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Can Fisheries Agencies Learn from Experience?

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ABSTRACT

The essential steps in learning from experience are documentation of decisions, evaluation of results, and organizational response to the evaluation. Learning is slow in fisheries management because of the difficulty of replication and control and, to a lesser extent, the variability of natural systems. Thus, it may take a long time to determine which kinds of management actions are best, and we stand a significant chance of making false conclusions about the efficacy of specific actions. Even when decisions are documented and evaluated, fisheries agencies have few mechanisms of institutional memory to retain the lessons learned. Agencies need to develop a systematic plan for learning, including listing of identified uncertainties, methods for resolving the uncertainty, how to evaluate existing actions, and mechanisms for retaining the lessons learned in the institutional memory.

Introduction

I once participated in a meeting of fishing industry officials and senior Canadian Department of Fisheries and Oceans (DFO) officials in British Columbia when one of the industry representatives stood up and condemned the current fishery management system. He said, in words that relegated the DFO officials to the lowest circle of fisherman's hell, that DFO was running the fishery by trial and error. If only it were true!

Trial and error is the way we must learn; it is unavoidable. We must try different things, see which ones work best, and then use the ones that work and discard the ones that don't. We must make mistakes (errors); wisdom comes through not making the same mistakes over and over. To learn by trial and error we must first know what we have done; decisions must be documented. We must then examine the results to know what happened; we must evaluate. We must finally learn by experience and not repeat the unsuccessful trials. There must be feedback between documentation, evaluation, and decision-making. Each of the steps is essential; if decisions are not based on results of evaluation, learning will not take place. If the details of implementation are not documented so that the agency actually knows what was done, learning will not take place. If monitoring or evaluation are ignored, learning will not take place.

We would all like to believe that fisheries management agencies learn and improve their performance over time. However, remarkably little consideration has been given to the essential steps in such learning. Nor has there been much consideration given to the actual difficulty of learning about fisheries systems. The purpose of this paper is to consider whether fisheries agencies can learn and to discuss the major impediments to learning. A large body of literature on institutional behavior and learning exists; March (1988) is an excellent recent example. As the purpose of this paper is to present some general ideas, rather than develop a formal model of decision-making, I will not directly document the correspondence between the organizational behavior literature and fisheries institutions.

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Learning

The most pervasive single feature of fisheries decision-making is uncertainty: the biological, economic, social, and political milieu for fisheries decisions are uncertain and changing. We never know for sure what decision is going to be best; each decision is a gamble. In an earlier paper (Hilborn 1987) I discussed the types of uncertainty faced by fisheries managers. I imposed a personal taxonomy, depending upon how much experience we had with the particular form of uncertainty. Things we have clearly identified as variable and about which we have historical experience, I call "noise." Noise in fisheries systems is year-to-year changes in weather, fluctuations in price, or shifting in senior administrators. We all know these things are not constant, and it happens often enough that we expect such change. Noise is the least problematic because it is acknowledged and quantified.

A second level of uncertainty is called "uncertain states of nature." These are things we have identified but cannot quantify for lack of experience. For example, we now recognize that many pelagic communities are subject to major changes in structure, as occurred in the Great Lakes (Smith 1968), the California current (Soutar and Isaacs 1969), and Peruvian upwelling system (Pauly and Tsukayama 1987). However, we do not have enough experience with these changes to quantify the likelihood or the exact nature of such changes.

The third category of uncertainty is "surprise." Surprise is something that we have not considered, the new problem that takes us by surprise and consumes all our extra resources and time. Invasion of the Great Lakes by sea lamprey, Indian fishing rights, and the Crown of Thorns starfish were all such surprises.

