# Ecosystem Management: A Comparison of Greater Yellowstone and Georges Bank

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ABSTRACT / Ecosystem management links human activities with the functioning of natural environments over large spatial and temporal scales. Our examination of Greater Yellowstone and Georges Bank shows similarities exist between human uses, administrative characteristics, and some biophysical features. Each region faces growing pressures to replace traditional extractive uses with more sustainable extractive or noncommodity uses coupled with concern about endangered species. Ecosystem management as a set of practical guidelines for making decisions under evolving expectations is far from complete, and it embodies new demands on individuals and institutions. In each system these challenges are considered relative to: the public's symbolic understanding of the management challenge, ecosystem management ambiguities, information availability, information use, administrative setting, and learning capabilities of governance organizations. Progress in making ecosystem management operational may occur as refinements in content and approach make it an increasingly attractive option for resource users, the public, and government officials.

Natural resource management evolves in response to increasing knowledge about the environment and changes in social aspirations. Ecosystem management, a developing concept, is a comprehensive approach to protecting the structural integrity and natural functioning of large geographic regions in perpetuity. Under ecosystem management, sustainable human economies should be integrated into overall ecosystem capabilities. "Ecosystem management is one of the most intriguing developments in contemporary natural resource policy" (Freemuth and Cawley 1993, p. 26). Many ecosystem management efforts worldwide are contemplated, beginning, or underway. Efforts to bring ecosystem management into being as practical policy promise benefits both to human society and to the maintenance of the natural world.

Two major North American opportunities for ecosystem management are ongoing in the Greater Yellowstone Ecosystem (GYE), a terrestrial region in the northern Rocky Mountains, and in the Georges Bank Ecosystem (GBE), a marine region off the northeast coast (Figure 1). Ecosystem management is in its formative stages, and a comparative examination of different initiatives encourages elaboration of the concept. The terrestrial and marine communities of policy specialists, managers, scientists, and advocates seem little aware of the activities of each other. Our comparison helps inform managers and others about the growing debate about ecosystem management in the two systems. This paper examines the biophysical features, history, human uses, and current management of the two ecosystems. Finally, we address challenges and opportunities to bring about ecosystem policy and management.

KEY WORDS: Ecosystems; Policy; Management; Greater Yellowstone; Georges Bank; Administration; Organizational learning

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## Greater Yellowstone and Georges Bank Ecosystems

A brief overview of the two ecosystems is a requisite to later discussions. The GYE is that block of contiguous forested mountains and prairies and basins surrounding Yellowstone National Park (YNP) that comprises the richest, most nearly intact complex of wildlife and wil-

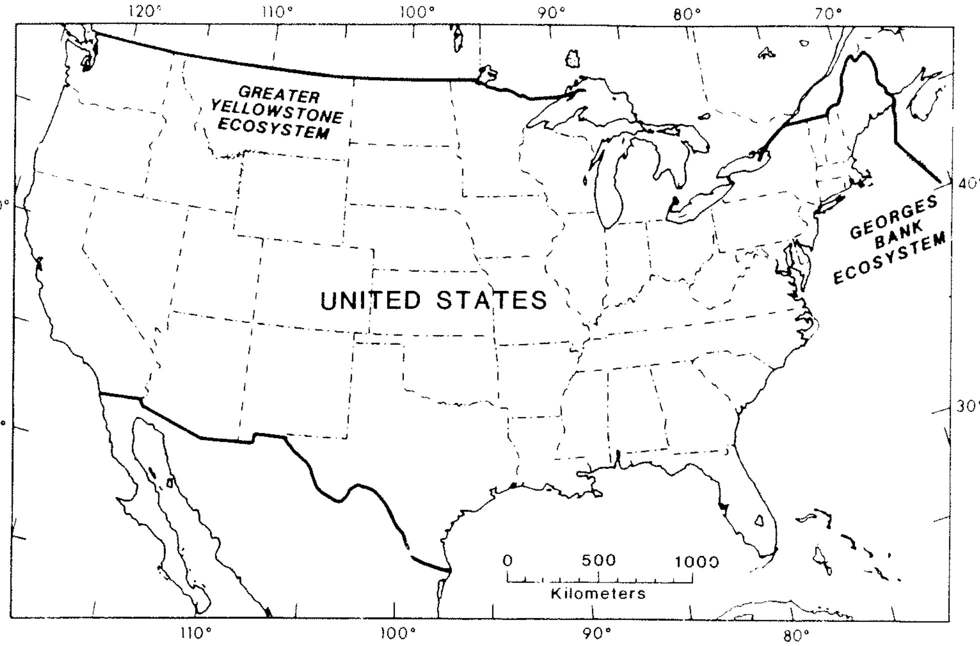


**Figure 1.** Greater Yellowstone and Georges Bank ecosystems. Sources: Clark and Minta (1994) and Backus and Bourne (1987a).

derness in the lower 48 United States (Fishbein 1989). YNP and surrounding lands set national and international standards for how public lands are managed (Keiter and Boyce 1991). GBE is a shoal area off northeastern North America, which historically has been one of the world's most productive fisheries and, by virtue of its location on a biogeographical boundary, exhibits a rich diversity of species. It too has a precedent-setting profile.

## Biophysical Features

The two systems have very different biophysical characteristics (Table 1). The GYE is a distinctive geological and biological system enclosed in an irregularly shaped area about 480 km from north to south and 240 km east to west (Figure 1) covering about 77,000 sq km. The Continental Divide almost bisects GYE, which lies at the northern end of the Central Rocky Mountains. The GYE is comprised of the Yellowstone Plateau (2500 m above sea level) and various mountain ranges and basins, with many peaks exceeding 3000 m. Over 10,000 geysers and thermal features occur in the GYE. Soils are of recent origin following extensive Pleistocene glaciation. GYE's climate shows brief cool summers and long cold winters. Precipitation is over 60 cm/yr. The GYE is headwaters to several major river systems (Yellowstone–Missouri, Green–Colorado, and Snake–Columbia) and influences a huge region in western North America.

