LESSONS FROM A MULTIDISCIPLINARY STUDY OF PORT HACKING ESTUARY

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In these times of financial restraint, marine sciences enjoy a very special position within the range of scientific activities. Rather than suffering from reduced funding, they are expanding at a considerable rate. In Australia this is partly due to neglect in the past, partly a result of increased importance of the waters around this continent to industrial activity of various sorts. The development is, of course, welcomed by marine scientists. At the same time, those of us who consider their social responsibilities realise that accepting the extra money and retiring to the old desk or small and remote field station is just not good enough. As Field (1982) pointed out recently, "a plea can be made for more team projects involving several disciplines and a spectrum of organisations, with frequent reviews of direction and aims".

The Division of Fisheries and Oceanography of CSIRO (now reorganised into the Division of Fisheries Research and the Division of Oceanography, jointly known as the CSIRO Marine Laboratories) organised the 'Port Hacking Estuary Project'. It ran from 1973 to 1978 and involved some 15-20 research scientists from various institutions (although most of them were from CSIRO). It was multidisciplinary in character and guided by a model of carbon flow, and its goal was to use the information obtained to build a predictive dynamic model of the flow of carbon in a typical Australian estuary.

By the time this issue of *Wetlands* goes to press, the results from the Port Hacking Estuary Project will just be published (Cuff and Tomczak 1982). Although the delay from Project completion to publication is more than we would have liked, the resulting book seems to be just in time to take up the discussion on how to organise Australia's coastal research in the future. "Well thought out and planned long term studies are required with a firm policy of continuity of funding", concludes Field (1982). The experiences from the Port Hacking Estuary Project will certainly be helpful here and this brief review of the project is presented as a contribution to a discussion which has just started.

One of the first problems the marine scientist encounters when working on Australian estuaries is the problem of classification. Existing classifications such as those presented by Pickard (1961) or Hansen and Rattray (1966) are based on estuaries of temperate zones and do not describe tropical or subtropical estuaries very well. South West Arm of Port Hacking, which was the study area for most of the Project (Figure 1) is a basin of about 25 m depth, connected with the main Port Hacking basin by a shallow sill. In geomorphological terms it can be classified as a coastal lagoon (Bird 1968). In terms of hydrodynamics it is best described as a fjord, in the sense of Pickard (1961), which varies from 'active' to 'passive' states as the inflow of freshwater varies. Freshwater inflow of South West Arm is controlled completely by local rainfall, which is highly intermittent and does not display a strong seasonal pattern. As a consequence, South West Arm exhibits two states which alternate nearly at random. In one state it is simply an arm of the sea, while in the other, which occurs for short periods following rainstorms, freshwater sits at the surface and saline tidal water enters over the sill and falls down into the basin.

The intermittency of the freshwater inflow has a marked effect on the ecosystem in South West Arm. We believe that similar estuaries exist in various places around the world and that the changes in the ecosystem forced by the intermittent freshwater supply are important enough to be taken into consideration in estuary classification. The Port Hacking Estuary Project can, therefore, be seen as a case study for estuaries of this type; we call them 'intermittent estuaries'.

Figure 1. Aerial view of Port Hacking, with South West Arm at the upper left, surrounded by the Royal National Park.

Another problem which occurs at the outset is that of conceptualisation. A multidisciplinary study has to have some kind of framework, and it is here where the modeller comes in. The Port Hacking Estuary Project was a *model-guided* project, i.e. all field work was expected to contribute, in some way or other, to a model of some agreed-upon key quantity (in our case the flow of carbon). The making of the model initially goes through stages of increasing complexity, as demonstrated in Figures 2-4. Having established the model, the team turns to field work, and the model invariably goes through additional stages, this time of increasing simplicity. While the first stages develop from scientific reasoning the later stages follow from administrative, financial and personal reasoning, and the resulting model is usually a compromise between the interest of the participants, the support available and priorities dictated by logistics.

The development outlined here is common to all multidisciplinary studies of estuaries. The Port Hacking Estuary Project did not differ from any other similar study in this regard. All the problems so familiar to anyone whoever happened to be drawn into a multidisciplinary study were there: makeshift laboratories and 'gumboot and rowboat' field work during the early phase of the Project; development of a computer data base for simulation efforts during, rather than before, data collection, leading to several changes of data format; personal frustrations and animosities etc.

But the Port Hacking Estuary Project differed from other estuarine studies in two important aspects. The participants decided not to patch up their incomplete model by borrowing from other sources, and not to cover up their problems in the final report. Comparable studies from overseas present the scientific community with a final account of their achievements which leaves nothing to be required: here is the model, these are the parameters, such are their values, and here are our predictions on estuarine ecosystem behaviour! A closer look reveals that not all parameter values were actually determined by participants in the study, but missing values were imported from the literature or presumably comparable ecosystems. In some cases, this is true for complete algorithms or functional relationships between variables. Generalisation is the backbone of science; but to strike the correct balance and to apply adequately general principles to special problems without introducing improper assumptions into the ecosystem under study is a gift not equally bestowed on all scientists. How much can be achieved by the 'right' degree of generalisation and 'proper' selection of information from other 'similar' ecosystems, is not always as obvious as in Sheldon and Kerr's (1972) derivation of the numbers of monsters in Loch Ness from a clearly rudimentary data set. But the technique can certainly be useful if a multidisciplinary team is faced with the task of filling observational gaps in order to produce a convincing final report for its sponsors.