There are two possible management responses to the types of uncertainty and change described above. One response is to evaluate our current state of knowledge, choose a management policy that appears to have the best chance of success given what we know, and simply use it with no thought of learning in the future or evaluating this policy. Such a policy might be labeled "blind faith." Make your best choice and hope it works. Such policies are called "open loop" in the optimal control literature, because there is no connection between our decision choice now and any evaluation of outcomes. There is no allowance for monitoring, evaluation, or learning. Such a course of action might appear to be idiotic: who would make a decision and then blunder on without any thought to seeing if it actually worked? Is "blind faith" only for the blind? I think not; "blind faith" is actually a very reasonable policy under certain circumstances, particularly when monitoring and evaluation costs are high or the time required for evaluation is very long.

The alternative to "blind faith" is learning. Our response to the uncertainties of surprise, uncertain states of nature, and noise is to try to learn more about them and respond better to them in the future.

Types of Learning: Reactive, Passive, Active

Most institutions can learn from experience, and there are several modes of learning. The slowest form of learning I call reactive. In reactive learning no explicit monitoring and evaluation mechanisms exist to review past action and make recommendations about future actions. Learning is slow, but no matter how inefficient or obdurate an organization may be, if it keeps repeating the same mistakes, it may eventually learn its lessons and realize its errors.

The next step in sophistication is passive learning. A passive learning system does have explicit monitoring and evaluation systems. When a management action is taken, it is determined *a priori* what will be measured and how it will be evaluated. At each decision point, management chooses the action that is expected to produce the best payoff.

Active learning involves taking management actions deliberately designed to be informative in addition to the explicit monitoring and evaluation systems of passive learning. Rather than just taking the management action that is expected to produce the greatest yield, active learning systems explicitly analyze the uncertainties and design management experiments to try to resolve them.

Reactive learning is commonly called fire-fighting. Managers rush from one crisis to the next, never having the time or budgets to design monitoring systems or to evaluate past actions. Symptoms of reactive learning are staff shortages, intensive overtime, missed deadlines, and an overall inability to look beyond the next crisis. No one ever has the time to look back and see if anything was learned. Some individuals may have acquired some perspective and experience, but they have either been transferred or quit before they had a chance to use these. In reactive learning the message does finally filter through, and after enough fires are fought, some changes are made. Most natural resource agencies would seem to fall in this category. Firefighting and staff turnover greatly inhibit their ability to learn, but some learning eventually takes place if the lessons are obvious enough.

Passive learning is typified by the rather well-established stock assessment and management procedures now in place in many fisheries organizations. Routine data collection, standardized assessment procedures, and a well-accepted method for making management recommendations characterize such passive learning. If stocks are declining, surveys or virtual population analysis will eventually detect the problem, and some management action (perhaps belated) will be taken. The Canadian Atlantic Fisheries Statistical Advisory Committee and the Pacific Stock Assessment Review Committee procedures on the East and West Coasts, respectively, of Canada are good examples, as are the annual assessment procedures of the International Council for the Exploration of the Seas, the International Pacific Halibut Commission, and many other organizations.

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Examples of active learning systems are few. The best example is a management experiment undertaken in Australia to evaluate alternative management strategies for a tropical, mixed-species fishery. In this study, described in Sainsbury (1989), experimental areas were designated for different fishing methods, and an intense monitoring and evaluation procedure was established to determine which fishing method was most effective. Another example is the management of sockeye salmon in Rivers Inlet, British Columbia, where a multi-year experiment of increased escapements was implemented to determine if larger spawning stocks would produce larger adult returns. These two active learning examples are characterized by their deliberate experimental design. Rather than simply using the management action that appeared to be best, different management actions were tried in different places (in the Australian case) or at different times (in the Rivers Inlet case). Active learning is the application of experimental scientific methods to fisheries management.

Essence of Learning: Monitoring, Evaluation, Response

For an institution to learn, whether it be reactive, passive, or active, there are three essential steps: monitoring, evaluation, and response. Data collection systems must be in place to actually see what happens; this is monitoring. An organization is blind if it does not monitor the system being managed. Evaluation is the analysis of the monitoring data that have been collected and the formulation of a set of recommendations for management action. It is pointless to collect and then fail to analyze data. Finally, you must modify the management action based on monitoring and evaluation. If you cannot respond to what you have learned, you really have not learned at all.

