CHAPTER 21

WHAT IS WRONG WITH OUR APPROACHES TO FISHERIES AND WILDLIFE MANAGEMENT? – AN ENGINEERING PERSPECTIVE.

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When we think of the subject *Wildlife Conservation – in pursuit of ecological sustainability* our thoughts usually tend towards public awareness campaigns backed by scientific studies of the state of the world and how to make these generate the political case for conservation. In my essay, I am going to take a different perspective because many jurisdictions have already adopted laws and policies that give great weight to conservation, and yet many of the benefits we expected to follow from these changes have fallen short of our hopes. Poor conservation outcomes continue despite public commitments to "sustainable development" and "ecosystem-based management". Of course, I do not mean that the need for public awareness, backed by good science and directed towards political action has diminished, but we need not only calls for action but concrete ideas as to what those actions should be. The perception is that even where we have good laws and policies they are failing to deliver. This shows that we need to identify the sources of the failures and hence promote corrective actions.

There are three broad reasons why we, as societies, continue to achieve poor conservation outcomes:

1. We are not serious about ecological sustainability.
2. We do not know how to achieve it.
3. Our institutions are not up to the task.

There is little doubt that (1) plays a major part in the failures of fisheries and wildlife management (FWM). I doubt that (2) is a major contributor; we have developed a range of approaches to FWM that have the potential to be effective. However, one problem is that these approaches are not applied as frequently or as thoroughly as required. This means that (3) must be a substantial part of the problem. If FWM practitioners are unaware of, or unable to implement, sound approaches to FWM, then our institutions are at fault. I argue that even if we were to solve problem (1), we would still fail to achieve ecological sustainability unless we also reform the institutional framework of FWM.

In this essay I will tend to concentrate on fisheries because that is where I have the greatest experience. However, I have had some experience with other wildlife management issues, from which I can suppose that the development of a coherent management paradigm does not appear to be significantly closer than that developed so far for fisheries. I have also had another life away from the science of fisheries management where I worked in electronic, mechanical, chemical and control systems engineering. This has often had me pondering why engineering is so much more successful in achieving its objectives than we seem to be in the field conventionally known as fisheries and wildlife management.

An important qualification is that none of our human institutions are perfect or even perfectible. However, that should not stop us from enquiring into what seems to work well and what does not. In contrasting engineering with FWM, I am not supposing that the practice of engineering is perfect, or that many of the principles used in engineering are not evolving in FWM. My premise is that instead of rediscovering the lessons of engineering slowly and painfully by trial and error, we should compare directly engineering and FWM to see where the experience of the engineering profession can guide us more quickly to our goal of ecological sustainability.

There are many famous engineering disasters; no doubt there are more to come. However, engineering is a profession in which disasters are a rarity; thousands of mundane engineering projects are completed everyday, millions of technological products are in use continuously; catastrophic failure is rare. In contrast, fisheries mismanagement is common, for example, 58% of some 232 well studied fish populations had declined by 80% or more.[1] In many cases, it is unclear when, or even if, the species or the ecosystems that supported them will ever return to the conditions that prevailed before their collapse. The human hardship and economic losses from our mismanagement of the exploitation of fisheries and wildlife resources are also catastrophes. Many commentators now refer to the crisis in world fisheries. Wildlife and remnant natural ecosystems are under pressure globally from the inexorable greed of the developed world and from the economically marginalised who are displaced onto shrinking areas of previously little-used and marginal habitat.

What are the differences that allow us to be confident that engineering enterprises have a very high probability of success, while our fisheries and wildlife management systems are now widely recognised as being highly failure prone? That we can be enormously successful in the field of engineering suggests that we should examine the processes that are responsible for that success. Then we should examine whether those same processes are at work in FWM and, if they are, why then do they fail? If some of the processes are absent, we should determine whether they could be applied or adapted to FWM. Of course, many of our failures in FWM arise from institutional or political causes, but engineering also operates within the same institutional and political framework and still attains a high level of success. So could there be something about the practice of engineering and its interactions with our institutional and political systems that accounts for the difference?

We could suppose that FWM is intrinsically much more difficult than engineering, for example, that engineering has to deal with less complex systems than the natural world. This may be true to some extent, but engineers deal successfully with very complex systems. A commercial airliner consists of millions of parts, and no one engineer understands how they all work. Such a piece of technology is exceedingly complex. Nor can it be that aircraft engineers have complete knowledge; the flow of air over an aircraft wing can be chaotic and unpredictable. Engineering successfully deals with other bewilderingly complex systems that are expected to remain serviceable in the face of unexpected events. The recent (2003) blackout in the Northeast of the USA and Eastern Canada shows that catastrophic failures can occur but, equally importantly, that such failures are surprisingly rare – failures of such magnitude occur less than once a decade even though hundreds of equipment failures occur every day. Moreover, engineers do have to deal with the vagaries of the natural world. For example, extreme weather and unknown properties of rocks and soils that support structures are routinely allowed for in construction. Power grids are hit by the unpredictable effects of solar flares and lightning. In many cases, failures occur not because of faulty engineering but because of failures in our other institutions: the systems are not used as designed or we fail to enforce adequate maintenance and training standards (two factors that contributed to the mega-blackout).[2]

From a historical perspective, engineering and FWM have both long been key human activities. We probably tend to think of technology as a recent activity, but tool making and construction date back to the hunter-gatherer period of human history. Our most successful "fisheries and wildlife management" activities came to be known as agriculture – one of our first and most transformative and engineering approaches to the environment. That which was left outside of agriculture is what we now consider to be FWM. The key characteristic that leads to certain species and ecosystems remaining outside agriculture is low controllability, in the sense of both controlling the animals and excluding other humans from their use. Interestingly, the relatively recent trend of establishing property rights over fish by means of individual transferable quotas (ITQ) is a step towards establishing a form of ranching in the marine environment.