Seven floras converge in the GYE (Romme and Knight 1982). About 1700 plant species are known and coniferous forests dominate. GYE's fauna is largely intact, showing about 128 butterfly and about 400 vertebrate species (Clark and others 1989). GYE supports the largest elk herds in North America and substantial populations of other large mammals (e.g., moose, grizzly bears). Threatened or endangered species include one fish, three birds, four mammals, and other species that are either candidates or proposed for listing under the Endangered Species Act (Table 1). The physical setting of this terrestrial system stands in marked contrast with the marine system of Georges Bank.

Georges Bank lies approximately 190 km east of Cape Cod, and the top of the bank is marked by the 100-m contour from the Northeast Channel to the east to the Great South Channel to the west (Figure 1). The area encompasses 33,700 sq km (Backus and Bourne 1987b). GBE is part of the Scotian province or cold temperate portion of the continental shelf and is influenced by the Gulf Stream and the colder Scotian Shelf waters interacting over a relatively wide high relief shelf with sandy sediments on the bank top (NOAA 1991). During the recent glaciation, lowered sea level exposed the GBE.

Primary production, measured by the carbon-14 method, is about 455 g C (grams of carbon)/sq m/yr on the bank top, which places it among the most productive coastal upwelling systems in the world. As a

Table 1. Some comparisons of biophysical features of Greater Yellowstone and Georges Bank ecosystems

| Feature | Greater Yellowstone Ecosystem | Georges Bank Ecosystem |
|---|---|---|
| Environment | Terrestrial | Marine |
| Location | Northern Rocky Mountains, US | Northeastern North America continental shelf waters of the US and Canada |
| Size (approximate) | 77,000 km$^2$ | 33,700 km$^2$ |
| Climate | Brief cool summers, long cold winters | Cold temperate marine |
| Dominant topographic feature | Mountain ranges, high plateau and basins | Shoal surrounded by deeper basins |
| Vegetation | Coniferous forest | Coastal upwelling system |
| Animals | Numerous large mammals (e.g., >40,000 elk and ~250 grizzly bears) | Ground fishery (e.g., cod, haddock, flounder) |
| Threatened/endangered species[a,b] | | |
| Plants | Ross bentgraw (P), Shultz's milkvetch (P), Wyoming tansy (P), North Fork *Lomatium* (P), Absaroka beard tongue (C), Shoshonea? (C), 3 others—no common names (C) | Not determined |
| Fish | Fire-spotted snake, Bonneville cutthroat trout (C), Arctic grayling (C), Kendall Warm Springs dace (E) | Not determined |
| Reptiles | None | Loggerhead turtle (T), leatherback turtle (T) |
| Birds | Whitefaced ibis (C), bald eagle (E), whooping crane (E), mountain plover (C), long-billed curlew (C), penegrine falcon (E) | Not determined |
| Mammals | Spotted bat (E), gray wolf (E), grizzly bear (T), black-footed ferret (E) | Fin whale (E), sperm whale (E), right whale (E), humpback whale (E), sei whale (E) |
| Species present | | |
| Flora | 1700 vascular plants | >446 plankton species |
| Invertebrates | 20,000+ | >700 benthic species |
| Fish | 12 | >100 |
| Amphibians | 4 | 0 |
| Reptiles | 6 | 2 |
| Birds | 250+ | 32 |
| Mammals | 68 | 5+ |

[a]Symbols: P = proposal, C = candidate, T = threatened, E = endangered.

[b]Overall, 15 other species are considered "sensitive or rare" in GYE.

[c]Surveys are incomplete.

result, the bank was a prolific fishing ground, which in 1981 accounted for 10% of the US national total of commercial landings of edible fish and shellfish (Backus and Bourne 1987b). Recent listings show the GBE contains one threatened (loggerhead) and one endangered (leatherback) turtle (Shoop 1987). In addition, other endangered animals include the fin, sperm, right, humpback, and sei whales (Winn and others 1987).

## History and Human Uses

The two ecosystems have different histories but converging patterns of human use (Table 2). The GYE's history and human use patterns can be divided into four phases (Clark and Minta 1994). First, the early settlement phase (Paleo-Indians to white settlement) is prior to 1872, when YNP was set aside. Before that, various Indians, explorers, fur trappers, traders, missionaries, surveyors, military, and railroad builders visited or occupied the region. They had a relatively minor effect on the GYE. Second, the carving up of the ecosystem included formal declaration that the western frontier was closed; ranching, mining, and logging came to dominate land uses; and the US Forest Service and the National Park Service were established as well as the states of Idaho, Montana, and Wyoming. The Yellowstone region was colonized by European descendants, relatively recently, compared to other parts of the continent. Third, the resource extraction phase continued until the 1980s. The phase included damming of the Snake and Green rivers, extensive logging, mining,

Table 2. Comparison of historic human uses of Greater Yellowstone and Georges Bank ecosystems

| Greater Yellowstone Ecosystem | | Georges Bank Ecosystem | |
|---|---|---|---|
| Dates | Period/activities | Dates | Period/activities |
| Late Pleistocene | Regional human occupancy | 1497, 1609 | Exploration/first notice of extensive northwest Atlantic fisheries |
| ~1807+ | First European contact with native peoples: depletion of fur resources by 1840; westward US national expansion | 1820s on | Directed fishery on Georges Bank: cod, halibut, mackerel |
| | | 1850s | Halibut overfished |
| <1872–1890 | European settlement: destruction of native peoples, reduction of wildlife (especially large mammals) | 1880 | Iced haddock fishery expands, salt cod declines |
| 1873–1916 | Carving up the ecosystem: massive reduction in wildlife, timber cutting, mining, tourism increase | Early 1900s | Steam-driven otter trawlers and fishery expansion |
| 1916–1980s | Resource extraction: organized, expanding, natural resource extractive industry: endangerment of species: tourism explosion | 1930s | Diesel trawlers, first signs of haddock overfishing |
| | | 1960s–mid-1970s | Overfishing expanded through increased foreign effort |
| | | Late 1970s | Oil and gas development proposed: sanctuary proposed |
| | | 1970s–1980s | Ecosystem management suggested |
| 1980s+ | Emergence of ecosystem management: transition to tourism economy underway; species and habitat protection and restoration given higher priority than before | 1990s | Large areas closed to fishing |

ranching, and hunting, and increases in tourism. Fourth, the emergence of an ecosystem approach began about 1980 with publication of scientific papers concerning the ecosystem concept relative to grizzly bears and establishment of the Greater Yellowstone Coalition (GYC), a nongovernmental organization (NGO) whose mission is to bring about region-wide policy and management consistent with ecosystem science and sustainability.

