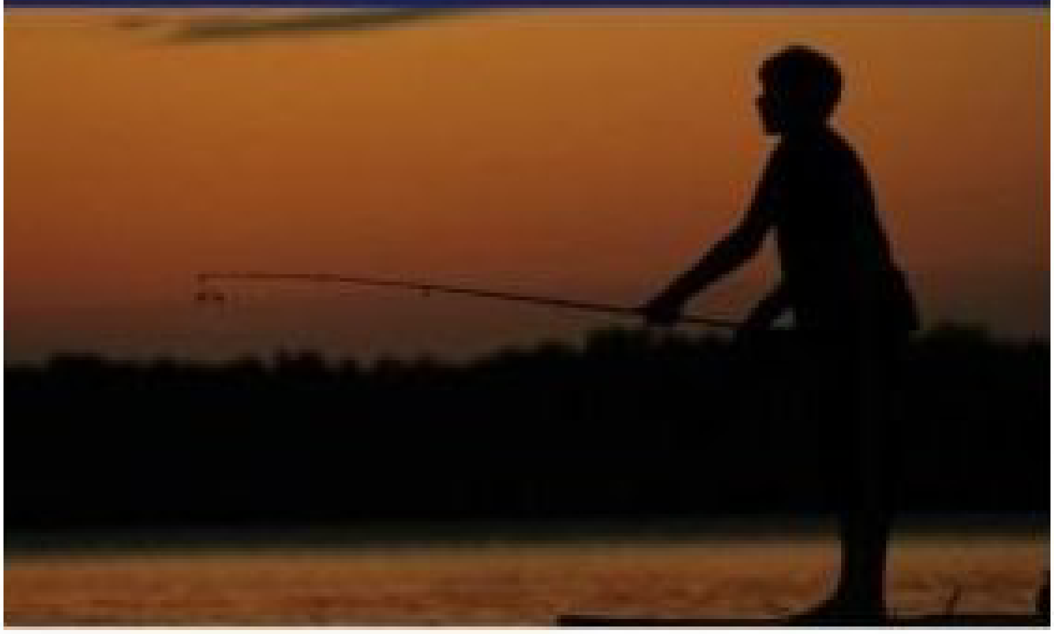

Renae Tobin

Recreational Only Fishing Areas

Have they reduced conflict and improved recreational catches in North Queensland, Australia?

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LIST OF ABBREVIATIONS:

AFANT	Amateur Fisherman's Association of the Northern Territory
ANSA	Australian National Sportsfishing Association
CHRIS	Coastal Habitat Resources Information System
CPUE	Catch per unit effort
CRC Reef	CRC Reef Research Centre
DPA	Dugong Protection Area
ECIFF	East Coast Inshore Finfish Fishery
EoNF Project	Effects of Net Fishing Project
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
NSW	New South Wales
NRIFS	National Recreational and Indigenous Fishing Survey
QDPI	Queensland Department of Primary Industries
QDPI&F	Queensland Department of Primary Industries and Fisheries
QBFP	Queensland Boating and Fisheries Patrol
QSIA	Queensland Seafood Industry Association
RAP	Representative Areas Program
RFISH	QDPI&F Recreational Fisher Monitoring Program
ROFA	Recreational Only Fishing Area
WA	Western Australia

CHAPTER 1: GENERAL INTRODUCTION

1.1 Introduction

Competition and conflict between commercial and recreational fishers over shared fish stocks is a historic and current reality, and has been documented in all developed and some developing countries (Ruello and Henry 1977; Gartside 1986; Aas and Skurdal 1996; Sumaila 1999; Kearney 2002a, b; Pitcher and Hollingworth 2002; Sumaila 2002; McPhee and Hundloe 2004; Arlinghaus 2005). Although recreational and commercial fishing sectors are often in competition to the point of conflict with other users (including within their own sector), apparent conflict between recreational and commercial fishers is currently one of the most significant issues for fisheries management in Australia and many other countries (West and Gordon 1994; Brayford 1995; van Buerren et al. 1997; McPhee and Hundloe 2004; Arlinghaus 2005). Conflicts may be severe and expensive of management resources, regardless of whether they are "real" or only perceived (i.e. based on fishers' beliefs but not substantiated) by one or more of the involved fishing sectors (Jacob and Schreyer 1980; Aas and Skurdal 1996).

Many authors suggest conflict between recreational and commercial fishing sectors is increasing as contact between the sectors increases, particularly in coastal areas and close to population centres (Gartside 1986; Edwards 1991; Hannah and Smith 1993; Brayford 1995; Ramsay 1995; Scialabba 1998; O'Neill 2000; McPhee et al. 2002; Steffe et al. 2005b). Increasing contact between the sectors may be due to a number of factors including: increased population; increased recreational fishing participation; and improved accessibility to previously remote fishing areas (Smith 1980; Henry 1984; Edwards 1990; van der Elst 1992; Hannah and Smith 1993; Green 1994; West and Gordon 1994; Kearney 2001, 2002b; Williams 2002a; Sumner 2003; Steffe et al. 2005b). Although conflict can occur when commercial and recreational fishers target different species, the conflict situation is enhanced when the same species are targeted by both sectors (Arlinghaus 2005).

In an attempt to reduce contact between competing sectors and hence reduce conflict, sector-specific closures are introduced in previously shared areas (Samples 1989; Department of Primary Industries and Fisheries 2003). Recreational Only Fishing Areas (ROFAs) (i.e. areas where commercial fishing is banned, leaving exclusive access to recreational fishers (anglers)) are becoming increasingly common in Australia and other developed countries (Owen 1981; Rogers and Gould 1995; Kearney 2002b; McPhee et al. 2002; Walters 2003). All States and Territories in

Australia have implemented ROFAs, particularly in coastal areas. For instance, in New South Wales (NSW) in May 2002, 30 areas along the coast became “Recreational Fishing Havens” (termed ROFAs here), where commercial fishing was either completely banned or significantly restricted. These ROFAs resulted in the closure of 24% of the State’s estuarine waters to commercial fishing (NSW Department of Primary Industries 2004; Steffe et al. 2005b). In the Northern Territory, the rise of the recreational fishing sector in the 1980s shifted the focus of barramundi management to the allocation of the resource between the competing sectors. This resulted in the exclusion of commercial fishing from some areas including all freshwater areas, plus Darwin Harbour, Kakadu National Park, and the Daly, Mary and Roper Rivers (Pender 1995; Griffin 2003). In Victoria, only 4 of 25 bays and inlets allow commercial finfish fishing, making the remaining areas effectively ROFAs for finfish (Murray MacDonald, Department of Primary Industries Victoria, pers. comm., 2006)

Commercial Only Fishing Areas (COFAs), on the other hand, appear extremely rare. There is one published example of COFAs available: in the north-western Mediterranean there are areas where small-scale restricted commercial net fishing is allowed but recreational line and spear fishing is banned. However the purpose of such restrictions was for conservation of fish species, rather than segregation to reduce conflict (Francour et al. 2001). In Western Australia, priority access (but not exclusive access) is given to commercial salmon fishers for a set period on southern beaches (Bartleet 1995).

Given this trend, ROFAs are the focus of the present study. In north Queensland, Australia, a number of estuaries have been closed to commercial netting (effectively making them ROFAs for finfish) to reduce conflict between recreational and commercial fishers competing for shared estuary fish, particularly barramundi (*Lates calcarifer*) (Mark Doohan, QDPI&F, pers. comm., 2005). Although some of these ROFAs have been in place since the 1970s there has been very little evaluation of their social and biological effects. In most cases, the extent to which ROFAs are successful in segregating competing sectors, and thus reducing conflict, has not been tested.

In addition to potentially segregating competing sectors, ROFAs also have additional potential benefits for the recreational sector. In particular, with the exclusion of commercial fishing, there is less competition for previously shared fish stocks in the area. Consequently, improved recreational catches are expected, producing potential flow-on effects of increased effort from this sector, which may lead to increased spending and potentially increased value to the community (Ruello and Henry 1977; Kearney 2001; Dominion 2002; McPhee and Hundloe 2004). While significant anecdotal evidence suggests such benefits are being realised, there are few cases where actual catch trends and flow-on benefits are examined, and when they are the results are mixed.

The introduction of ROFAs also attracts various potential costs. Many of these costs will be borne by the excluded commercial sector; however there are also potential costs to the community and the fish stocks (Kearney 2003a; MacDonald 2003). In practice, ROFAs are permanent – i.e. there are no published cases of ROFAs being reverted back to shared-access where both sectors are targeting the same species (McPhee and Hundloe 2004). Thus, with increasing calls for ROFAs from recreational fishers, and more claims for compensation for loss of commercial livelihood as a result, it becomes important to look at the actual costs and benefits of implementing ROFAs (Dominion 2002).

This project examines whether the expected benefits of ROFAs – in terms of reduced conflict between recreational line fishers and commercial gill net fishers, and improved recreational catches – exist within the north Queensland barramundi fishery. In addition to providing an understanding of the benefits of ROFAs within this fishery, results will be relevant to many situations where ROFAs are being proposed or have been introduced with the goal of reducing conflict and/or improving recreational catches.

1.2 Literature Review: The benefits and costs of Recreational Only Fishing Areas

Sector-specific fishing closures (where one sector is excluded from an area to provide exclusive use of the resource to the other sector), designed to separate competing user groups (sectors) date back to the early 20th century (Department of Fisheries Western Australia 2000). Traditionally, fisheries resources were accessible to all sectors, with fisheries resources generally considered common property: i.e. the resources are owned collectively by a group and not owned by anyone (Rogers and Gould 1995; van der Elst et al. 1997; Marshall and Moore 2000). However, traditional ‘open access’ to common property resources can lead to depletion of stocks, through Hardin’s well-known “Tragedy of the Commons” situation, where each fisher will have the incentive to catch as much as possible before someone else does (Smith and Pollard 1995; van der Elst et al. 1997; Kearney 2001). To avoid this, most fisheries are managed via regulation by the government or state, which allocates both commercial and recreational rights (Charles 1992; Rogers and Gould 1995; Marshall and Moore 2000). However, there is a lack of agreed processes for determining appropriate sharing/allocation targets for particular resources (Henry and Lyle 2003), and both the commercial and recreational sectors aim to maximise their share of limited and finite fisheries resources, often at the expense of the other sector (Ruello and Henry 1977; Henry 1984; Smith and Pollard 1995).

Central to the problem of increasing competition between sectors is this question of ownership of the resource (Charles 1992; Kearney 2003a). Commercial rights may be regarded as a form of private property right purchased in the form of a transferable licence that provides a degree of ownership over the resource (Marshall and Moore 2000). For some commercial fisheries catch shares for each licence are also well-defined (Craig 2000; Kearney 2001). For recreational fisheries, although most anglers consider fishing to be their birthright, collectively their rights have not been defined (Rogers and Gould 1995; McMurran 2000; Kearney 2001; McPhee et al. 2002; Kearney 2003a). With increasing pressures on, and competition for, limited fish stocks there are increasing demands from the recreational fishing sector for greater recognition and definition of their rights of access (McPhee et al. 2002). With the rise of the recreational fishery there has been an increased political push for exclusive access to some areas and species (Teirney 1995; Kearney 2001; McPhee and Hundloe 2004). Allocation decisions such as these are unique in that the best available scientific information is not central to the conflict resolution (Hannah and Smith 1993).

