish. Consequently, <u>their recovery following significant changes in inundation and sediment deposition</u>, as would be caused by construction of the tidal power barrages, <u>should be a critical aspect of the assessment of environmental effects.</u>

If the planners have misjudged the behaviour of sediments in the system, their confident predictions of recovery and even expansion of the mangroves could be completely wrong.

For this reason alone, understanding of the dynamics of the sediments in Doctors Creek and King Sound is **absolutely necessary** before valid assessment of this project is possible.

<u>1. Sediment Properties and Behaviour.</u>

The least convincing, and in some ways most crucial aspect of the CER is the account of the sedimentary nature of the system. Quite frankly, I am amazed that such an important factor was treated with so little sophistication or concern.

From the CER I have identified several critical uncertainties about the sedimentary regime of the Doctors Creek ecosystem that seem to me to be potentially devastating for

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[1] The Bay of Fundy wetlands are saltmarshes. My only experience with mangroves has been limited work in the Caribbean and New Zealand.

project. These are dealt with in outline below. In general, however, the information about sedimentary processes presented in the CER seems to me to be completely inadequate.

a) According to the CER the system is turbid. In this respect it is similar to almost all other macrotidal estuaries[2]. However, the authors of the CER (P. 29), state that sediment concentrations are in the range from 110 – 650 mg/L, with an average around 300 mg/L. It appears that these values were based upon a series of measurements made in both arms, on ebb and flood tides during the month of July 1997. There is no mention of any seasonal variation – presumably the data do not exist. There is no mention of wave or turbulence conditions when the data were obtained. Finally, there is no mention of the grain size, or the organic content, or the mineralogy of the sediments, or the salinity variations, **all of which are absolutely critical pieces of information for any sensible judgement about the behaviour of sediments under a changed current velocity regime.** All of the above factors – wind, waves, seasonal variation (etc) - can produce <u>orders of magnitude</u> variations in suspended sediment concentrations. There is no information about the vertical distribution of the sediments beyond the bland and unconvincing statement: "Analysis of the field data showed that there were no significant vertical gradients in turbidity or suspended sediments." (p. 29).

b) The lack of information on the sediment concentrations makes it absolutely impossible to predict the consequences of a change in current velocity. I have been unable to find <u>any</u> evidence in the CER that the proponents or their consultants have used any of the many numerical models that have been constructed to predict sediment behaviour. (I will add that many of the models are in themselves inadequate, because they tend to be based on physical and sedimentological parameters only, and do not incorporate biological factors.) Nonetheless, any attempt at modelling would clearly have been impossible given the paucity of the data.

[2] Except, significantly, the La Rance system in France, which is predominantly a rocky estuary with relatively low suspended sediment loads. For this reason, any conclusions about the sedimentary environmental effects of the La Rance tidal power station have no bearing on the situation in Doctors Creek.

Consequently, the figure purporting to show areas 'available for mangrove colonisation' in the East arm (Fig. 6.8) is presumably only based upon the decreased maximum water level to be maintained in the low pool.

c) Are these criticisms important? Our experience in the Bay of Fundy system, the Miramichi (Canada), the Humber and Severn Estuaries (UK) and the work of colleagues in the Netherlands and around the world shows that the fine sediments that dominate suspensions in the water column of macrotidal estuaries <u>do not behave in any way like non-cohesive sediments</u> (e.g. sands) that engineers have traditionally modelled. Their settlement rate depends upon: particle size, salinity of the water, temperature, the mineralogy, the organic content, and the presence and activity of biological factors such as bacteria and phytoplankton. Once settled on the bottom, these sediments continue to display entirely unique properties. If allowed to dry out, as occurs in intertidal locations, the sediments <u>may</u> become extremely resistant to erosion, especially when low tide occurs in the middle of the day. In Minas Basin, for example, we found that over a two month period in summer the stability of the mudflat increased by several orders of magnitude because the sediments were held together by mucus secretions from benthic diatoms, bacteria, molluscs and worms. This is a seasonal phenomenon that causes sediments to settle and stay on the bottom, building up a bank that may accumulate many centimetres over the summer. When the sediments were examined in traditional ways in an engineering laboratory, it was found that they could be up to **80 times more resistant to erosion** than one would have predicted on the basis of their grain size. Biological factors are recognised as playing extremely important roles[3].

