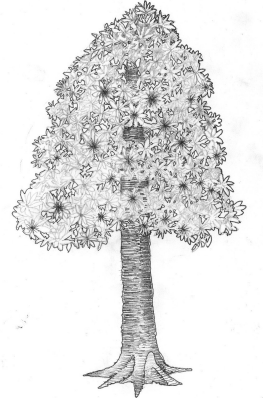


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**THE ECONOMIC  
AND  
ECOLOGICAL  
BENEFITS  
OF  
MARINE SANCTUARIES  
IN THE  
PORT STEPHENS-  
GREAT LAKES MARINE  
PARK**

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## 1. Summary.

Marine sanctuaries or no-take marine reserves are the major functional element of any marine park zone. Marine sanctuary zones have been shown to lead to gains for fish, fishers and society (Sanchirico and Wilen, 2001).

Many benefits stem from the creation of marine sanctuaries. These include reducing the variation in the marine biomass of an area, therefore leading to lower variation in the average catch of target species by commercial and recreational fishers and charter operators within the Marine Park generally.

The protection of habitat features such as corals, bryozoans, crinoids and sponges, and iconic animals such as Grey Nurse sharks, Black Cod and Dolphins provide great interest to recreational divers and tourists. Tourist operators generally benefit from the long-term protection of areas from intense fishing. Indeed, international experience shows that sanctuaries within marine parks generate significant economic benefits to the regions where they are created, due to substantial increases in tourist numbers. These tourists generally stay longer and so, spend more than the current day or weekend visitors who frequent the Port Stephens-Great Lakes Region.

Nevertheless, all these benefits stem from the protection of marine biodiversity. Some of these observed benefits within sanctuary zones are:

1. Increasing abundance, size, age, diversity and spawning biomass of fish, plant and invertebrate species.
2. Eliminating mortality of non-target species.
3. Assisting in fished species population recovery.
4. Protecting species from genetic changes and altered sex ratios.
5. Reducing the risk of populations or habitat being destroyed by a catastrophe.
6. Allowing for scientific study of unfished areas.
7. Protecting rare and threatened species.
8. Protecting essential and vulnerable habitats.

These observed benefits within sanctuary zones lead to further benefits outside of the area protected.

The observed benefits to areas outside and nearby sanctuary zones are:

1. Increase in tourism, especially derived from diving and trophy fishing.
2. Less seasonal variation in tourist numbers.
3. New opportunities for marine research and conventions.
4. Biomass spillover to areas outside.
5. Enhancing fished populations through increased larval output, exporting species to fishery grounds.
6. Decreasing annual catch variability.
7. Maintaining or enhancing yields in fished areas.
8. Increasing catch per unit effort.
9. Protecting against stock collapse and recruitment failure.
10. Reducing the cost of fisheries management mistakes.
11. Increasing size and number of trophy fish caught near to sanctuary zones.
12. Substantially increasing resource rent.

Overwhelmingly, studies have found that the larger the sanctuary zone, the greater the benefits to both the biodiversity within the sanctuary zone and to fishers and fisheries outside or nearby marine sanctuaries, as well as regional tourism.

To maximise the above proven benefits of marine sanctuary zone protection, at least 20% of all habitat types existing in the Manning Shelf Bioregion, and most experts suggest 30% to 50%, must be protected from fishing and associated impacts within marine sanctuaries.

The total area of the NSW jurisdiction of the Manning Shelf Bioregion is 263,657 ha. This is only 30% of the entire Manning Shelf. The Port Stephens Great Lakes Marine Park is only 36.87% of this area, or 97,200 ha.

To achieve the minimum of 20% reservation of the NSW managed proportion of the Manning Shelf within the single declared PS-GL Marine Park, corresponding to 52,729 ha, or about 54% of the Park needs to be established in sanctuary zones.

However, many marine scientists and resource economists suggest far higher percentages for sanctuary protection if they are to achieve the best outcomes for sustainable fisheries, tourism and biodiversity protection.

To achieve this outcome the existing fishing effort cannot be allowed to be displaced to other areas outside of sanctuaries. A sustainable outcome must incorporate a significant reduction in overall commercial fishing effort through an adequate and equitable buyout formula.

The \$10 million dedicated for the buyout of commercial fishing effort in the Park may be inadequate for this to occur. The amount needed may be closer to \$20 million to \$25 million. A further \$10 million to \$15 million could be allocated from this years sale of recreational fishing licenses.

Further buyout funding could be allocated from existing commercial licence charges associated with shared fisheries, environmental management and environmental assessment fees, or levies imposed on commercial operators within the Marine Parks.