Many fisheries researchers advocate sector-exclusive access/closures to areas as a feasible way to reduce conflict by reducing contact between competing sectors (e.g. Hendee 1974; Brown 1977; Owen 1981; Samples 1989; Brayford 1995; Rogers and Gould 1995; Taylor-Moore 1997; van der Elst 1997). For example, van der Elst (1997), suggested ongoing competition for King George whiting (*Sillaginodes punctatus*) in South Australia and Victoria could be resolved through sector-specific zonation by restricting recreational anglers to areas close to urban centres and allocating commercial rights beyond.

Other authors believe sector-specific closures are detrimental or unpopular, and may themselves cause conflict (Beaumariage 1978; Hannah and Smith 1993; Bennett et al. 2001). Resource allocation is one of the most challenging issues for fisheries managers (Department of Primary Industries and Fisheries 2004) and requires the most conflict producing decisions within fisheries management as they “pit group against group” (Hannah and Smith 1993). The likelihood of allocations to produce conflict depends on whether allocations are shared equally, or whether one sector gains at the expense of the other (such as in the case of sector-specific closures) (Hannah and Smith 1993). Conflict caused by dissatisfaction regarding allocation decisions can cause problems for the involved fishing sectors as well as fisheries managers. Time and money spent on conflict resolution efforts (including via legal proceedings) can be costly (Daigle et al. 1996).

Regardless of these varied opinions, sector-specific closures are becoming increasingly common, and it is most common to exclude commercial fishing to the advantage of recreational fishers (anglers) – i.e. to introduce ROFAs (Pender 1995; McPhee et al. 2002; Rogers and Curnow 2003).

There are various possible benefits and costs of providing exclusive access to recreational fishers through areas such as ROFAs: for recreational and commercial fishers, the community, and the fish stocks. Often such benefits and costs are hypothesised, but few cases examine whether these benefits are actually realised, and whether they outweigh associated costs. Where expected benefits and costs are examined, results are mixed.

Despite the extensive use of ROFAs, detailed literature searches revealed that few case studies outlining examples of ROFAs, both pre- and post-implementation, are published in peer-reviewed scientific journals. Available literature on this topic is dominated by internal fisheries reports, conference proceedings and other grey literature (perhaps because conflict resolution is often seen as a local issue (Brayford 1995; Rogers and Gould 1995)). Consequently, available information about the effectiveness of ROFAs is limited.

1.2.1 Benefits of ROFAs

a) <u>Reduction of conflict between recreational and commercial fishers</u>

Where there is an overlap of recreational and commercial fishing in terms of fished species and area, ROFAs are expected to reduce contact between competing groups thereby reducing or eliminating the need for direct conflict intervention (Samples 1989). If successful, this resolution of conflict will benefit both of the competing fishing sectors as well as fisheries managers.

There are many cases within Australia and other developed countries where ROFAs have been suggested and/or implemented in order to reduce competition and conflict between sectors (see Owen 1981; Gwynne 1995; Dominion 2002; Department of Primary Industries and Fisheries 2003). For example, in Western Australia (WA), Fisheries Adjustment Schemes were developed which aimed to reduce commercial effort in specific areas or fisheries where there was a high level of conflict or competition for the available catch, particularly between the commercial and recreational fishing sectors. WA's Department of Fisheries advocated spatial separation of groups, and in 1996 the WA government provided $8 million to directly fund the voluntary surrender of commercial fishing licences in areas where there was community demand for greater recreational fishing opportunities. The scheme successfully removed 46 licences by 1999 (at a cost of $3.2 million) from the smaller but often highly contentious commercial fisheries in estuaries and inshore areas (Department of Fisheries Western Australia 2000). There is no further published information available outlining whether this scheme has reduced conflict in the long-term.

The effectiveness of ROFAs in resolving conflict may depend on: 1) the cause of the conflict; and 2) how the ROFAs are implemented. Each of these points are discussed below.

i) Causes of conflict

In most situations the cause of conflict between recreational and commercial fishing sectors is the perception that stocks, or at least catches, are declining, which is generally attributed to the competing sector. Such conflict can come from either or both sectors (Henry 1984; Samples 1989; Dovers 1994; Kearney 2002a; Arlinghaus 2005). Apparent conflict in Australia's Sydney Estuary in the 1980s reflected this: Anglers claimed that commercial gill net fishers killed many small fish, resulting in depleted fish stocks and poor angler catches. Commercial fishers reciprocated by claiming anglers also killed many undersize fish, either by deliberately keeping them or through poor handling prior to release (Henry 1984). Unfortunately, in most cases there is an absence of adequate stock and catch data, particularly for the recreational fishery, making such claims unresolvable as it is unknown whether they are based on misperceptions or reality (Dovers 1994; Presser 1994; Department of Fisheries Western Australia 2000; Murray-Jones and Steffe 2000; Kearney 2002a).

It is most common for anglers to blame commercial fishers for perceived catch declines (Ruello and Henry 1977; Quinn 1988; Macreadie 1992; Bartleet 1995; Gladwin 1995; Kearney 1995a; Griffiths and Lamberth 2002; Kearney 2002a, 2003b). If conflict is present due to anglers' perception of a commercial fishing impact on stocks and catches, the removal of commercial fishing should reduce the animosity anglers feel towards commercial fishers for that particular area. However, commercial fishers are likely to feel resentful unless there is compensation for the lost fishing area (Kearney 2002a; Olsen 2003). In some cases compensation is available to displaced commercial fishers. For example, fees from newly introduced recreational fishing licences were used to buy-out commercial licences in Victoria, Australia. Such fees removed 52% of commercial licences, and complete buy-outs were effective in some waters making these areas ROFAs. The buy-outs, which were voluntary and endorsed by the peak body for recreational fishing (Morison and McCormack 2003), may reduce conflict in the area that has been ongoing for many years (see Gladwin 1995; van der Elst 1997; Kearney 2002a). However the long-term effects of the buy-outs on both the commercial and recreational sectors still needs to be assessed (Morison and McCormack 2003).

The success of ROFAs in resolving conflict resulting from blame for catch declines may further depend on whether the impacts of the commercial sector on recreational catches are perceived or real. In many cases perceptions of recreational catch declines are not examined, and where there is a lack of data anecdotal claims take precedence (Smith and Pollard 1995; Griffin and Walters 1999). Where perceptions are examined, results are mixed. In some cases the impact of commercial fishing on angling catches is found to be real, and intervention is required. For example, in 1997 an experimental tuna longline fishery was initiated off South Africa. Due to a number of factors, the 'bycatch' of swordfish (*Xiphias gladius*) made up 70% of the total landed catch up to January 1999. At the same time there was a dramatic decline in recreational catch of swordfish. This situation, not surprisingly, led to considerable conflict between the two sectors, and the recreational sector strongly pushed for a closure of the commercial longline fishery[1] (Griffiths and Lamberth 2002).

In many fisheries, however, catch declines are misperceived. For example, Sztramko et al. (1991) examined anglers' catch rates at Long Point Bay on Lake Erie, Canada. Anglers were concerned about the effects of incidental catches of small-mouth bass (*Micropterus dolomieu*) in commercial gill nets targeting yellow-perch (*Perca flavescens*) and were thus calling for tighter restrictions on gill netting in the area. Creel surveys from the area's own angling group, however, showed an increasing trend in angler success rates. Thus, further restriction or banning of gill netting was not warranted, and the conflict was diffused. In many cases conflict results from misperceptions, and thus many conflicts can be resolved through education of the parties involved rather than via ROFAs (see Ruello and Henry 1977; Henry 1984; Kearney 1995b; McLeod 1995; Aas and Skurdal 1996; Griffiths and Lamberth 2002).

[1] For interest, closure of the longline fishery based on unavoidable swordfish bycatch was unlikely to occur at the time of publication, as foreign vessels within the fish's migratory path also target the South African swordfish stock. There is no international limit on swordfish catch; however the South African longline fleet has been limited to a swordfish catch of 3500 tonnes (Griffiths and Lamberth 2002).

ii) Method of implementation:

Recreational Fishing Only Areas can be implemented in a number of ways including political lobbying, through a management agency decision, or via consultation and stakeholder involvement. Whether conflict is resolved by ROFAs appears to depend on how the ROFAs are implemented.

Many ROFAs are implemented via political lobbying. Some authors consider fisheries managers have dealt with allocation issues by minimising the “political whinge” between user groups: i.e. managers have dealt with public perception and made adjustment to rules as combined fishing and/or lobbying pressure has increased, taking the minimal action needed to satisfy the most vocal stakeholders in what are regarded mostly as local concerns (Brayford 1995; Rogers and Gould 1995; Walters and Cox 1999; Rogers and Curnow 2003).

Anglers have significant power when it comes to influencing political decisions regarding allocation of fisheries resources (Owen 1981; Hushak et al. 1986; Charles 1992; Adams 1994; Kearney 2001; McPhee et al. 2002; Walters 2003). Australia’s peak national body for recreational and sport fishing, Recfish, states that in many reallocation scenarios, scientific considerations will be over-ridden by political decisions as a result of vocal and skilful political lobbying. They further state that anglers’ awareness of lobbying power is reflected in the common bumper-sticker “I fish and I vote” (Recfish 2001).

Apparently, calls for ROFAs are often made by only a small number of vocal anglers. They are however, the people to whom the government is most responsive (Ruello and Henry 1977; Beaumariage 1978; Henry 1984; McPhee 2001). Even the perception of such a political situation may increase the conflict between the groups as commercial fishers see the government bowing to a select group of recreational fishers who may not actually be representative of the recreational sector (Sutton 2006).

The most well known international example of recreational fishing groups’ political power is the Florida ‘netban’: In this case, anglers perceived inshore commercial net fishing as having a detrimental impact on fish stocks and mega-fauna, and they sought to introduce a ban on the use of entanglement nets. An active multi-million-dollar media campaign ensued, with recreational fishing and conservation lobby groups arguing the nets indiscriminately killed endangered species and depleted finfish stocks. Despite the fact that available scientific information did not support these perceptions, the controversial campaign was successful in encouraging voters to approve a constitutional amendment in 1994 that prohibited the use of commercial entanglement nets in State waters, as well as other nets larger than 500 square feet in nearshore and inshore waters (Renard 1995; Anderson 1999; Adams 2000; Smith et al. 2003).

While ROFAs introduced via political decisions may appear to resolve conflict issues in the short-term, long-term solutions need better future planning. The use and success of political lobbying can lead to a distrust of management, and tensions over shared access will likely intensify unless there is consistency in allocation decisions (Brayford 1995; Rogers and Gould 1995; Daigle et al. 1996; Nakaya 1998; Walters and Cox 1999; Recfish 2001), which is difficult where political, local scale decisions are involved.

Adjustment in resource access between groups has historically taken place through government intervention. However managers are beginning to realise that conflict over resource allocations is more likely to be resolved if the relevant stakeholders are involved in decision-making (Charles 1992; Gladwin 1995; Hancock 1995; Rogers and Gould 1995; Hutton and Pitcher 1998; Department of Fisheries Western Australia 2000; McMurran 2000; Recfish 2001; Kearney 2002a). For example, recurring tensions regarding commercial netting in coastal waters in Portland Bay, Victoria (Australia) were resolved in the 1990s through mediation meetings involving recreational and commercial fishing representatives. Anglers were calling for a ban on commercial netting based on a perception (that was not supported by science) that commercial netting was depleting fish stocks and/or affecting the quality of angling. The issues were highly emotive, but it was recognised that this was social problem, not a stock conservation problem. Together with a mediator, both sectors developed a Code of Practice which included a "net free zone" (i.e. ROFA) in one area for times when recreational fishing participation was highest (i.e. Christmas holidays, during recreational fishing competitions and on long weekends), and a net free zone in another area for the whole year. The code of practice was approved by all delegates (Gladwin 1995).