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[3] Further information can be derived from: Amos, C.L., N.A. Van Wagoner and G.R. Daborn. 1988. The influence of subaerial exposure on the bulk properties of fine-grained intertidal sediment from Minas Basin, Bay of Fundy. Est. Coastal Shelf Sci. 27 : 1-13. Amos, C.L., G.R. Daborn, H.A. Christian, A. Atkinson and A. Robertson. 1992. In situ erosion measurements on fine-grained sediments from the Bay of Fundy. Mar. Geol. 108 : 175-196. Grant, J. and G.R. Daborn. 1994 The effects of bioturbation on sediment transport on an intertidal mudflat. Neth. J. Sea Res. 32(1) : 63-72. Paterson, D.M. and G.R. Daborn. 1991. Sediment stabilisation by biological action : significance for coastal engineering. Proceedings of the Conference on Developments in Coastal Engineering, Bristol, U.K. Pp.

Potentially, such accumulations would quickly fill up an estuary, but in our region winter conditions are harsh enough to remove much of the summer's accumulation.

In order to understand this behaviour we need to know in detail: sediment concentrations, sediment type (mineralogy and grain size), organic content, current velocities, shear velocities, turbulence, wave height and period, diatom concentrations and growth rates, invertebrate types and densities[4], and important vertebrates such as fish and birds that have major effects on benthic invertebrates. None of this information seems to have been available to or acquired by the consultants that prepared the CER. **Consequently, I suggest that it is impossible at this time to make any judgement beyond pure guesswork about the effect of the barrages, the channel and the filling/discharging operations that would be involved in building this project**. To make even a preliminary estimate of sediment fate will require a field campaign covering a full four seasons, and aimed at making the kinds of measurements indicated above, followed by a thorough modelling exercise.

d) To illustrate the importance of such information, I rely on some of our own experience.

In Atlantic Canada we have constructed three dams across macrotidal estuaries that are comparable in size to those proposed for Doctors Creek: The Petitcodiac Causeway (about 1955), the Annapolis Causeway (1960) and the Windsor Causeway (1970). In all three cases, the dams diminished the water velocities that had prevailed previously. Two of these, at Petitcodiac and Windsor, caused massive deposition of

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111-119. Faas, R.W., H.A. Christian, G.R. Daborn and M. Brylinsky. 1991. Biological control of mass properties of surficial sediments : an example from Starrs Point mudflat, Minas Basin, Bay of Fundy. Proceedings of the Nearshore and Estuarine Cohesive Sediment Transport Workshop, St. Petersburg, Fla. 42: 360-377.

[4] Some invertebrates are *biostabilisers* that tend to make the sediments less susceptible to erosion, whereas others are *bioturbators* that make it more susceptible.

sediments on the seaward side of the dam as well as accumulation in the lake/headpond above the dam. At Windsor, accumulation on the seaward side during the first year occurred at rates of up to 15 cm/month until it reached the mean high water level (i.e. about 8 m in thickness). Now, after 28 years, the new mudflat is still growing down the estuary; and is causing increasing problems for shipping at the port of Hantsport, some 11 km away from the dam. The Annapolis Causeway had the opposite effect: it has accumulated a large amount of sediment upstream of the dam which is steadily filling in the headpond, but appears to have induced **accelerated erosion** on the seaward side that threatens one of Canada's most important historic sites.

In all three cases, construction of the dams caused massive deposition of suspended sediments, but why the differences?

The answer relates to the **source** of the sediment. At Petitcodiac and at Windsor, the major sources of sediments were from the seaward side, generated by the erosion of sea cliffs subjected to tides of up to 16m range. The sediments accumulating behind the dam were mostly derived from agriculture-induced erosion upstream. At Annapolis, most of the sediment was derived from upstream, and, prior to building of the causeway, this was maintained in suspension by a tidal system that oscillated from 5 to 9 m in range. When the dam was built, all upstream sediment tended to settle out as flows decreased in the lower estuary, and got trapped in the headpond. In addition, any sediment in water brought in from the sea that passed through the open fishway in the dam also got trapped upstream. This had the effect of creating a sediment deficit in the tidal water on the seaward side, and thus caused the greater erosion occurring along the shore of the Annapolis Basin.