A low interest government loan of \$10 million to \$15 million could be repayed over say a 15 year period.

## **2. Benefits of marine sanctuaries to biodiversity.**

Protection from fishing allows animals and plants in marine sanctuaries to survive longer and grow larger, in turn allowing them to reproduce and proliferate more effectively. Habitats can recover inside sanctuaries and better sustain the plants and animals that rely on them and the plentiful prey in reserves can support more predators. Marine sanctuaries are currently the only marine management tool that provides this unique combination of effects, promoting the recovery of entire ecosystems.

Halpern (2002) compared the results of 89 separate studies to show that;

“...values for all four biological measures are significantly higher inside reserves compared to outside (or after reserve establishment versus before) when evaluated for both the overall communities and by each functional group within these communities (carnivorous fishes, herbivorous fishes, planktivorous fishes/invertebrate eaters, and invertebrates).”

On average, Halpern (2002) found that the density - or number of animals in an area – triples, and the number of species is 1.7 times higher in marine sanctuaries than in unprotected areas. In addition, he found that the average body size of animals is 1.8 times larger in reserves than in fished areas. These findings include not just fished species but non-fished species, plants, and invertebrates.

The relationship between body size and the number of young is well known. Bigger body size is one of the most important biological changes in marine reserves, because large fishes and invertebrates can produce enormous numbers of young.

For many marine fishes and invertebrates, small increases in body size can lead to large increases in the number of eggs produced. For example, a 23-inch vermilion rockfish can produce 17 times more young than a 14-inch fish (PISCO, 2002).

As Halpern (2002) concludes:

“Overwhelmingly, reserves were associated with higher values of density, biomass, organism size, and diversity of species for overall trends and for all four functional groups [studied].”

However, the most consistent positive changes found in these studies occurred for carnivorous fishes (more often the most important target species). For example, the biomass of carnivores was 3.12 times higher inside the reserve than outside.

Halpern *et al*, (2004) state that:

“Marine reserves affect areas outside reserve boundaries via the displacement of fishing effort and the export of production....For a settlement-limited fishery, export of increased production from within reserves can offset the effects of displaced fishing effort.”

Many well documented examples of the ecological benefits of sanctuary zones are available in the literature. Below, we provide a few examples of these.

## **2.1 Case study 1 –California USA.**

After fishing was banned in the Anacapa Island Ecological Reserve (California) in 1978, studies found that by 2000 that lobsters were six times more numerous, red urchins grow 1.7 times larger, and some fish are three times more plentiful in the reserve than in nearby fished waters: and kelp plants, which form crucial habitats for other species, grow five times more densely and persist longer in the reserve than in waters nearby (PISCO, 2002).

In 1997/98, Beers and Ambrose (2003) compared fish populations inside and outside five no-take marine reserves at three island and two mainland sites in southern California. They concluded that;

“For all five reserves, there were on average 16 times more harvestable *P. clathratus* (bass) and 8 times more harvestable *Semicossyphus pulcher* (California sheephead) inside than outside... Habitat characteristics of the reserve and control areas were not significantly different. This study demonstrates that southern California no-take areas lead to increased numbers and sizes of harvested fish species.”

## **2.2 Case study 2 – Washington USA.**

In 1990, areas of the San Juan Islands of Puget Sound (Washington) were declared no-take Marine Sanctuaries . Studies on the effectiveness of the sanctuary area found that biomass of the fish studied was two to four times greater inside the protected areas than outside. Reproductive fish were ten times more abundant in the reserves. Further, small numbers of previously absent fish species had begun to appear. (PISCO, 2002).

## **2.3 Case study 3 – Queensland, Australia**

In 1987 no-take marine sanctuaries were established in the central Great Barrier Reef within the Palm and Whitsunday Island groups. Williamson *et al.* (2004) estimated the density and biomass of coral trout, *Plectropomus* spp (the major target of the hook and line fisheries on the Great Barrier Reef) on inshore fringing reefs in these areas after studying them for 3-4 years before (1983-1984), and 12-13 years after (1999-2000) the establishment of these no-take reserves in 1987.

They found that:

“...the density and biomass of coral trout increased significantly, (by factors of 5.9 and 6.3 in the Palm Islands, and 4.0 and 6.2 in the Whitsunday Islands) in the reserve sites, but not the fished sites, between 1983-1984 and 1999-2000. In 1999-2000, density and biomass of coral trout and a secondary target of the fisheries, *Lutjanus carponotatus*, were significantly higher in the protected zones than in the fished zones at both island groups. The density and biomass of non-target fish species (Labridae, Siganidae and Chaetodontidae) did not differ significantly between reserve and fished zones at either island group. This is the most convincing data to date that the management zoning of the world's largest marine park has been effective, at least for coral trout on inshore reefs.”