The Port Hacking Estuary Project abstained from such practices, partly because of the particular character of intermittent estuaries for which only very limted information can be found in the literature. The decision was aided by the fact that Wilf Cuff entered the Project at a very late stage and had to look at modelling possibilities without any possibility of influencing data collection. He decided to investigate how much could be learned from a synthesis of available data, without resorting to outside data of doubtful validity to Port Hacking. I then came in at an even later stage, when a large part of the writing-up had been completed and participants turned to me for publication. It was clear that the usual job of covering up difficulties had become impossible with Wilf Cuff's decision not to go and borrow data from elsewhere, but it took us some hard work to convince everyone that the only way out was to simply be frank and honest about all aspects of the Project.

So, here is the result: a book quite incongruous in its different parts but a true image of a – should I say typical? – multidisciplinary study. There are two chapters on the history of the Project and its actual implementations. They are followed by seven chapters on various topics, from geology, physical oceanography, nutrient chemistry to phyto- and zoo plankton. From character and presentation they are of interest in their own right but serve here to provide the reader with an understanding of South West Arm. They do not, of course, represent the total published output from the Project, but they indicate the multidisciplinary character of the study. Three chapters are devoted to project-specific data collection, algorithm development and data base set-up, another three chapters describe the simulation efforts, from a static carbon budget to an exploration of the possibilities for dynamic modelling with a limited data set and a description of the various possible stages of ecosystem modelling for South West Arm or similar intermittent estuaries.

The final two chapters, each written by one of the editors, take up the story of the introductory chapters in an attempt to evaluate the Project and draw conclusions. It will be obvious to the reader that our conclusions do not always coincide although our general assessment does. Wilf Cuff makes the valid point that an investment of A$2,000,000 over five years may seem exorbitant but is in fact reasonably modest if seen in terms of cost per published paper (which is probably a reasonable measure for success rate): A$50,000 per paper compares rather well with open ocean science where a 14-day cruise, at A$3,500 per day for the vessel alone, often results in a single publication. Maybe the argument is not really a valid one, but it should convince us that the apparent lack of trust in multidisciplinary estuarine research which could be observed in recent years is ill-founded. I suspect that it is partly the scientists' own fault that funds for this type of research are hard to come by. They tried hard to present stories of total success where everyone familiar with the work knew its limitations. We chose the opposite approach: by discussing its limitations, we hope to convince scientists, administrators and sponsors that multidisciplinary studies do work and offer worthwhile investment.

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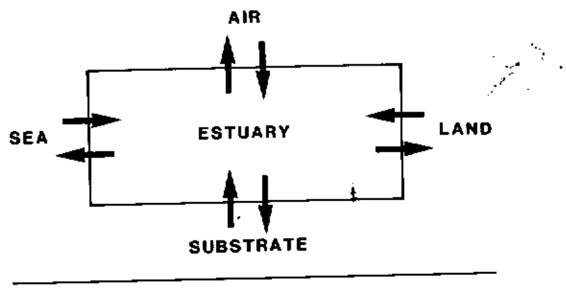

Figure 2. The starting point for a model of estuarine carbon flow. From Parker, Rochford and Tranter (1982).

Donor \ Recipient	DIC	AUT	HET	DOC	DET	
DIC		R				Dissolved inorganic carbon
AUT	D		B	D	D	Autotrophs
HET	D			D	D	Heterotrophs
DOC		R	R		D	Dissolved organic carbon
DET			R	D		Detritus

Figure 3. Qualitative interaction matrix of the estuarine ecosystem. Material fluxes are shown as determined by the donor compartment (D), the recipient compartment (R), or both (B). From Parker, Rochford and Tranter (1982).

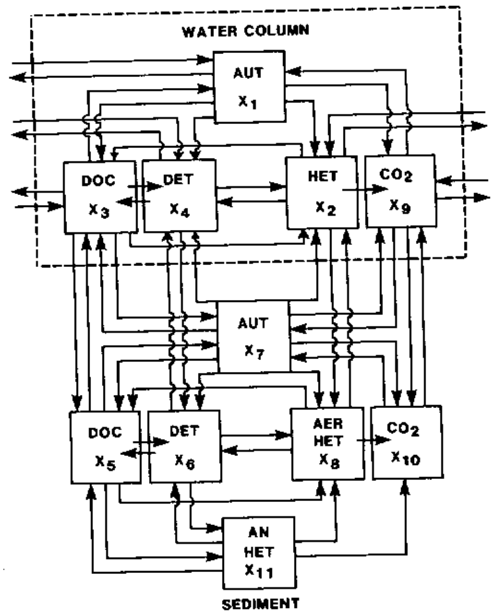

Figure 4. Carbon flow diagram derived from Figures 1 and 2, with additional distinction of aerobic (AER) and anaerobic (AN) heterotrophs. From Parker, Rochford and Tranter (1982).