Are Natural Systems Amenable to Learning?

Not all systems are equally amenable to learning. If we recognize that the scientific method is nothing more than an approach to learning about nature, then we should look to the experience of science to see how to learn. In basic laboratory science, there are two essential components to experimental design: replication and control. If we treat one test tube with substance x, we leave another test tube untreated as a control. In the absence of controls, we would have very little confidence that our experimental treatment caused the observed result.

We also repeat the experiment and the control several times, to assure ourselves that the observed results are repeatable. Indeed, replication is perhaps the most essential part of the scientific method. We must not only replicate our experiment, but someone else must be able to replicate the experiment in another laboratory. The list of scientific wonders that did not survive replication in other laboratories is long and marvelous, with "cold fusion" only the most recent.

The cold fusion story (Peat 1989) illustrates what I believe is the most unacknowledged aspect of fisheries management and environmental science in general: the difficulty of replication and control. As most will remember, two researchers suddenly announced at a press conference that by placing a palladium wire in a solution of heavy water and passing an electric current through it, they generated heat, neutrons, and helium. These were three expected results of fusion, and the technique promised a short-cut to inexpensive and nearly inexhaustible energy. The experimental apparatus was built at little cost and quickly replicated in dozens of laboratories around the world. In the first few weeks following the announcement, several labs reported confirming some of the observations, such as generation of heat, neutrons, or helium. A noted theoretical physicist from Harvard announced he had a modified theory of fusion that was compatible with cold fusion. However, as the experiment was replicated more and more times, it became clear that fusion was an unlikely explanation for what was going on: neutrons and helium were not being generated, and the source of the extra heat found in some experimental apparatuses was unclear. In less than 6 months, what might have been the scientific discovery of the 20th century has apparently been discarded as an electrochemical anomaly.

Now imagine a similar "discovery" in fisheries or any environmental science. In most fisheries systems this discovery might take years or decades to replicate, if this could be done at all. One or two replications might be performed, and if they initially appeared to be confirmatory (as the initial cold fusion replicates did) no more replicates would be done, and the "discovery" would enter the text books as one of the principles of fisheries science. Any anomalies would be explained away. A small list of major fisheries "discoveries" that might prove to be misconceptions (if they could be well replicated and controlled) is (1) El Niño caused the collapse of the Peruvian anchoveta, (2) lake fertilization and hatcheries will increase total production of Pacific salmon, and (3) mesh-size restrictions in the North Sea have improved yields.

Natural resource management agencies obviously have considerable trouble with both replication and control. Many resources are unique; there is absolutely no potential for replication and control. There is only one blue whale stock, only one Antarctic ozone layer. Other resources are more easily replicated and controlled. Most states and provinces have hundreds or thousands of lakes. Managers interested in assessing management strategies, be they fisheries management, waterfront zoning, or pollution control, could in principle have replicates and controls on different lakes. Several states and provinces have explicitly experimental programs for lake management.

It is difficult to overstate the tie between replication and control and learning. Think back to trial and error. Replication is multiple tries. Control is the ability to know if the fact that a trial worked was due to whatever you were trying. In some of his most interesting experiments, B. F. Skinner (Ferster and Skinner 1957) placed pigeons under "random schedules of reinforcement." This meant that pigeons were placed in the famous "Skinner box" and were rewarded with a pellet of food randomly; when they received food was independent of what they did. The result was that after a number of sessions in the Skinner box, each pigeon had adopted its own unique and usually bizarre form of behavior. Some pigeons sat immobile with their head under a wing, others stood on one foot, and some bounced rapidly from one corner to the other.

The conclusion from Skinner's work is that when reinforcement is unrelated to the action taken, the experimental animals adopt many strange behaviors. I believe these experimental results apply to individuals and agencies as well. If you have ever been fishing you will find that almost all anglers have some form of unique behavior: one uses a special knot, another always brings the same sandwich for lunch. These anglers are like the pigeons; they have been rewarded in the past more or less at random, and they have adopted a behavior that is unrelated to the actual reward.