Regardless of how ROFAs are implemented, the question of whether they are successful in resolving conflict has yet to be answered – there are no published examples of ROFAs being examined post-implementation to test whether they were successful in reducing or resolving conflict. Conflict is often manifested via media articles and letters to fisheries departments (Ruello and Henry 1977; Henry 1984; Anderson 1999; Kearney 2002b): if such media outlining the conflict cease, then it could be assumed that the conflict is resolved. In many cases, however the same issues are raised again some years after ROFAs are implemented (or called for but deemed unnecessary at the time), usually with demands for further ROFAs. For example, in Australia's Northern Territory there has been a progressive implementation of ROFAs since the 1960s (Reed 1992; Pender 1995; Griffin 2003). Initially, commercial gill netting was prohibited in freshwater as a specific resource conservation measure. In 1978 the Mary River was closed to commercial fishing at the river mouth in response to declining recreational catch rates and high commercial pressure. This closure was extended in 1989. From 1987 the Commonwealth began progressively closing the Alligator Rivers in Kakadu to commercial fishing. The Daly River in 1989, and the Roper River in 1991 were closed to commercial netting in response to recreational fishing requests and in recognition of the importance of recreational fishing to the Northern Territory's outdoor oriented lifestyle (Reed 1992). In 2002, the McArthur River was closed to commercial fishing, apparently due to lobbying efforts of the Amateur Fisherman's Association of the Northern Territory (AFANT) (AFANT 2005).

Perhaps understandably, commercial fishers are concerned that there seems to be no "bottom line" when it comes to negotiations with anglers over resource allocation (Loveday 1995). Consequently, to reduce conflict in the long-term the implementation of ROFAs requires more future planning and consistency of implementation based on scientific knowledge, rather than via the current 'ad-hoc' manner (Brayford 1995; McLeod 1995; Rogers and Gould 1995). In many cases anglers are unaware of previous changes that have been made in their favour, which highlights the need to make such information more readily available (Ruello and Henry 1977; The Recreational Fishing Consultative Committee 1994).

b) <u>Improved recreational catches</u>

Anglers advocate the implementation of ROFAs on the presumption that such action will improve the quality of angling (in terms of numbers and size of certain species caught) (Ruello and Henry 1977; Kearney 2001; Cox et al. 2003). Such improvement in angling quality may increase the value current anglers place on fishing (Hendee 1974; Graefe and Fedler 1986). There is significant anecdotal evidence through fishing clubs and the media that ROFAs do result in improved catches for anglers (see Griffin 1995; Brown 2001; Anon 2002b; AFANT). There is at least an expectation that anglers' catches will improve in ROFAs given the removal of commercial fishing effort (so that fish previously harvested by commercial fishers are now available to the recreational sector only) (Steffe et al. 2005b), however there is no scientific information to support claims of improved fishing quality in most cases, and therefore anecdotal claims can take precedence (Smith and Pollard 1995; Griffin and Walters 1999).

There are a few cases where recreational catches are examined in ROFAs following their implementation. For example, in Iceland, anglers found a 28-35% increase in their catch when they effectively closed the River Hvitá mainstream to commercial netting from 1991. Recreational catch rates in the 'closed' area (i.e. ROFA) from 1991-2000 were compared to catch rates 10 years prior to the closure for the same area. The post-closure catch rates were also compared to catches in two other rivers that remained open to commercial fishing. Results showed significant increases in rod catches in the ROFA post-closure, while in the 'open' rivers the catches declined. Note that in this fishery the number of rods allowed on each river is fixed: i.e. it is not open access for recreational fishing (Einarsson and Gudbergsson 2003).

More recently, Steffe et al. (2005a) examined recreational harvest in the Tuross Lake estuary in NSW, which was declared a ROFA in May 2002. They compared two separate daytime, boat-based, recreational fishing surveys, with the first annual survey prior to ROFA implementation (March 1999 – Feb 2000), and the second 1.5 – 2.5 years post-ROFA implementation (Dec 2003 – Nov 2004). They found significant increases in recreational fishing effort (about 25%) in the post-ROFA survey year, and significant increases in harvest of many recreationally important species such as dusky flathead and bream. Some species harvest decreased, meaning there was no difference by number between survey years in the total annual harvest, but there was a significant difference by weight (41.6%) in the annual harvest of fish, crabs and cephalopods. This was due to the increase in mean and median size of most species harvested post-ROFA implementation. Further, the proportional increases in recreational harvest were all much larger than the corresponding proportional change in fishing effort. The authors stated the changes detected may be in part attributable to the implementation of the ROFA and/or may be in part attributable to natural fluctuations in fish abundance and catchability (which can be large in an open estuary system). Nonetheless, the comparison between the two annual survey periods shows that real differences occurred in the recreational boat-based fishery in the Tuross Lake estuary since the implementation of the ROFA.

In many other fisheries, improvements in recreational catches are not evident. For example the Florida net ban was expected to result in improved recreational catches in terms of catch per unit effort (CPUE). This is not evident according to current publications, which some authors suggest is due to increases in recreational effort to the degree that total fishing mortality rates returned to previous levels (Anderson 1999; Adams 2000; Walters 2003). Ruello and Henry (1977) found no noticeable improvements in recreational catches in Australia's Port Hacking and Brisbane waters despite being closed to commercial netting since the 1930s. They further stated that Botany Bay, which was open to commercial fishing, was considered a better angling area than either of these two ROFAs, despite anecdotal claims to the contrary[2]. In the Pumicestone Passage in Queensland, O'Neill (2000) examined recreational catches before and after commercial fishing was banned in 1995. No improvements in recreational catch rates were found.

Unfortunately, most of the studies that do examine recreational catches in ROFAs lack scientific rigour, either through a lack of comparable catch data from before and after ROFA implementation, a lack of time series data following the ROFA, or a lack of replication in sites. For instance, Einarsson's (2003) study in Iceland, while examining before and after closure data, was unable to provide a replicate ROFA with which to compare catch rates. Thus the changes in catch rates may have been a characteristic of the particular area. Steffe et al.'s (2005a) study provides a good comparison of recreational harvest pre- and post-ROFA implementation, however they do state that changes may be due to natural fluctuations and they recommend continued monitoring at intervals of about 3-5 years. Ruello and Henry's (1977) observations for Port Hacking and Brisbane waters were based on anecdotal information from 'experienced' fishers. Finally, O'Neill (2000) recommended re-examining angler catches in the Pumicestone Passage in future years as he sampled probably too soon since the closure to notice any potential catch improvements. O'Neill also noted he needed to interview twice as many anglers to have about an 80% confidence in detecting a 15% difference in catch rates between the before- and after-closure periods.

A more scientifically rigorous study was successful in showing higher fish abundances in ROFAs compared with non-ROFAs, although they did not examine recreational catches: Halliday et al. (2001) used commercial gill net fishing techniques to compare estuarine catches in three ROFAs and three non-ROFAs in north Queensland bimonthly over two years. The study found higher abundances of large barramundi (over 800 mm total length) in ROFAs compared to non-ROFAs. These results suggest improved angler catches of large barramundi in ROFAs are possible.

However, many studies show that there is not a strong relationship between fish abundance and angler catch rates because angling success is highly variable (Ruello and Henry 1977; Johnson and Carpenter 1994; Anderson 1999; Pierce and Tomcko 2003). For example, in Lake Mendota, Wisconsin, examination of 7-year creel survey data for the walleye (S*tizostedion vitreum vitreum*) fishery revealed that catch per unit

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[2] Interestingly Botany Bay was declared a ROFA in 2002 (NSW Fisheries 2003) – 25 years after Ruello and Henry's publication.

effort varied independently of fish abundance (Johnson and Carpenter 1994). Further, the closure of the Mary River in the Northern Territory to commercial gill net fishing resulted in expectations of improved angling success. However, despite a rise in the availability of barramundi (due to commercial exclusion as well as a good wet season and strong recruitment), angler success rate did not change, with only 50% of parties landing a barramundi (Griffin and Walters 1999; Griffin 2003). With any commercial or recreational fishery, there are factors that affect catch rates outside of the abundance of fish stocks, such as the composition of fishing fleet (including number and skill level of fishers), method of fishing, and where and when fishing occurs (Maunder and Punt 2004).

Another explanation for the lack of relationship between angler catch or success rate and stock abundance may be that overall recreational fishing effort increases as stocks increase such that an individual angler's fishing quality doesn't improve because there is higher competition between more anglers (Cox and Walters 2002; Cox et al. 2002; Le Goffe and Salanié 2005).

Some authors suggest that recreational catches may improve in newly implemented ROFAs, but such benefits may only be realised by 10% of the recreational fishing population – i.e. by the more skilled anglers who catch 90% of the recreational harvest – rather than the average angler (Johnson and Carpenter 1994; Griffin and Walters 1999; McPhee and Hundloe 2004).

c) Flow-on benefits for the community

If improved angler catches are expected or perceived, ROFAs may result in greater recreational fishing effort (Griffin and Walters 1999; Cox and Walters 2002; Cox et al. 2002; Pereira and Hansen 2003; Post et al. 2003; Denny and Babcock 2004). Such increased participation may in turn result in benefit to the community in terms of increased expenditure within the community (Hushak et al. 1986; Dominion 2002; Pereira and Hansen 2003) and potentially increased social well-being, such as health, social cohesion and quality of life, which result from participation in an outdoor recreational past-time such as fishing (Pretty et al. 2005; Cox 2006). The possibilities of increased effort and economic benefit are considered below. While social well-being is an important benefit, it is difficult to measure and few studies examine the well-being benefits of recreational fishing compared to other activities specifically.

i) Increased recreational fishing effort

In many situations where ROFAs are introduced, an increase in recreational effort is expected. In NSW, for example, a rise in recreational demand is expected within the 30 ROFAs introduced in the year 2002 (Dominion 2002; NSW Fisheries 2003; McPhee and Hundloe 2004). This expectation was fulfilled at least in one of the ROFAs – in the Tuross Lake estuary – where recreational effort (boat days) increased by about 25% approximately 1.5 to 2.5 years after ROFA implementation (Steffe et al. 2005a). For the walleye fishery in Lake Mendota, Wisconsin, angler expectations of increased catches due to stocking resulted in increased annual effort in the fishery (although the expectations were linked more to publicity than actual improvements in catch rates for the average angler) (Johnson and Carpenter 1994).

On the other hand, the relationship between angler effort and fish abundance is not known for most fisheries (Post et al. 2003), and some authors argue that even if angler catches improve, there is not a positive relationship between fish abundance (or catch rates) and the number of anglers (O'Neill 2000). For example, after commercial fishing was banned in the Northern Territory's Mary River an increase in recreational fishing activity in response to improved fish stocks was expected but did not occur. In contrast there was a decrease in recreational fishing activity despite increases in available barramundi stocks. The authors concluded that while abundance of fish is the basic factor that determines whether or not fishing activity will occur, it is not the only factor (Griffin 1995; Griffin and Walters 1999).