On the face of it, we might suppose that our collective human experience in FWM is, on evolutionary time scales, much longer than our experience in engineering, so that it should be engineers who are studying the long and successful history of FWM in order to improve their discipline. However, despite its apparently shorter history, engineering is more highly evolved than FWM. Part of this is due to historical attitudes. There was no perceived need for FWM for much of human history because there was always the frontier, with new stocks of wildlife to be had just over the next hill. We usually found substitutes for products from wildlife, and we did not value wildlife because it was one of nature's "free" services. When we lose a natural service it is usually gradually, and often imperceptibly. By contrast, when your bridge falls, the loss is immediate and obvious. If you need the bridge you have to replace it, and you do not want the new one to fall. We value the bridge because we expended effort and treasure to build it. So engineering is more mature because historically we have demanded more of it and more ruefully lamented its failures.

That engineering is a more successful and trusted professional discipline than FWM is starkly indicated by:

Engineers

- Trusted to deal within areas of expertise
- High levels of technical success
- Users trust the solutions offered
- Politicians defer to technical expertise
- Profession is self regulating
- Able to designate who is an engineer

Fisheries and Wildlife Managers

- Areas of expertise not well defined
- Low levels of technical success
- Users dispute the solutions offered
- Politicians interfere
- Not recognised as a profession
- Does not have recognised membership

A key point about the way ahead in FWM is that, although there are many things yet to learn, we already have appropriate paradigms[3,4] with which to pursue ecological sustainability. The main problem is that the paradigms are not widely understood, accepted or applied. The paradigms are closely related to an engineering approach to problem solving. The fact that good ideas for improving FWM are around but resisted, ignored or overlooked suggests that current FWM institutions are part of the problem, and that institutional reform must be part of the solution. Therefore, a major task is to incorporate the paradigms into social, political and educational processes, a process that is much more complete with engineering paradigms and the engineering profession. Improvements in FWM will depend on the transformation of Fisheries and Wildlife Management into a professional discipline with similar attributes to that of Engineering.

A COMPARATIVE ANALYSIS OF ENGINEERING AND FISHERIES AND WILDLIFE MANAGEMENT

The broad objectives of engineering and FWM

Engineering and FWM both contribute to our aspirations, and that entails the full complexity of our mix of humanist and ecocentric philosophies. In contemporary societies both engineering and FWM are expected to increase human well-being in the terms encapsulated in "sustainable development". However, in this essay I am going to consider our objectives at a more operational level and, in particular, what the two disciplines imply in terms of professional attributes and objectives. In both activities the objectives are to provide for meeting society's needs, including protecting the environment. Both activities have ethical practice as objectives. If we accept that both the objectives and the constraints imposed by society are broadly similar for each, then differences in broad objectives cannot explain why engineering is more successful than FWM. The key differences must therefore be primarily institutional.

Both FWM and engineering are scientifically based

Engineering has a long history of empirical knowledge that has been incorporated into its body of knowledge. Engineering is supported by engineering science, but engineering science is not the practice of engineering. The other contributor to the scientific base of engineering is research and development. We can think of the "pure" end of engineering science as including fields such as physics, chemistry and materials science – developing basic theories about the nature of energy and matter and how we might be able to create new or improve existing materials. Microbiology and genetics are now looking much more like engineering sciences than biological sciences. Research and development usually relates to how to turn engineering science into better engineering outcomes, how to improve processes or turn discoveries into practical technologies.

Engineering is outcome oriented. Engineering depends on applying what we know – not on a wish list of what we would like to know. Engineering theories face tough tests; they are tried out in practice and modified or discarded. Engineering failures are the subject of intense scrutiny. A major engineering failure will lead to judicial review or Commissions of Inquiry. Considerable scientific and investigative effort is expended to determine why an engineering product failed, particularly if there is injury and loss of life or significant property or economic loss. Aeroplane crash or bridge collapse investigations are well known examples. Much of the investigation is scientifically based and one of the principle objectives is to add to the body of engineering knowledge to ensure that faulty design is avoided in future, and that other instances of the defective design are corrected. The science is combined with empirical experience to build a body of knowledge that becomes codified in the form of engineering standards. Engineering is committed to learning from its mistakes. This is because we hold engineers liable for their mistakes, and they usually have little choice when it comes to acknowledging their errors because the consequences of engineering blunders are usually obvious. It is also very hard to shift the blame for engineering errors onto others or the vagaries of nature. Even though engineers err, we trust in the engineering profession that the errors will be confronted and corrected.

