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THE DARK SIDE OF REFERENCE POINTS

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Reference points were "designed by geniuses to be used by idiots,"
with apologies to Herman Wouk

ABSTRACT

The United States and many other countries have developed sets of standard reference points that can be used to determine allowable harvests. Here I explore some of the problems that have arisen in this practice, including (1) uncertainties in current stock biomass and virgin stock biomass as applied in reference point formula, (2) the inappropriateness of reference points applied to species for which they were not derived, (3) the tendency of reference-point use to produce an environment in which stock-assessment scientists rarely evaluate alternative management policies, and (4) the role of concern about reference points as a displacement activity for scientists that keeps them from working on more significant problems in fisheries management. I suggest that alternative, data-based, rather than model-based, approaches to setting quotas should be preferred. I consider the true meaning of the precautionary approach and the trend toward neglect of the purpose of a fishery—to produce social and economic benefits to society; it is those benefits that need protection. Finally, I suggest that the key to successful fisheries management is not better science, better reference points, or more precautionary approaches but rather implementing systems of marine governance that provide incentives for individual fishermen, scientists, and managers to make decisions in their own interest that contribute to societal goals.

Management by reference point has become the de facto management procedure for many U.S. and Canadian fisheries. The process has the following steps: (1) estimate the current and virgin stock size from some form of fisheries stock assessment, (2) calculate the target catch for the fishery by using accepted reference exploitation rates that depend on current and virgin stock size, (3) manage the fishery to try to achieve the target catch by using a variety of tactics. Figure 1 shows the so called 40:10 rule that has been accepted by the Pacific Fisheries Management Council. If the stock is above 40% of its virgin stock size, the target catch is the population size multiplied by a target reference exploitation rate u_{ref}. If the stock is below 10% of its virgin size, no catch is permitted. If the stock is between 10% and 40% of the virgin stock size, the target exploitation rate increases from 0 to u_{ref}. Similar procedures have been proposed or are in place in other jurisdictions, most notably in Canada (Haigh and Sinclair 2000), where a similar procedure has been defined as the precautionary approach to fisheries management. This approach is also consistently taken by the Northwest Atlantic Fisheries Organization and the International Council for the Exploration of the Sea.

Although a body of literature shows that such management systems will work well in theory (Hilborn, 1979, for example), the purpose of the present paper is to raise questions about the dark side of reference points...that such fisheries-management systems may not be such a good idea, that there may be better ways to manage fisheries, and that our concentration on reference point management has led us to neglect the more important issues of fisheries management.

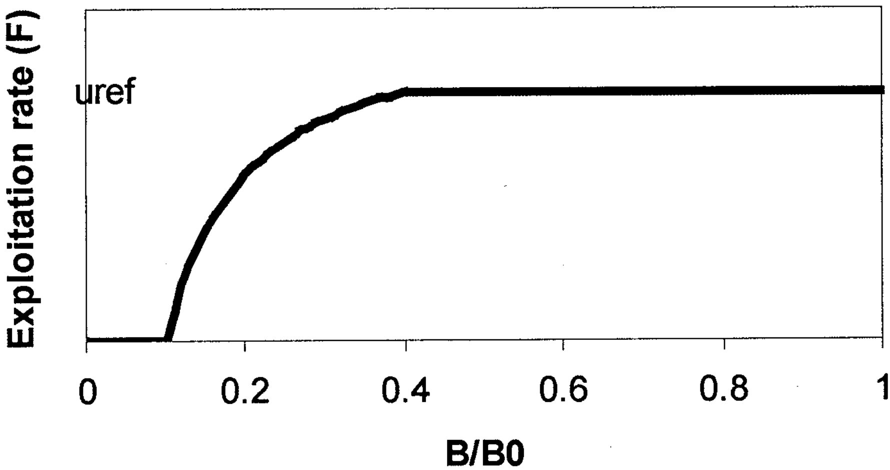

Figure 1. The 40:10 rule of the Pacific Fisheries Management Council.

The Dark Side of Reference Points

We Cannot Estimate Absolute Abundance Very Reliably.—John Shepherd once said "counting fish is like counting trees—except they are invisible and they keep moving." Reference-point management, including its simplest form, harvest rate management, is predicated on some actual ability to measure abundance. We must admit we have little ability to measure absolute abundance for most marine fishes. It is not at all uncommon for the estimates of abundance of some fisheries to be off by 2-fold or more. The classic example is the overestimation of the abundance of the northern cod in eastern Canada in the 1980s, and perhaps more important was the underestimation of the abundance of Pacific halibut in the 1980s and 1990s. The stock was really half of, or twice, the estimate. Walters and Pearse (1996) recognized this problem, and it caused Walters to say on many occasions that any fishery managed by quotas derived from multiplying estimates of stock size by a harvest rate will eventually overharvest the stock as a result of random errors. Of course, the most insidious problem is that these errors are not random, and if we overestimate the abundance in one year, we are likely to overestimate it again the next year.