At the heart of the GYE debate is the future of the region's economy (Patten 1991, Jobes 1993, Rasker 1993) (Table 3). Increases in traditional land uses, including agriculture, recreation, and urban development show a direct, negative relationship to the GYE's ecological integrity through biodiversity declines (Clark and Minta 1994). The region's gross annual product is about \$5.5 billion. Economic analyses have been completed (Bureau of Economic Analysis 1991, Jobes 1991, 1993, Patten 1991, Power 1991, Rasker 1993, and others 1992). About 300,000 people reside in the region and another 10 million visit annually. The GYE's population is growing very rapidly, and its economy is largely tied to public lands—national parks and forests. In recent decades, the area's economy has moved away from extractive industries towards tourism (Rasker and others 1992). However, federal and state land and wildlife managers still largely administer public lands for commodity production (Rasker and others 1992). In contrast, the economy is diversifying into activities that depend on preserving the region's ecological integrity and beauty. The new economic realities and the old and new cultures clash, sometimes sharply, as in the case of oil and gas development.

The history of GBE is that of fishing during the discovery and settling of North America (Table 2). Voyages in 1497 and 1602 that noted prolific fisheries in the northwest Atlantic were followed by settlement in 1620 and a fishery that expanded seaward (Merriman 1982). Whaling and groundfishing were attempted in the early 1700s, and in the 1820s significant groundfishing began (Backus and Bourne 1987a). By early 1850s the bank had been overfished for halibut (Merriman 1982). This pattern of discovery and overexploitation, usually with the aid of new or refined technology, continues to the present.

By the late 1970s, the advent of oil and gas explora-

Table 3. Some comparisons of present human economy in Greater Yellowstone and Georges Bank ecosystems

| Feature | Greater Yellowstone Ecosystem | Georges Bank Ecosystem |
|---|---|---|
| Present resident human population | 300,000 | 0 |
| Estimated annual number of visitors/users | 10,000,000 people | Formerly 1500 vessels |
| Principal activities | Tourism, recreation, oil and gas, timber, mining, livestock grazing, and hunting activities | Commercial fishing |
| Estimated annual gross product | \$5.5 billion in 1990 | Estimated 1992 harvest \$192 million ex vessel US[a] |
| Trends | 10+% annual increase in human population | >50% decrease in groundfish biomass and harvest over three decades |
| Conflict among principal economic activities | Potentially large if oil development considered and tourism and second homes are unchecked; great conflict over means of allocating resource benefits | Potentially large if oil development considered; great conflict over means of reducing current overfishing |

[a]Ex vessel refers to the price US fishers receive when they sell at dockside.

tion, legislation potentially calling for control of overfishing, and the possibility that GBE be designated a marine sanctuary collectively forced a more comprehensive evaluation of the system. This period of widening public interest and potential for new extractive uses generated intense debate and initiated discussion of ecosystem management for the region. That debate continues. No sanctuary within GBE has been designated. However, fishing has been closed in areas on and adjacent to GBE (US Department of Commerce 1994).

The human economy of GBE is dominated by commercial fishing (Table 3). While that results in few tourists and no permanent residents, 1992 produced a US fish harvest from GBE of \$192 million (S. Clark, personal communication 1993) even with severely depleted groundfish stocks. Most recently, large areas of GBE were closed to fishing to allow stocks to recover. Approximately 1500 vessels can utilize GBE, and New England processing and wholesaling employed over 8000 people in 1992 (NMFS 1993). The recovery of the full potential of this fishery has been a subject of intense debate for over two decades.

## Organizational Dimensions

A host of governmental units and NGOs are active in both ecosystems (Table 4). The GYE is a complex of land ownerships and jurisdictions. The history of legal responsibility for what is now the GYE has changed over the last 150 years (Haines 1977, Bartlett 1985). Today, at least 28 local, state, and federal governmental agencies manage the GYE, but federal agencies maintain dominant control.

The National Park Service (NPS) and its policy and management have been the subject of much study (Zaslowsky 1986). The agency's prime directive is to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service Organic Act 1916). The US Forest Service (FS) operates under multiple-use policies detailed in several laws (Zaslowsky 1986). The national forests are managed for timber, watershed, mining, range, wildlife, and outdoor recreation. The states of Idaho, Montana, and Wyoming have game and fish departments and state land boards that exercise tremendous influence over wildlife and land management, especially outside the national parks. Although cooperation is ongoing on various fronts, the underlying tension of states' rights vs federalism philosophies is ever present.

There are many other participants active in the GYE policy debate, including the Greater Yellowstone Coalition, the People for the West, Multiple Use Advocates, the media, organized business interests, and elected officials. Many roles conflict, sometimes dramatically. Roles of participants in the policy debate are a function of history, power relationships, and bureaucratic structures and behaviors. The GYE policy discussion is complex and highly contentious.