In contrast to engineering, FWM tends to be process oriented. We spend more time on the data and methods we are going to use to assess the state of exploited fish and wildlife than we do on how the results can be translated into required outcomes of ecological sustainability. Similarly we put more effort into setting regulations than we do in measuring whether they have been effective.

In the early days, fisheries and wildlife science drew on the academic interests of "gentleman naturalists" who tended to ignore the empirical experience of "working class" harvesters, and so failed to absorb, or at least consciously evaluate, empirical knowledge. Historically, a great error was made when the need for FWM began to become apparent in the 19th and 20th centuries, because this was also the age of unbridled optimism about our capacity to find scientific solutions for every problem. The supposition that if we studied the animals we would be able to "manage" them is an enduring fallacy. This supposition created a vast enterprise of studying the detailed life history of commercially important species and, although many important things were learned, it is also now clear that this cannot be enough to predict the effects of exploitation on a community of species. In a nutshell, biology is necessary, but not sufficient for FWM, in much the same way that physics is necessary, but not sufficient, for engineering.

Engineers do not study molecules when designing structures; it is sufficient to study the bulk properties of the materials by direct experiment. Engineering has a much greater experience of focusing on the relevant. If something breaks, engineers study why it broke; they rarely study why it did not break (unless it was supposed to). Once the properties of a material are understood, engineers do not have to repeat the studies unless a new material or application is to be developed. Information on the properties of various materials is available to the practicing engineer in the form of specifications expressed in a standard way.

When it comes to empirical experience, most engineers listen when an artisan says that there is an easier way to fabricate something or that he or she is concerned that something is not right. This is for two reasons; the artisan could well be right or, if there are good reasons for sticking to the plan, it is important that those implementing it understand those reasons if the project is to succeed. The practice of FWM still has a paternalistic and arrogant undercurrent, where any form of knowledge other than science (in fact, scientific orthodoxy) is discounted. FWM is long on science and pure research and short on empiricism and known good practice. Research and development in the sense analogous to engineering is under-represented in FWM.

Pure scientists address questions such as, how does this system work? They aspire to work on open-ended questions where theories are incomplete. So practitioners in FWM with training in pure science tend towards reductionism; if we understand all the pieces we will be able to predict how species will respond to exploitation. Reductionism usually leads to a large list of things we wish we knew. Unlike the application of engineering theories, many of these predictive FWM theories have been tried, have failed and, despite their failures, they have then been retained. This may be in part due to the predominance of scientists with pure science training in FWM. Pure sciences have a relatively poor record in discarding flawed theories; we cling to our favourite theories long after they are broken. Ecology is particularly prone to this pathology.[5] In engineering, a broken theory may mean a failed project with serious losses; in FWM it may mean broken populations, human, non-human animal or both; in pure science it is an inconvenience.

A good example of a failed FWM theory is the use of catch per unit effort data in stock assessment. It has been known for at least 30 years that such data are unreliable indicators of the status of exploited populations[6] and yet these data are still widely used in fisheries management. One may suppose that this reflects a dearth of alternatives, but I do not believe this to be the case. We should be consciously compiling those methods that seem to work and those experiences that seem not to work so as to undertake the research and development phase of our nascent discipline.

What engineers and FW managers do is different when the best available science is poor. Engineers first try to design around the uncertainty, and if this is not cost efficient they undertake further, highly targeted research. Traditionally FWM has ignored the uncertainty. Now FW managers are supposed to act cautiously in the face of uncertainty in accordance with the precautionary approach.[7,8] However, this rarely takes the form of a design either to acquire the required knowledge or to evaluate whether the extant management strategy is sufficiently robust to work adequately despite the uncertainty. When we do undertake further research, it is usually without evaluating the management system to find out which uncertainties are the most important. We tend to rely on intuition as to the best piece of research to carry out, and without evaluating the effect of reducing a few of probably many uncertainties on the overall management result.

An interesting example is the relatively recent enthusiasm for "ecosystem management". Many people have come to the conclusion that single species and sectoral management has failed and so the obvious way ahead is to capitalise on our failures to solve the difficult problems of single-species management by making management even more difficult. Many scientists are enthusiastic about this idea because they can use it to justify even more and broader scientific research. Environmental NGOs like it because it saves having to worry about the humdrum of small decisions about whether a particular form of human activity is sustainable or not, because they can always say that we are not looking at the big picture. Cynics like it because they can use it to justify continuing with business as usual while everyone tries to figure out just what ecosystem-based management means.