## **2.4 Case study 4 – Western Australia.**

In 1994 four reef observation areas or marine protected areas (MPAs) were established in four clusters of islands and reefs off the central coast of Western Australia, near to the Houtman Abrolhos Islands, to examine their value in protecting vulnerable reef fish species, including the sub-tropical wrasse, *Choerodon rubescens*, and the coral trout, *Plectropomus leopardus*.

While these Marine Protected Areas are clearly an effective tool for increasing the local abundance of reef fishes, the spatial and temporal scales required for their success varies among species (Nardi *et al.*2004)

These authors found that:

“Although there were no significant increases for *P. leopardus* for the first three years of closure, after eight years of protection there were significantly larger numbers of *P. leopardus* in the closed areas. There was a three-fold increase at the Easter Group and a seven-fold increase at the Wallabi Group, relative to open fishing areas, attributed primarily to reduced fishing mortality. Significant closed areas (17% of the *P. leopardus* habitat) provided substantial stock-wide impacts”.

## **3. Benefits of marine sanctuaries to fisheries and tourism.**

Numerous studies have been undertaken in long-established marine sanctuaries and Reserves (where no fishing is allowed) to determine how successful no-take marine sanctuaries have been in providing benefits additional to that of protecting biodiversity. These studies invariably have found that the observed ecological benefits within a marine sanctuary area translate to significant ecological and economic benefits outside the sanctuary.

Hastings and Botsford (1999) found that:

“For populations with sedentary adults (invertebrates and reef fishes), reserves have important advantages for sustainability, making marine reserves the preferred management approach...Modelling studies suggest that reserves should increase the spawning stock biomass and that higher densities inside the reserve should lead to spillover to areas outside. Fish size and diversity are also assumed to increase inside reserves because individual fish can grow larger and rarer species will be protected.”

The relationship between body size and the number of young is well known. Bigger body size is one of the most important biological changes in marine sanctuaries, because large fishes and invertebrates can produce logarithmically larger numbers of young.

The bigger and more abundant animals living in marine sanctuaries can produce more young than their smaller neighbors in unprotected waters. As a result, marine reserves can support higher growth rates which lead to recruitment in surrounding fished areas.

Marine reserves also lead to an increase in the abundance of spawners providing insurance against recruitment failure and maintaining or enhancing yields in fished areas (Bohnsack, 1998).

The benefits of no-take marine sanctuaries go well beyond the protection of biodiversity (Brunckhorst & Bridgewater 1995). They can also add considerable economic value to the region where they are established (Farrow 1996).

Marine sanctuaries have been shown to benefit tourism (Agardy 1993; Davis & Harriot 1996; Davis & Tisdell 1996), the replenishment of fisheries and the protection of the natural resource bases of fisheries (Harmelin *et al.* 1995), as well as nursery and recruitment habitats (Alcala & Russ 1990; Bohnsack 1994; Bennett & Attwood 1991; Fairweather 1991; Jones *et al.* 1992; Agardy 1994; Clark 1996; McClanahan & Kaunda-Arara 1996; Russ & Alcala 1996).

### **3.1 Case study 1 – Spain.**

The Medes Islands in the Mediterranean Sea were protected in 1983 as a no-fishing area by the Spanish Government. By 1989, the increase in diving activities was spectacular, reaching 2000 divers per day and more than 200 000 divers per year (Ribera 1992). However, a new law was introduced in 1990 which increased the size of the MPA and a maximum limit of 500 divers per day was established (about 50 000 dives per year) due to the significant impacts these divers were having on the marine environment.

Economic activities in L'Estartit, the small village on the mainland opposite the Medes Islands, are exclusively related to tourism on the islands; these include diving centres, hotels, restaurants, snorkelling tours and glass-bottom boating. Even with the reductions in diver numbers, it has been estimated that all this economic activity represents a direct income of about US\$7 million per year (Capellà *et al.* 1998).

In 1996, 10 of the diving centres operating in the area had 125 employees and 17 boats with a total capacity of 725 passengers (each diving boat also containing an auxiliary pneumatic boat), representing an investment of US\$3.6 million (Costa Brava Sub 1997 cited in Badalamenti, *et al.*, 2000). In L'Estartit, a reduction in the seasonality of tourism has been observed when compared to other tourist resorts in the area (Ribera 1992).

Another marine sanctuary was established also over the Columbretes islands located 30 miles from the Spanish mainland. Since the creation of the Marine Reserve an increase in the inflow of recreational boats has been observed from the reports taken daily by the Reserve keepers (Goñi 1998, cited in Badalamenti *et al.* 2000).