Interestingly, GYE has experienced no clearly evident system-wide policy or management crises or catastrophes such as the current fishery collapse in GBE. An historical episode closest to being considered a crisis was fear for grizzly bear extirpation in 1970s. We believe that part of the reason for the lack of crises is that the

Table 4. Some administrative and policy comparisons of the Greater Yellowstone and Georges Bank ecosystems[a]

| Feature | Greater Yellowstone Ecosystem | Georges Bank Ecosystem |
|---|---|---|
| Ownership | Complex mix federal, state, and county government and private owners | Federal governments of US and Canada |
| Estimated no. of government units | 28+, NPS, FS, USFWS, BLM, BOR, ID, MT, WY, and others | 13+, EPA, NOAA, BLM, MMS, State, USCG, Defense, NJ, NY, CT, RI, MA, NH, ME, and others |
| Key administrative events | 1872 Yellowstone Nat'l Park est.<br>1889 Montana statehood<br>1890 Wyoming and Idaho statehoods<br>1891 Yellowstone Forest Res. est.<br>1895 US Forest Service est.<br>1916 US Nat'l Park Service est.<br>1940 US Fish and Wildlife Service est.<br>1946 US Bureau of Land Management est. | 1871 BOF est.<br>1946 BLM est.<br>1949 ICNAF est.<br>1970 NOAA and EPA est.<br>1982 Minerals Management Service est.<br>1984 US–Canada marine boundary established |
| Key federal policies | 1895 US Forest Service Organic Act<br>1916 US National Park Service Act<br>1964 Wilderness Act<br>1968 Wild and Scenic Rivers Act<br>1969 National Environmental Policy Act<br>1973 Endangered Species Act<br>1976 National Forest Management Act<br>1970 Clean Air Act<br>1972 Federal Water Pollution Control Act Amendments | 1953 Outer Continental Shelf Lands Act<br>1955, 1970 Clean Air Act<br>1969 National Environmental Policy Act<br>1972 Marine Protection Research and Sanctuaries Act<br>1972 Federal Water Pollution Control Act Amendments<br>1972 Coastal Zone Management Act<br>1973 Endangered Species Act<br>1976 Fishery Conservation and Management Act<br>1978 Outer Continental Shelf Lands Act Amendments<br>1990 Coastal Zone Act Reauthorization Amendments |
| New proposed legislation | 1990's Yellowstone Park Protection Act<br>Northern Rockies Ecosystem Act<br>Endangered Ecosystem Act<br>Biodiversity Bill | Groundfish restoration bills |
| Role of courts | Medium and growing | Large |

[a]Symbols: NPS, National Park Service; NOAA, National Oceanic and Atmospheric Administration; FS, Forest Service; USFWS, US Fish and Wildlife Service; BLM, Bureau of Land Management; BOR, Bureau of Reclamation; EPA, Environmental Protection Agency; MMS, Minerals Management Service; USCG, US Coast Guard; BOF, Bureau of Fisheries; and ICNAF, International Commission for the Northwest Atlantic Fisheries.

GYE is relatively young with regard to exploitation. It has only been in recent years that sharp concern has been raised about the rate and extent to which management can effectively respond to the declining status of some natural resources and changing human values.

In contrast to GYE, the jurisdictional setting in GBE is in some respects a lot simpler. In 1984 the continental shelf and fisheries jurisdiction boundary between Canada and the United States was established by the International Court of Justice (Cooper 1986). This boundary assigns the Northeast Peak of Georges Bank to Canada (Figure 1). As GBE is located within 371 km (200 miles) of land, it is governed by the adjacent countries under international law. In the United States this direct management is federal and has been exercised by the National Oceanic and Atmospheric Administration (NOAA) for fishery and sanctuary activities. Oil exploration is supervised by the US Department of the Interior. Unlike GYE, legislation affecting GBE is recent (Table 4).

Prior to the 1970s, GBE was the exclusive province of the fishing industry and units of the federal government involved with that industry. However, in the 1970s environmental groups (Natural Resources Defense Council, Conservation Law Foundation), the oil industry, and the coastal states proposed contrasting futures for GBE. Observed and presumed system-wide crises with respect to overfishing and oil development, respectively, brought about heightened activity from all actors. Oil development in the United States part of GBE is unlikely in the near term. Overfishing with subsequent biological and economic disruption remains a substantial challenge, as evidenced by recent closures (US Department of Commerce 1994).

Table 5. Obstacles to ecosystem management in the Greater Yellowstone and Georges Bank ecosystems[a]

| Feature | Greater Yellowstone Ecosystem | Georges Bank Ecosystem |
|---|---|---|
| Key public "metaphor" | Grizzly bears | Groundfish |
| Ecosystem management definitional ambiguities | Desirable concept but disagreement on exact definition | Ecosystem management definitional debate still pending |
| Information availability | Various boundary proposals with no agreement on spatial or temporal dimensions | Bathymetrically defined boundaries with potential expansions based on biological features |
| | Overall data base lacking | Overall data base lacking |
| | Significant uncertainties about cumulative anthropogenic stress on the ecosystem | Significant uncertainties about cumulative anthropogenic stress on ecosystem |
| Information use | No regional EIS | First regional EIS 1976 |
| | Endangered species (bears, wolves, bald eagles) and other biological issues drive development of ecosystem management idea | Endangered species circumscribe oil development proposals and may change fishery activities |
| | Weak translation of theoretical ecology into practical management | Emerging ecological understanding directed only at fishing |
| Administrative setting | "Protected" core present as national park and wilderness | No "protected" core |
| | Intergovernmental effort via Greater Yellowstone Coordinating Committee (FS and NPS) lacks appropriate organization and mechanics to deal effectively with ecosystem-wide issues in a timely way | Past intergovernmental effort via Biological Task Force (USDI, EPA, and NOAA) but no continuing administrative structure for ecosystem management |
| | Top-down governance misses local jurisdictional controls preferences, and support | Top-down governance of federal lands and waters suffers from lack of local support and cooperation |
| | Short time horizons for management action widely used | Ecosystem management actions and hence time horizons not meaningfully defined |
| Learning capabilities[a] | Plan only within narrow problem constructs (grizzly bears) which are separate and often competing | Plan within separate and often competing constructs (fisheries management vs oil and gas development) |
| | No "complex" learning mechanism institutionalized | No complex learning mechanism institutionalized |

[a]See text for explanation.