e) Inspection of the CER suggests that a scenario much like that at Windsor and Petitcodiac is highly probable. With the dams in place, highly turbid water will enter the arms and fill up the high pond. As velocities fall in the upper reaches, that sediment will settle out, particularly in more peripheral areas, and some of this sediment at least will probably remain, because subsequent velocities as the water flows through the turbines will not be high enough to resuspend it. As a result, the water will become somewhat clearer[5]. However, the next filling of the headpond will be with turbid water derived from King Sound, which **represents an almost infinite supply of new sediment**. It is hard to imagine that there will not be massive accumulation of sediment in the west arm of Doctors Creek over time, just as we have seen in all our Canadian examples. The CER fails to provide any evidence to counter that intuitive interpretation; I could be persuaded that it is wrong only if there was an adequate attempt to model the behaviour of the sediments. As I indicated above, there are some models that, while not perfect, would give some confidence in their forecasts, but there do not appear to be any data on Doctor's Creek sediment at present that would be adequate to begin working on such a model.

f) The problem of sediment behaviour is a potentially fatal flaw for a project of this kind. If sediments do accumulate in the headpond, they will dramatically alter the expected lifetime of the system (which as I have indicated is inordinately optimistic). Given that King Sound provides the sediment supply, and this is turbid because of a large agriculture-dominated drainage basin, it is highly probable that operation of the project will cause continuing deposition behind the dam[6]. A rough estimate of the amount of sediment that has deposited in 28 years outside the Windsor dam is about 9 Mm^3 – not far off the estimate of 10 Mm^3 that is estimated must be dredged to increase the power generating capacity of the station (CER p. 19)! One of the fundamental features of estuaries is that they tend to be sinks for sediments, and whenever we increase their depth by dredging, we tend to **accelerate** the rate at which sediments accumulate. Dredging is a self-perpetuating activity that almost never produces a permanent solution – unless one happens to own the dredging company with the contract!

[5] A conclusion drawn by the authors of the CER (p. 46).

[6] It will be noted that I do not at this time predict any significant deposition on the seaward side of the dams as happened with the Petitcodiac and Windsor examples. This is partly because of the configuration of the Doctors Creek system as an obliquely oriented branch of the Sound. I suspect that strong flows in the Sound might minimise the extent of any bed created at the mouth of the Creek. The fact that **no**

g) The casual discounting of sedimentary effects from the project is unacceptable and unnecessary. Although the field is a complex and confusing one, there are numerous ways in which a much clearer perception of likely effects can be derived. Modern numerical models of the factors controlling sediment deposition and erosion are available[7], and, although far from perfect, could be used with suitable validation to examine the probable gross effects. This should be the objective of a multidisciplinary investigation of Doctors Creek that ought to be carried out before any decision is made to proceed with the project.

In general, I have to conclude that the consultants actually know very little about the dynamics of cohesive sediments. This, coupled with an almost complete absence of information renders any of the statements in the CER about sediment-related effects of the project completely unreliable.

2. Effects on Aquatic Vertebrates.

A second major area of concern with the CER relates to the larger fauna such as fish and reptiles that inhabit the system. Despite recording the presence of several species of fish that have commercial value, and of reptiles that have conservation value, the consultants apparently conclude that operation of the tidal power station will have no significant effect on them. I find that conclusion highly improbable.

To be fair, I must admit that when we first began seriously to assess the potential for tidal power development in the Bay of Fundy in the 1970s, our view of the fishery issue was about the same. Despite the fact that the land surrounding the Bay of Fundy has been settled by Europeans for almost 400 years, and that there were two substantial marine

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information is provided about the oceanography (currents, waves etc.) of the Sound is yet another obvious inadequacy of the CER.

[7] An example, developed from years of research in Canada and the United Kingdom, is appended for information.

research institutions nearby, our knowledge of the fish of the Bay was pitiful, and our first major review[8] made only passing reference to them. Nonetheless, we identified fish stocks as an area of inadequate knowledge and attempted to improve on it in subsequent years.