The main activity of these boats is sports fishing (72% of boats in 1996). At the time of the creation of the Marine Reserve in 1990, sports fishing was a marginal activity. Now this is one the main recreational pursuits in the area after diving (Goñi 1998 cited in Badalamenti *et al.* 2000).

### **3.2 Case study 2 – Italy.**

With the establishment of the 16,000 ha no-take marine reserve in Ustica, off the coast of Sicily in 1987, many new activities have been initiated and pre-existing ones improved.

Badalamenti *et al.* (2000) found that the new activities flowing from the establishment of the reserve included:

- the development of a visitor centre and an aquarium;
- the training of Reserve guides;
- glass-bottomed boat tours for tourists;
- the renovation of a medieval tower to use as an international conference centre;
- the creation of a marine laboratory;

- the obtaining of funding for research activities in the Reserve;
- the stipulation of an accord with the University of Palermo;
- summer courses in marine biology and underwater archaeology;
- a summer school in marine chemistry and practical fieldwork classes in marine ecology organized by the University of Palermo;
- classes given by fishers on the construction and use of traditional set gears;
- marine-based didactic activities for school children organised at a national level;
- a convention on underwater activities;
- a festival of underwater photography;
- facilities for divers including diving centres, and
- a decompression chamber and underwater trails.

While no data on tourism are available, Badalamenti *et al.* (2000) found that anecdotally, an increase in tourism of about 35 000 visitors in the first four years seems to have occurred.

### **3.3 Case study 3 – Florida, USA.**

In 1962, the U.S. government banned all access to portions of the Merritt Island National Wildlife Refuge to create a security zone at Cape Canaveral. In the late 1980s, biologists compared the marine reserve to nearby fished waters and found that fish in the reserve were older, bigger, and 2 to 13 times more abundant (PISCO, 2002).

PISCO (2002) reported that:

“Fish tagged inside the reserve were recaptured outside, demonstrating spillover of adults and juveniles. More world records of some popular sport fish are caught near marine reserves than in all other areas of Florida combined. The rest of the state has yielded no new world records for black drum since 1985, despite a variety of statewide management measures, while areas near the reserve continue to produce bigger and bigger fish. Red drum and spotted sea trout show similar results; a disproportionate number of Florida’s recent record-breaking fish come from waters near the reserve.”

Johnson *et al.* (1999) sampled several sites in this area, in both fished and unfished areas, from 1986 to 1990. The study found that catch per unit effort was consistently higher in the unfished areas.

During the study, these authors tagged nearly 13,000 fish from 14 species. Less than 1%, or 125 tags, were returned by the end of the study. Tag returns showed that some fish tagged inside the protected areas moved beyond them, a few as far as 20 - 40 miles from where they had been tagged. In addition, several world record fish (red and black drum) were caught by sport fishers near the sanctuary during the period of the study (Johnson *et al.* 1999).

Johnson *et al.* (1999) suggested that:

“Given that game fish inside the unfished areas were generally larger, it is possible that these trophy fish came from the protected areas. The fact that the study team frequently saw sport fishermen fishing along the edge of the protected areas suggests that they knew these areas were sources of larger fish.”

### **3.4 Case study 4 – Hawaii, USA.**

The Coconut Island Marine Reserve (no-take) in Kaneohe Bay, off the Island of Oahu, Hawaii was established more than a decade ago. It has been found that giant trevally (*Caranx ignobilis*) appear to move to the Coconut Island marine reserve from the adjacent bay floor upon attaining a size of approximately 20-25 cm fork length. After several years spent frequenting the reserve, giant trevally were found to move out of the bay into deeper water.

Wetherbee *et al.* (2004) found that:

“Tracked fish spent considerable time within the marine reserve moving along the reef slope, but frequently ventured outside of the reserve boundaries. The recapture rate for tagged fish was 11%, with an average time at liberty of 346 days. Nearly one-third of recaptured fish were caught at distances greater than 3 km from the tagging site with maximum values demonstrating long-term (more than 7 years) and long-distance (30 km) movements.”

### **3.5 Case study 5 – The Philippines.**

The Sumilon Island Marine Park, in the Philippines, was declared in 1977. Fishing and collecting are prohibited in the core area and allowed in the surrounding buffer only by “ecologically sound methods” with approval (Salm and Vlark 1984).

Alcala (1979) found that, despite the closure of 30% of the area to fishing, then total yield of reef fish increased from 3,633kg in 1976 to was 6,900kg in 1977 and 6,948 kg in the first 10 months of 1978.

