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Contrasting recreational and commercial fishing: Searching for common issues to promote unified conservation of fisheries resources and aquatic environments

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ABSTRACT

Commercial fishing has repeatedly been identified as a major causal factor for global declines in fish stocks. Recently, recreational fisheries have also been considered as having the potential to contribute to fisheries declines. Here, we take a global focus, contrasting the characteristics of commercial and recreational fisheries relevant to conservation and sustainability of exploited fishes in both marine and freshwater environments. We provide evidence to support our assertion that the same issues that have led to global fisheries concerns regarding commercial fishing can have equivalent, and in some cases, magnified effects in recreational fisheries. Contrasts revealed that the issues of bycatch and catch-and-release, fisheries-induced selection, trophic changes, habitat degradation, gear technology, fishing effort, and production regimes are remarkably similar among fishery sectors. In recognition of this conclusion, we present a new vision for recreational fishing that positions it on the same scale and urgency as commercial fisheries. Efforts to manage and conserve fisheries must recognise that issues and threats are similar in these fundamentally and philosophically different fisheries, as may be the solutions. Failure to recognise the similarities will further polarise these sectors and retard efforts to conserve aquatic resources. Fishing activity of any kind, whether commercial or recreational, has the potential to affect negatively fish and fisheries, as well as aquatic environments.

1. Introduction

Commercial and recreational fishing are both important sources of protein, and contribute substantial economic benefits to local and national economies (e.g., Arlinghaus et al., 2002; Cowx, 2002; Hilborn et al., 2003). Recreational fisheries are usually considered those where fishing is conducted by individuals for sport and leisure, with a possible secondary objective of catching fish for personal consumption (FAO, 1997; Pitcher and Hollingworth, 2002). Sometimes this definition is stretched to include selling surplus catch to offset costs (Cowx, 2002). Commercial fishing on the other hand is conducted specifically to capture fish products for sale (Smith, 2002). In recent years, commercial fisheries have been repeatedly identified as the primary causal agents in the decline of fish stocks globally (Botsford et al., 1997; Smith, 2002; Christensen et al., 2003; Hilborn et al., 2003; Pauly et al., 2003). However, the notion that recreational fisheries

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can also result in declines in fish stocks has been given less attention.

Post et al. (2002) stated that there were few documented instances of declines in fish stocks attributed to recreational fisheries. However, they identified four high profile fisheries (lake trout *Salvelinus namaycush*, walleye *Sander vitreus*, northern pike *Esox lucius*, and rainbow trout *Oncorhynchus mykiss*) in Canada that showed evidence of dramatic declines attributable to recreational fisheries. These declines were largely unnoticed by fisheries managers, a characteristic that may be widespread in recreational fisheries. The authors concluded that recreational and commercial fisheries are not inherently different, with both having the potential to affect fisheries negatively. In Australia, McPhee et al. (2002) concluded that without changes to management and monitoring of recreational fisheries, they may not be sustainable in the long term. More recently, Coleman et al. (2004) suggested that fish populations had declined in several coastal regions of the US and that recreational fisheries (in addition to commercial fisheries) were contributing to those declines.

Here, we expand beyond Post et al.'s (2002) focus on complex angler behaviour and the system level consequences on recreational fisheries they explicated for Canada, McPhee et al.'s (2002) examination of the ecological effects of angling in Australia, and Coleman et al.'s (2004) focus on declines in US marine recreational fishes. Our focus is broader (as per the recommendations of Arlinghaus and Cooke, 2005), explicitly contrasting the characteristics of commercial and recreational fisheries, highlighting global examples from both marine and freshwater fisheries. At present, there are no examples of such contrasts between recreational and commercial fisheries. The only comparative treatments that we are aware of focus on the different considerations of each fishery sector when fisheries are viewed as common-pool resources (See Policansky, 2001), or as context for the presentation of global recreational fishing estimates (See Cooke and Cowx, 2004). Also, our purpose is not to question the value or ethics of recreational angling; both of these issues are dealt with at length elsewhere (Arlinghaus et al., 2002; Cowx, 2002; Pitcher and Hollingworth, 2002). Instead, our goal is to elucidate the potential role of recreational fishing in the decline of global fisheries. It is our assertion that some of the same issues that have lead to fisheries problems worldwide due to commercial fishing can have equivalent, and in some cases, magnified effects in recreational fisheries.

2. Recreational and commercial fishing contrasts and comparisons

2.1. Scale and diversity

Global trends in marine and freshwater fisheries catches are generally on the increase (Fig. 1). However, these increases mask the true situation. The main commercial fisheries are subject to intense exploitation and catch-per-unit-effort in many fisheries is declining (e.g., Botsford et al., 1997). Consequently, new fisheries, often targeting deep-water, slow-growing species (Merrett and Haedrich, 1997), species once not considered commercially important, or those occupying a lower trophic level, are being sought (e.g., Pauly et al., 1998).

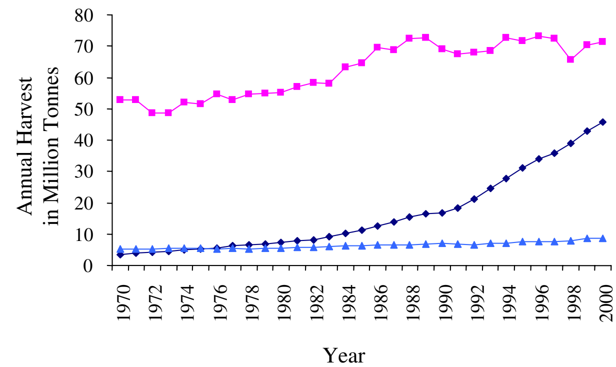

Fig. 1 – Trends in catches from marine and inland fisheries (■– total marine harvest; ◊– aquaculture production; ▲– inland fisheries harvest) (based on FAO, 2002). Note that this excludes recreational harvest.

The FAO (2002) estimated that ~47% of fish stocks are exploited to their maximum sustainable threshold. A further 18% are estimated to be over-exploited, and 10% are depleted. Although there are assumptions, limitations, and circumspection about these data, the message is clear – commercial fishing can deplete fisheries resources. Whilst opportunities remain to exploit some stocks, commercial catches are still declining despite increased effort (Reynolds et al., 2001). The proliferation of aquaculture is also a worrying trend and is potentially unsustainable. Aquaculture relies heavily of feeds formulated from fish protein sources and this puts further pressure on the already dwindling wild stocks (Naylor et al., 2000).

Despite the perception that recreational fishing is a benign activity, participation world wide is vast (Table 1), and appears to be increasing in most jurisdictions, e.g., in Australia (Australian Department for Agriculture Fisheries and Forestry, 2003) and Europe (Arlinghaus et al., 2002). Even in locations where per capita participation has remained stable or fallen, such as North America, the increase in population size has resulted in higher absolute levels of participation (International Association of Fish and Wildlife Agencies, 1999). Globally, recreational fishing is now highly developed and pursued by large numbers of people, primarily for pleasure, but also for income generation and to supplement food supply (Table 1). The fundamental principles of recreational fisheries are high effort and low catchability (Pereira and Hansen, 2003) whereas in commercial fisheries they are high catchability and low effort. This is relevant not only to understanding the characteristics of the fisheries but also to potential management and conservation strategies.