Less than 10 years later, we knew the following about the Bay of Fundy system :

- The turbid, macrotidal bays (Minas, Cumberland, Chignecto and Shepody Bays) at the head of the system are feeding grounds for more than 50 species of fish, several of which (e.g. salmon, cod. halibut, haddock, herring, shad) are among the most important commercial species of eastern North America and the North Atlantic. For at least a few of these, notably the American shad, the headwaters of the Bay provide a feeding ground for all Atlantic stocks of the species: during their sea phase (which lasts 3-4 years prior to first spawning), all individuals migrate into the Bay during summer to feed on its richness.
- More than 20 species of fish spawn in the muddy estuaries of the Bay or migrate through to the rivers. Their young often spend most of the first few months of life using the tidal areas as a nursery.
- The Minas Basin and Chignecto Bay are the major feeding grounds for more than 90% of the world population of Semipalmated sandpipers, and large percentages of several other migratory waders. These two areas have now been made International Ramsar sites.
- The outer Bay of Fundy harbours the largest concentration of the rare Northern Right Whale remaining alive.
- The productivity of the muddy tidal flats equals that of upwelling areas at the mouth of the Bay of Fundy, and is a significant contributor to the whole Gulf of Maine – Georges Bank area – previously one of the world's greatest fishing areas.

How could we have so completely underestimated the importance of this familiar, macrotidal system?

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[8] Daborn, G.R. (Ed.) 1977. ***Fundy Tidal Power and the Environment***. Publication No. 28. Acadia University Institute. iv + 304 p.

There are undoubtedly several reasons. Because of the large tidal range (up to 16 m on the astronomical high tides, and an average of 12 m) and the very strong tidal currents, there has never developed a significant mid-water trawl fishery. A small drift net fishery operates in limited areas where tidal turbulence is less, because in other areas the boiling action of tidal water tends to wind drift nets up into Gordian Knots. This fishery is abandoned in mid-summer when the Minas Basin region is invaded by huge numbers of dogfish (*Squalus acanthias*). The major fishing activities in modern times have been small boat operations focussed on lobsters and flounder. Consequently, there were no traditional fishery records to indicate just how abundant many of these species are. Until we began the research and tagging programmes in the late 1970s we had no idea that the fish populations were so diverse, so abundant, or that these muddy systems played such a significant role in the ecology of the western North Atlantic.

Other reasons for our ignorance relate to the question of visibility. The waters are so turbid that one cannot see the fish that swim beneath the surface. The vast intertidal zone that is exposed at low water is, to the untrained eye, a lifeless expanse of muddy wasteland. The truth is quite different. The sediments harbour some of the highest densities of benthic invertebrates recorded in a relatively natural coastal system – a fact that was clear to the birds and fish. The food chain is based partly on saltmarsh detritus (analogous to one of the roles of mangroves in tropical systems), but also on microscopic diatoms that inhabit the mud system. Similarly, we have found that the extremely turbid water itself contains some of the highest concentrations of plankton ever recorded. Thus, until we looked, we were unaware of the richness of these tidal flats and the water that flows over them.

Does the same thing apply to Doctors Creek? From this distance it is obviously impossible for me to say. However, in more than two decades of work on macrotidal estuaries on three continents I have concluded that they are all exceptionally biologically productive. I am confident that some real and intelligent research on the Doctors Creek ecosystem would show that much of the richness has been overlooked.

It is clear that the information about the aquatic vertebrates inhabiting the system has to be significantly improved before any estimate of effects from building and operating a tidal generating station can be made.

Despite that, the CER provides information that suggests some large fish and reptiles (crocodiles are mentioned, but are there also any turtles?) inhabit the system. This immediately raises the problem of mortality in turbines.

I regret to say that some of the 'predictions' made on page 58 are so naïve as to be almost laughable. For example, it is stated with (apparent) confidence that ***"larger fish will be prevented from entering the turbines through installation of an exclusion mesh'.*** Such a statement suggests to me that the authors cannot have attempted to model the effects on flow of a screen with a mesh size small enough to exclude most commercial sized fish, and that they are unfamiliar with the huge amount of research that hydro power generating companies have carried out on this topic. Mesh screens simply reduce the cross-sectional volume to such an extent that they seriously impede flow. Consequently, the output of a generator is reduced. Furthermore, where exclusion screens actually are used (e.g. in the intake channels of power stations through which cooling water is drawn), they require a great deal of maintenance, are easily fouled, and become obstructed by fish impacted upon them. In estuaries, the biofouling community is extremely well developed, and any structure will become coated very quickly. In view of the large size of the intake tube, and the need for good flow through the turbine, exclusion screens are not really an option.

We must then assume that fish of varying sizes, and possibly reptiles, will end up passing through the turbine.