In conclusion, managing these two ecosystems as self-sustaining entities faces various obstacles and opportunities. Several of these are reviewed below.

## Challenges to Ecosystem Management

In both systems, the tension between commodity extraction and ecosystem management is significant. Anticipated changes include a shift to a much broader mix of noncommodity and service activities and a long-term spatial–temporal sustainability focus. The six primary challenges to the changes are shown in Table 5 and described below.

### Public's Use of Key Symbols

The ecosystem management debate is highly symbolic (Cawley and Freemuth 1993, Lichtman and Clark 1994, Reading and others 1994). To some constituencies, ecosystem management is improved natural resource management, conservation of biodiversity, and improved government coordination. To other people, it means a threat to traditional livelihoods, a takeover by big government, and a loss of state's rights and local control. Each ecosystem is defined politically by key symbols that link biophysical attributes with human uses that infringe on the natural functioning of the system (Table 5). The kinds of symbols used in the debates very much influence how issues are understood and acted upon. Differing symbols are used by proponents and opponents to ecosystem management. Newly recognized environmental trends and social preferences form the basis for new symbols, and hence policies. Managers must both anticipate and contribute to this discussion, if improvements are to be made (Clark 1992).

For example, in GYE, potential loss of threatened grizzly bears is a major symbol for ecosystem proponents. In GBE the declining groundfishery is the current metaphor for the ecosystem. Because these and other symbols both capture the public's attention and oversimplify the content and importance of the policy debate, they are simultaneously helpful and harmful. They are helpful in that the symbols collapse a complex issue into a convenient shorthand for thought and action. They are harmful in that they oversimplify or misstate the nature and complexity of the issue. As a result, symbols may promote cosmetic, incomplete discussion, weak democratic processes, and limited management responses.

For proponents of ecosystem management, the symbols of ecosystem and biodiversity are widely used, but the public little understands them (S. R. Kellert, personal communication 1993). Studies of the GYE public's knowledge and attitudes about ecosystem management showed that most people recognized the importance of coordinated region-wide management to conserve and protect the ecosystem's natural features, but these same people misunderstood or were worried about the economic and political impacts of ecosystem management (Freemuth and Cawley 1993, Reading and others 1994). Thus, at one level people are for ecosystem management, and simultaneously at another they are opposed to it. A similar dichotomy exists for fishers utilizing GBE. Obviously, long-term ecosystem health is mandatory, yet reduced fishing effort is almost universally condemned by fishers. Participants seem to appreciate the long-term benefits of ecosystem management, but are opting for short-term business as usual.

In conclusion, in both ecosystems, an analysis of symbols in the public policy debate would be very helpful. Identification of the key symbols invoked by proponents as well as opponents of ecosystem management would yield considerable insight into the debates and the human values behind them. It is clear that much more knowledge about the public's use of symbols in the debate is needed as basis for involving them more directly and carrying out democratic processes that will promote ecosystem management. Part of the debate also revolves around the concept of ecosystem management itself. Clarifying its definition will help matters too.

## Ecosystem Management Ambiguities

Ecosystem management is proposed as a solution to current management problems in both ecosystems. Yet many definitional and practical ambiguities remain when ecosystem concepts are viewed as a means to specify remedial administrative actions (Allen and Hoekstra 1992, Moote and others 1994, Grumbine 1994). Ecosystem management is not only a technical concept, but also a concept of land and ocean management. As such, it is both a consequence and a determinant of social attitudes, values, and institutions. Currently, there is widespread disagreement among the participants in each system as to what ecosystem management is in specific terms, how it will solve existing problems, and how it can be effectively applied. For example, consideration of ecological integrity as a concept to inform management awaits development in these systems (Kay 1993). Successful ecosystem managers will need to recognize the definitional ambiguities, capture the opportunities inherent in their setting, and move forward under an open, flexible "learning" approach as described below.

For example, in GYE there appears to be a broad consensus that ecosystem management is desirable although the meaning of the concept is not specified (Clark and others 1991, Clark and Minta, 1994). Each definition was constructed by its author(s) based on a combination of objective knowledge and subjective values (Thompson 1993, Cawley and Freemuth 1993). The consensus is that there are problems, but there is disagreement over what they are, their magnitude, and especially, what needs to be done to solve them. For Clark and Minta (1994), ecosystem management in GYE targets the protection of ecological processes at bioregional scales with attention to several variables including: biophysical characteristics, individual and organizational issues, scientific/management topics, and policy processes. Clark and Harvey (1990), for example, note that improved GYE policy would expand intergovernmental cooperation and increase emphasis on nonconsumptive uses (see also Keiter and Boyce 1991, Glick and others 1992).

In the marine environment, Juda and Burroughs (1990) propose comprehensive ocean management as a means to increase benefits derived from resource and nonresource uses of the ocean consistent with politically determined values. Avoidance of conflict and damage to the environment are assumed to be foremost. Initial approaches toward marine ecosystem management may be inferred in the transition of fisheries management from harvest limits on individual species to recognizing interactions among all species while some are under high levels of fishing pressure. The concept of large marine ecosystems (LME) embraces this shift and focuses on biogeographic regions. LME's possess unique hydrographic regimes, submarine topography, and trophically linked populations (Sherman 1986a, p. 3). Proposed objectives for LME management include long-term sustainability of primarily commercial species, manipulation to improve higher value stocks, and maximizing economic benefits to the fishers (Alexander 1993).

The entry of offshore oil drilling to GBE in 1973 expanded ecosystem approaches to nonrenewable resources. Interaction between oil and fish was poorly understood and presumed dire at the time. One extractive use threatened another potentially sustainable one. Ecosystem management in theory could resolve such a trade-off problem. This opportunity has not been realized yet.