There is the growing notion that non-catch related reasons are the principal motivation for recreational fishing (Henry 1984; Holland and Ditton 1992; Fedler and Ditton 1994; Vigliano et al. 2000; McPhee and Hundloe 2004), and that a certain amount of angler behaviour is fixed, or at least unresponsive, to catch rate (Johnson and Carpenter 1994). There are conflicting views on the level of importance anglers place on catching fish (Schramm et al. 2003): some authors state that catching a fish remains a primary goal of angling, meaning there must be some probability of catching a fish before non-catch motivations gain more importance (Hendee 1974; Graefe and Fedler 1986; Arlinghaus 2005); while others argue that fishing quality contributes to satisfaction but for most anglers it is less important than other factors such as the physical setting of the fishing experience and social and leisure factors (Holland and Ditton 1992; Fedler and Ditton 1994; Vigliano et al. 2000; Ready et al. 2005). For example, Responsive Management (2004) conducted a survey in Pennsylvania, USA, in 1993 and 1996 to examine why anglers who bought a recreational fishing licence the previous year decided not to buy a licence on the year of the survey. Most anglers cited a loss of interest, lack of free time, work and family obligations, etc. Only 10% of anglers stated the quality of fishing affected their decision of whether to fish (Responsive Management 2004; Ready et al. 2005).

Given the level of importance attributed to fishing quality may vary widely between individuals and individual situations, it is unknown whether an improvement in angling quality will result in increased recreational effort.

ii) Increased economic value

Regardless of these varied views and outcomes, if there is an increase in effort in a ROFA, it is theorised that expenditure of anglers in the area adjacent to the ROFA will increase (Hushak et al. 1986; Pereira and Hansen 2003). Expenditure of current anglers may also increase as anglers may place a higher value on a fishery with greater fishing quality (Dwyer and Bowes 1978; Cauvin 1980; Graefe and Fedler 1986). Some authors consider an increase in expenditure to be equivalent to an increase in economic 'value' (Nicholls and Young 2000; Young 2001; Murphy 2003), and this is a common argument used by anglers to promote further ROFA implementation (McPhee and Hundloe 2004).

In some cases increased economic input into the community is expected. For example, the recently appointed NSW ROFAs are expected to result in an increase in expenditure on fuel, bait, supplies, fishing gear, boats, etc, resulting in an expansion in employment in the recreational sector. Such economic gains are expected to exceed those lost from the commercial fishery[3] (Dominion 2002). Similarly, Mann et al. (2002) suggest the proposed introduction of commercial gill net fishing in a previously recreational only estuary in South Africa would probably not provide as much employment and economic gain as that generated by the recreational fishery.

While economic benefits are theorised, there are no published cases where such expectations of increased expenditure as a result of ROFA introduction in the adjacent community have been tested following ROFA implementation. For example Hushak et al. (1986) estimated the required increase in recreational effort and expenditure to offset commercial losses following allocation of yellow perch (*Perca flavescens*) and white bass (*Morone chrysops*) to the recreational fishery in Ohio's portion of Lake Erie. Whether this increase would occur, however, was unknown: the authors stated that further research is needed to confirm the response of anglers to reallocations. In some situations changes to recreational effort has been examined, but whether related expenditure has increased as well is not explored. Some authors

[3] There are no current publications available outlining whether recreational expenditure has increased in areas adjacent to these NSW ROFAs as expected.

suggest that angler success apparently does not strongly influence angler expenditure (McPhee and Hundloe 2004).

If, hypothetically, angler expenditure does increase in the region adjacent to the ROFA, it may merely be a transfer or re-distribution of spending from other areas (e.g. other nearby towns, or other leisure activities), so the overall net national benefits would be zero (Edwards 1990; Hundloe 2002; Kearney 2003b; McPhee and Hundloe 2004). This may certainly be the case in Queensland where the overall number of recreational fishing participants is declining (Higgs 2003), as it is in other areas (e.g. America (Fedler and Ditton 2001)), and thus the likelihood is low that any increased expenditure comes from new anglers.

Importantly, there is also abundant literature available arguing that an increase in expenditure is not equivalent to an increase in 'value' to the community (see Gordon et al. 1973; Edwards 1990, 1991; Kearney 2001; Hundloe 2002; Pitcher and Hollingworth 2002; McPhee and Hundloe 2004). There are numerous papers debating the use of various economic methods for assessing economic value and allocating resources accordingly between recreational and commercial fishing sectors (see Edwards 1991; Nicholls and Young 2000; Hundloe 2002; McPhee and Hundloe 2004). Currently, however, there is no consistent or accepted method for evaluating recreational fisheries – a common problem against which Gordon et al. (1973) made a plea for consistency in the 1970s – much less for comparing recreational and commercial fishing values. Given numerous differences between these two sectors, values (social and/or economic) are difficult to compare (Beaumariage 1978; Coastal Engineering Research Center 1984; Winwood 1994; Gresswell and Liss 1995; van der Elst 1997; van der Elst et al. 1997; Kearney 2002b; Pitcher and Hollingworth 2002), and there is a lack of studies that examine the social and economic values of the recreational and commercial sectors at the same time and/or using the same methods (Holland et al. 1992; Hobson 1993; Peterson 1994; van der Elst 1997; The South Australian Centre for Economic Studies 1999; McPhee and Hundloe 2004). Furthermore, there are few data available for any method of economic evaluation or comparison, particularly for the recreational sector (Holland et al. 1992; McLeod 1995; Rogers and Gould 1995; Kearney 2001; Rogers and Curnow 2003).

With the inability to demonstrate comparable values, it is impossible to demonstrate comparable costs and benefits of different allocation strategies (van der Elst 1997), and there is a scarcity of studies examining the net economic impacts of reallocating resources from the commercial to the recreational sector (Berman et al. 1997; Sharma and Leung 2001). Therefore it is important the economic costs and benefits are monitored or assessed where allocation changes are made (McPhee and Hundloe 2004).

Regardless of whether economic values are available or correct, some authors argue that ROFAs may be "second best" in terms of economic efficiency (Edwards 1990; McPhee and Hundloe 2004), although they may have the advantage of political expediency (Samples 1989; Rogers and Gould 1995). Allocation based on economic value infers that stocks should be allocated to the sector which gains the greatest marginal value from using the resource, hence maximising benefits to the community (Edwards 1991; Presser 1994; van der Elst et al. 1997; Department of Fisheries Western Australia 2000; Kearney 2002b). McPhee & Hundloe (2004) argue that if the purpose of reallocation is to increase community benefits, resources should be allocated to the point where net marginal benefits for each sector are equal, rather than providing one sector with exclusive access such as via ROFAs.

d) Conservation of fish stocks

Some proponents of ROFAs believe ROFAs will be able to fulfil sustainability or conservation goals by removing the more efficient commercial effort; the catch from which may not be completely harvested by recreational fishers (MacDonald 2003; Rogers and Curnow 2003; Denny and Babcock 2004). For instance in Iceland, following the closure of the River Hvitá to commercial fishing, while anglers' catches improved, they were only able to harvest 39-52% of the previous commercial catch (Einarsson and Gudbergsson 2003), which may be a positive outcome for the fish stocks. This outcome, however, may differ in open access recreational fisheries (in Iceland there is a limit on recreational rod number per day) because recreational effort may continue to increase to the point that the original total harvest is taken (Cox and Walters 2002; Cox et al. 2002; Rogers and Curnow 2003; Walters 2003). Unfortunately in most cases where ROFAs are introduced the total recreational harvest from the area prior to and following ROFA implementation is unknown.

On the other hand, many authors suggest resource allocation and conservation issues should be treated separately, as allocating a resource to one sector does not necessarily address conservation imperatives (Kearney 2003a; MacDonald 2003; O'Regan 2003; Denny and Babcock 2004). In Western Australia, for example, there are calls by anglers to remove commercial fishing in an attempt to improve sustainability of the dhufish (*Glaucosoma hebraicum*) fishery. In the short-term fish stocks may benefit from the removal of commercial fishing and recreational catches would likely improve. However, current recreational bag limits are ineffective – the recreational bag limit is 4 fish per person per day, but catch surveys indicate the average catch is 0.4 dhufish per angler per trip. Hence there is room for angler catches to increase within current regulations, meaning long-term benefits to the stock of removing commercial harvest would likely be zero as recreational effort increases in response to improved CPUE (Rogers and Curnow 2003). In the Tuross Lake estuary in NSW, there were concerns that dusky flathead were growth overfished (where excessive fishing effort leads to the harvesting of many smaller fish such that they do not get a chance to reach their maximum growth) prior to ROFA implementation. Surveys of recreational fishing 1.5 to 2.5 years after ROFA implementation revealed only a small improvement in average size of dusky flathead, indicating that the increase in recreational fishing effort (25%) was sufficiently large to offset most of the potential gain made by removing commercial fishing effort (Steffe et al. 2005a).

In many fisheries, though estimates are not considered reliable, the total recreational catches are at least as high as those of the commercial sector, particularly in coastal areas close to population centres (Anon 1995; Hancock 1995; Rogers and Gould 1995; McPhee et al. 2002; Sumner 2003). For instance recreational harvest is similar to commercial harvest for King George whiting, snapper, garfish, blue crabs and squid in South Australia (Hall 1993), barramundi on Queensland's east coast (Williams 2002a), and snapper in New Zealand (Sullivan 1997). In some fisheries the recreational catch exceeds commercial take and is seen as a major threat to the resource (Cox et al. 2002; Schroeder and Love 2002; Cooke and Cowx 2004), such as within the tailor (*Pomatomus saltatrix*) fishery in southern Queensland (Pollock 1979; Pollock 1980; Williams 2002a); red drum (*Sciaenops ocellatus*) in the South Atlantic (where recreational harvest is 93%of total harvest); and red snapper (*Lutjanus campechanus*) in the Gulf of Mexico (where recreational harvest is 58% of total harvest) (Coleman et al. 2004). Thus removal of commercial effort in fisheries where recreational harvest is dominant is unlikely to result in conservation of fish stocks.

In situations where recreational harvest is significant (as a proportion of total harvest) or where effort and catches increase dramatically as a consequence of declaring ROFAs, ROFAs are unlikely to be effective in meeting conservation goals without management intervention to limit or reduce recreational effort (and harvest). Some authors advocate limiting recreational effort in ROFAs through catch quota, limited licensing, or even limited facilities at boat ramps (Cox and Walters 2002; Mann et al. 2002; Cox et al. 2003; Walters 2003). However, there is often reluctance by fisheries managers to limit recreational access in many fisheries (Pereira and Hansen 2003).

1.2.2 Costs of ROFAs

Costs of ROFAs are not often considered when ROFAs are proposed. Some studies outline hypothetical costs (e.g. Dominion 2002), but fail to detail actual costs. There are various potential costs, not just for the excluded commercial fishers, but also for recreational fishers, the community and the fish stocks. There are also potentially significant costs to fisheries agencies and the government of implementing ROFAs.

a) <u>Costs to commercial fishers</u>

For the commercial sector, ROFAs bear the obvious potential cost of reduced product and income, due to a decrease in area available for fishing (Hushak 2000). In some cases there is a complete loss of livelihood from fishing if the fisher's licence is bought back, such as via the ROFAs introduced recently in NSW (see Dominion 2002; NSW Fisheries 2003) and Victoria (see Morison and McCormack 2003). Increased pressures of reduced disposable income are likely to be felt both at the family and the broader community level (Bureau of Rural Sciences 2003).