A no-take marine reserve was established at Apo Island, Philippines in 1983. Since then studies have found significant spillover of fish to surrounding areas.

For example, 18 years after the establishment of the reserve, the biomass of the surgeonfish *Naso vlaminghii* tripled. During that time, the biomass of *N. vlaminghii* increased by a factor of 40 outside but close to the reserve boundaries (200 to 250 m) but not at greater distances (250 to 500 m) (Russ *et al.* (2003).

Russ *et al.* (2003) found tha:

“In 2000/2001 hook-and-line catch per unit effort (CPUE) for *N. vlaminghii* was 45 times higher within 200 m of the reserve boundary than for all other fishing grounds combined, with 62.5% of the hook-and-line catch records being recorded within 200 m either side of the reserve, in just 11% of the reef fishing area.”

These reports indicate that neither communities, tourist operators, or fishers should be concerned that large sanctuary zones will reduce their businesses profitability or fishers ability to catch fish in areas adjacent to marine sanctuaries. Indeed, the establishment of sanctuary zones has been observed to lead to substantially increased fish catches of substantially bigger fish. They have also invariably led to significant business opportunities in and around Marine Parks and sanctuaries.

Fishers' concerns about sanctuary zones generally stem from the loss of fishing grounds that sanctuary zones represent. However, the increased overall catch provided by sanctuary zones, given time, have been found to offset this initial loss.

For example, Grafton *et al.* (2004) found that the establishment of a sanctuary zone:

“...reduced the effects of the negative shocks on the fishery, effectively smoothing the harvest of biomass, improving the resource rent generated in the fishery. “

Grafton *et al.* (2005) further state that whilst the use of protected areas

will not guarantee against a population collapse, they can generate economic benefits through the buffer effect of higher stocks.

Similar results were obtained by Greenville and MacAulay (2005) who found that the establishment of protected areas in a multi-species fishery, open to uncertain stock collapse events, improved the level of resource rent.

## 5. Reducing fishing effort.

Displacing fishing effort to other areas will lead to greater impacts in areas outside of reserves unless overall fishing effort is reduced (see De Martini, 1993; Horwood *et al.*, 1998; Horwood, 2000).

Bohnsack (2000) found that;

“Establishing no-take marine reserves (NTRs) displaces fishing effort to surrounding areas, creating concerns about short-term impacts on resources and fishers before long-term benefits can accrue.

...NTRs protected sedentary species in approximate proportion to the total habitat closed to fishing but provided less protection as species mobility increased. These differences in protection due to mobility were greater for reserves covering small percentages of total habitat. Predicted short-term displacement impacts on fishers were low for reserves covering small percentages of the total habitat, but they increased exponentially as the percentage of total habitat closed increased.”

However, this author concluded that:

“When combined with traditional management tools, no-take reserves offer increased flexibility for supporting fisheries and protecting resources.”

The NSW Marine Parks Authority has been allocated a mere \$10 million for buyouts of professional fishing effort in the Port Stephens-Great Lakes Marine Park. This is well below what is needed. To provide the fishers who remain fishing in the area with long-term sustainable catches, large sanctuary zones are required. Buyouts proportional to the level of sanctuary and habitat protection in the Park are required. Therefore, for the establishment of

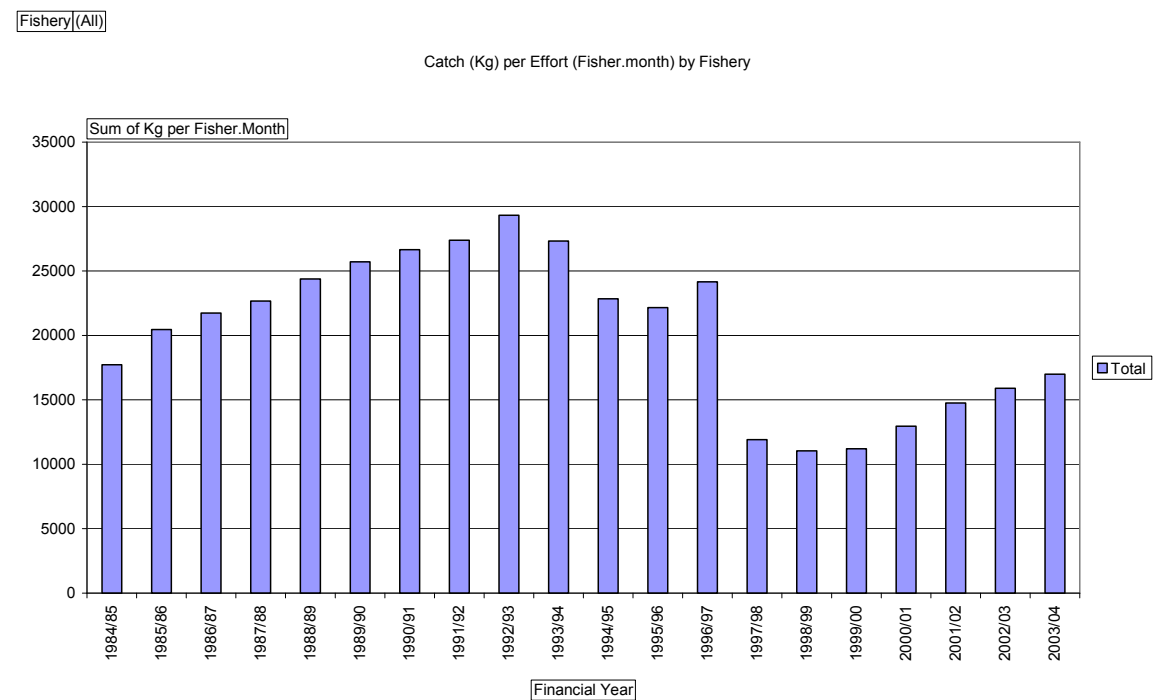
sanctuary zones covering 50% of the Marine Park, would require buying out 50% of the commercial fishing effort within the Marine Park.