This is management based on what we wish we knew rather than what we know. I am not for a moment advocating that we abandon ideas that we need more holistic approaches to the management of human activities.[9] My concern is that we are always eager to hitch ourselves to the next bandwagon, when actually making progress involves attention to the humdrum. The problem with ecosystem management is that it easily leads us into the trap of saying we don't know enough, the best available science is not sufficient, we need more research. This is not to say that we don't need more research – we clearly do – but we must not fall into the trap that we need more research **before** we take any action, nor should we rush off and do just any research in the **hope** that it will solve some poorly specified problem. Scientists are forever justifying their predilection for studying various interesting scientific problems because they claim it will be of use to conservation and management, claims that they are virtually never called on to demonstrate. Just as classically we perpetrated the fallacy that to manage fish and wildlife it was sufficient to study animals, we are now in danger of creating a new fallacy that to manage ecosystems we have to understand them. First, ecosystems only exist in our heads[6,10] and, because they are rather subjective, we will spend many fruitless hours attempting to decide whether this patch of turf is an ecosystem or not. Second we do not manage ecosystems (they manage us); our goal is to manage human activities so that our use of ecosystem services is sustainable.[9]

In contrast, engineering conquers complexity by appropriate division of a project into sub-projects. It does this without falling into the trap of reductionism, because it employs a top-down approach, but with iteration. An engineering project has to have an overall design, but as a designer one usually finds that some aspect of the grand design cannot be finalised until it is clear what the properties are of one or more of its components. Once clarified, the grand design can be revised to the next iteration. Engineers cannot afford to lose sight of the requirement that all of the sub-projects have to work together, and each has to be completed. The worst engineering foul-ups in terms of delays and cost overruns occur when this principle is overlooked, but sooner or later, engineers are reminded when they forget to deal with reality.

There is a structural problem, a partial vacuum in the centre of FWM. In engineering there is a clear gradation from pure science to engineering science to engineering practice. The greater numbers of engineers are involved in practice, but engineering scientists and practicing engineers see themselves as participants in the same profession. In contrast, FWM science is dominated by biologists, whose traditional training in pure science has not suited them to the tasks they face. They see themselves as distinct from FW managers, who have heterogeneous professional training which in most cases will not have suited them to the tasks they face either. Communication between these groups is often poor.[11] Each tends to blame the other for the failures of their enterprise, which they do not see as being shared. They lack a common basis of technical understanding because they see themselves as separate professions, and they receive little, if any, training that bridges the gap. Hence, we need to fill the gap between the pure science training of biologists and the social and political process by developing a new profession of FWM that develops the applied science of FWM, including a research and development function and the accumulation of empirical experience.

Part of our problem is that we suppose our solutions to FWM problems have to be "discovered by the application of science"; actually our solutions have to be tailored to our existing scientific knowledge, and that brings me to the next important set of differences between engineering and FWM.

Role of design

Engineering projects are designed and evaluated before being put into practice. In most countries this is a legal requirement. The essence of the engineering professions is to design things. In contrast, FWM is dominated by scientists who were trained to see their role as finding out how nature works. They have no historical tradition in designing systems, they see the world as an extant system:"we cannot design nature, our job is to discover and understand nature's design".

Some twenty years ago I began to demonstrate the idea that the management system for fishery or wildlife exploitation was a problem in control theory and that such systems were in fact "designs" and that they could be evaluated.[12] Reactions to these ideas included scepticism and indifference through to outright hostility. Fortunately a small number of people had been developing similar thoughts[4] and a few more embraced these ideas. At the recent (2004) World Fisheries Congress in Vancouver, these ideas now seem much closer to becoming generally accepted at least by some FW scientists. That being said, the number of cases where FWM systems have been designed or evaluated to see if they can work even in principle is still pitifully small. Even so there remains considerable resistance among FW managers, who always seem to be saying that they need "flexibility", which usually means having no specific objectives, or re-inventing them whenever tough decisions loom. At least several major fisheries collapses have been the result of promising to be good later – but we need to give the industry time to adjust. The natural systems that we exploit are indifferent to pleas for flexibility; they have their own rules, and we have to develop our rules accordingly.

If you set out to design something you need a clear idea of what it is you are trying to achieve. Engineering relies on (and has the advantage of) achieving practical outcomes. No engineering project starts from the premise that we need a bridge or an airport but we will decide which a bit later down the track. Engineering projects are expected to work as intended. Building a bridge that gets you 90% of the way across a river is no bridge at all. And it will be too small to use as an airport.

FWM should achieve practical outcomes; where we fail is that we are often too coy to say what they are, or too craven go beyond the vague generalities that allow everyone to interpret the objectives in the ways that suit them. While this may be convenient politics, it is lousy management. Engineers are not permitted to say they are going to build something and have half the population expecting a bridge and the other half an airport.

We ruthlessly require that engineering designs be efficient. We do not usually require bridges to be made of brick or masonry to keep lots of people in work – we require that the most cost-effective solution be found. This means that we are used to evaluating alternative designs and costing them. After a while we don't need to do this every time because engineers develop formulae that give sufficiently accurate forecasts of the costs of implementing a project in different ways and so narrow the field of possible candidates. This becomes part of the practical empirical knowledge drawn on by professional engineers.

However, there is one depressing similarity between engineering and FWM, and that is in the transfer of solutions designed for use in highly developed countries to less developed countries. There is little point in foisting inappropriate designs (either for engineering or FWM) on societies that lack the resources to support them. The ideas of appropriate technology are just as important for FWM as they are for any other form of infrastructure development.