We Cannot Estimate B0 Very Reliably.—If estimating absolute abundance is difficult, estimating the virgin biomass is even harder. In most fisheries assessments, estimating B0 depends either on extrapolating back to well before we began to have any data or on taking estimates of annual recruitments and calculating what virgin biomass these would have produced. All such calculations are highly arbitrary. If the stock has been subject to recruitment overfishing, using recent recruitments to estimate virgin biomass will lead to serious underestimation. If environmental conditions have changed, what was virgin biomass in the past will not be virgin biomass in the future.

We Cannot Estimate U_{REF} Very Reliably.—The reference exploitation rate depends on a range of life-history parameters but most importantly on the sensitivity of recruitment to spawning stock. A large literature addresses the problems in estimating the spawner-recruit relationship (see Hilborn and Walters, 1992, for example), and the most recent approach has been meta-analysis using large numbers of data sets (Myers and Barrowman, 1996). In essence we have given up on the ability to estimate this relationship within the data available for most fish stocks, so to estimate u_{ref} we rely on extrapolation from other species. Although this is the correct approach, it does introduce a considerable amount of uncertainty into the appropriate level of catch, compounding the uncertainty in the current stock size and in B0.

Two of the fisheries I have worked on in the last decade are rock lobster and snapper in New Zealand. These are two of the five most important species in the commercial fisheries of New Zealand; snapper is also the most important recreational species. In both cases the current stock assessments for the major fisheries on these species show that the stock has been at roughly 10% or less of the virgin biomass for the last 30 yrs, yet it has been sustainably managed and produces near maximum sustainable yield (MSY) at this level. For a variety of reasons the government and industry have chosen to rebuild stock abundance slowly—not so much in expectation of higher yields but because of legislative mandates to manage at B_{MSY} and in expectation of better catch per unit effort (CPUE). If the 40:10 rule adopted by the Pacific Fisheries Management Council had been used, both fisheries would have been closed immediately as serious conservation crises. Fortunately, data are available for each species to suggest that no such crisis exists. These two cases clearly illustrate that extrapolation of reference points from species to species is full of pitfalls.

RELYING ON REFERENCE POINTS CAUSES US TO NEGLECT PROJECTIONS AND POLICY EVALUATION.—The default format for calculating recommended catch levels in the U.S. and Canadian fisheries is to follow the procedure outlined above and multiply the estimated stock size times the u_{ref}. Few assessments I have seen include any evaluation of alternative policies or evaluation of consequences under uncertainty in the stock assessment. Reference points have led us to ignore the important question of what will happen if we take different levels of catch. Most calculations relative to reference points are long-term equilibrium yields and stock sizes. These calculations ignore the trajectory from where we are now to where we will be at equilibrium. These trajectories are important, and yet in my experience few stock assessments present trajectories.

THE NEED FOR TRANSPARENCY.—To be successful, fisheries management must be transparent so that all parties—government, industry, recreational fishermen, and conservation groups—understand how the fishery is being managed and approve of the management process. The current morass of litigation in the United States, from both industry and conservation groups, shows we are far from any consensus. Management by reference points is not transparent because so many arbitrary decisions are made in the stock assessments in the process of arriving at a biomass to multiply by the reference point. Modern fisheries stock assessments rely on dozens, sometimes hundreds, of individual judgments about which data to use, how much weight to give them, which years to include, and what to assume about initial conditions in the models. The 1997 and 1998 assessments for sablefish on the west coast of the United States differed 10-fold in estimated stock size, primarily because of assumptions that the 1997 authors of the assessment accepted but the 1998 authors did not. Stakeholders, be they commercial fishermen or conservation groups, will not accept any process that involves this degree of arbitrariness. As mentioned above, estimates of B0 and u_{ref} may involve similar arbitrary decisions. Although the process of reference-point management outlined in the introduction seems transparent, in practice it is not so because none of the key parameters of the rules, stock size, B0, and u_{ref} are directly measured.

Moving Beyond Reference Points

Data-based Rules May Be Better.—In the New Zealand rock-lobster fishery, a rebuilding plan was formulated that depends on measured CPUE (Starr et al., 1997). If CPUE does not rise as quickly as the rebuilding plan outlines, catches are lowered. If CPUE rises faster, catches are increased. Although complex stock-assessment models were used to test and evaluate the rules, the rules themselves are simple and transparent and do not rely on assessment models. In 1999 this decision rule caused catches to be lowered in two areas and raised in one. In the Canadian fishery for chum salmon in Johnstone Strait, the decision rules are based on the catches at specific test sites—simple rules allow a fisherman to start with the catches at the test sites and determine the regulations that will be in place (Hilborn and Luedke, 1987). Both these data-based rules have been used to manage fisheries—and they work. The data used in such rules can be fishery-independent surveys or fishery-dependent data, depending on what is available and the confidence in the data as measures of trends in abundance.