Now think of the management agencies you know. Every agency I know has its own rituals: certain types of size or area regulations, specific data collection methods, definite forms of decision-making. These management agencies are remarkably like the pigeons: few of their decisions have been replicated or controlled, and therefore they simply do not know if their successes are a result of their actions; they have adopted some strange modes of management as a result. There is a surprising resistance to controls. Few if any management agencies ever explicitly control management decisions by keeping some places the same while they try a new action elsewhere. This is not unique to natural resource management agencies.

A good example is found in coronary bypass surgery and coronary angioplasty. These little "procedures" cost American patients and insurance companies $5–10 billion per year. It took over 10 years before anyone conducted a controlled experiment on bypass patients. The result was that bypass surgery doesn't save lives: patients given the operation have no longer life expectancy than patients not given the operation (Moore 1989). Similar results are found with coronary angioplasty. When coronary surgeons were asked why they were so reluctant to test the new surgical technique by designating some people as controls, they said they could not deny this life-saving operation to any of their patients.

The critical point in the comparison to cold fusion and medicine is that although physics and chemistry may often be very easily controlled and replicated, fisheries is far from alone in the difficulty of learning. Replicates and controls can take two basic forms: spatial or temporal. If we want to know if our car is pinging because of the no-name gas we have been using, we try a tank of no-name gas and then a tank of higher-priced, name-brand gas. This is temporal control: we have only one car, but we try experiment and control sequentially. Temporal replication requires assumptions of independence between times; we must assume that the no-name gas does not affect the performance of our car when we put in a fresh tank of the high-priced gas.

The other dimension for replication and control is spatial, as in the 10,000 lakes of Minnesota. The problem with spatial replication is that unlike test tubes, no two systems are exactly the same. This poses two problems. First, we must be careful to assign the treatment and controls randomly. Because the replicates are not identical, we must be sure that we don't bias the selection of which sites will receive which treatment. Similarly we must be careful that we don't bias our evaluation of performance. The "double blind" experimental design was formulated for exactly this problem, although it is almost impossible to implement in natural resource systems.

The lack of perfect spatial replication means that we must make some careful decisions about optimal sample sizes. In the laboratory test-tube world, larger sample sizes are always better. However, in the real world we usually have a limited number of potential sites for experimentation and control, and the larger we make our experiment, the more heterogeneous the "replicates" become. Walters et al. (1988) showed that the optimal sample size for specific experiments was often very small (2 or 3). Thus, even with infinite budgets we still could not have extensive replication and control.

Temporal replication is equally difficult in environmental systems. Given the difficulty of perfect control and the inevitable small sample sizes (usually 1), the time required to discriminate between competing hypotheses can be great. In 1968, the Canadian government embarked on an experimental program to build artificial spawning rivers for salmon on Babine Lake on the Skeena River in northern British Columbia. The lake appeared to have considerable unused capacity to rear sockeye salmon because of a lack of spawning rivers. Several miles of artificial river were built at a cost of over $10 million. It now appears that production from the Skeena system is approximately 1,000,000 fish higher now than it was before the project began (West and Mason 1987). West and Mason (1987) estimated the benefit-cost ratio for the program to be 3:1, a successful project by almost any standard. However, it was 12 years (brood year 1975, return years 1979 and 1980) before the first significantly larger return occurred. During these 12 years, it appeared that the project had failed to produce more adult sockeye. More recently, Henderson and Diewert (1989) have estimated the net gain in production could be as low as 500,000. It took roughly 20 years to have much confidence that the project worked. It takes a long time to learn about natural systems.

Even after 20 years, the evaluation is not unambiguous. There is no control, either spatial or temporal. What would have happened if they had not built the artificial rivers? The two largest sockeye-producing systems in North America—Bristol Bay, Alaska, and the Fraser River, British Columbia—have also increased significantly since 1968 and in fact have increased proportionally more than the Skeena systems. If we accept Bristol Bay and the Fraser River as controls, the Babine spawning channels are a failure (Hilborn, in press). It not only takes a long time to learn, but even then the results may be ambiguous.