Although commercial fisheries harvest more fish than the recreational sector on a global basis, the converse can also be observed or recreational catch can contribute significantly to the overall catch from a particular fishery. For example, during the 1990s the Atlantic States Marine Fisheries Council reported that recreational harvest rates for striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), sea bass (Serranidae), dolphinfish (*Coryphaena hippurus*), redfish (*Sebastes marinus*), and tautog (*Tautoga onitis*) off of the eastern coast of the United States exceeded those of the commercial fisheries (Beal et al., 1998). This pattern is also evident on a broader scale

Table 1 – Recreational fishing statistics highlighting the scope, magnitude and importance of recreational fishing

Location	Recreational fishing statistics
Regional statistics	
Europe	• Amongst 22 European countries there are an estimated 21.3 million anglers, with an estimated expenditure on recreational fishing in 10 of the countries in Western Europe where data were available, in excess of $US 10 billion (Cowx, 1998b)
United States	• In, 1996, 18% of the US population 16 years of age and older, i.e., 35 million persons, spent 514 million angler-days in fresh waters, expending $US 38.0 billion (US Fish and Wildlife Service, 1997).
	• In 2001, anglers in US marine waters of the Atlantic, Gulf, and Pacific coasts made an estimated 84.3 million fishing trips and captured more than 440 million fish of which 187 million were estimated to have been retained (US Department of Commerce, 2002).
	• In the United States, only 12% of the entire population have never participated in recreational angling (US Department of Commerce, 2002).
Canada	• In Canada, 3.6 million anglers spent 47.9 million days and caught over 232.8 million fishes while spending $US 6.7 billion of which $US 4.7 was wholly attributed to the sport in, 2000. Of these fishes some 84.6 million were retained (Department of Fisheries and Oceans, 2003)
Australia	• In 2002 an estimated 3.4 million anglers in Australia contributed to 20.6 million angler days and caught in excess of 70 million finfish, while spending in excess of $US 1.3 billion (Australian Department for Agriculture Fisheries and Forestry, 2003)
Global statistics	• In 1995 it was estimated that total recreational catch worldwide is of the order of 2 million t, and represents an important source of animal protein in many developing countries (Coates, 1995).
	• In 2004 it was estimated (using extrapolations from North American fisheries statistics) that total annual recreational catch worldwide may be in the order of 47 billion fish per year of which roughly 2/3rds are released (Cooke and Cowx, 2004)
	• It was estimated that freshwater recreational fishing effort represents roughly half of the food fishing effort from a global perspective relative to all fishing effort (e.g., marine recreational and commercial fishing effort; Kapetsky, 2001).

Statistics are presented first for several regions and then on a more global basis. Recreational fishing surveys are conducted by only a few countries so recreational fisheries statistics tend to emphasize trends in Europe, Australia, and North America. Data presented are from the most recent fisheries surveys wherever possible.

within the United States marine fisheries (United States Department of Commerce, 2002; Fig. 2). In the western Pacific Ocean, including the waters surrounding Hawaii, American Samoa, Guam, and the Northern Mariana Islands, overall recreational fish harvest was estimated to be as high as 36% (Western Pacific Fishery Management Council, 2002). In an area of the Caribbean around Trinidad, recreational fisheries accounted for 11% of the catch (Mike and Cowx, 1996).

In the commercial sector, the development of new fisheries is typically characterised by an initial fishing-down phase. This involves harvesting at rates that do not permit the maintenance of a viable population (Hilborn and Walters, 1992). Declines may not be noticed until well after the event because fishers are mobile and can relocate to other areas to maintain their catch rates. In recreational fisheries, anglers also respond to changes in catch rates by shifting location, presumably to maintain or increase catch rates, as observed for rainbow trout in British Columbia (Cox et al., 2002). Thus, to some degree, recreational fisheries are self-regulating and may obscure potential declines (Pereira and Hansen, 2003). However, it should be recognised that recreational fisheries can operate in areas that are unprofitable for, or inaccessible to, commercial fisheries, e.g., small systems or complex habitats. Anglers in many countries are now turning to heavily stocked lake fisheries to maintain catches (North, 2001) or are moving further afield, often to sport fisheries in more remote locales such as the tropics (Cowx, 2002), because returns from natural systems do not satisfy their angling needs.

In some regions it is difficult to determine whether exploitation from commercial or recreational fisheries is responsible for changes in fish population parameters (e.g., population structure and abundance). For example, in Australia, age structures differed among exploited and unexploited systems, but it was unclear as to the relative contribution of each fishing sector to the alterations (Griffin, 1988). In some instances, recreational fishing has negatively influenced fish populations (see Post et al., 2002). In central Spain, riverine brown trout (*Salmo trutta*) populations have been impacted by angling, causing decreases in density, biomass, egg production, and breeding stock relative to unexploited rivers (Almodóvar et al., 2002; Almodóvar and Nicola, 2004). Similar findings were reported in salmonid streams in Colorado (Anderson and Nehring, 1984). There are many instances where commercial fisheries have been restricted due to concerns about population structure and abundance, and recreational fisheries have expanded. For example, during the 1990s, red drum (*Sciaenops ocellatus*) became popular table fare and when declining stocks were observed in the Gulf of Mexico, commercial fisheries were curtailed, but the recreational fishery expanded (Gulf of Mexico Fishery Management Council, 1999).

The increased application of aquatic protected areas has also provided opportunity to assess the consequences of different fisheries sectors on fish populations and communities. For example, in Australia, recreational fishing outside a marine park resulted in reduced biomass and community composition (driven largely by the lethrinid fishes) relative to protected areas within the park (Westera et al., 2003). In California, protected areas had the highest density and best size structure (i.e., mix of all age classes) of rockfish (*Sebastes* spp.),

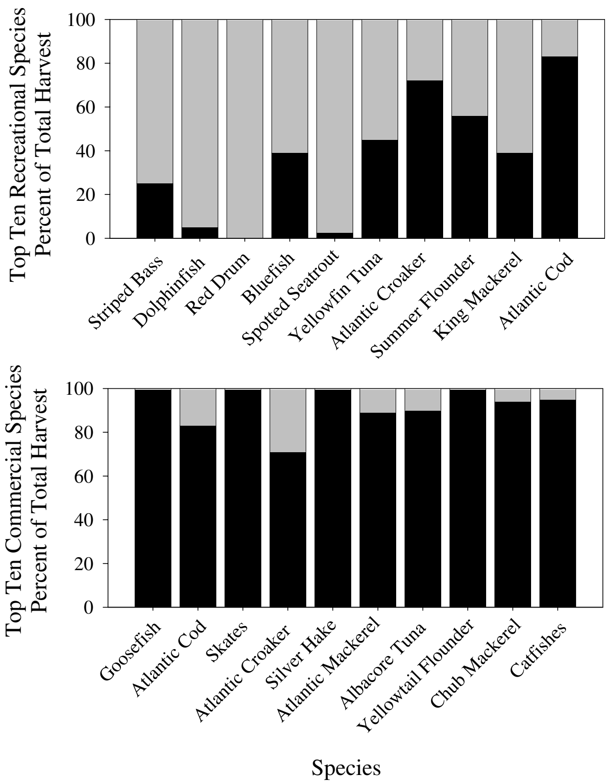

Fig. 2 – Comparisons between the top 10 marine species in order of abundance by mass for US recreational harvests (top panel) and commercial landings (bottom panel). On each panel, the black indicated the commercial component and the grey the recreational component. Additional details on the visualised data are available from U.S. Department of Commerce (2002). The figures illustrate the relative contribution of both fishery sectors to total harvest.