In conclusion, the concept of ecosystem management has been invoked for both regions but details and intent vary. In GYE, noncommodity and service values receive greater attention than they do in GBE, where the concept focuses on multiple instead of single species affected by the commercial fishery. For both, conversion of the ecosystem management idea to concrete management action is contemplated but far from accomplished. Improving scientific information could help advancement.

### Information Availability

Adoption of ecosystem management in concept raises a number of questions that stretch the current capabilities of scientific understanding (Clark 1993). Successful ecosystem managers will have to tailor current management programs respecting these constraints, while at the same time encouraging research necessary to expand relevant knowledge. A procedurally rational, or "learning" approach is to carry out small-scale "experiments" and to learn from them (Primm and Clark 1995). In contrast, the traditional approach requires a relatively high degree of preexisting knowledge before moving forward. The learning approach promotes advancement and learning at the same time.

The idea of adjusting human activity to ecosystem requirements implies that boundaries to the systems are known (Slocombe 1993), that cumulative impacts can be understood, and that a variety of other issues can be resolved to initiate adaptive management and organizational learning (Table 5). In these settings, complete scientific descriptions, while desirable, are frequently precluded because postponing decisions often can be more damaging than making them with incomplete scientific information.

In GYE, there are a host of conflicting definitions about the size and location of the ecosystem (Clark and Minta 1994). Federal government documents frequently show maps of the area, but do not delineate the ecosystem boundary for management. Some maps show an area about 77,000 sq km (Greater Yellowstone Coordinating Committee 1987, 1990), whereas elsewhere in these documents the area is shown as 47,000 sq km. Greater Yellowstone Coalition documents show an area about 73,000 sq km (Glick and others 1992). Here (Figure 1) we have used a 77,000-sq-km area (see Clark and Minta 1994, p. 15). In conclusion, definitions of size and location of GYE vary. This matter is not likely to be easily resolved soon, but sufficient agreement exists about it to experiment with ecosystem management.

In GBE, boundaries were initially defined in the early part of this century. Bigelow (1927) used bathymetry to establish a morphologic feature of about 25,900 sq km. Current evidence supports contentions that morphologic and biologic boundaries may be coincident. A recent definition shows the area inside the 100-m contour and extending east from 69°W at the Great South Channel (Figure 1) for a total area of 33,700 sq km (Backus and Bourne 1987b). In addition to exhibiting distinctive phytoplankton communities, GBE also has rates of production within the diatom-dominated community that are an order of magnitude richer than adjacent water masses at certain times of the year (Cura 1987).

Three other definitions of GBE have been proposed. First, Sherman (1986b, p. 212, Sherman and others 1988, p. 280) includes GBE in the larger Northeast Shelf ecosystem that extends from Cape Hatteras to the Northeast Peak of Georges Bank and north into the Gulf of Maine. A subunit of this larger area is equivalent to GBE as used here. Second, the Council on the Marine Environment (CME) has identified the Gulf of Maine, Georges Bank, and adjacent waters northeast and southwest as a logical unit for planning (Wiggin and Mooers 1992). Third, the US and Canadian Man and the Biosphere programs have targeted Georges Bank as a site for a possible biosphere reserve.

In addition to boundary issues, the systems differ in their integration of existing data sets to solve regional problems. An ideal overall data base would include a basic description of habitat, biomass, species, and populations along with data base or geographical systems to manipulate information. In GYE (Clark and Minta 1994) and GBE (Wiggin and Mooers 1992), data base management systems are being contemplated or established, but comprehensiveness and versatility remain as major challenges.

Lack of adequate data about these systems is most apparent when cumulative impacts are considered. These synergistic effects on the environment of incremental past, present, and future actions (CEQ 1978) are a pervasive form of environmental alteration that is most difficult to portray precisely. However, causes for cumulative impacts in GYE are evident from inspection of Tables 2 and 3, which show timber activity, wildlife harvest, mineral extraction, resident population growth, and tourist visitation increases. Relating individual causes to specific effects is extremely difficult, as is summing the impacts, but the plight of some key species in GYE (Table 1) is strong evidence to consider.

In GBE there is a lack of explicit analytical protocols for cumulative impact assessment and the science to inform them. An approach that has been used for cumulative impact assessment includes understanding what is to be protected, over what geographic region, and from which hazards (Hunsacker 1990). Next, the nature of the modification and the likelihood of it happening are considered. In GBE neither of the major perturbations, oil drilling or commercial fishing, are well enough understood to complete this process for changes in fishing or oil development.

In conclusion, two distinctly different thresholds of information availability may be considered for determining boundaries or assessing cumulative impacts for GYE and GBE. One is a scientifically unequivocal understanding that is not currently possible for either system. Alternatively, a sufficient scientific understanding to start ecosystem management is available for both systems. Initiating ecosystem management places requirements on information use and administration.

## Information Use

Information affects attitudes that people hold about their relationship to the environment and guides subsequent actions (Clark 1993). The kinds and quality of information available determine if ecosystem management is possible and how it will be carried out. Successful ecosystem managers will be particularly adept at handling information that suggests changes to previous management practices. Information may be ecological, social, economic, organizational, or political.

The grizzly bear case illustrates some of the complex issues that confront policy and management in GYE (Clark and Minta 1994). Reliable population data were difficult to obtain for the most recent grizzly bear recovery plan due to forest cover, small sample size, and for other reasons (D. Mattson, personal communication 1994). The result is a grizzly bear recovery plan under the Endangered Species Act that remains uncertain and highly contentious (Clark and Minta 1994). Population numbers and other scientific issues are seldom clear; concise statements are sometimes lacking; and solutions to management problems are not assured.