How Management Differs from Science

A scientist who thought about the problems of replication and control would realize that if he or she wanted a productive career in science, it would be better to stick to systems that are easily replicated and controlled. Science is conservative; we are all familiar with the 0.05 and 0.01 levels of confidence for statistical tests. These "confidence levels" reflect the fact that science in the form of its journals and meetings will not accept results that could have been due to chance alone with a probability of 5% or 1%. In systems that are difficult to replicate and control, it is difficult to achieve such levels of confidence. Is science in these systems possible? The simple answer appears to be no!

In systems where experiments may take decades and spatial replication and control are problematic, we will have great difficulty in meeting 1% and 5% confidence bounds on results. It will always be possible that a result is due to chance alone. To those of us brought up with scientific methods, such difficulties are discouraging. However, things are not really as bleak as they may appear, because while science may be very conservative, scientific management need not be so.

In the 1960s, limnologists working for the Canadian Department of Fisheries began an experimental program of lake fertilization in Great Central Lake, located on Vancouver Island. Fertilizer was dumped into this oligotrophic lake to see what effect it would have on the phytoplankton, zooplankton, and fish communities. One of the results was that juvenile sockeye salmon, which fed on the now more abundant zooplankton, grew much faster in the lake and survived much better when they returned from the ocean (LeBrasseur et al. 1979). What had been a minor sockeye salmon fishery became the hottest fishery in British Columbia. The harvest, which had been in the tens of thousands, started approaching half a million fish.

Lake fertilization was quickly transformed from a limnological experiment to a major fisheries production technique. Ten other oligotrophic lakes were designated for fertilization—the real attraction was that it was inexpensive. All you had to do was charter an aerial tanker (of which British Columbia has many to fight forest fires), fly over the lake, and let go a few thousand gallons of fertilizer. No capital expenses, no major construction period—just put the fertilizer in the planes and start bombing.

The second part of the lake fertilization metamorphosis was political. British Columbia was engaged in a large-scale, government-funded Salmonid Enhancement Program (SEP) that involved construction of many facilities, including hatcheries. The proponents of SEP needed the economics of SEP to look good; no money from the Ottawa government was forthcoming unless they could come up with attractive benefit-cost ratios. The benefit-cost ratio of lake fertilization was very attractive, roughly 10:1. For a few hundred thousand dollars you could produce millions of dollars in sockeye salmon. In 1981, there was a Royal Commission on Pacific Fisheries (Pearse 1982), and one of the items for consideration was SEP. In the documents submitted to the Commission, the benefit-cost ratio for SEP depended entirely on the lake fertilization program. The hatcheries and spawning channels by themselves had a rather lackluster expected performance—a little better than 1:1, but not much. However, when the lake fertilization results of Great Central Lake were extrapolated to the 10 other lakes that were potential sites for fertilization, the benefit-cost ratio looked great. When you examined it critically, the entire economic performance of SEP depended on the extrapolated results of Great Central Lake.

Given all that was at stake, how much confidence was there that lake fertilization had been responsible for the increase in sockeye production? What replication and controls were available? Because the original fertilization program had been conceived as a scientific experiment, there was a control. Sprout Lake lies a few miles from Great Central and is reasonably similar in limnological characteristics. Sprout Lake was left unfertilized as a control. This was all to the good.

Unfortunately, the sockeye populations in Sprout Lake had also increased dramatically at the same time Great Central Lake had increased (Manzer 1976). The increase in Sprout Lake was not as large as in Great Central (360% increase in Sprout versus 670% in Great Central), but the increase in Sprout Lake casts serious doubt on the causal effect of fertilization on increased adult abundance. By the normal standards of science, it is questionable if lake fertilization had been responsible for the increase in sockeye production. Lake fertilization was an interesting limnological experiment, but not a proven salmon production technique.