Studies of Marine Protected Areas suggest costs can be significant for individual fishers (Bureau of Rural Sciences 2003; Cook and Heinen 2005). For example, the implementation of a 'no take' area within the Florida Keys National Marine Sanctuary was expected to impact 8% of shrimp catch, 14% of king mackerel catch, 12% of lobster catch and 20% of reef-fish catch. These catch reductions would result in a loss of almost $844,000 in harvest revenue and 49 jobs by commercial fishing operations (Cook and Heinen 2005). The Representative Areas Program (RAP) implemented in 2004 in the Great Barrier Reef Marine Park (GBRMP), Queensland, was estimated to result in a $10.5 million reduction per annum in the gross value of production of key commercial fisheries (otter-trawl, net, line and crab), which represents on average approximately 10% of production value (Bureau of Rural Sciences 2003; Hand 2003).

Factors which will influence the level of impact on individual fishers include the magnitude of the change (i.e. the extent to which ROFA will reduce access to resource fishers currently use), fishers' capacity to shift effort, change the nature of their fishing operations or take other mitigating action, fishers' level of dependence on the fishery, their individual resilience to managing change (which varies among individuals depending on socio-demographic factors such as age and family structure, income, housing type, employment, and education, plus how localised their fishing operation is), and the level of compensation available. There may be a range of responses from fishers, including changing their fishing location (which may increase travel and running costs), increasing effort to maintain production, or changing the nature of their operations (e.g. shifting operations to higher value outputs or to other target species). Some fishers may leave the fishing industries altogether (potentially with assistance from government buy-outs), although previous studies reveal fishers prefer to remain in the industry (Bureau of Rural Sciences 2003; Hand 2003; Cook and Heinen 2005).

In those areas where no, or insufficient, licences are bought-out from newly implemented ROFAs, the resulting effort shift can potentially put greater pressure on remaining areas and result in increased competition within the commercial sector and between recreational and commercial fishers in areas to which commercial effort is displaced (Department of Primary Industries and Fisheries 2004).

There are also potential social costs for affected commercial fishers and their families, such as those outlined following the Florida net ban. These costs included mental health impacts and emotional problems, higher use of drugs or alcohol, and higher divorce rates. These negative impacts lasted well after the net ban was implemented (Anderson 1999; Bureau of Rural Sciences 2003; Smith et al. 2003). In NSW, social impacts including declining coastal communities and effects on family cohesion were hypothesised but not measured (Dominion 2002). The ability of families within the industry to manage can be examined in terms of a family resilience measure which includes socio-demographic factors such as age and family structure, income, housing type, employment, and education. The strong self-identification of fishers with their industry highlights the potential for increased feelings of alienation if commercial fishing options are no longer available. Many fishers have difficulty transferring to other employment outside the fishing sector both due to lack of formal skills and education, and due to cultural resistance to shifting out of the fishing sector (Bureau of Rural Sciences 2003; Hand 2003; Cook and Heinen 2005). There are no published cases where such costs have been quantified to examine whether they are outweighed by benefits gained from ROFAs.

b) <u>Costs to recreational fishers</u>

For the recreational sector, some anglers claim that the benefits of exclusive access may be negated by a disproportionate increase in recreational effort. As catches improve (perceived or real), the number of anglers may increase, leading to increased pressure on the resource and increasingly crowded conditions, which would be detrimental to angling satisfaction (Anderson 1999; Hunt 2005; Le Goffe and Salanié 2005; Ready et al. 2005). Further, as more anglers enter the area, individual angling success may decrease as competition increases within the recreational fishing sector

(Cox et al. 2003; Arlinghaus 2005). There may also be increased conflict between recreational and commercial fishers in areas adjacent to ROFAs if commercial effort is displaced to these areas (Hancock 1995; Bureau of Rural Sciences 2003; Department of Primary Industries and Fisheries 2004).

c) Costs to the community

There are various potential costs to the community, depending on how central commercial fishing is to the community as a whole. In some cases while costs may be significant for individual fishers, costs may be minor for the overall community, depending on the proportional contribution to the community from fisheries compared to other industries (Bureau of Rural Sciences 2003; Cook and Heinen 2005). For instance, the direct economic impacts of closing a reserve within the Florida Keys National Marine Sanctuary to commercial fishing was expected to have significant impacts on affected commercial fishers, but was projected to be unnoticeable on the Monroe County economy. As a proportion of the Monroe County total catch, only 1.16% of harvest revenue would be lost. Plus only 0.08% of total annual income and 0.08% of total employment, of Monroe County would be negatively impacted (Cook and Heinen 2005).

For other communities there may be significant impacts. The introduction of the RAP in the GBRMP was expected to have significant impact on 13 of 20 town resource clusters (TRCs) along Queensland's east coast which relied solely or heavily on the Marine Park for their fishing activities. Some regions will be more vulnerable than others as a consequence of their underlying socio-demographic characteristics such as dependency on the fishing industry, housing, age, labour force, occupation, weekly incomes, education, family structure and proportion of Indigenous persons (Bureau of Rural Sciences 2003). Other studies have found that fishing-related populations are older than average, have lower levels of education, and have been strongly associated with fishing employment for some time. Fishing dependent communities also generally have higher than average dependency ratios (ratios of young and aged people to those of working age). All of these factors affect a community's ability to cope with closure to commercial fishing (Bureau of Rural Sciences 2003).

Further, commercial fishing provides local employment directly, plus employment in upstream and downstream industries and businesses associated with it (Bureau of Rural Sciences 2003). Anderson (1999), highlighted the effects of the Florida net ban on industries related to commercial fishing: The affected industries included gasoline, diesel and oil suppliers; ice, bait and fishing gear suppliers; services associated with docking, registration and licences; and fish processing plants, warehouses and distributors. Fenton and Marshall (2000) outlined the flow-on effects of fisheries closures in Queensland resulting from reduced income of commercial fishers and predicted effects on neighbouring towns or regions where fishers would normally spend their income.

While there may be costs of economic loss to the community through a reduction in commercial product, some authors consider these may be offset by increases in recreational spending (Dominion 2002), Others dispute this theory, however (see *Flow-on benefits for the community* above). For example, in Lake Erie, stock increases of yellow trout were expected to result in increased recreational effort and expenditure; however, these expected increases did not eventuate (Hushak 2000).

There are also other costs to the community aside from direct economic loss from commercial product. For example, authors have listed positive reasons to keep commercial fishing in an area including local seafood and bait supply for residents and tourists, plus the importance to the national economy (e.g., via decreased dependence on imports) (Ruello and Henry 1977; Peterson 1994; Hushak 2000; Bureau of Rural Sciences 2003). Loss of local seafood for local and tourist consumers may also result in an increase in price of seafood, or forced substitution with lesser valued or imported species (Lampl 1989; Anderson 1999; Hushak 2000; Dominion 2002). Further, commercial fishing can have strong historical links in local communities, and for many is considered a defining industry in the livelihood and character of the region (Bureau of Rural Sciences 2003).

d) Costs to fish stocks

Costs to the fish stocks are also possible, though they are rarely considered or monitored when ROFAs are suggested or implemented. There are potential costs from unmonitored recreational fishing, costs to adjacent areas from displaced commercial effort, and potential costs for mobile species, as outlined below.

There is a perception that the exclusion of the commercial sector may result in a more sustainable use of the resource (see *Conservation of fish stocks* above). Some authors and anglers argue that anglers are more conservation conscious than commercial fishers (Arlinghaus 2005; Grimm 2005). This is not always supported by the limited available data, however. Individual recreational fishers may be conservation-minded, but they rarely take into account the high numbers of people participating, which together can have a significant impact on the resource (Brayford 1995; Francour et al. 2001; Kearney 2001; McPhee et al. 2002; Pitcher and

Hollingworth 2002; Schroeder and Love 2002; Kearney 2003a; Walters 2003; Coleman et al. 2004; Hecht and Vince 2004). Whether the potential impacts of recreational fishers in ROFAs outweigh the combined impacts of commercial and recreational fishing in shared areas is unknown. However, the potential impacts of recreational fishing in ROFAs are outlined here.

Recreational fishing can have significant impacts on fish stocks within ROFAs. Westera et al. (2003), for example, compared fish abundance and size between 'sanctuaries' (where no fishing is allowed) and ROFAs in Ningaloo Marine Park, Western Australia. They examined three regions, each containing one sanctuary and one ROFA, and found higher abundances of legal-sized Lethrinids (the most targeted finfish family) in sanctuaries than in ROFAs, concluding that recreational fishing does have an impact on target species. Similarly, New Zealand snapper (*Pagrus auratus*) populations were compared between the Mimiwhangata Marine Park, which is open to some recreational fishing methods only (i.e. effectively a ROFA), to areas with no protection (i.e. open to all fishing) and areas with complete protection (i.e. no fishing allowed). The study found Mimiwhangata had fewer and smaller snapper than in any of the other areas, concluding that partial closures are ineffective as conservation tools. The authors further stated that there may be a perception that, in the absence of commercial fishing, fish are larger and more plentiful in the ROFA, which may result in higher recreational fishing effort (Denny and Babcock 2004).

Open-access recreational fisheries may respond to perceived or real fish abundance increases within ROFAs with strong effort responses that may negate any gains in quality of fishing for individual anglers (Sullivan 1997; Department of Fisheries Western Australia 2000; Cox and Walters 2002; Cox et al. 2002; Pitcher and Hollingworth 2002; O'Regan 2003; Walters 2003; Arlinghaus 2005; Le Goffe and Salanié 2005), although some authors dispute whether this will occur (see *Flow-on benefits for the community* above). Some authors state there is potential for the recreational sector to fish stocks to a lower level than the commercial sector would as anglers derive their personal incomes independent of fish resources: this means their fishing operations are 'subsidised' in an economic sense, and subsidised fisheries often collapse (van der Elst 1992; Hall 1993; Department of Fisheries Western Australia 2000; Francour et al. 2001).

Conventional management methods, such as size and bag limits, aim to limit recreational harvest in many fisheries. However these measures are considered ineffective in many open access recreational fisheries (Cox et al. 2002; Post et al. 2003; Morales-Nin et al. 2005). These management measures assume that released fish survive, however post-release survival rates are variable between species and often unknown for many species (Post et al. 2003; Sumner 2003; Coleman et al. 2004; de Lestang et al. 2004; Thorstad et al. 2004; Bartholomew and Bohnsack 2005). In some high-effort recreational fisheries post-release mortality has been found to be high (Bohnsack 1993), such as in the walleye fisheries in Alberta, USA (Sullivan 2003 in Pereira and Hansen 2003), and the common snook (*Centropomus undecimalis*) in Florida (Muller et al. 2001 in Pereira and Hansen 2003). For the Atlantic striped bass (*Morone saxatilis*) catch-and-release mortality losses were estimated to be 1.2 million fish compared to the total recreational landings of 1.4 million fish in 1998. This level of mortality, when combined with total commercial fishery losses, led to an overfishing declaration for striped bass (NMFS 1999 in Cox et al. 2002). Research suggests that all recreational fishing results in some level of injury and stress to an individual fish, however, the severity of the injury, magnitude of stress, and potential for mortality varies in response to a variety of factors such as fishing gear (e.g., type of hook, bait or landing net) and angling practices (e.g., duration of fight and air exposure, fishing during extreme environmental conditions, fishing during the reproductive period) (Cooke and Sneddon 2007). Bartholomew and Bohnsack (2005) reviewed 53 release mortality studies, and found release mortality varied greatly between and within species. They listed various important factors that affected mortality, including anatomical hooking location (the most important mortality factor), type of bait, removing hooks from deeply hooked fish, hook type, depth of capture, warm water temperatures, and extended playing and handling times. There is also growing debate regarding the ethics of catch-and-release angling in terms of pain and suffering experienced by released fish (Cooke and Sneddon 2007).