whereas in recreational fishing areas, densities were lowest and size structure was poor (Schroeder and Love, 2002). Also, for 16 of 17 near-shore stocks, harvest by recreational fishing exceeded that of the commercial fishery, including for two species recognised as imperiled (Schroeder and Love, 2002). Impacts of recreational fishing activities (including spears and rod-and-reel angling) have also been reported in South Africa (Buxton and Clarke, 1991), Florida (Sluka and Sullivan, 1998), the Mediterranean (Jouvenel and Pollard, 2001), and Australia (Young et al., 1999).

There are also many instances of allegations by different fishing sectors that others are responsible for observed changes in populations and communities. For example, there is a long-standing perception that commercial Atlantic salmon (*Salmo salar*) coastal fisheries are responsible for reduced angler catches, resulting in the buyout of many coastal net fisheries (Chase, 2003). However, there is no empirical evidence to show this strategy has improved angler catches. It is more likely that distant water commercial fisheries for Atlantic salmon and poor recruitment are the root cause of the decline in adult salmon stocks in rivers (Mills, 1993, 2000). In the Sydney estuary, Australia, recreational anglers alleged that commercial fisheries were responsible for changes in fish abundance, but no long term change in abundance was observed, and harvest rates were ~50% higher for recreational fisheries than commercial fisheries (Henry, 1984).

Collectively, these examples suggest that we must reject the assumption that recreational fishing impacts are negligible or less than that of commercial fisheries (sensu Schroeder and Love, 2002). Note, in this context, if the concept of recreational fisheries contributing to the decline in fish stocks is considered a real problem, more examples, perhaps on a greater scale, are likely to be found. Thus, accepting the notion that any fishery has the potential to produce negative consequences, and that both recreational and commercial fisheries can contribute to fishery declines, may help to foster co-management strategies that encourage more holistic and inclusive conservation strategies.

2.2. *Discards and bycatch*

The problems of injury and mortality caused by the release of bycatch and discards have become an important issue in commercial fisheries (Greenstreet and Rodgers, 2000). Most highly regulated fisheries are managed using total allowable catch, quota systems and minimum mesh sizes, which result in excessive catch and under-sized individuals being dumped, with few surviving the experience. It was estimated that between 17.9 and 39.5 million t of fish are discarded each year in commercial fisheries (Alverson et al., 1994). Considerable efforts have focused on understanding the factors that result in mortality, and attempts to devise methods and gears for reducing bycatch and bycatch mortality (Van Marlen, 2000).

Recreational fishing has a parallel to bycatch in that a variable proportion of fish are released because they are not the intended target, or are undesirable, or are illegal sizes. Voluntary catch-and-release behaviours where anglers release fish because it is the *modus operandi*, or for ethical, conservation, or sporting reasons (Policansky, 2002), are also characteristic of recreational fisheries, which may contribute to the view that recreational fishing is benign relative to commercial fishing. In some fisheries, voluntary release rates can reach near 100%, such as the coarse fisheries of Western Europe (Cowx, 1995) or elitist resources such as bonefish (Policansky, 2002). Overall, it is believed that approximately 60% of fish captured by recreational anglers are released (e.g., United States Department of Commerce, 2002; Department of Fisheries and Oceans, 2003). However, an unknown proportion of fish captured by anglers and released under that assumption that they will survive, die post release (Cooke et al., 2002a).

The magnitude of the mortality for catch-and-release can be extensive when viewed in actual numbers. For example, in striped bass (*Morone saxatilis*) fisheries on the eastern seaboard of North America, >12.5 million fish are landed, of which over 90% are released (Millard et al., 2003). Estimates of catch-and-release mortality for this fishery are around 28% (95% confidence interval 17–44%) or approximately 3.2 million striped bass per year (Millard et al., 2003). These mortality estimates do not incorporate reduced productivity associated with sublethal growth impairments or fitness impacts. Indeed, knowledge of the sublethal physiological effects and their influences on fitness is poor (Cooke et al., 2002a), and represents additional means by which recreational fishing can indirectly alter fisheries. In addition, mortality rates associated with hooking of fish during angling are highly variable both within and among species and are influenced by factors such as gear type, water temperature, and handling (Muoneke and Childress, 1994; Cooke and Suski, 2005). Mortality rates in the almost strictly catch-and-release fishery for bonefish (*Albula* spp.) in the Bahamas can exceed 40% due to post-release predation by sharks (Cooke and Philipp, 2004). Even very low levels of catch-and-release mortality (i.e., 1–5%) could have devastating effects on populations of long-lived species with low reproductive rates, such as giant sea bass (*Stereolepis gigas*; see Schroeder and Love, 2002).

There is evidence of similarities between the effects of catch-and-release angling and bycatch discards. Common stresses identified for both recreational and commercial fisheries include handling and air exposure (commercial, Alverson, 1998; Davis, 2002, recreational, Cooke and Suski, 2005). Furthermore, considerable external physical damage can occur from gear in both commercial (Chopin and Arimoto, 1995) and recreational (e.g., Raat et al., 1997; Barthel et al., 2003) fisheries. Since both fisheries sectors aim to return more fish alive after capture (commercial, Hall et al., 2000; recreational, Cooke and Suski, 2005), progress could be gained from common research programs. At present, however, only one study discussed the applicability of their results on capture and handling mortality in both commercial and recreational fisheries (Patterson et al., 2000). Knowledge of catch-and-release is imperfect, as is commercial bycatch mortality reduction. We contend that these issues are strongly coupled, as should be the solutions. The reasons for releasing fish may differ by fishery sector, but the factors that contribute to discard mortality do not.

2.3. *Fisheries induced selection*

Several syntheses (e.g., Policansky, 1993; Law, 2000; Heino and Godo, 2002) have characterised the selection pressures induced by fishing, although they have focused on the marine commercial fisheries. These studies identified that the direct effects resulting from elevated mortality and indirect effects on system properties and function can result in fisheries-induced changes, suggesting that fishing does have an "evolutionary" effect. Although viewed with circumspection for many years, as long ago as the 1950s (e.g., Miller, 1957) scientists recognised that commercial fishing may result in genetic changes in fish populations; a now accepted phenomena (Hauser et al., 2002). In addition to genetic changes, the phenotypic correlates associated with selection can also result in deleterious changes in population characteristics, such as life-history traits, behaviour, and mortality (Policansky, 1993; Law, 2000; Heino and Godo, 2002).