Decisions, decisions, decisions…

When you design something like a structure or a chemical process you have to make lots of decisions. Engineers are used to making decisions. If you are to complete a project you do not have the option of deferring decisions indefinitely. Many engineering decisions are a consequence of having a clear idea of the objectives of the project. You cannot design a thing unless you know what it is to achieve. I wrote earlier that we already have a suitable paradigm for the development of FWM. It is simply the standard management paradigm for any project; define objectives and evaluate the means for achieving them. Some years ago I suggested that we could think of this as a MOP (Management Oriented Paradigm) for tidying fisheries management.[3] A MOP consists of the following elements:

1. management objectives which are measurable;
2. a management procedure based on decision rules;
3. assessments based on specific data and methods;
4. a prospective evaluation of the management procedure using performance measures.

The first three elements need to be set up in such a way that the properties of the resultant system can be evaluated. The evaluation is primarily carried out using simulation methods, in which the physical world is replaced by hypothetical simulated worlds. Different simulated worlds are used to characterise our uncertainties about the real world. Models are also used that reflect how fisheries and fisheries investment respond to the physical and regulatory environments, because our management system is not about managing fish and wildlife populations, it is about managing us.

Like any other system or structure, FW management systems have to be designed. There are many control measures, assessment methods and tools available. The choices about which to include are taken by evaluating their ability to meet the objectives at a cost that is commensurate with the benefits. The development process is iterative, with various approaches to management being simulated, modified and re-evaluated. After a recent lecture in which I discussed the MOP, I was asked by a student, what if you cannot afford to evaluate management policies? My answer was, if a society cannot afford to design its management policies in terms of deciding what it is that it is trying to achieve, determining what means are at its disposal and then evaluating whether the policy can be made to work, then it is not serious about management. That is the nub of many of our problems, when you look at how we tackle FWM issues, it is starkly clear that in very many cases we do not take them seriously. Deciding not to decide on some issue is a decision to continue the *status quo*. If that involves the continuation of the exploitation of a fish or wildlife population or the degradation of their habitat then we are deciding that we are indifferent to the outcome; in essence we are deciding not to manage our activities. Delay in taking decisions has been a common factor in the collapse of many fisheries.

Sometimes we hear the view that fisheries and wildlife systems may be so unpredictable as to be "unmanageable". This view arises from the faulty premise that we manage fish or wildlife. A MOP is not broken by this observation because in saying that something is unmanageable we are really saying that we have not organised ourselves to take into account that we are unable to predict or rely upon a particular system conforming to our wishes of a steady state.[13] We face the choice of transforming the world into a more predictable form, as we have with irrigation and agriculture, or we should reform our activities so that we know what to do when the unpredictable downturn begins. We should not continue to flog a declining resource because we failed to plan for any alternatives. This is one of our commonest failings, recognising in good time that we need to reduce exploitation because the abundance of an exploited population has taken a downturn. This failure means that we make a bad state of affairs worse, and that consequently we will have exposed the population to even greater risks of extirpation, or at least substantially delayed its recovery to productive levels,[1] while reducing the circumstances of the people dependent on it. This means that we should have some form of insurance, in the form of alternative employment of people and capital when the inevitable downturn occurs in some unpredictable species. Prudent levels of insurance are something we can evaluate using a MOP.

Engineers tackle "predictable failure" by redundancy and monitoring. By predictable failure, I mean that a failure is inevitable, but when it will occur cannot be accurately predicted. A key engineering strategy is redundancy; in a typical industrial process any piece of equipment prone to predictable failure will have a backup. Critical pieces of equipment might have two backups. Engineers monitor the performance of equipment to identify incipient failure so that the backup can be brought into service without any serious disruption.

In FWM we do not plan for failure; we hardly ever consciously set aside some region (e.g., a protected area) or species so that there is a backup when things turn sour. We usually allow exploitation on everything simultaneously. Even when alternatives emerge serendipitously we may fail to organise ourselves so that those people who were worst affected are the first in line when an alternative emerges. A recent example is the collapse of the northern cod fishery in Canada[11] that left more than 10,000 small-scale inshore fishermen without substantial employment. The paradox is that the fisheries in the region are now worth more than before the cod collapse because they are now dominated by a high-value shrimp fishery.[14] However, most of the 10,000 unemployed cod fishermen are still there, but now we have a relatively small number of shrimp millionaires as well.[14]

Trust me, I'm a professional

Engineering is a well established example of a profession since it has all of the attributes set out in Table 21–1. We can also use Table 21–1 to determine if FWM has the characteristics of a profession. Clearly FWM in pursuit of ecological sustainability is an essential service (1) and is concerned with an identified area of need or function (2). It also satisfies (4) – involvement in decision-making in the service of clients – and usually (10) strong motivation and lifetime commitment. These are sufficient conditions for asserting that FWM should be a profession.