Given these potential impacts, some fisheries departments are becoming increasingly concerned about the unmonitored impacts of recreational fishing in ROFAs. Unfortunately, when commercial fishers are excluded from an area, the time-series data provided by commercial catch logbooks is also lost (Hancock 1995; Cowx 1999; Cox et al. 2002; McPhee et al. 2002; Griffin 2003; Hall 2003; Cooke and Cowx 2004). Thus, some managers recommend monitoring of recreational catches, implementation of limited access within ROFAs, or even allocation of quotas for anglers (Sullivan 1997; Cox and Walters 2002; Cox et al. 2002; Anon 2003; Sumner 2003; Walters 2003). Fisheries independent monitoring within ROFAs may be required, however, as angling alone may not provide the necessary data to accurately assess the status of fish stocks (Cowx 1999; Arlinghaus 2005).

Other environmental impacts of recreational fishing should also be considered. While there are no data available on the environmental impacts of recreational fishing, anecdotal evidence outlines problems such as discarded line, lead weights, litter, impacts on habitat through bait harvesting, direct impacts on sea-birds, marine mammals and reptiles, and potential trophic or ecosystem effects similar to commercial fisheries (Dominion 2002; McPhee et al. 2002; Sumner 2003; Coleman et al. 2004; Cooke and Cowx 2004).

Implementation of ROFAs may also affect adjacent areas or other species, by moving commercial interests from one area or stock to another (Hancock 1995; Bureau of Rural Sciences 2003). This was shown in the case of the Florida net ban, where commercial fishers previously targeting mullet moved to other species such as stone and blue crab which apparently now require increased regulations to protect these intensely targeted species. Such action will probably refocus or intensify commercial efforts on yet another species as commercial fishers' families strive to retain their way of life (Anderson 1999; Smith et al. 2003). In situations where commercial licences are bought-out to implement the ROFA, there is less likelihood of increased pressure on remaining areas or other species.

Size of ROFAs may also be important, particularly for mobile species, because closed areas are less effective for species that have larger home-ranges. Fish that settle in a ROFA can be exposed to the commercial fishery if relocations take them outside the ROFA boundaries (Kramer and Chapman 1999).

e) <u>Costs to the government:</u>

Authors such as McPhee and Hundloe (2004) suggest other costs of a new fisheries allocation plan to the community should also be considered: i.e. costs of management (e.g., legal proceedings and licence buy-backs), compliance, research and education. There are expected costs for changing legislation, but additional costs such as buying out commercial licences, or paying compensation, can be significant. For example, 114 commercial licences were initially bought-out as a result of the RAP in the GBRMP at a cost of over $31 million (QSIA 2004). Assistance to fishing and related businesses as a result of the RAP exceeded $87 million (Campbell 2006). In some instances costs of licence buy-outs and compensation for ROFA implementation may be funded by recreational fishing licences, such as in NSW, where the creation of 30 ROFAs required the purchase of 251 fishing businesses at cost in excess of $18.5 million (NSW Department of Primary Industries 2004; Steffe et al. 2005a).

Costs of negotiation and legal proceedings can also be significant. While there are no exact figures published, the Florida net ban for example was preceded and followed by numerous challenges taken to the Supreme Court by conservationists, recreational fishers and affected commercial fishers (Renard 1995; Smith et al. 2003).

Sutinen and Johnston (2003) state that in the US, litigation costs have increased in such a way that resources are diverted from the basic tasks of fisheries management.

Other studies highlight the need for ongoing public education and stakeholder analysis over time, which incur costs but are necessary to ensure the public are aware of closures and to allow managers to better-understand any social impacts or benefits (Cook and Heinen 2005).

1.2.3 Conclusion

While many benefits and costs of ROFAs are possible, there are few cases where they are examined and quantified, much less compared, to determine whether the benefits outweigh the costs involved. Considering the mixed results for both benefits and costs outlined above, and with continued pressure from angling bodies to implement more ROFAs, potential benefits and costs of current ROFAs should be examined and monitored. There is a need for fisheries managers to develop clear management objectives for ROFAs, and for investigation into whether these objectives are achieved.

The present study focuses on whether benefits of current ROFAs for commercial and recreational fishing sectors are being realised within the Queensland east coast barramundi fishery. An investigation of costs of current and future ROFAs for this fishery is beyond the scope of this study. Information on potential costs provided here, however, highlight the importance of examining whether benefits of ROFAs are realised, as ROFAs are unlikely to come without costs.

1.3 ROFAs within Queensland east coast estuaries

Following concern for fish stocks, in 1976 all or part of 6 river systems on Queensland's east-coast were closed to commercial gill net fishing, effectively making them ROFAs for finfish (commercial crabbing is still allowed in these areas) (Healy 1995). Later, a further approximately 35 estuaries north of Fraser Island were closed or partly closed to commercial gill netting. All estuarine ROFAs are listed within Queensland's Fisheries Regulations 1995 (see Appendix 1 for a list constructed from the Regulations), however information on the timing and reason for each closure is not readily available – a number of areas were permanently closed to commercial netting due to their role as nursery habitats where fish are in relatively high numbers and can be more susceptible to net capture (including inshore seagrass beds, upper reaches of estuaries within rivers, and whole estuaries of some smaller creeks) (Zeller and Snape 2005); and an unknown number of estuaries were closed to commercial netting in order to reduce conflict between competing recreational and commercial fishers (Mark Doohan, QDPI&F, pers. comm., 2005).

In January 1998, further closures and restrictions to commercial gill netting were introduced via the implementation of 17 Dugong Protection Areas (DPAs) on Queensland's east coast. While these areas were set aside specifically for dugong conservation, some of these DPAs effectively became ROFAs for finfish (particularly barramundi) because set gill netting was banned or restricted. The DPA regulations appear complicated when combined with other fisheries regulations. Of most interest to this project is the DPA encompassing the Hinchinbrook Channel – due to a combination of fisheries regulations and the DPAs, within the Hinchinbrook Channel there is a large area (from approximately the Herbert River to just south of Cardwell, see Figure 1.2), where no netting is allowed within the channel and adjoining estuaries. Adjoining areas allow restricted netting under 'N1' and 'N6' symbols, with which no barramundi are allowed to be kept (there are a number of netting symbols in the East Coast Inshore Finfish Fishery – see *The commercial fishery* below). Other DPAs allow restricted netting. The introduction of DPAs resulted in some commercial effort displacement from areas where DPA 'a' zones were declared to areas where lesser restrictive DPA 'b' zones were implemented, and to adjacent non-DPA areas (see Queensland Department of Primary Industries 1995; Williams 2002a; Zeller and Snape 2005; Great Barrier Reef Marine Park Authority unknown-a) for further information).

More recently (in July 2004) approximately 50 inshore 'Conservation Park (yellow) Zones' were implemented through the Great Barrier Reef Marine Park Authority's (GBRMPA) 'Representative Areas Program' (RAP) (Zeller and Snape 2005; Great Barrier Reef Marine Park Authority unknown-b). Many of these yellow zones were mirrored within the Great Barrier Reef Coast Marine Park for the low to high tidal waters, including part of some rivers (Environmental Protection Agency 2004). Yellow zones were implemented with the aim of protecting biodiversity and as such certain fishing methods are restricted. Within these zones, line fishing with one line and hook per person is allowed, but commercial netting (except baitnetting) is banned (Great Barrier Reef Marine Park Authority unknown-b). Hence for inshore areas these yellow zones are effectively ROFAs for barramundi at least, for which there is no commercial line fishing (Queensland Department of Primary Industries 1995; Department of Primary Industries and Fisheries 2004). There are very few estuaries closed to all fishing (i.e. both recreational and commercial fishing) in Queensland (Queensland Department of Primary Industries 1995; Halliday et al. 2001), however a number of bays (not including adjoining estuaries) were closed to all fishing within 'Marine

National Park (green) Zones' in 2004 via the RAP (Great Barrier Reef Marine Park Authority unknown-b).

Recreational and commercial estuarine fishers are also separated through time segregation: No commercial gill netting is allowed in estuaries on weekends, allowing recreational fishers exclusive access at a time when angler activity is highest (Healy 1995; Queensland Department of Primary Industries 1995).

Currently, there are calls for the introduction of further estuarine ROFAs on Queensland's east coast (see The Recreational Fishing Consultative Committee 1994; Eussen 2001; Knowles 2001; Sunfish 2001), in an attempt to: a) reduce apparent conflict between the commercial and recreational sectors; and b) improve angler catches of barramundi (primarily) and other fish species.

1.3.1 ROFAs for barramundi

While commercial and recreational estuarine fishers share access to most estuarine fish species, barramundi (*Lates calcarifer*), is the main target of commercial gill net fishers within the East Coast Inshore Finfish Fishery (ECIFF) in the Great Barrier Reef World Heritage Area (GBRWHA), and is one of the most important target fish for recreational line fishers in north Queensland (Healy 1995; Welch et al. 2002; CRC Reef Research Centre 2005a; Robinson and Cully unknown). Barramundi drive many of the calls for further ROFAs and claims of effects of commercial gill net fishing on angler catches (see Brayford 1995; Brown 2001). Consequently, barramundi has been selected as the focus species of this project.

1.3.2 Goals of ROFAs

a) <u>Reduction of conflict</u>

In Queensland, overall recreational fishing participation has declined in recent years (Higgs 2003). This decline may be due to a number of factors, however one suggestion is that declining recreational fishing participation is often attributed (by anglers) to declines in fish stocks and increasing competition with commercial fishers. Regardless of this decline in participation, increased access to fishing locations has apparently increased contact between the commercial and recreational fishing sectors, which may be increasing conflict (Higgs 2003).

Overlap in species taken by recreational and commercial fisheries within the Queensland ECIFF has created, and will continue to create, conflict over resource allocation (Department of Primary Industries and Fisheries 2004). Conflict between recreational anglers and commercial gill net fishers over barramundi has been reported in some areas since the 1960s (Griffin 1987a). Currently the presence of such conflict is apparent through various media articles, letters to fisheries departments and lobby groups, at public meetings and vandalism at boat ramps (see The Recreational Fishing Consultative Committee 1994; Eussen 2001; Hansford 2001; Knowles 2001; Sunfish 2001; Anon 2002a; Olsen 2002). It is unknown, however, whether the majority of the general fishing public experiences the conflict. Also, the causes of the conflict have not been investigated. Such questions are rarely asked in resource competition situations; however their answers will have important implications for possible solutions to conflict, including whether ROFAs would be successful in reducing apparent conflict.

b) Improve recreational catches

Anecdotal claims of improved recreational catches in current ROFAs also frequent media articles (see Brown 2001). Concerns over the impact of commercial fishing on recreational catch rates in shared areas encourage the push for more ROFAs. For example, during the 1993 Queensland Inquiry into recreational fishing, the committee was of the view that “prospects for recreational fishers were diminished as a consequence of commercial effort being applied to a number of specific areas”. This view was based on strong anecdotal evidence presented at public meetings and within a number of submissions (48% of 4085 submissions) that expressed concern about commercial gill netting in Queensland estuaries. The committee subsequently recommended the introduction of more estuarine ROFAs, particularly near population centres (The Recreational Fishing Consultative Committee 1994).

There is currently no scientific information, however, to support or refute claims of the effect of commercial fishing on angler catches and improved angler catches in Queensland estuarine ROFAs. Recreational catch data for barramundi are limited to state-wide surveys (see Higgs 1997; Higgs 2001; Henry 2003), with insufficient detail at the small-scale to allow comparisons of catches between specific estuaries. Such lack of information is common where ROFAs have been introduced.