Was it wrong, therefore, to embark on an aggressive program of fertilization to 10 other lakes? Clearly not. As a management decision it was the right thing to do, because the costs were low and the potential benefits were very high.

There is a great difference between science and scientific management. Science is conservative; scientific management is calculating. Science is conservative to prevent erroneous results from becoming accepted in the literature. Management involves decision-making under uncertainty, and no specific values for type I or type II error are appropriate—it all depends on the risks associated with these two types of error. Peterman (1990) makes an excellent case for consideration of both types of error, but as Peterman noted, the normal practice of statistical decision theory (Raiffa 1968) is a more appropriate tool for management.

We can get discouraged by the difficulty of replication and control, but we must keep in mind that it is not as important for management as it is for science. Managers must go where scientists fear to tread.

Institutional Memory

Given that a system is physically amenable to learning, can an organization actually learn? A major component of organizations' ability to learn is their ability to remember what has happened in the past—their institutional memory. In his book *Military Incompetence: Why the American Military Doesn't Win,* Richard Gabriel (1985) cites the lack of institutional memory as one of the principal reasons that the U.S. military has been unsuccessful in its major military missions since the end of the Vietnam War. Gabriel believes the American military simply doesn't learn from its past mistakes. He argues that the lack of institutional memory is due to a number of factors, among them (1) the high turnover of staff, so that no officer remains long enough in one position to master its skills; (2) the lack of mechanisms to retain lessons learned and convey them to new officers; and (3) the lack of a general staff, which is a long-term body of officers who remain together to become the institutional memory of the organization. Much of his critique is summarized in the following paragraph.

> Unfortunately, since we have no general staff system, the American military has no institutional memory. There is no place where the lessons of past wars are brought together and analyzed for dissemination throughout the corps. Although one would think that some institutional mechanism to do this would be evident within the office of the Joint Chiefs of Staff, in fact it is not. Further the education of officers is such that *they do not, as a rule, study the failures of their own history, especially if those failures tend to be recent.* Consequently, there seems to be a marked tendency for military commanders who plan and execute military operations to repeat the mistakes of the past. As one wag remarked with regard to this tendency in Vietnam, 'We were not in Vietnam for ten years; we were there for one year ten times'. It has been said that the corrupt Bourbon monarchy remembered everything and learned nothing. The same is true of the American military high command.

As an example, he cites the 91 missions conducted by various branches of the U.S. military to rescue prisoners of war during the Vietnam War. Not one of these missions rescued a single U.S. serviceperson alive, yet even after 90 failures, they tried a 91st time.

As I read Gabriel's book, I was struck by similarities in fisheries agencies, where staff may turn over at very high rates and there are no mechanisms to capture the experiences gained by staff as they retire or move on to new positions. We are all familiar with the expression that "doctors bury their mistakes" and recognize that this goes on in all aspects of life. Certainly within an organization there are usually few benefits for advertising or documenting one's mistakes. In *In Search of Excellence: Lessons from America's Best-run Companies* Peters (1982) describes how one corporation gives rewards for "great failures" and holds a ceremony within the organization when someone is willing to admit and describe such a failure.

Gabriel was a frequent commentator during the Gulf War, and he said that there had been a major revamping of the study of U.S. military history after Grenada, so that young officers now do study the recent failures of Grenada and Panama, and that most of the lessons learned in these two small-scale actions were absorbed in time for the Gulf War.

Sources of Institutional Memory

Four sources of institutional memory in fisheries agencies are (1) files, (2) reports, (3) computerized databases, and (4) peoples' minds.

Much information sits in individual files that are not committed to any long-term storage. This information is never published and is often unknown except to a few individuals. Most agencies have folklore, recent or past, of someone digging through old files and finding a "gold mine" of information that was nearly lost. The work on evaluation of the lake enrichment program in British Columbia (Hyatt and Steer 1987) depended on the discovery and use of old files (many over 50 years old) on fish passage counts.