How does FWM stack up against the other requirements and can this help explain its poor standing as a profession? Although (3) is true, the body of knowledge and repertoire of skills can be identified, they are not sufficiently known by many of the practitioners currently employed in FWM, nor are our successes and failures being sufficiently and systematically accumulated to add to that body. Another problem for FWM is (5); although we can identify the under-girding disciplines, concentration is still too narrowly focused on biological sciences, with insufficient attention being paid to mathematics and statistics, control and management theory, sociology and economics. In terms of (6), FWM has relatively little in the way of professional associations, certainly none in the same class as engineering professional associations, and this is probably a key factor in the lack of recognition of FWM as a profession. Both (7), standards, and (8), training, are great weaknesses in the development of FWM as a profession. A high level of public trust (9) is one of our most serious problems. The keys to progress as a profession are to establish a track record of success and to continue the trend of working with public and industry groups to increase public understanding of the nature of FWM. Both of these will require that we address the other weaknesses in relation to particularly (3), (5), (7) and (8). Then we should be able to achieve (11) and (12), which will then further help with reducing the effects of the political weaknesses of FWM.

"Politics is the art of looking for trouble, finding it everywhere, diagnosing it incorrectly and applying the wrong remedies."[16]

A society deciding what it wants to achieve is politics. However, societies do not have unbounded choices but usually consider a series of options, and these inevitably involve tradeoffs. The role of professions is of course not to make those decisions on behalf of society, but that does not mean that professions do not express views and advocate various solutions (however, both engineering and

Table 21–1. Defining characteristics of professions[15]

1. Professions are occupationally related social institutions established and maintained as a means of providing essential services to the individual and the society.
2. Each profession is concerned with an identified area of need or function (for example, maintenance of physical and emotional health, preservation of rights and freedom, enhancing the opportunity to learn).
3. The profession collectively, and the professional individually, possesses a body of knowledge and a repertoire of behaviors and skills (professional culture) needed in the practice of the profession; such knowledge, behavior, and skills normally are not possessed by the nonprofessional.
4. Members of the profession are involved in decision-making in the service of the client. These decisions are made in accordance with the most valid knowledge available, against a background of principles and theories, and within the context of possible impact on other related conditions or decisions.
5. The profession is based on one or more undergirding disciplines from which it builds its own applied knowledge and skills.
6. The profession is organized into one or more professional associations, which, within broad limits of social accountability, are granted autonomy in control of the actual work of the profession and the conditions that surround it (admissions, educational standards, examination and licensing, career line, ethical and performance standards, professional discipline).
7. The profession has agreed-upon performance standards for admission to the profession and for continuance within it.
8. Preparation for and induction into the profession is provided through a protracted preparation program, usually in a professional school on a college or university campus.
9. There is a high level of public trust and confidence in the profession and in individual practitioners, based upon the profession's demonstrated capacity to provide service markedly beyond that which would otherwise be available.
10. Individual practitioners are characterized by a strong service motivation and lifetime commitment to competence.
11. Authority to practice in any individual case derives from the client or the employing organization; accountability for the competence of professional practice within the particular case is to the profession itself.
12. There is relative freedom from direct on-the-job supervision and from direct public evaluation of the individual practitioner. The professional accepts responsibility in the name of his or her profession and is accountable through his or her profession to the society.

FWM are usually at their worst when engineers and scientists make political decisions in policy vacuums, e.g. flood control by the US Army Corps of Engineers for much of the 20th century). Moreover, we rely on professions to delineate what is possible given the current state of resources, what is technically feasible, what the various options are expected to cost and what sort of benefits will result, including what are the trade-offs between conflicting objectives.

We are used to deciding on practical tradeoffs in engineering projects. Once we have decided to implement an engineering project we trust engineers to design it and supervise its implementation. The decision, say, to build a dam is a political one; what sort of dam to build is subject to the advice of engineers. It would be a very brave politician indeed who would override the advice of the engineering profession. Although mega-projects are not immune to political interference, engineers are in any case well able to defend their expert turf against political interference. Even when engineers work for governments, Professional Engineering Associations provide protection in the form of agreed best practice and ethical standards that enable its practitioners to resist political pressures at the technical level.

Engineering fares well in the political process because it has earned society's trust through its:

- Track record of success
- Commitment to learning
- Commitment to ethical practice[17]
- Standards and regulations
- Accountability
- Resistance to political expedience
- Distinction between technical and political processes

FWM does not fare so well in the political process because of its:

- Track record of frequent failure
- Reluctance to learn from mistakes
- Lack of guidance on ethical practice
- Few standards and enforceable practices
- Low levels of accountability
- Susceptibility to political interference
- Confusion between technical and political processes

For politicians, credit for the sustainable use of natural systems is much more nebulous than it is for an engineering mega-project. One hardly ever receives credit for things that do not go wrong – whereas fixing things is one method for achieving fame and adulation. This is one reason, coupled with the history of regarding natural services as free, that conservation has a low rating in terms of political relevance. However, politicians usually share the blame when things go awry, so they have some incentive for reforming the practice of FWM. Opportunities for reform usually only arise when things are seen to be broken. However, politicians are not reluctant to override the day-to-day advice of FW managers.[11] When doing so they enjoy the benefits of popularity with whatever constituency lobbied them, and they do not incur much in the way of opprobrium from FW managers. In most countries, FW managers are civil servants who can be instructed or pressured by politicians to adjust their advice. Even without instructions, most civil servants know "what will go down well with the Minister". The lack of a professional culture with accepted standards increases the vulnerability of FW managers to such pressures; they lack the protective mantle of an organised professional association. The absence of an independent professional body also decreases the likelihood that politicians will be held to account. For a time, environmental NGOs were successful in this role, but this success is declining because NGOs are now less likely to be regarded as impartial,[18] and indeed the rewards for a politician may well arise from showing environmental do-gooders just who is in charge.