Selection pressures documented for marine commercial fisheries may also occur in recreational fisheries. Nuhfer and Alexander (1994) suggested that different levels of angler exploitation may have altered the genetic potential for growth and catchability of wild brook trout (*Salvelinus fontinalis*) strains in Michigan. Angling tended to select for larger, faster growing individuals, and the removal of these fish resulted in the production of fewer, larger, fast growing offspring. Garrett (2002) suggested that angling may select for more aggressive individuals or dominant individuals that have higher fitness than less vulnerable conspecifics. Cooke (2002) found that largemouth bass (*Micropterus salmoides*) selected for angling vulnerability provided more intense and vigilant parental care than those selected for reduced angling vulnerability. In addition, individuals selected for high angling vulnerability had higher metabolic rates than those selected for low angling vulnerability. Thus, in recreational fisheries that target bass, the individuals most vulnerable to angling are those that have the potential to contribute the most offspring to future generations (Cooke, 2002). By simulating the harvest from a non-specific fishery (i.e., not intended to be specific to the commercial or recreational sector), Conover and Munch (2002) concluded that, over four generations, removal of large individuals (a common activity in both recreational and commercial fisheries) selected for slow growth of the remaining individuals.

Documentation of recreational fisheries-induced selection in the wild has been retarded due to an absence of long-term monitoring and the lack of knowledge on unfished populations. Only recently have the evolutionary consequences of fishing been considered, with most effort devoted to the impact of commercial fishing (Heino and Godo, 2002). Recreational angling usually concentrates more on coastal or smaller, insular, defined regions (e.g., coastal and inland). For this reason, and when not confounded by stock enhancement (see later), recreational angling may have great potential to alter the evolutionary trajectory of fish populations. This issue is exemplified by the demise of multi-sea winter Atlantic salmon in Western Europe. These are valuable, larger individuals that tend to migrate into rivers in spring and early summer and are targeted by commercial and game fisheries alike. This component has more-or-less collapsed in many fisheries and is under threat, thus affecting the genetic composition of stocks (Youngson et al., 2002). In an effort to ameliorate the problem, several countries have opted to impose mandatory catch-and-release schemes on these multi-sea-winter fish (e.g., the British Isles, see Youngson et al., 2003) and/or adjust the fishing season to afford some degree of protection. This issue was highlighted only because of the long-term data sets that exist on catches of salmon in many North Atlantic rim countries. The example serves to demonstrate that both commercial and recreational fisheries would benefit from the establishment of long-term monitoring programs coupled with rigorous experimentation to understand the frequency and consequences of fishing-induced selection. In the interim, fisheries managers responsible for both recreational and commercial fisheries should be aware of the potential evolutionary consequences of fishing and develop management strategies to minimise the effects. "Evolutionarily enlightened" (Ashley et al., 2003) strategies such as appropriate closed seasons, use of aquatic protected areas, harvest regulations (e.g., slot limits) and the stocking of progeny from targeted specific components of the populations could be imposed in both fishing sectors to minimise these problems.

2.4. *System level changes arising from fishing*

Food webs, trophic relationships, and the flow of energy are central to the functioning of aquatic systems (Sarvala, 1992).

The trophic balance of an aquatic system can be disrupted by direct and indirect effects of commercial fishing (e.g., Hall, 1999; Kaiser and de Groot, 2000). Commercial fishing can also indirectly affect trophic structure in the benthic community through harvest practices that degrade benthic habitats (e.g. Frid and Clark, 2000).

Caddy and Garibaldi (2000) determined that there was a shift towards greater exploitation of higher trophic level fishes over a 50-year period, and concluded that top-down removal of predators is affecting lower trophic production, resulting in a declining mean trophic level. This was evident from a move downward in the trophic level targeted; a process called 'fishing down' food webs (Pauly et al., 1998). However, commercial fishing is only one of several possible causal agents, and it may not always impart changes in trophic structure. Estuaries and near-shore ecosystems have perhaps been most affected due, in a large part, to their productivity and accessibility. Fishing in estuarine and nearshore habitats has clear impacts on the structure and functioning of these ecosystems, including disruption of nursery functions, trophic cascading, and potential for local extinctions (Blaber et al., 2000).

There are fewer reports of recreational fishing induced changes in trophic or community structure, but they exist. Most examples of change in trophic structure are based upon field observations. Roell and Orth (1994) determined that food web structure in a stream in West Virginia was influenced by recreational exploitation of adult smallmouth bass (*Micropterus dolomieu*) but stated the harvest of crayfish and hellgrammites for bait resulted in more drastic changes in ecosystem function. Similarly, observations on the effects of callisid shrimp collection by recreational anglers in Australia suggest the potential for changes in ecosystem function, including biogeochemical cycling (McPhee and Skilleter, 2002). Traps used by recreational anglers to capture these callisid shrimp also capture higher trophic organisms including platypuses (*Ornithorhynchus anatinus*; Grant et al., 2004). Further evidence of the potential for fisheries-induced changes in ecosystems structure and function can be derived from differing harvest regimes that appear to produce alternative food web structures, and this knowledge can be exploited by managers to manipulate key trophic linkages in aquatic food webs (Roell and Orth, 1998; Kitchell et al., 2000). Sometimes the effects from bait harvesting can extend beyond aquatic environments. For example, commercial baitworm harvest for recreational angling reduced the foraging efficiency and ultimately migratory energy stores of semipalmated sandpipers (*Calidris pusilla*) in eastern Canada (Shepherd and Boates, 1999).

Recreational game anglers primarily target piscivorous fish (i.e., high trophic levels; Coleman et al., 2004), often for consumption, that can be captured by simulating or using natural forage as bait. Morales-Nin et al. (2005) determined that recreational fishing activity on the Mediteraanean Island of Majorca removed about 31% of production at the highest trophic level. Recent shifts towards "alternative" species not commonly regarded as gamefish may represent changes in response to reductions in catch of more conventional target species, or other sociological factors such as crowding. Recreational anglers will, however, not tend to "fish down" food webs (Pauly et al., 1998) to the same extent as in commercial fisheries because many of the lower trophic feeders are not readily susceptible to capture by anglers. Notwithstanding this, as noted above, harvest of some species for bait can alter system functioning and structure.

For years commercial fishing has been implicated in the collapse of wildlife populations, especially birds (Camphuysen and Garthe, 2000; Cowx, 2003a). Overfishing in coastal areas can result in starvation of fish-eating birds (Camphuysen and Garthe, 2000). Whilst recreational overfishing probably has not led to the demise of bird populations per se, the proliferation of inland breeding populations of species such as cormorants (*Phalacrocorax* spp.) and sawbill ducks (*Merganser serrator*) has generated conflict between fisheries and bird conservation lobbies. Whilst there is no doubt cormorants can cause damage to intensively stocked still-water fisheries (see Cowx, 2003a for examples), there is still debate over the level of damage to other natural freshwater fisheries (Feltham et al., 1999). At present, there are calls for control of birds, especially cormorants, by fishery managers and anglers, but this is contested by conservationists (Russell et al., 1996). The upshot is potential persecution of the birds, which may affect trophic functioning within the water bodies.