It is unknown whether opinions portrayed in the media and via submissions are representative of the general fishing public, although it is often assumed by fisheries managers that they are, These generally negative opinions, however, may be held only by a vocal minority group that apparently consist either of those peripherally engaged in fishing or those within organised fishing groups. Hence, the degree to which statements found in the media are representative is unclear. Because such opinions can influence management decisions, their representativeness should be investigated (Beaumariage 1978; Henry 1984; Pender 1995; Smith and Pollard 1995).

1.3.3 Available data for Queensland estuarine ROFAs

Halliday et al. (2001), using commercial gill net techniques, examined the abundance of barramundi and other species in north Queensland estuaries open and closed (i.e. ROFAs) to commercial gill net fishing through the Effects of Net Fishing (EoNF) Project. They found significantly fewer large (>800 mm total length (TL)) barramundi in estuaries open to commercial gill netting (‘open’ estuaries) than in the ROFAs. Barramundi ranging from 600-800 mm TL were commonly caught at all sites. Their study supported the notion that ROFAs could benefit the recreational fishery in terms of improving catches of large barramundi. They noted, however, that the lower abundances of large legal barramundi in open systems might also be due to unquantified recreational fishing pressure. For interest, the study also found no significant differences in the abundance of other species between estuaries open and closed to commercial gill netting.

While the EoNF Project did find higher abundances of larger barramundi in estuarine ROFAs than in open estuaries, suggesting this may translate into improved angler catches, it is unknown whether this will occur – some studies suggest it may not because angling success is often highly variable (see Ruello and Henry 1977; Johnson and Carpenter 1994; Anderson 1999; Griffin 2003).

1.4 Objectives of Project

The overall aim of the current project is to examine the effectiveness of north Queensland estuarine finfish ROFAs in: a) resolving apparent resource competition and conflict between recreational and commercial fishers in north Queensland estuaries, and b) improving recreational catch quality for barramundi in north Queensland estuaries. To achieve these aims, the specific objectives are:

1. To explore the nature and source of apparent competition and conflict between recreational line and commercial gill net fishers in north Queensland;
2. To examine whether fishers support the current and future use of estuarine finfish ROFAs to reduce conflict between the two sectors;
3. To determine if there is a difference in recreational line fishing quality between estuaries that are open and closed (ROFAs) to commercial gill net fishing.

The impartial data obtained will be provided to all Queensland fisheries stakeholders and managers, in an attempt to reduce or resolve potential resource competition and conflict regarding barramundi. Data from this case study may be relevant to other situations where resource competition and conflict is present.

1.5 Study Area

The study area, within north Queensland (see Figure 1.1 for the location of the study area within Australia) includes all estuaries between the Murray River (north of Cardwell), south to Cape Upstart (south of Ayr) (Figure 1.2). The residential area of interest is Cardwell south to Ayr. This area was chosen due to proximity to Townsville and was considered a manageable area to study for a PhD project. Approximately 11 estuaries within the study area have been partly or completely closed to commercial gill net fishing for many years prior to commencement of the study – the exact date specific closures were implemented is unknown but is between four (prior to DPA implementation) and 25 years – Information about timing of closures is available only in archives (to which I was unable to gain access) at QDPI&F, reflecting the ad hoc nature with which these closures were implemented. Regardless, the closure periods are considered long enough to notice potential improvements in recreational catches for barramundi which typically recruit to the commercial fishery at about 3 years of age (Williams 2002a). Further gill net closures are encompassed by the DPA of the Hinchinbrook Channel (including all adjoining estuaries) which was implemented in January 1998. Other DPAs within the study area restrict netting only in the encompassed bays, not including adjoining rivers. There are differences between each DPA zone: DPA 'a' zones have stricter netting controls than DPA 'b' zones. In DPAa zones, the use of offshore set, foreshore set and drift nets are prohibited, but river set nets are allowed with modifications except in the Hinchinbrook Channel. In DPAb zones, mesh netting practices are allowed to continue, but with more rigorous safeguards and restrictions than prior to DPA implementation (Zeller and Snape 2005; Great Barrier Reef Marine Park Authority unknown-a).

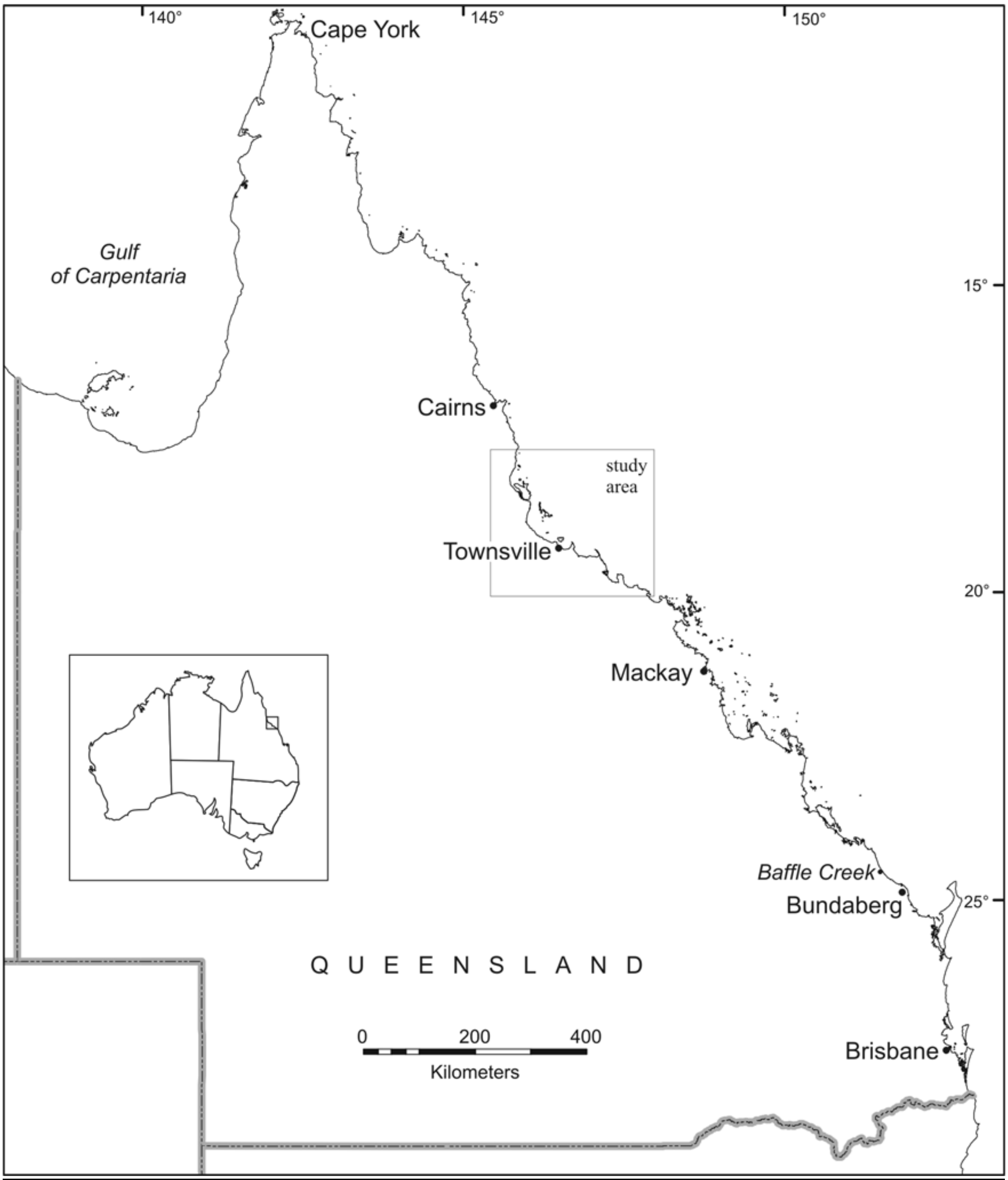

Figure 1.1 Map outlining the study area within Queensland, Australia**.**

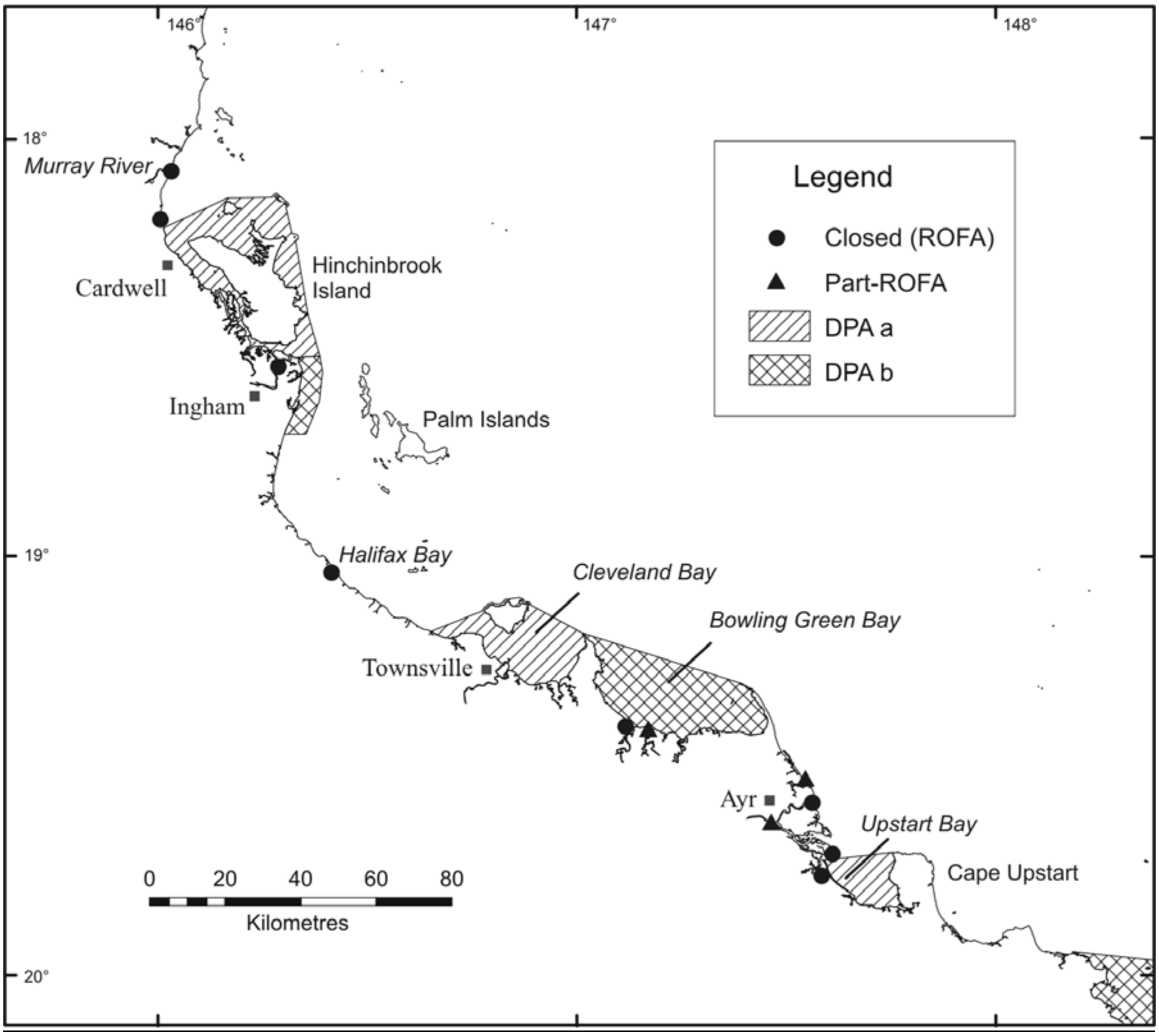

Figure 1.2 Map of study area in north Queensland outlining ROFA and part-ROFA estuaries and Dugong Protection Areas (DPAs).