In many jurisdictions, a politician is, in legal fact, the Fisheries and Wildlife Manager, and there is a confusion of delegation and technical responsibilities between the politician and the bureaucracy. A better system would look more like engineering, where management objectives are political decisions. However, once the political decisions are reached, we should be able to rely on professional FW managers to implement the decisions using methods in which there is widely shared trust. Such a system reduces opportunities for direct political intervention at the behest of vested interests.

Even when engineers work in government bureaucracies they remain accountable to their profession. When an engineer designs something, he or she has to sign their name to it, as does his or her supervisor. Signing your name to something has a salutary effect on your sense of responsibility for what you do. Although currently many bureaucratic systems expose FW managers to political pressure, the system also shields managers from responsibility by its ability to spread the blame around. So, while professional reform will involve the reduction of bureaucratic anonymity, increasing accountability has to be tempered by increased protection for individual managers, so long as they have discharged their responsibilities according to defined professional and ethical standards.

The role of standards

An Engineering Standard is a book of rules compiled by a Standards Committee. The rules define acceptable engineering practice and engineers apply those standards in the routine exercise of their profession. The rules usually specify matters such as how a structure is to be designed, allowable stresses in various materials, how metals are to be welded, what sort of documentation is to be produced and so on. There are standards for almost every aspect of practical engineering. They codify much of the theoretical and empirical knowledge used by engineers and they are continually revised as engineering knowledge and practice evolve. Standards usually have backing in law and failure to apply the Standards is professional misconduct for which an engineer is legally and financially liable. However, Standards also limit the liability of engineers in the event of an engineering failure so long as they have been adhered to. Reading and applying Standards is fundamental in the training that engineers receive.

It is not that standards are completely absent in FWM. In fisheries we have a number of "standards" set by international bodies, particularly the Food and Agricultural Organisation of the United Nations (FAO). These include the application of precautionary management[7] and the Code of Conduct for Responsible Fisheries.[19] Other standards are emerging through the Marine Stewardship Council.[20] But the compilation of standards is not a core activity of FW managers in the way it is for engineers. The lack of accepted standards makes it much more difficult for FW managers to defend the decisions they make against outside pressures. We should be actively compiling our theory and our practical experience of what works and what does not in the form of standards so that professional FW managers can find and apply sound practice.

Role of professional associations

The peer group for engineers is other engineers. Engineers can point to a set of accepted professional standards that guide their conduct. This enables them to resist cooption, and they have a professional association that can support them in the event of coercion. Ethical standards and codes of conduct are an essential component of the engineering profession. Engineers delineate the professional duties they owe to their employers, those they owe to their profession and those they owe to society. Legislation on engineering regulations is based on advice from Engineering professional associations and usually results in the force of law backing up the rights and responsibilities of the profession. The law and professional standards reinforce each other. If an engineer follows the rules and Engineering Standards but nonetheless something goes wrong, the professional association can provide technical and, often, legal support. This assists the engineering professions to confront mistakes in the practice of engineering and to learn from them.

In the absence of a professional association, the peer group for FW managers is more likely to be the bureaucracy, its political supervisors and those that it regulates. This increases the proneness of FW managers to capture by those that they regulate, both by direct cooption from daily contact and indirectly through political influence. The absence of profession-specific ethical standards and codes of conduct make it difficult for FW managers to delineate the bounds of practice within which they can comply with political demands. The normal perception of the duty of a FW manager is to their employer. Their duties to society and to the species and habitats on which they manage human impacts are either absent or vaguely specified in legislation. Legislation is often vague because of the lack of FWM professional standards and codes of practice that carry their imprint into the law. If a FW manager makes an error, he or she lacks an institutional professional support system, and either the bureaucracy finds him or her a convenient repository for all blame, or has a system where blame is so diffused that no one has to accept any. In either case, mistakes are not really confronted and the opportunity for institutional learning is stunted.

In many jurisdictions, a key role of an Engineering Professional Association is that they define who is legally able to practice as an engineer. They designate the professional skills that an engineer requires, and membership of the association is a sufficient qualification to practice. The principal method that engineers qualify for membership is by completing a degree in engineering, accredited by the Engineering Professional Association, at a University or College.

In some places FWM is moving towards establishing professional associations, for example, Registered Professional Biologists in Canada, and the certification schemes in the USA initiated by the Wildlife Society and by the American Fisheries Society. These are certainly steps in the right direction. However, the focus of these schemes is predominantly on fisheries and wildlife science, although the American Fisheries Society does recognize non-scientific training and experience in fisheries as grounds for certification. These steps need to be emulated more widely, but also expanded to recognise that FWM is a profession that involves a range of technical skills that link policy and science to ecological sustainability as well as social and economic outcomes. Thus, these schemes also require further development to reflect better the breadth of education required for certification and then in accrediting University and College Degree courses that provide the required training. Further, these emerging schemes will need to be strengthened through legal recognition that confer rights and responsibilities similar to those accorded to professional associations such as in Engineering and Medicine.