Fisheries management activities associated with maintaining recreational fishery performance, especially stock enhancement, are also responsible for change in trophic structure. Stocking and introductions of fish have altered the trophic structure of many fish communities worldwide (see Cowx, 1997, 1998a), often by increasing the trophic level through the introduction of targeted predatory species or emphasising a particular trophic level (Welcomme, 1988, 1992). This issue will be discussed in more detail later.

Overall, there is evidence that changes in trophic structure and ecosystem function can be altered by both commercial and recreational fishing. Additional research and modelling to elucidate general patterns of fishery impacts on ecosystem function would benefit both sectors.

2.5. *Habitat degradation arising from fishing*

There is considerable literature documenting the effects of commercial fishing on aquatic habitats (see Dayton et al., 1995; Kaiser and de Groot, 2000). Towed bottom fishing gear typically results in both short and long term disturbances in physical habitat and community structure that can result in further changes in other species that depend upon the bottom habitat for growth and survival (Watling and Norse, 1998). In addition to physical damage to habitat, loss of fishing gear can result in "ghost fishing" when gear continues to capture and kill fish and other organisms while unattended (Kaiser and Jennings, 2002). Noise pollution can also contribute to making waters less suitable for some fish species (Popper, 2003).

Superficially, recreational fishing is considered to cause less habitat degradation than commercial fishing. However, there are forms of habitat degradation and pollution that are unique to, or more common than in commercial fisheries. In addition, the intense, but spatially restricted, nature of recreational fisheries can result in degradation of localised habitats from increased boat traffic, particularly in near-shore and inland environments (Bellan and Bellan-Santini, 2001). Similar to commercial fishing, recreational fishing motorised vessels can disturb benthic habitat or aquatic vegetation. Sargent et al. (1995) documented that over 6% of seagrass beds in Florida exhibited damage caused by propellers, representing some 70,000 ha. Although both commercial and recreational fishery boats can scar seagrass, 95% of boats registered in Florida are recreational (not that all engage in recreational fishing) and it is those boats that typically operate in shallow, near-shore environments. Noise from recreational fishing vessels can also disturb fish. In the Adriatic Sea, noise from the passage of outboard boat engines resulted in behavioural alterations in gobies (Gobidae; Costantini and Spoto, 2002). In Florida, there is concern that boat traffic (both anglers and non-anglers) on and adjacent to bonefish flats has altered distributions and disrupted foraging activity, although there is an absence of conclusive data (Ault et al., 2002). In small inland waterways or near-shore areas, vessels can also generate waves that erode shorelines, suspend sediment, and may disturb fish, especially where movements are excessive and uncontrolled (Pygott et al., 1990; Mosisch and Arthington, 1998). This leads to collapse of banks, loss of riparian vegetation, and on a more subtle level, change of littoral water temperatures that directly affects juvenile growth and recruitment (Hodgson and Eaton, 2000).

Although superficially less harmful than commercial fishing gear, litter in the form of fishing line (Laist, 1997) or lead sinkers (Donaldson et al., 2003) and hooks (Cryer et al., 1987a) can lead to localised habitat degradation. Although rarely quantified, fishing line and hooks can become entangled in a variety of wildlife species including birds, marine mammals, and turtles (e.g., Nemoz et al., 2004). When line is ingested or when animals become entangled, it can result in injury or mortality. Fishing hooks and line can also result in damage to sensitive sessile invertebrates (i.e., coral habitats). In the Florida Keys National Marine Sanctuary, lost hook-and-line fishing gear accounted for 87% of all fishing debris encountered and was responsible for 84% of impacts (i.e., tissue abrasion, partial individual mortality, colony mortality) to sponges and benthic cnidarians (Chiappone et al., 2005). However, overall damage to sessile invertebrates was quite minor. In Asia, coral colonies entangled with fishing line were consistently in poorer condition, had higher rates of mortality, and larger proportions of dead or damaged coral (Yoshikawa and Asoh, 2004). Similar recreational fishing impacts were reported for cauliflower coral (*Pocillopora meandrina*) by Asoh et al. (2004). Collectively these studies suggest that fishing activities that result in the fouling of reefs with fishing line can cause damage to corals and possibly the fish communities that reside in these regions. A challenge with all studies on lost or discarded fishing equipment is determining whether it was generated by commercial or recreational fishing. Therefore, an experimental *Oculina* research reserve recently incorporated recreational angling into a ban that had previously only been focused on commercial fishing (Reed, 2002).

Lead fishing sinker deposition from angling can have major negative consequences on local environments. Jacks et al. (2001) estimated that in Swedish Atlantic salmon fisheries, up to 200 t of lead fishing sinkers are lost in river mouths. In littoral regions of the waters of South Wales, United Kingdom, between 24 and 190 sinkers/m^2 were found (Cryer et al., 1987a). In Canada, environmental inputs from lead fishing sinkers accounted for 14% (~500 t) of annual lead releases (Donaldson et al., 2003). In Canada, lead fishing sinkers have been found in the digestive tracts in ten wildlife species including turtles, raptors, fish-eating birds, and waterfowl, and in the United States they have been found in over 20 species (Donaldson et al., 2003). Lead sinkers have been responsible for high levels of mortality in loons (*Gavia immer*) in North America and of mute swans (*Cygnus olor*) in the UK (Donaldson et al., 2003). Educational efforts by governments and environmental organisations have been successful in promoting the use of alternatives to lead sinkers, and in the UK the use of small lead sinkers in angling has been banned (Cowx, 2002). However, even with the reduction of lead inputs from fishing sinkers in the UK, there are still more than 2000 tackle-related mute swan rescues annually (Perrins and Martin, 1999). Other litter from bait containers, tackle packaging, etc. does not directly affect fish, but is generally not compatible with natural environments.

Angling, although essentially a quiet and often solitary activity, can disturb wildlife. Commonly, waterfowl, and coastal and wetland birds, many of which are now rare, are liable to disturbance if access to waters or shoreline is uncontrolled (Cryer et al., 1987b). Most damage is done at the nesting time when birds are disrupted or prevented from gaining access to their nests (Maitland, 1995). There are also many mammals commonly found associated with the rivers and lakes, most of which are shy and sensitive to disturbance, e.g., otters (*Lutra lutra*), and prefer secure places to rear their young (Jefferies, 1987). Closed seasons or protected areas, are designed to minimise these impacts, but problems still persist. Anglers wading in streams can also damage aquatic habitats. For example, Roberts and White (1992) reported that anglers wading on trout eggs and pre-emergent fry resulted in mortality as high as 96%. In addition, recreational angler activity can also affect the production of invertebrates that can serve as important food sources for fish. For example, Mueller et al. (2003) reported that dragonfly fauna were negatively affected by bank trampling caused by recreational fishing activity in a Hungarian river. This problem is exacerbated when anglers modify bankside and littoral zone vegetation to gain access to fishing sites. Smith and Murray (2005) reported that angler foot traffic combined with the collection of mussels (*Mytilus californianus*) for bait may reduce cover for mussels and create mussel-free gaps.