However, it is not only professional fishers that impact fisheries and marine habitats, recreational anglers also have a profound affect. For example, in NSW more black-spotted pigfish, yellowtail kingfish, mulloway, bream, dolphinfish, teraglin and pearl perch are caught by recreational anglers than professional fishers (Anon 2005).

This is a serious implication. Since the introduction of restricted NSW fisheries in 1997 the number of fishing businesses in the industry has been reduced from about 2,800 to about 1,300 in 2004. This has been achieved through transfer and amalgamation programs and Marine Park and recreational fishing haven buyout processes. However, it is generally recognised within industry that further adjustment is required and the preferred approach is through a buyout program.

Catch per unit effort, however, has not increased in a corresponding manner.

**Chart 4. Catch per unit effort for combined NSW Fisheries -kg by fisher month by fisher between 1984 and 2004**



Catch per unit effort has increased somewhat from 1997 (from about 1,200 kg per fisher month to 1,700 kg per fisher month in 2004), further buyouts are desperately required to allow those in the industry to sustain their businesses on an ecological basis.

The buyout program associated with the PS-GL MP sanctuary zoning process can therefore be seen as part of an ongoing program of reducing professional fishing effort along the NSW coast.

This process is being assisted by the Recreational Fishing Saltwater Trust Expenditure Committee (RFSTEC) funded through sales of recreation fishing licence sales. The RFSTEC has identified latent, real, surplus and excess fishing effort or pressure as a major long-term risk to the sustainable management of fisheries.

The Department of Primary Industries (Fisheries) is currently developing a strategy for a buyout scheme. It was noted at a recent RFSTEC meeting that the buyout program need not be restricted to estuary commercial fishing entitlements associated with Recreational Fishing Havens. (RFSTEC, 2004).

There is approximately \$1.5 million dollars available in the Saltwater Trust that is likely to be committed to removing commercial fishing effort from high interaction areas such as the Clarence, Manning, Camden Haven and Hastings areas on the north coast and the area from Tuross through to Bermagui on the south coast. However, this was reduced to \$1.2 million in June 2005 (see ACRF, 2005)

Nevertheless, there is a total of \$20 million available that could be allocated to buyouts now, through the Recreational Fishing Haven fisher buyout loan (see RFSTEC, 2004). Furthermore, the total income from recreational licence sales in 2004-05 was \$10 million (RFSTEC, 2005).

This year's recreational licence sales should be allocated to buyouts of commercial licences within the PS-GL Marine Park. Should this money be allocated, \$20 million could be used for commercial fishing buyouts in the Park. This would provide a much better socio-economic and ecological outcome.

Commercial fishers who remain fishing in the Park will, however, have to burden reduced fishing areas, within which significantly increased catches associated with the establishment of sanctuaries may not become realised for several years.

To help fund transitional arrangements for those wishing to be bought out of the industry, an industry loan scheme is proposed. Currently, commercial fishers pay a base licence fee of about \$550 (see appendix 1, table 2). However, for those whose fishing businesses are secured by being able to fish within the Marine Park, an additional fee might be imposed. This would need to reflect the increased catch per unit effort and reduced catch variability derived from fishing nearby sanctuary zone. The funding derived from such a fee could be brought forward through loan arrangements paid back over subsequent years.