The bulk of long-term institutional memory resides in published reports in agency libraries. As a general rule, if it isn't published, it is lost once the people who performed the work are gone. If files are properly archived, they will enter the institutional memory and become available for later use, although without any accompanying explanatory text, few files ever see the light of day again.

Computerized data bases are a new and potentially powerful form of institutional memory. The fact that data bases can be easily accessed means that they are probably used more than tables of data published in reports.

The richest form of memory is stored in the cerebrum of the staff of fisheries agencies. We sometimes forget how much an individual may have learned in 20, 30, or even 40 years of work in an agency. For each documented experience there are probably 10 that are left unwritten. Those that are documented may be a biased sample. Journals do not often publish negative results: managers don't like to hear bad news—we don't document our failures. When someone retires, much information walks out the door along with the gold watch.

There are other potential sources of institutional memory. Standard operating procedures may well reflect a lot of experience. An agency may do things a certain way because it has tried other ways and they didn't work. However, if the trials and errors aren't documented, new staff are likely to try the same thing again and discover for themselves that it didn't work. The standard operating procedures, whether they are how fisheries regulations are set or how a hatchery is operated, are a form of memory, but not a particularly useful one.

Similarly, the physical plant of a hatchery or an organizational structure will also store historical information on how a system was operated. Certainly a digital computer or an automobile contains a lot of information about how to make computers (or cars). Again, however, they do not contain information about what has not worked.

Why Memory Gets Lost

Knowledge is lost with distressing ease. Files are lost as soon as the people who know of them discard them, forget about them, or leave. Human memory leaves with its owner. Computer data bases are, unfortunately, subject to loss just as are paper files. In the last year, I have attempted to obtain three data bases that had appeared in agency technical reports. All three had been in a computer data base, and none of the three was currently available in computer readable form—the only way I could use these data bases was to pay for the data entry again. Computer systems or staff had changed, and the tapes had been lost in each case.

Similarly, I argue that most of the experience that is preserved in libraries is equally lost to new staff. They do not know what is there, do not read it, or cannot find it. The useful lessons, which could perhaps be summarized in two pages, are hidden in 100-page reports full of technical tables.

To maintain institutional memory, the experiences of the past must be transmitted to the present staff. Being "stored" in the library is fine, but unless the current managers know about it, past experience does them no good. Fisheries agencies, like the American military, do not have a mechanism to "study the failures of their own history."

What Can be Done to Retain Memory

I know of few systematic attempts in fisheries agencies to retain and transmit institutional experience. The Pacific Region of the Canadian Department of Fisheries and Oceans recently attempted to implement a decision documentation system. This is certainly a good first step but clearly only a beginning. The three steps of (1) decision documentation, (2) decision evaluation, and (3) transmission of experience to new staff must all be in place for an organization to learn from its failures.

There are a number of steps that, at low cost, might greatly improve the storage and transmission of historical experience. I admit I do not know whether these mechanisms will work, but I am willing to put them forward for criticism and possible implementation.

1. Short experience reports. Agencies could establish a report format that is very brief (perhaps five pages) in which staff summarize the lessons learned and point to the detailed documentation in reports. These experience reports would serve primarily as pointers to library information.
2. Old-timers' seminars. The establishment of an occasional seminar series in which long-term employees reminisce about important lessons they learned could serve to transmit some of the human memory from old staff to new staff.
3. Division historians. Each division or department could appoint a "historian" to encourge others to document lessons, or to do it themselves.
4. An annual historical review. Once a year, each unit could hold a meeting to decide what was learned during the year and assign people to prepare experience reports.
5. Memoirs of retiring staff. Retiring staff could be given a few weeks to document what they felt were the most important lessons learned in their career.
6. New staff training. Part of new staff training could be the reading of the experience reports. Long-term staff could give overviews of what they have learned.