In some recreational fisheries, ground-baiting (with cereals, maggots or other bait) or chumming, the process of distributing bait in water to attract fish, is common in both freshwater and marine environments. When used excessively, it can lead to a deterioration in water quality, (Cryer and Edwards, 1987), increased phosphorus loading (Edwards and Fouracre, 1983; Niesar et al., 2004), and substantial reduction in benthic fauna (Cryer and Edwards, 1987). In many places this practise is now discouraged.

Collectively, recreational and commercial fishing both result in considerable habitat degradation. Efforts to reduce habitat degradation should be a common goal for both fishing sectors. Common efforts devoted to educating fishers about the causes and consequences of habitat degradation, and developing techniques or gear that minimise such degradation, should be explored.

2.6. Advances in gear technology

Fishing technology for commercial fisheries has lead to major advances in the ability to capture fish, particularly after 1950 (Valdemarsen, 2001). Technological advances that permit fishers to locate fish more rapidly (Pillai et al., 1997) and effectively reduce wasted time can increase efficiency, but also identify regions important for conservation and management (Dewar, 1998). The average size and power of fishing boats has increased over time, and fish are now frequently processed on board (Fridman, 1999). Vessels can travel further, more quickly and for longer periods. Access to greater depths has made less of the world's aquatic biota immune to capture (Merrett and Haedrich, 1997). The introduction of synthetic fibres in gears such as trawls, purse seines, and gill nets has also served to improve fishing gears (Valdemarsen, 2001). There is no doubt that fishing has been profoundly changed by gear technology; but some in the fishing technology industry (i.e., Fitzpatrick, 1989) have argued that technological advances are required to meet the demand for fish, especially in the face of dwindling stocks. Others have argued that proliferation of technological advances is partially responsible for current global fish declines in commercial fisheries (Serchuk and Smolowitz, 1990).

Technological advances from the commercial fishery have also been applied increasingly in recreational fisheries to the point where some have suggested that "recreational fishing increasingly resembles commercial fishing" (Bohnsack and Ault, 1996). These technologies provide recreational fishers with equipment to travel longer distances and then locate and capture fish, basically providing anglers with the same tools available to the commercial fishing industry (Leadbitter, 2000), e.g., global positioning systems (GPS) and depth finder technologies. Increasingly, anglers are also demanding access to government research that uses telemetry to track fish movements (Grover, 2001), to identify potential fishing locations. A proliferation of companies marketing portable underwater cameras has provided anglers with the opportunity to view fish or fish habitats to increase capture efficiency. The price of these tools is such that they can be afforded by recreational anglers, and they are designed with features and simplicity of operation to make them easy to use. The synthetic fibres used in commercial fishing have also begun to appear in recreational fishing lines instead of monofilament nylon. These lines have increased strength and abrasion resistance, resulting in higher fish landing rates. In addition, the lures used by anglers incorporate a multitude of characteristics that increase realism, such as holographics, scents, and lights. Collectively, these gear advances provide anglers with more tools to permit the hooking and landing of more and bigger fish.

Paralleling the increase in fishing vessel technology in commercial fishing, recreational fishing vessels have also made great advances. Many boats are outfitted with the most recent technical advances, including reliable and more powerful motors that increase the distance that anglers can venture safely.

There has also been the realisation that advances in gear technology can provide conservation benefits by reducing selectivity, bycatch, and habitat degradation (MacLennan, 1990). For example, circle hooks have recently been applied to both recreational and commercial fisheries and this technological advance in hook design has reduced injury and mortality of discarded or release fish and indeed other organisms (see review by Cooke and Suski, 2004). Other efforts have been devoted to developing revival boxes for bycatch (Farrell et al., 2001) or improving live-wells for fish in recreational boats (Cooke et al., 2002b). Indeed, we advocate that research in both sectors is expanded to reduce the impact of fishing on discards and habitat. However, for the most part, technological developments have focused on improvements in efficiency of both locating and capturing fish for both commercial and recreational fisheries. Fisheries managers must keep abreast of the latest developments in fisheries technology so that management strategies are reflective and responsive to these advances. Ethical questions regarding the level of technology that is appropriate will likely continue to develop in both sectors (Hummel and Foster, 1986).

3. Management strategies

3.1. Regulations

Management of commercial and recreational fisheries follow similar strategies to reduce over exploitation of the fishery and maintenance of a suitable stock structure (Table 2). The imposition of a closed season is designed to allow uninterrupted reproduction and the early development of the fish, including, for migratory fish, free passage to spawning grounds. In practice this action has been extended to protect stocks that are heavily exploited through restricted catch. This restriction has often come under heavy criticism because closed seasons are wrongly timed and do not protect the fish when they are most vulnerable, such as during the reproductive period (Maitland, 1995; Cowx, 2002).

Closed areas are designed to protect stocks directly by denying access to exploitation, and are now well represented in the literature with the increased emphasis on aquatic protected areas (National Research Council, 2001). These can range from sanctuary areas, where fishing is prohibited to protect vulnerable life stages of fish, to restrictions to fishing in areas where the fish are particularly vulnerable to exploitation. In marine systems, protected areas have typically been focused on restricting or eliminating commercial fisheries. However, there are now greater efforts to regulate both fisheries sectors (i.e., commercial and recreational) with use of protected areas (e.g., Helvey, 2004; Meester et al., 2004). Fishing is also regulated through access restrictions. In commercial fisheries operating within the fishing waters of a particular nation (i.e. the exclusive economic zone, EEZ) this is usually controlled by licensing access, often linked to catch quotas. Outwith EEZs, few restrictions to access apply. Restrictions on access in recreational fisheries vary between countries. In highly industrialised countries such as the UK, much of

Table 2 – Comparison of tools to regulate fishing practices in commercial and recreational fisheries

Regulatory tool	Commercial fisheries	Recreational fisheries
Closed areas	Protected areas and nursery habitats	Protected areas and nursery habitats
Closed season	linked to spawning periods or vulnerable periods during migration	Usually linked to spawning periods
Catch limit	Quotas	Bag limit
Effort regulation	Licensing	Partially in some jurisdictions (e.g., UK)
Type of gear	To minimise damage to stocks through, for example, mesh size or highly efficient, destructive gears	Usually only in specialist fisheries
Size of fish	Minimum size limits usually linked to size at maturity	Minimum size retained in some fisheries
Species of fish	Quotas	At specific times and in specific places
Code of conduct	FAO CCRF	National guidelines in some countries; international guidelines linked to FAO CCRF in preparation

the freshwater fishing is in private hands or leased by clubs, and permits have to be purchased to fish. In other countries there are no access restrictions or fishing is only regulated by national licensing schemes. Notwithstanding this, Pereira and Hansen (2003) concluded that in commercial fisheries, effort control can be effective, but due to complex technical and socio-political challenges, effort control in recreational fisheries may be problematic.