In another paper (Hilborn et al., 2002) I have compared data-based and reference-point-based rules and show that, under a considerable range of circumstances, data-based rules will perform better. Butterworth and Punt (1999) argue for management rules that are model based, rather than data based, but in which the model is completely specified—that is, it too is totally transparent. I suspect that the relative success of model- and data-based rules will depend on the frequency and reliability of the data. In the Butterworth and Punt approach, models are essentially used to smooth the data. In fisheries where frequent surveys are conducted, data-based rules that simply smooth the data may work well. When data are sparse, clearly some form of model will be needed to smooth and extrapolate from the data.

The Precautionary Approach Should Be About Process, Not Reference Points.—Reference points have become closely identified with the precautionary approach to fisheries management in the United States, Canada, and Europe (Haigh and Sinclair, 2000). Indeed, reference points have become so synonymous with the precautionary approach that it has been defined as lower harvest rates in the reference points (Hilborn et al., 2001). The Food and Agriculture Organization of the United Nations (FAO) convened an expert consultation on the precautionary approach in 1995 (FAO, 1996) that identified key aspects that are almost exclusively procedural. To be precautionary, a fishery needed a management system that measured catches and abundance, rules about how catches would be changed in relation to the data collected, and the ability to enforce changes in catch. The vast majority of the world's fisheries are not precautionary—not because the reference exploitation rates are too high but rather because catch cannot be measured or catch limits enforced, because abundance cannot be estimated, or because rules do not state how catches will change in relation to stock size. The key message is that it is the process that is precautionary, not the specific reference points.

The Pacific Fisheries Management Council recently completed a multiyear reevaluation of the default value for u_{ref} for rockfish. It involved a significant proportion of the scientific effort within the council process, several workshops, a dozen papers written or presented, and in the end a revision of the reference exploitation rates. Other than the annual stock assessments, this was the major scientific effort over the last several years. This at a time when essentially no biological work is done on the fishery except a survey on the continental shelf every 3 yrs and a survey on the slope every year. This at a time when a significant portion of the commercially valuable product is being discarded at sea because of the trip-limit system. This at a time of staggering overcapitalization and a great need for fleet reduction. This at a time when it is clearly recognized that we need much better ways to estimate abundance of the 66 species of rockfish in this fishery.

Contemplation about reference points has become the displacement activity that allows the scientific community to ignore the real problems in our fisheries management system. We do need to be more precautionary, but changing our reference points is a small part of the process.

Overfishing Is Overrated—Other Problems Are More Pressing.—The emphasis on reference points goes back to a central myth of our time, that the problem with fisheries is overfishing. Overfishing is indeed a fisheries problems but clearly not the biggest. We have all heard the familiar litany that 33% of U.S. fish stocks are overfished or depleted, which implies that we are losing at least 33% of our total yield to overfishing. The National Marine Fisheries Service estimates that we are losing 14% of our potential yield to overfishing (NMFS, 1999). FAO estimates that we are losing 4% of potential yield worldwide to overfishing (FAO, 1997). Although these estimates are undoubtedly not terribly accurate, they highlight the relatively small loss of yield to overfishing. In comparison, the economic loss due to overcapitalization, loss of yield due to discarding, and the threat to nontarget species due to by-catch are much more serious.

A stock is technically overfished when it is held at a biomass below which maximum sustainable yield will be produced or is fished at a fishing mortality at which yield per recruit is lower than maximum. Such a stock is not, however, necessarily unsustainably managed. In the New Zealand snapper case mentioned above, the official stock assessment estimated the stock to be at half of the biomass that would support MSY but producing 92% of the maximum potential yield. This stock was technically overfished but sustainably so, and it is indeed rebuilding while being sustainably overfished.

Certainly overfishing is a serious problem for individual stocks that may be severely depleted, and as a long-term target almost all considerations would lead us to wish to manage stocks at a biomass larger, not smaller, than that producing MSY. The societal urgency is much greater, however, to tackle overcapitalization and eliminate discarding and by-catch. Overfishing is primarily a symptom of overcapitalization and fisheries management systems that do not work. We should treat the cause of the problem, not concentrate our energies on one of the symptoms.

International Structure Is the Key.—The U.S. council system is not precautionary; no one is in charge of individual fisheries; allocation issues are mixed with management decisions; and the councils, which consist of many vested interests, cannot possibly solve allocation in a way that is deemed fair. The number of lawsuits against the National Marine Fisheries Service and the councils alone make it clear that the system has failed. The only good news is that it could be worse—we could be like Europe.

Recognition is growing that the key to good fisheries management lies in the institutional structure (Heinz Center 2000). We need (1) firm allocation among user groups, (2) property rights for all user groups, (3) simple institutional structure with direct responsibility, (4) simple decision rules that do not use complex stock-assessment models, and (5) determination of data collection and science budgets by management authorities.

Reference points are a side issue and should not have come to dominate the agenda. We need to find management procedures that are robust despite the broad uncertainty in stock abundance. Spending time on reference points is like rearranging the deck chairs on the TITANIC—a perfectly sensible thing to do in the absence of more pressing issues. Reference points depend on our knowing how many fish there are in the ocean—I only wish we did.

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