It is not only fisheries agencies that lack institutional memory. Fisheries science as a discipline also needs better mechanisms to document what has happened. Documented case studies of fisheries histories are greatly needed. At present there are no readings suitable for a graduate or undergraduate course that summarize the history of specific fisheries. What I envision is a set of 30–50-page reports that give the biological, economic, social, political, and decision history of specific fisheries. Such case studies are not available at present and constitute a major impediment to transmitting the lessons of the past to the managers of the future.

Transmitting all the lessons of the past to the next generation is not sufficient. Unless the managers of the future are willing to act upon past experience, institutional memory does no good. Many hatcheries that have been shown to not produce fish are still operated, and fisheries that are recognized to be overexploiting stocks continue in their present state. Institutional memory is important, but evidently not sufficient in itself.

More Impediments to Learning: Changing Dynamics, Goal Displacement

There are two further impediments to learning: changing dynamics and goal displacement. One of the basic assumptions we make when considering learning is that what we learn about our system today has some applicability tomorrow. If there is systematic change in the system, old information may not be relevant to future decisions. If the system is changing too fast, we simply cannot learn about it (Walters 1986).

Finally there is a phenomenon called "goal displacement" (Dowell and Wange 1986). This occurs when an intermediate tactical measure of success displaces the real objective. Hatcheries have been built for Pacific salmon in order to increase the catch of fish. Hatchery managers are told to produce juvenile fish, which when released will presumably return as adults and be caught by anglers. The release of juveniles is supposed to be a measure of individual hatchery efficiency, yet it has become (in many if not most instances) the measure of hatchery system performance. Often no one asks if the hatchery systems are producing more fish in the catch—as long as they produce juvenile fish, the system is deemed to be working.

In the extreme, goal displacement goes so far that the physical hatchery itself becomes the objective. I was recently told of two attempts to close hatcheries in Oregon. One hatchery for trout was an antiquated facility, and it was proposed to shift all of the production to a new facility. The fish would still be released in the same place; the anglers would still get as many fish. Yet the opposition to closing the old facility was so extreme that the agency was unable to close it.

The second hatchery was for Pacific salmon and had been shown to be totally ineffective at producing adult fish. All attempts at fixing the facility had failed and the agency wanted to simply shut it down. This too proved impossible, because shutting down the hatchery appeared to indicate

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a lack of commitment to the resource. The goal had shifted from producing fish to showing a commitment to producing fish.

Similar forms of goal displacement have been found in insect pest control systems, where spraying of the insects is supposed to reduce economic damage (Dowell and Wange 1986). Spraying becomes the measure of success, and the more area sprayed, the more successful the program, regardless of the success at reducing insect damage.

Summary

Assuming that key individuals want their organization to learn, what steps should they take?

First, they should clearly identify the types of uncertainty they face by listing them and outlining how much experience they have with this particular type of uncertainty. Is it noise, surprise, or somewhere in between? Particular emphasis should be given to all the surprises that have come upon them in the past; can the surprises be characterized?

The second step is to consider the potential for learning about the uncertainties they face. Can the systems be replicated and controlled? How long will learning take? How much would a suitable monitoring and evaluation system cost? Will a passive experimental design work, or does it need to be deliberately experimental?

Third, the institutional impediments to learning need to be realistically appraised. Where would the system likely fail? The staff turnover, budgetary stability to fund evaluation programs, mechanisms for institutional memory, and the probability that the institution would respond to learned information once acquired must be considered. Does the system change so much that learning is irrelevant? Is the organization so complex that goal displacement becomes inevitable? The mechanisms of institutional memory need to be examined and improved, perhaps along the lines given earlier in this paper.

Finally the institution must realistically assess if it can change its behavior once it has learned.

Can we learn about learning? The most important step is to put learning on the agenda—to make it a subject of discussion.

Acknowledgments

The ideas in this paper are the product of many years of discussion with colleagues, particularly Carl Walters, Kai Lee, C. S. Holling, and Ralf Yorque. The research was supported by Washington Sea Grant. This paper is contribution no. 854, School of Fisheries WH-10, University of Washington, Seattle, WA 98195.

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