Where the catch is removed for consumption, limits are frequently placed on total catch in attempts to control over exploitation and conserve the spawning stock. Typically this is imposed through catch restrictions, i.e., quotas in commercial fisheries and bag limits in recreational fisheries. These restrictions do not apply when the fish is returned to water alive after capture. Such restrictions allow for the sharing of the catch when stocks are low or under intense pressure for exploitation. Bag limits are commonly applied to migratory game and put-and-take fisheries to provide equity of catch. An alternative to the bag limit is catch-and-release where restrictions are placed on harvest and all excess fish must be released back to the water.

Gear specifications are used to reduce exploitation of populations by influencing the efficiency of fishing, and the size and species of fish caught. In commercial fisheries, gear type and dimensions, e.g., mesh size and size of net regulation, are used to minimise capture of immature and unwanted fish. Much research is now focused on designing gears that select for specific target species and sizes of fish, thus minimising the bycatch. In recreational fisheries, gear restrictions are usually linked to the type of angling method, e.g., fly fishing or spinning, and the baits used, and more recently the use of barbless hooks or circle hooks.

The final mechanism commonly used is restriction of size of fish harvested. These restrictions are common in commercial fisheries, but are equally applicable to recreational fisheries. The restriction is designed to ensure immature fish are not targeted or are returned to the water to allow them to mature. For size limitations to work, they must be based on sound information about the population size structure, size at sexual maturity and natural mortality rates. Unfortunately, in commercial fisheries most of the undersized fish caught do not survive and, thus, are lost to the fishery. This is less critical in recreational fisheries where a much higher proportion of fish returned survive to contribute to the fishery. Birkeland and Dayton (2005) identified that it is important to release larger fish, which are relevant to both fisheries sectors, but especially recreational fisheries.

Although most commercial fisheries are managed based on the regulations outlined above, these have failed to halt the demise or retard the degradation in the world's fisheries. This is partly because it is difficult to enforce regulations where resources are limited. Consequently, management of fisheries is moving away from command control systems of fisheries towards ecosystem based management and community participation approaches. Whether these achieve the desired sustainability of the stocks in question remains to be seen. However, such approaches in recreational fisheries are unlikely to function because of the individualistic behaviour of the proponents (Pereira and Hansen, 2003), although Cowx and Gerdeaux (2004) believe that a change in emphasis to incorporate stakeholders in the decision-making is the best way forward. Unfortunately, such involvement may only be successful in privately owned fisheries run by high profile clubs or associations, as found in the UK, or in highly managed fisheries such as in Scandinavia. New approaches to recreational fisheries management, which take on broad impacts outlined previously, are needed if the potential detrimental characteristics of the sector are not to be implicated in the demise of stocks worldwide. Furthermore, there may be opportunities to share knowledge from experiences in both fishing sectors.

3.2. *Stock enhancement*

Stock enhancement is probably the most widespread, and abused, management tool used in freshwater fisheries today (Cowx, 1998a; Petr, 1998). Most countries report stocking of freshwater fisheries as more conventional approaches to management have failed to control fisheries exploitation or reduction in stock biomass through environmental degradation, or in attempts to increase fishery yield (Petr, 1998). The scale of stocking in inland waters is extensive. For example, Cowx and Godkin (2000) estimated that some 40 billion individuals are stocked annually in European fresh waters and stocking to a similar scale is common across the world (Petr, 1998). There is, however, little evidence of successful enhancement of marine fish stocks through stocking (Leber, 2003), whether recreational or commercial.

Enhancement of fish stocks in natural waters can be done for a variety of reasons including to improve recruitment, bias fish assemblage structure to favoured (i.e., some specific management goal) species, or maintain productive species that would not breed naturally in the system (Cowx, 1994). Unfortunately, stocking can be damaging to native stocks through competition, predation, loss of genetic integrity, or the spread of disease and parasites (Cowx, 1994; Cowx, 1998a; Cowx and Godkin, 2000; Cambray, 2003; McGinnity et al., 2003; Almodóvar and Nicola, 2004; Peeler et al., 2004; Van Zyll de Jong et al., 2004). If a species is being released in high numbers then changes in the ecosystem are likely to occur via fish species interactions and food web dynamics. Vulnerable fish species, and aquatic flora and fauna can be eliminated through predation, and the stocking, intended to enhance the fishery, can result in the opposite effect, including elimination of species (Cowx, 1997; Cambray, 2003). The loss of genetic integrity of the native stock, which is thought to have adapted to local environmental conditions over many years, is a major issue and considered responsible for the decline of many fisheries (Carvalho and Cross, 1998).

In addition, the introduction of new species to promote angling diversity has been practiced since the beginning of the 19th century (Cambray, 2003). In the UK, this practice was most common in the 1960s and 1970s (Welcomme, 1988), but concerns over the impact of this activity and the implementation of tough regulations have restricted the practise in many industrialised countries in recent years (Hickley and Chare, 2004). Introductions have also arisen because of release or escape of fish used as live-bait for predatory species (Welcomme, 1988; Cowx and Godkin, 2000). Introductions have proven successful in a number of cases, e.g., rainbow trout and largemouth bass, but this has usually been at great cost, most often expressed through the demise of indigenous species or spread of diseases (Cowx, 1997, 1998a; Cambray, 2003). Other introductions have been disastrous, with wholesale ecosystem change and elimination of species (Cowx, 1997). With the recent decline in the status of many fisheries, there is renewed interest in species introductions. However, Cowx (1997) advocated that the cause of the deterioration in extant fisheries should be identified and where possible addressed prior to introducing novel species (Cowx, 1997).

The practise of enhancement, whether by stocking or introductions, is perhaps one of the most insidious threats to fish conservation and the sustainability of indigenous fish stocks worldwide. Stock enhancement activities have become part of the suite of tools used within recreational fisheries to promote the angling experience, yet the activities are recognised as a global environmental degradation problem, and, thus require a global solution (Cambray, 2003). Addressing this issue is the responsibility of the recreational fisheries sector, and concerted action through environmental education programs, improved understanding of the processes and better legislation (Cowx and Gerdeaux, 2004), is needed if the sector is not to contribute further to the extirpation of fish species worldwide.

4. A new perspective on recreational fisheries?

Post et al. (2002) and McPhee et al. (2002) identified a series of reasons why the contribution of recreational fisheries to the collapse of many fish species stocks may be invisible in Canada and Australia, respectively. Although both countries are regarded as prosperous, the remote and diffuse nature of many fisheries precludes rigorous monitoring programs. In less developed nations, or in countries with less advanced fisheries research and monitoring infrastructure, the ability to detect impacts from recreational fishing may be even more challenging. Resource managers must at least acknowledge that recreational fisheries have many characteristics that emulate what is well documented in commercial fisheries, including catch-and-release and bycatch, fisheries-induced selection, trophic changes, habitat degradation, gear technology advances, fishing effort, and production regimes. We believe that there are many fisheries at risk from recreational fishing simply because the de facto assumption is that recreational fishing is unlike (i.e., less damaging than) commercial fishing. As we have demonstrated, there are examples of recreational fisheries that have paralleled or even surpassed the negative effects observed in commercial fishing. As efforts to conserve global fisheries take shape with increasing urgency, it is essential to incorporate recreational fisheries into management plans and conservation strategies.