Role of education

An interesting insight into our professional development as FW managers occurred at the recent (2004) World Fisheries Congress in Vancouver. During the panel discussion in the closing session a panelist exhorted the attendees to produce statements about how fisheries management can be improved, directly implying that such material is lacking. In a response to this exhortation a participant asked the audience for a show of hands as to how many had not read the (1995) FAO document on the "Precautionary Approach to the Management of Capture Fisheries".[7] More than half the audience admitted to having not read this fundamental piece of literature. This document and similar documents has now been around for sufficient time for at least FW managers that have graduated in the last ten years to have seen them. That they have not shows that they are not receiving the breadth of training they need for the tasks they face in FWM.

Engineers require high-level skills in quantitative methods and a sound knowledge of mathematics. A typical engineering course has high-level mathematics subjects in every year, and consequently engineering graduates are virtually applied mathematicians. Much of engineering training is directed towards avoiding the mistakes of the past. However, this is not achieved by dwelling on the study of mistakes but by studying the known good solutions that were devised to avoid their repetition. However, we should always study some mistakes because, besides combating hubris, it helps us to recognise patterns of practice where mistakes become more likely.

FWM requires high-level skills in quantitative methods and a sound knowledge of mathematics. Most graduates who end up employed in fisheries science and management have backgrounds in biology or even non-scientific training. Many biology programs are still producing graduates with limited mathematical and statistical training. Moreover, typical statistics courses concentrate on hypothesis testing – a pure science preoccupation. The important statistical subject in FWM is estimation. The key analyses are not about rejecting hypotheses that observed samples are similar between two groups of animals, but of the type; how many animals are there in a given area? The Masters students who enter the fisheries program at my university usually have Bachelors Degrees in Biology. Although we require our students to have received good grades in calculus and statistics, many of them took these subjects early in their degrees. In their higher level undergraduate studies they have had little or no further exposure to mathematics, to the extent that one of my teaching tasks is to refresh students' knowledge of basic mathematics. Very few students have any undergraduate experience in computer programming or mathematical modeling, skills of enormous utility in FWM.

If we are to fill the gap between pure science and FW management as it is practiced today we need new educational courses designed to equip practitioners with the mix of skills they require. Since FWM is largely about managing human activities, FW managers need education in this area and in economics. Not only do we often do a poor job at a technical level in designing our management systems, we have too frequently failed to consult on what is socially and operationally feasible, and how to ensure that the regulatory systems we set up will be observed. The body of knowledge relevant to our nascent discipline is a unique combination of the applications of:

- Biology and ecology
- Economics
- Mathematics, statistics and estimation
- Control systems theory
- Sociology
- Management theory
- Politics and policy formation

CONCLUDING REMARK

I often get the impression that the lack of trust accorded to FW managers from both industry and environmental NGOs is now bordering on contempt. Failure to arrest this trend will be a serious error if it means that we turn good people away from careers that will contribute to a sustainable future. We do not turn our backs on engineering even when we have calamities; we should not turn away from the development of a scientifically based profession of FWM because of its failures either. Thus, the foregoing critique of FWM as a profession is not intended to focus criticism on the people that currently practice it. The focus of my criticism is on our societal failure to recognise FWM as a profession that requires a unique body of knowledge and to ensure that the people taking up careers in FWM have the skills, training and institutional support they need to be effective. If we succeed in that, then we should also begin to achieve more surely our objectives of *Wildlife Conservation – in pursuit of ecological sustainability.*

NOTES AND SOURCES

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[16] A quotation from Marx, Groucho not Karl!

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ADDENDUM

During the discussions at the Forum some participants expressed the view that natural systems are more complex than engineering systems and this explains why engineering is relatively more successful than FWM. As I assert in my paper, I do not believe this to be a substantial cause of the differences in the success rates of engineering and FWM. Consider a petro-chemical plant; this is an extremely complex system. If viewed at a molecular level as a physical and chemical system, it is chaotic and unpredictable. Fluid flows are turbulent; the chemical compositions of the feedstocks and their physical and chemical properties are variable and incompletely known. The plant is operated by erratic and unreliable humans and hundreds of unobserved variables can affect the outcome. The design of the system would consider literally thousands of variables. No one could predict where to set the hundreds of control valves, pump speeds, furnace thermostats, cooling water flows and so on to produce the required outputs. The plant changes over time; catalysts degrade, pipes erode, heat exchangers become fouled, and equipment wears or fails. Yet engineering is able to deal with this complexity to a high degree of reliability. By a blend of empiricism and theory, engineers have developed experience on which classes of complexity can be ignored. They design the plant to deal with foreseeable uncertainties so that its operation can be adjusted using negative feedback. Engineers approach complexity hierarchically by dividing complex systems into assemblies of less complex subsystems. Many engineering components are designed using simplified and empirical models. Even chaotic systems such as turbulent fluid flow have predictable emergent properties. It is these approaches that engineers exploit to deal with complex systems. We should apply similar ideas in FWM.

Gro promoted sustainable development
Used by corporations for global envelopment
It cut up the pie
So the rich can go high
And the poor get enviro-dishevelment.

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