Through such a loan scheme, those commercial fishers who wish to be bought out of the industry can be assisted by those who wish to remain fishing in the Park and who may have to wait for three to five years before the substantial fishery benefits of the sanctuaries are realised.

Similar loan schemes could operate to increase the amount of buyout funding, such as a permit fee for commercial operators within the park. For example, a \$10 million low interest government loan (<5% pa) could be allocated by the NSW government to ensure adequate commercial fisheries buyouts are achieved as part of the Zoning Plan. Such an arrangement would ensure the establishment of 50% of the Park in sanctuaries. This loan could be serviced through moderate sales of permits to all commercial operators within the Park. The funding of adequate commercial fisher buyout would not, thereby have to borne by fishers alone, but all commercial operators in the Park, whose businesses would be expected to grow considerable from the additional tourism generated by sanctuaries.

## **6. Marine sanctuaries as a fisheries management tool.**

We accept that the current scope of the Zoning Plan process is too limited to take into account fish life cycles and larval transport mechanisms to establish a zone plan that would provide specifically targeted benefits to fisheries management in the Region. However, larger sanctuary zones will provide a correspondingly larger benefit to fishers, tour operators, divers and biodiversity protection.

Apart from these benefits it is necessary to establish large sanctuary zones to assist in fisheries management generally. In the absence of fully-protected marine sanctuaries, it is impossible for scientists to study “natural” marine ecosystems. That being the case, determining sustainable catch levels for different species and habitat requirements becomes guess-work, extrapolating from historic industry data.

The case for creating many large marine sanctuaries in NSW is compelling: Only when we have an example of all marine environments undisturbed by fishing activity, will we be able to set informed sustainable limits on the fishing industry to prevent it from becoming unviable.

In terms of the long-term survival of marine environments, in the face of human-induced climate change, the more sanctuary protected marine areas, the better.

As Murray *et al.* (1999) conclude;

Multiple reserves, or replication, reduce risk that populations or habitat are destroyed by a catastrophe, assists successful reproduction and is critical for rigorous scientific testing and improved management.

Indeed, Murray *et al.* (1999) suggests that;

No-take reserve networks can complement existing management practices, improve efforts to interrupt declining trends in fishery populations, and help improve marine ecosystems for future generations. Ecosystems are now suffering decreased biodiversity and habitat degradation, and species' populations are declining in size and number.

Sanctuary zones are seen as one of the few mechanisms that can address declining fish catches and catch per unit effort.

## **7. Size of sanctuary zones.**

Overwhelmingly, studies have found that the larger the sanctuary zone, the greater the benefits. In the US, targets range up to 80% of the total management region in marine sanctuaries for the protection of fisheries (see table 1).

**Table 1. Summary of studies estimating marine reserve area relative to the conservation of management objective - reproduced from Table 6.3 in NRC 2001.**

<b>Citation</b>	<b>Criteria</b>	<b>% sanctuary</b>	<b>mean</b>
Ballantine 1997	Typical terrestrial	10%	10
Lauck et al. 1998	Uncertainty in stock assessment	31-70%	50
Roughgarden 1998	Recruitment overfishing	75%	75
Guenette et al. 2000	Spatial model, with and without additional regulations (cod).	20%	20
Mangel 2000	Maintain stock at target levels	20-30%	25
Goodyear 1993	Prevent recruitment overfishing	20%	20
Mace 1994	Precautionary approach	40%	40
Mace and Sissenwine 1993	<b>Prevent recruitment overfishing</b>	35%	35
Sumaila 1998	Bioeconomic model, cost-benefit (cod)	30-50%	40
DeMartini 1993	Yield-per-recruit model, adult mobility (coral reef fishes)	20-50%	35
Man et al. 1995	Metapopulation model	20-40%	30
Soh et al. 1998	Target high biomass areas (rockfish)	4-16%	10
Foran and Fujita 1999	Fecundity and recruitment (Pacific ocean perch)	25%	25
Guenette and Pitcher 1999	Fecundity and recruitment (cod)	30%	30
Pezzy et al. 2000	Bioeconomic model (coral reef fish)	21-40%	30
Sladek Nowlis and Roberts 1997, 1999	Fishing intensity (reef fish)	40%	40
Sladek Nowlis 2000	Fishing intensity (Caribbean white grunt)	30%	30
Sladek Nowlis and Yoklavich 1998	Catch enhancement (Pacific rockfish)	20-27%	24
Holland and Brazee 1996	Bioeconomic model (red snapper)	15-29%	23
Hannesson 1999	Bioeconomic model (cod)	50-80%	65
Polacheck 1990	Yield/recruit model, adult dispersal (cod)	10-40%	25
Hastings and Botsford 1999	Reproductive output (sea urchin)	35%	35
Botsford et al. 1999	Vulnerability to recruitment overfishing (sea urchin)	8-33%	21
Attwood and Bennett 1995	Increase spawning stocks (recreational surf zone fishing)	33%	33
Quinn et al. 1993 Allee	effects and dispersal (sea urchin)	50%	50
Daan 1993	Reduce fishing mortality by fishing	10-14% (cod) 25%	20
Turpie et al. in press	Species representation, complementarity (fish)	10-36%	23
Bustamente et al. 1999	Representative habitats	36%	36
Ward et al. 1999	Habitats and species assemblages	40%	40
Halfpenny and Roberts (in review)	Habitat representation or replication	10%	10
Trexler and Travis 2000	Selective pressure from fishing	10-20%	15
Roberts in review	Dispersal distance	30%	30
<b>MEAN</b>			<b>31%</b>