1.6 The Barramundi fishery

1.6.1 Barramundi biology

The barramundi (*Lates calcarifer* (Bloch)) is a predatory centropomid perch, generally found in freshwater, estuarine and coastal habitats (Dunstan 1959; Russell and Garrett 1983; Davis and Kirkwood 1984; Russell and Garrett 1985; Garrett 1987; Russell and Garrett 1988; Welch et al. 2002). Recreational and commercial fishers compete for shared stocks of barramundi in bays and estuaries (i.e. tidal waters of coastal rivers (Coastal Engineering Research Center 1984)) – netting is not allowed in non-tidal waters (Queensland Department of Primary Industries 1995).

In Australia, barramundi are found from southern Queensland, north to the central coast of Western Australia (Dunstan 1959; Shaklee and Salini 1985). In

Queensland, this protandrous hermaphrodite matures as a male between 45 and 75 cm total length (TL) (4-5 years of age), then changes sex between 55 and 95 cm TL (usually 7-8 years of age). Female barramundi can live for more than 30 years and reach 1.5 m TL and 60 kg body weight. They recruit to the commercial fishery after approximately 3-5 years (typically 3 years on Queensland's east coast), sometimes still sexually immature (Dunstan 1959; Garrett 1987; Department of Primary Industries and Fisheries 2001; Welch et al. 2002; Williams 2002a).

Barramundi are highly fecund, and spawning aggregations occur just before the onset of the wet season at estuary mouths. Juveniles subsequently take advantage of the aquatic habitat that results from flooding (Dunstan 1959; Russell and Garrett 1983, 1985; Davis 1987; Russell and Garrett 1988; Griffin and Walters 1999; Halliday et al. 2001; Welch et al. 2002; Williams 2002a). In some localities the severity of the wet season determines the number of spawners available, and the amount and timing of rainfall affects the amount of freshwater habitat available for coastal wetland nursery areas (Dunstan 1959). Positive relationships have been found between the amount of freshwater flow and barramundi year-class strength (Staunton-Smith et al. 2004).

1.6.2 The Barramundi Fishery

Catches of barramundi by the commercial and recreational fishing sectors on Queensland's east coast have been comparable (Zeller and Snape 2005): In 1999, 204 commercial boats reported a harvest of 211 t in tidal waters, and Queensland's Department of Primary Industries and Fisheries (QDPI&F) bi-annual recreational fishing monitoring program (known as 'RFISH') reported a harvest of about 270 t of barramundi by Queensland anglers (non-Queensland anglers were not surveyed) in tidal and non-tidal waters (Williams 2002a). Both of these harvest estimates were reduced in 2002, particularly for the recreational sector: In 2002 172 commercial boats harvested 197 t of barramundi (Department of Primary Industries 2002)), while the recreational sector harvested 96 t (Higgs, QDPI&F, unpublished data) on Queensland's east coast.

QDPI&F's RFISH surveys estimated approximately 22 400 Queensland anglers targeted barramundi at least once a year in 2002, although the proportion of anglers targeting barramundi (33.5% of anglers) is higher in north Queensland than in other parts of the state (Higgs and McInnes 2003).

Indigenous fishers also capture barramundi, using lines, nets, spears and traps (Williams 2002a), however their barramundi catch is relatively small (5.7 t per annum in

Queensland in 2000/01 (Henry 2003)), and potential competition with the indigenous sector is not considered within this project.

Size restrictions apply to both the recreational and commercial sectors, with a minimum legal size of 580 mm total length (TL) and a maximum legal size of 1200 mm TL (to protect large females). A closed season to protect spawning stock applies from the 1st of November to the 1st of February each year on the east-coast of Queensland (Healy 1995; 1995; Halliday et al. 2001; Welch et al. 2002; Williams 2002a).

a) <u>The commercial fishery</u>

Barramundi is targeted commercially in Queensland in the Gulf of Carpentaria and on the east-coast: there are separate management plans for these two areas (Williams 2002a). The East Coast Inshore Finfish Fishery (ECIFF), the focus of this project, operates along the length of Queensland's east coast, though barramundi are harvested northward from Baffle Creek (24^0 30'S) to Cape York (Zeller and Snape 2005), (see Figure 1.1). The ECIFF, mainly comprising small, owner operated family businesses (Fenton and Marshall 2001), is a multi-species fishery where operators target a range of finfish species using a variety of net methods under N1-N8 and K1-K8 symbols (Healy 1995; Welch et al. 2002; Zeller and Snape 2005). Barramundi fishers are licensed with an 'N2' symbol (East Coast Set Net Fishery), though many east coast net fishers are mixed gear fishers with a number of licence symbols which they use when inshore finfish catches or market demand are low (Zeller and Snape 2005). The N2 fishery operates in all Queensland tidal waters east of longitude 142º09' east, but does not include waterways flowing into the Gulf of Carpentaria west of longitude 142º09' east (Queensland Department of Primary Industries 1995). On the east coast, the mean number of days spent fishing for barramundi per boat per year is about 25 days (varying from 50 days in Far North Queensland, to around 8 days in the Fraser Island Region) (Williams 2002a).

Commercial gill net licences were restricted in 1981, and since 1986, 272 licences were authorised to operate in the N2 fishery (Healy 1995), of which about 250 reported catch each year to the year 2000 (Williams 2002a). From the entire ECIFF (i.e. not only N2 licences), 38 licences were bought out during the implementation of measures to protect the dugong in 1997, 56 were bought out with the RAP restructure in 2004, and the latent effort policy in 2004/5 reduced the remaining licences by 40%. Following these buy-outs, 189 N2 licences remain (Mark Doohan, QDPI&F, pers. comm., 2005; Zeller and Snape 2005).

A gill net is a wall of netting which entangles finfish by their gills and other hard structures such as spines and fins. A gill net is fixed at both ends, often with one end tied to the bank of a river, and the other anchored. Set gill nets fish “passively”: i.e. fish must swim past the gear to be caught. The top of the net has floats attached and the bottom, with weights attached, sinks to the substrate forming a wall of mesh (Anderson 1999; Millar and Fryer 1999). Gill netting is considered a highly selective method of fishing with the ability to capture mostly targeted species: not all finfish species are susceptible to set gill nets due to their size, shape or behaviour (Russell and Garrett 1985; Petrakis and Stergiou 1996; Millar and Fryer 1999; Halliday et al. 2001; Gray 2002). Gill nets are also size selective for barramundi – Halliday et al. (2001) found catches of undersize fish in 150 mm mesh size nets were low, with less than 9% of the barramundi catch being under legal size, and large barramundi are capable of forcing their way through nets using the razor-sharp edges of their operculum (Department of Primary Industries and Fisheries 2001). Gill net selectivity is also a dependent on water clarity, net colour and hanging ratio, habitat, water currents, etc (Petrakis and Stergiou 1996; Gray 2002). The east coast set net fishery is restricted in rivers and estuaries to a prescribed net type (monofilament), length (3 nets totalling no more than 360 m in length), and mesh size (between 150 and 215 mm). These net restrictions differ slightly in foreshore areas where species other than barramundi are also targeted. Fishing predominantly occurs at night, with soak times varying between 2 and 6 hours. Most fishing effort occurs close to regional population centres (Zeller and Snape 2005).

b) The recreational fishery

The recreational barramundi fishery represents a multi-million dollar tourist industry in Queensland, including a private and charter sector, although exact estimates of value are unknown (Welch et al. 2002; Robinson and Cully unknown). There was an increase in recreational effort in the 1970s, mostly attributable to improved mobility and greater access to fishing areas (Healy 1995). Barramundi are caught using hook and line, with anglers restricted to a bag limit of 5 barramundi per person. Historic information on recreational catch is limited; however QDPI&F's RFISH surveys have been collecting catch information bi-annually through an extensive recreational fisher diary program since 1997 (Higgs 1997, 2001; Williams 2002a). As stated above, RFISH estimated the recreational sector harvested approximately 96 t on Queensland’s east coast in 2002 (Higgs, QDPI&F, unpublished data). Approximately 22 400 Queensland anglers targeted barramundi at least once a year in 2002, although the proportion of anglers targeting barramundi (33.5% of anglers) is higher in north Queensland than in other parts of the state (Higgs and McInnes 2003).

1.6.3 Threats to the resource

CPUE trends for the commercial fishery, showing a steady increase from 1981 to 2001, suggest current effort levels are not threatening to the stock. There was a slight downturn in biomass estimates on the east coast from 1999-2001, however this may be due to management changes introduced in 1998-9 (i.e. DPA introductions and associated licence reductions) (Welch et al. 2002). Other papers suggest the recreational catch needs to be incorporated into future fishery assessments before conclusions are drawn regarding resource sustainability (Williams 2002a).

Another concern for barramundi stocks that has been listed is the loss of habitat, particularly for juvenile fish, through urban and rural development and other land uses (Garrett 1987; Russell 1987; Williams 2002a). Coastal wetland nursery habitats appear critical to the life cycle of barramundi (Moore 1982; Russell and Garrett 1983; Davis 1985) and their destruction could lead to a decline in barramundi stocks (Russell and Garrett 1985; Russell 1987).

1.7 Chapter Outline

The perceptions of a representative sample of recreational and commercial estuarine fishers within the study area were examined via a questionnaire program, outlined in Chapter 2. The questionnaire program examined whether competition and conflict between the two sectors is an issue for the general fishing public, and what the nature and source of the conflict might be. Respondents were asked: how they view their own and the competing sectors' impacts on estuarine fisheries resources (relating to blame theory); how they think apparent conflict might be resolved; their knowledge of current ROFAs and support of future ROFAs; and whether they think ROFAs result in improved angler catches for barramundi.

Chapter 3: "Fishery-dependent recreational catch data" provides a comparison of current recreational catch trends between estuaries open and closed (ROFA) to commercial gill net fishing. The fishery-dependent data sources are: 1) three years of charter fishing records from compulsory QDPI&F logbooks for the study area; 2) a 2-year voluntary recreational catch logbook program, which recorded anglers' catch information including estuary, time of day and time spent fishing, number of fishers, methods, target species and catch (including species, length and fate); and 3) time series recreational catch data for the Hinchinbrook region from a group of fishers from the Australian National Sportsfishing Association (ANSA).

The results from the fishery-dependent data sources, which provide variable data, were verified through a more statistically valid fishery-independent structured fishing survey program, outlined in Chapter 4. The structured surveys sampled six randomly chosen estuaries within the study area (3 ‘open’ and 3 ROFA estuaries); similar to the design used for the EoNF project outlined above. The surveys used recreational line fishing techniques to test whether the EoNF project results translate into improved line catches in estuarine finfish ROFAs.

Each of these chapters are tied together as a general discussion in Chapter 5, providing an overview of whether competition and conflict within estuaries is an issue within the north Queensland fishing community as a whole; from where such conflict might originate; and therefore whether further ROFAs are appropriate to resolve this conflict. Other potential solutions to conflict are discussed. The general discussion also includes whether improved recreational catch rates in finfish ROFAs are real or perceived and what this may mean for future ROFAs and research needs.