Fish passage through turbines has been extensively studied for the last half century, and it is still a highly controversial topic. At Annapolis we have done some of the most relevant research in the past few years because it became clear right at the earliest planning stage that a mechanical barrier to prevent fish from entering the draft tube was simply not feasible. I can summarise the results of several years' work as follows:

1. Fish mortality is usually considerably higher than that predicted by traditional models[9].
2. Small fish are even more susceptible to being killed on passage through the turbine than large fish because of the sharp pressure drops to which they are subjected. This causes bursting of blood vessels in gills and eyes, pulping of body muscle, and occasionally shearing off of the head.
3. Experimental measurements of turbine mortality are extremely difficult to obtain with confidence. Handling and repeated catching of fish causes mortality in itself, and it is not easy to establish adequate controls so that the true effects of the turbine can be assessed.
4. We have some convincing evidence from the Annapolis studies that the age distribution of the American shad has changed since the turbine came into operation. Prior to 1985, the oldest fish were 11-13 years of age; now we rarely get one that is more than 7 years. Nonetheless, the population still exists and spawns in the river. Our attempts to estimate population abundance have been confounded by other events that affect stock size.
5. "Experts" do not necessarily agree on the results of the studies. My friend and colleague, Dr. Mike Dadswell[10], who is the most experienced fisheries biologist in the area has conducted the major studies of mortality using adult and juvenile shad at Annapolis. I co-supervised the study using juvenile shad, and have supervised further

[9] The most used model is the Von Raben formula, which uses such parameters as the length and girth of the fish, the number and diameter of blades, the velocity and water length, speed of rotation (etc). to predict the likelihood that a fish will come into contact with the blade during passage. It is not often recognised that Von Raben tested his model with eels, one of the hardiest species known, and had to apply an adjustment factor to his model to increase the predicted mortality rate to match that which he found with the eels! It does not consider pressure effects, and assumes that all fish enter the turbine stream in their usual orientation: head first and tail last. It generally dramatically underpredicts the mortality.
[10] Biology Department, Acadia University, Wolfville, Nova Scotia, Canada

juvenile work since that joint research. The results came out as follows: adult mortality was above 20%; juvenile mortality above 50% on each passage through the turbine. Dr. Dadswell is inclined to accept those figures as close to reality, whereas I argue that they are too confounded by methodological problems to be reliable. However we both agree that mortality is far higher than the predictions made by the consultants prior to the building of the station: less than 5% for adult shad and 0% for juveniles.

Turbine mortality is, I suggest, a potentially project-breaking factor for the Doctors Creek project. If the system is used by numbers of large fish and reptiles I see no likelihood that these can be prevented from entering the turbines. If the stocks have value for conservation (e.g. turtles, saltwater crocodiles, rare fish) or commerce, then the degree of risk must be assessed before a decision is made to proceed.

3. Effects on Birds.

Our growing knowledge of the role of estuaries in the life of coastal birds suggests that great care must be taken to assess the risks to them. Many species are critically tied to estuarine marshes and mudflats. Furthermore, as they migrate between one estuary or coastal wetland and another, they form an intricate web of connections. It is our view after 20-odd years of work (involving as many as 300 scientists and students over that time), that the Bay of Fundy is **biologically connected** to the Arctic, the Caribbean, and South America through the migratory movements of birds, fish and mammals. If we were to compromise the resources upon which they depend, the effect would extend far beyond our national waters.

Experience leads me to expect that if Western Australia were to conduct the kind of comprehensive studies that we have done in the last many years, it would be found that the King Sound ecosystem is biologically connected in various ways to wetlands and coastal habitats that may be many miles away. It could be that such knowledge would lead the inhabitants of the region to recognise that they too hold in trust a system of national or international interest.

Although I suggest that the Precautionary Principle should be invoked in any situation where knowledge is weak, I do not say that tidal power should never be developed in the King Sound system, or even in Doctors Creek, but it should certainly never be approved on such an inadequate basis. The CER is reminiscent of many early environmental impact statements from decades ago: it is shallow, based on extremely limited knowledge (and apparently understanding), and glosses over potential environmental effects that have been shown elsewhere to deserve serious consideration. It is no basis for a decision to proceed at this time.

I sincerely hope that the authorities will insist upon a complete and adequate environmental review of these plans.

Wolfville, Nova Scotia
22 May 1998.