There is no doubt that when an individual recreational angler fishing with a rod and line is contrasted with a 30-m commercial industrial trawler, recreational fishing appears overwhelmingly benign. However, the number of recreational anglers far exceeds that of commercial fishers. In addition, recreational anglers can target small inland waters or productive coastal zones that are often inaccessible to commercial fisheries. These coastal zones in particular can be important seasonal habitats for fish (from larval through to adults) and may make them more vulnerable to fishing during phases of their life-history (i.e., reproduction, migration), thus influencing recruitment processes. Thus, the potential for recreational fishing activity to alter localised environments is real. It is unlikely that recreational angling will ever on its own be responsible for the global collapse of fish stocks. However, recreational angling undoubtedly has the potential to contribute to both local expiration and more widespread collapse of species that are also targeted by commercial fisheries.

There is a need for more longitudinal (i.e., long term, time series) data on recreational fishing effort, catch, harvest, and population structure to evaluate the possible role of recreational fisheries. In freshwater recreational fisheries, the default action when fish stocks are depleted (either perceived or actual) is to supplement the population through stocking. In some cases, stock enhancement includes the introduction of exotic species which further impairs the ability of fishery managers to track changes in response to recreational fishing. Recreational fishery collapses may be more evident in fisheries where enhancement is limited due to funds, knowledge, or conservation concerns over stocking. We also need to incorporate estimates of non-harvest-related mortality from commercial bycatch and recreational catch-and-release fisheries. These factors are rarely included in the current analysis of fishing mortality as so few assessments have been made. As fishing mortality varies substantially by species, environmental conditions, season, and gear type, it is difficult to develop generalised values for predictive models.

For some time, there has been conflict between recreational and commercial fishing groups associated with differential allocation of fish and fishing opportunities, and both perceived and actual differences in effects of the fishing on the fishery. Our contrast of recreational and commercial fisheries should help to depolarise the debate, highlighting the commonalties between these fisheries and identifying that both can contribute to fishery declines. This shared view of the factors facing both recreational and commercial fisheries, and the likelihood of exploitation, can be used as a starting point for addressing issues in aquatic conservation. Indeed, such a focus was recently emphasised by Arlinghaus et al. (2002) who suggested that the sustainability of resource use is driven largely by societal demands. However, in response to a recent paper that criticized recreational fisheries (i.e., Coleman et al., 2004), a representative of recreational angling groups suggested that the commercial fisheries were to blame (Nussman, 2005). In recreational and commercial fisheries, the human dimension has received much attention as of late (see Arlinghaus et al., 2002; Arlinghaus, 2005 for reviews). Arlinghaus (2005) argues that there is a pressing need to identify, understand and manage human conflict in recreational fisheries because such conflicts may retard progress towards generating sustainable recreational fisheries. Indeed, there are complex socio-economic factors that underlie the actions of anglers and fishers, and only recently have efforts been devoted to understanding issues of exploitation related to human dimensions at the recreational–commercial interface (e.g., Policansky, 2001; Cowx, 2002; Arlinghaus et al., 2002). One issue that has been recognised is the economic importance of recreational fisheries to local and regional economies (Cowx, 2002; Cowx et al., 2004). The value of these recreational fisheries often outweighs that of the commercial fisheries and thus their sustainability is paramount to society in general. Consequently, there is a need to promote initiatives that take account of the strengths, weakness, opportunities and constraints of recreational fisheries (Cowx, 2003b) for the benefit of future generations.

5. Conclusions

Fishing activity of any kind, whether commercial or recreational, has the potential to affect negatively fish, fisheries, and aquatic habitats. Although rarely considered to be an important factor, recreational fishing does have the potential to result in effects that parallel those of commercial fisheries. As recreational fisheries researchers, our goal is not to merely cast a negative light on recreational fisheries. Instead, our intention is to reveal that recreational fisheries have the potential to result in, or contribute to, alterations in fish and fisheries, and that efforts must be devoted to trying to understand this impact in both commercial and recreational fisheries.

Due to the many similarities identified in this paper, we encourage efforts that facilitate the development of generalised theory and strategies that are relevant and applicable to both recreational and commercial fisheries, recognising of course that there are challenges (see Pereira and Hansen, 2003; Coleman et al., 2004). Governments, granting agencies, the peer review community, and publishing outlets all must realise that recreational fishing must be viewed in a conservation and sustainability context, not just that of applied fisheries management for the benefit of anglers. If these issues begin to appear in the conservation literature, we can expect more rapid development of collective thought on these problems, and thus more comprehensive insight and solutions. The similarities between recreational and commercial fishing sectors should also be striking to their constituents who typically have polarised opinions, assuming that the other sector is to blame for habitat degradation or fishery declines. If cohesive and unified management and conservation policy can be developed, this will surely be noticed by these different sectors. The realisation that both sectors can, and do, have negative consequences on fisheries should permit collective efforts to focus on effective management and conservation, rather than playing the "blame game". As an effective starting point, we urge further study on the role and magnitude of global recreational fisheries, including long-term monitoring and hypothesis driven experimentation. Perhaps the increased use of aquatic protected areas will help to elucidate the role of recreational fisheries in alterations to populations and communities.

Several authors have proposed a code of conduct for recreational fisheries (Hickley, 1998; Cowx, 2002, 2003b) similar to that championed by the FAO for commercial fisheries (code of conduct for responsible fisheries – CCRF; FAO, 1996). The FAO CCRF is designed to offer guidance on how to manage large scale, mainly marine, fisheries on a sustainable basis. It is now the basis of many fisheries development initiatives but its impact has yet to be realised to any degree. Within recreational fisheries there is no such code of conduct. Although recreational fisheries are undoubtedly widespread and of high values, there is a general lack of cohesive policy or international regulation.

It is also important to increase our understanding of the global participation and harvest in recreational fisheries. Interestingly, current FAO fishery statistics exclude recreational angling-instead focusing on landings of commercial fisheries. Nonetheless, the FAO recognises the role of fishing techniques in ecosystem management and the need for inclusion of recreational angling. It is essential that recreational fisheries catches are included in mainline databases (e.g., FAO catch statistics) to give a true reflection of fishery yield worldwide. In the absence of reliable statistics, the shifting baseline syndrome (Pauly, 1995) may further obscure recreational fishing declines. Observers and log books are mandatory in many commercial fisheries to record catch statistics (Pollock et al., 1994). The utilisation of diary programs for diffuse recreational fisheries may serve to provide tools for identifying changes in fish populations or catch dynamics (Cooke et al., 2000; Cowx, 2002). At present, many of the examples in the literature focus on industrialized regions. Information on the magnitude, importance, and effects of recreational angling in developing countries is sorely needed. Indeed, only then can we obtain more robust and defensible estimates of global recreational fish catch (see Cooke and Cowx, 2004). We contend that greater understanding of recreational fishing issues and their relationship with those in commercial fisheries will promote more effective management and conservation of all aquatic resources.

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