Analogous uncertainties beset management of oil and fish throughout GBE. Consistent with requirements of the environmental impact statement process, predictions about interactions of oil, fish, and other uses were attempted (Burroughs 1981). A recent statement projects impacts on plankton, benthos, fish, mammals, and turtles (USDI 1988). Endangered or threatened species (sea turtles and whales) have received more attention and are believed to be subject to low or, in the case of the right whale, moderate impacts (USDI 1988, p. IV-85). Interaction with the fishery through drill mud and oil contamination is viewed to be very low (USDI 1988, p. IV-154). These government findings have been questioned by scientists and environmental groups. In GBE cross-sectoral interactions surfaced, but the impact statements have not laid to rest a plethora of questions.

In fisheries management, a single sector problem, information has been used to set harvest levels. Beginning in 1964 with annual groundfish surveys by the Bureau of Commercial Fisheries, temporal variability on Georges Bank received attention (Wright 1987). That understanding has developed into a series of increasingly detailed quantitative models in the last decade that ultimately considered interactions among species (Fogarty 1987). Target species, principally groundfish, declined over the period (NMFS 1993). The groundfishery collapse has finally forced action. In 1993, the federally chartered fishery management council responded to litigation about overfishing and proposed a 50% reduction in fishing effort over several years (New England Fishery Management Council 1993). However, the authors concede that it is "almost impossible" to predict the consequences (New England Fishery Management Council DSEIS 1993, p. 280). By 1995, large areas of GYE were closed to fishing for at least several months. Elements of information use in an ecosystem management context are present here, albeit initially driven by court order. Laudably, restoration of stocks, a biological element of ecosystem management, is being pursued even in the face of scientific uncertainty. This requires substantial reduction in fishing effort, which displaces people. Solutions to that dilemma are still being devised.

In conclusion, agencies have been using various information to restore grizzly bear and are doing so with groundfish populations. The demand for improved use of high-quality information is driven by interests external to the agencies. That situation places great significance on administrative decision processes.

## Administrative Setting

The administrative setting for GYE and GBE may be characterized by duties prescribed, processes utilized, and the performance styles (Table 5). The former considers the extent to which the region is deemed to require ecosystem management. Processes vary from open, democratic ones to closed, autocratic ones. Style of performance emphasizes whether and how coordination and planning are achieved, at what time scales, and with what level of assurance and evaluation. Successful ecosystem managers will reshape their administrative settings through promotion of the segments of their charters that favor the concept. Organizational arrangements may need to be changed too.

Several factors affect administration of ecosystem management. Establishment of a core or protected area defines the objectives of the administrative system. For GYE, establishment of Yellowstone National Park in 1872 and subsequently Grand Teton National Park in 1925 made clear that special values were attached to the region. More recently, ecosystem management began with recognition that if the threatened grizzly bear population was to be conserved, a large regional "core" had to be managed (Craighead 1979, Clark and Minta 1994). In GBE over one century later, the attempt to establish a core area or sanctuary under the Marine Protection Research and Sanctuaries Act failed (Finn 1982). At the time of the first sanctuary paper (NOAA 1979), regulation of GBE resources was possible. After the sanctuary proposal failed, predictable intergovernmental discord ensued (Hildreth 1986).

Management with or without a protected core requires cooperation among at least 28 governmental entities in GYE and some 13 in GBE (Table 4). An attempt to bridge some of these diverse governmental units is evident in the "Framework-Vision" document for GYE (Lichtman and Clark 1994, Primm and Clark 1995). Through it the Park Service and the Forest Service attempted to identify the problem and solutions for coordinated regional management in GYE. In GBE after the sanctuary proposal failed and oil leasing had occurred, the National Oceanic and Atmospheric Administration and the Department of the Interior, with Environmental Protection Agency participation, formed a biological task force (BTF) to diffuse conflict (Leschine and Lahey 1987). It was created to advise on the protection of habitats and to design environmental studies primarily for benthic habitats.

Both "Framework-Vision" and BTF were short-lived and controversial. Neither moved the conflicting governmental forces toward significant agreement. The interests of the players were subordinated to other issues. In GYE coordination dominated the discussion, and in GBE monitoring program details assumed prominence. While these palliatives may buy managers time, they do not provide durable solutions because they avoid addressing the underlying value conflicts.

Furthermore the "Framework-Vision" and BTF exercises embody a subtle but predominant view that new management initiatives are up to the federal government to define and impose in a top-down manner. In GYE and GBE, federal officials established the forum, channeled the discussion, and adopted the often conflicting viewpoints, extractive uses versus noncommodity interests. State and local officials were at best peripherally involved, and stakeholders whose interests were not parallel with dominant federal agencies were left out of the discussions. In GYE Clark and Minta (1994) and Primm and Clark (1995) show that an incomplete involvement of affected constituencies hinders full exploration of ecosystem management and exemplifies problems that arise when the top-down approach does not engage legitimate local concerns.

In GBE local and state interests in opposition to federal oil leasing also grew and blossomed. Ultimately, local and state interests prevailed through provisions requiring federal consistency with some state wishes and through congressionally imposed moratoria on oil leasing. Missing from both of these examples is a conscious proactive attempt to involve state and local interests in designing a future for themselves. For ecosystem management to advance, state and local interests will have to be given a much bigger share of responsibility than is currently the case in the top-down approach.

In addition to local involvement, the administrative efforts require time horizons that match the biological variability in the system. In GYE, NPS planning is relatively short-term. For example, planning is influenced by a four-year budgetary view and park plans speak of five-year timelines. The Forest Service requires each forest to look ahead at least 50 years and revise plans every 10–15 years. In GBE the New England Fisheries Management Council attempted quota-based management of the fishery in a series of plans that are revised on a time interval that is usually less than every two years. Offshore oil, when active in the region, was subject to decade or shorter time horizons. Other government and nongovernmental organizations and interests manage on varying, but usually short-term timelines. Contrast this with scales of three to ten decades for population fluctuations (Steele 1985). Conservation biologists in universities and NGOs talk of species' viability planning in 100- to 200-year terms (Lindenmayer and others 1993). Administrative time horizons for management attention in GYE or GBE do not match biological scales.

In conclusion, for administrative structures to permit or enhance ecosystem management opportunities, a protected core, cooperation among levels of government and across agencies, local involvement, and time horizons for planning that consider biological phenomena are all required. Furthermore, learning new administrative behavior is vital to accomplish these objectives.

### Organizational Learning Capabilities

A central dilemma for GYE and GBE management is changing expectations about what the organizations are to accomplish. For other agencies, such as the Corps of Engineers, similar challenges have been extremely difficult (Burroughs 1991). The definition of appropriate resource use in the two systems is changing to incorporate new issues, and yet the organizations responsible for managing them appear to be relatively inflexible. Clearly, agencies have to learn new behaviors, and there are two means of doing so (Argyris and Schön 1978). In single-loop or simple learning, organizational errors are corrected so as to maintain the central features of the organization. In double-loop, or complex learning, incompatible organizational behaviors are detected and corrected by restructuring norms, strategies, and assumptions. Generally, government bureaus single-loop learn, but are poor at double-loop learning (Senge 1990). Ecosystem management introduces new publics and new ways of thinking and acting. Successful managers must move toward restructurings and new processes that advance changes embodied in ecosystem management. Particularly important is the extent to which managers can translate problems into new organizational approaches.

Government agencies operating in GYE and GBE have pursued single-loop learning approaches, which has prevented them from fundamentally questioning their own present values, assumptions, and structural arrangements. In GYE this is exemplified by the grizzly bear plan (Primm, personal communication). To comply with the Endangered Species Act, the Fish and Wildlife Service prepared a draft recovery plan in 1990 and a revised draft in 1992 (Clark and Minta 1994). In the second version, promotion of isolated population units and failure to address wildland habitat destruction continued to attract opposition and legal challenges from conservationists. The basic assumptions deeply embedded in agency outlooks and the planning process did not change from first to second drafts.

In GBE the sequences of groundfishery plans and oil and gas leasing plans are examples of the tenacity and permanence of fixed agency values. Through successive plans in each of these sectors the extractive use remained predominant. Even in the face of strong external influences to do so, there is little evidence that double-loop learning is taking place in GYE and GBE. Managers may need the assistance of outside organizational change specialists for double-loop learning to occur.

In conclusion, for agencies responsible for GYE and GBE, double-loop learning is a way out of their current dilemmas. It requires self-examination, risk taking, and change by agencies and individuals. Future pressures may well bring about some form of ecosystem management, but we find little is being done to prepare the agencies for the learning tasks ahead.

## Conclusion

Ecosystem management links changing scientific understanding of a region with evolving human values and needs as a basis for making decisions. The amount of extractive resource use in GYE and GBE that is appropriate is in dispute. Such use often has significant long-term costs to the environment but potential short-term benefits to current users. For both systems, the trend is toward nonconsumptive uses, which leads to controversy as it requires a change in established routines.

During the 1970s ecosystem management gained momentum through consideration of grizzly bear recovery in GYE and through questions about overfishing and oil–fish interactions in GBE. Since then, other resource issues have been considered in an ecosystem management context. GYE and GBE are large, contain threatened and endangered species, have similar administrative settings, and confront extractive use patterns that jeopardize their long-term biological integrity and sustainability of related human economic activity. Similarities between the two areas are paralleled by common challenges to elucidation and implementation of ecosystem management.

These challenges exist because, in spite of growing rhetoric about the viability of ecosystem management, there is little shared insight, agreement, and commitment among the varied interests about basic problems. These ongoing debates are highlighted through six areas. First, the symbolic value of the grizzly bear or the groundfishery simultaneously attracts interest and compresses detail. Thus, the democratic process must present specific information in depth beyond that available now. Second, refining the ecosystem management concept itself requires attention. Ecosystem management is generally viewed as helpful but details on intergovernmental cooperation, cross-sectoral management, and management of nonconsumptive use remain problematic. Third, information about boundaries, cumulative impacts, and other topics, while far from complete, can be quite influential when a fourth area, information use, is addressed. A combination of necessity for present action and uncertainties about consequences means that willingness to experiment and adapt management solutions is paramount. Fifth, administrative strategies must seek more proactive approaches to intergovernmental management that emphasize appropriate time horizons and significant bottom-up and outside involvement. Finally, to address this and other problems, open double-loop or complex learning processes that encourage reconsideration of agency values, procedures, and structures must be pursued.

Many ongoing activities such as lawsuits or organizational learning initiatives can resolve some of these challenges and force ecosystem management higher on the public agenda. These activities include: scientific advances, nongovernmental organization agendas, environmental crises, and public demands for change. At present, Endangered Species Act considerations, overfishing, and oil development moratoria are central to public debates about the future of these two systems.

Our greatest concern is that some incremental management change will occur, but that it will be minimal, technical, and merely couched in a rhetoric of ecosystem management. If this happens, current significant opportunities for new natural resource management philosophies and applications will be lost and crisis only delayed, not avoided. The future of real, as opposed to rhetorical, ecosystem management in GYE and GBE will be measured by the extent to which it becomes operational and practical. Some people might claim that discussion surrounding grizzly bear recovery or groundfish overharvest are examples of a growing acceptance that ecosystem considerations have on management. Yet far more specific actions are required if the concept is to become a practical reality. For example, the regular use of ecosystem management in cross-sectoral decisions that explicitly force consideration of consumptive versus nonconsumptive uses would be a major step. Future crises that could trigger such a consideration are the possibility of oil development or growing cumulative effects in either GYE or GBE.

Finally, ecosystem management will be central to continuing discussions about natural resource issues in these and other regions. Although ecosystem management is not now operational in either of these systems, signs for its eventual adoption remain fairly bright. Scientific developments, policy examinations such as this one, tentative governance responses, and other actions constitute the base for bolder future applications. Human pressure on these areas will continue to mount, and with appropriate preparation, ecosystem management concepts can furnish an increasingly attractive solution to foreseeable problems and conflicts.

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