In NSW, the usefulness of predictive models is still limited by a lack of biological data for most species, and scientists are frustrated by limited

resources for research and a perceived reluctance of managers to adopt more precautionary approaches to uncertainty (Tilzey and Rowling, 2001).

A 10% error factor should, therefore, be considered before any arbitrary sanctuary zone can be established. This is because natural variation in marine resources (such as fishable stocks) is known to exceed one tenth. The year to year variation, due to natural changes in weather and other uncontrollable factors, is generally much more than 10%. The implications of this are many and subtle, but it means that any arrangements made for using these resources must have at least a 10% safety factor built into them, if they are to be sustainable.

Because of economic and political pressures, it is very difficult to build a safety factor into actual extraction quotas, indeed they are often set with a risk factor of damage or collapse. This may be acceptable to the particular industry and the immediate economic conditions. We need a separate and additional system to provide for the overall public interest in long-term sustainability.

Starr (1998) states that;

Reserves should be large enough to contain fish during their lifespan. The lack of knowledge about reef fish movement patterns, especially in deep water, makes it very difficult to make clear recommendations about how large reserves should be.

However, Halpern (2002) concludes that;

Equal relative differences in biological measures between small and large reserves nearly always translate into greater absolute differences for larger reserves, and so larger reserves may be necessary to meet the goals set for marine reserves.

In the US, Martell *et al* (2000) have developed a general spatial model for estimating effects of age-dependent seasonal migration and dispersal on harvest mortality rates, including the effects of fishing effort movement in response to local abundance changes. The simulations suggest the sanctuaries of less than 1% of spawning grounds are too small to provide year-round protection of fishes with high exchange rates, large home ranges, or seasonal migrations for spawning. These species require very large marine reserves (Martell *et al*, 2000).

Greenville and MacAulay (2005) found that resource rent was improved even under optimal management for certain sized protected areas. However, they

suggest that for sub-optimal management, larger protected areas are required to maximize the resource rent generated in the fishery. We would challenge anyone who suggests that fisheries management in NSW is optimal.

In 2001 (see NRC, 2001), Marine Reserves Working Group (MSWG) and the US Natural Research Council (NRC) considered the goals for conservation of ecosystem biodiversity and sustainable fisheries as they developed a recommendation for reserve size for a Channel Islands Marine Reserve. Both the MRWG science panel and the NRC panel agreed that a network of no-take marine reserves would improve the conservation of ecological communities, provide insurance against uncertainty associated with fisheries management, and provide a means to evaluate the effects of natural versus human impacts through long-term monitoring.

In their review the NRC panel found that most theoretical and empirical studies indicate that protecting between 20 to 50 % of fishing grounds will minimize the risk of fisheries collapse and maximize long term sustainable catches.

The science advisory panel to the MRWG recommended protecting at least 30%, and possibly as much as 50%, of each of the representative habitats in each bioregion of the Channel Islands to achieve the conservation and fisheries goals established by MRWG.

Both science panels concluded that reserve networks must incorporate reserves of a variety of sizes to meet multiple goals for conservation and fisheries.

The NSW marine jurisdiction incorporates only 30% of the Manning Shelf Bioregion. To achieve the minimum of 20% reservation of this jurisdiction within the PS-GL Marine Park recommended by marine scientists and resource economists, corresponds to about 50% of the Park established in sanctuary zones.

However, many marine scientists and resource economists suggest far higher percentages for sanctuary protection if they are to achieve the best outcomes for sustainable fisheries and biodiversity protection.

### ***7.1 Above 50% of a bioregion in sanctuary protection.***

Halpern *et al* (2004) developed a simple mathematical models that indicate net fisheries benefits can accrue at closures up to and perhaps beyond 50% of total stock area through the export of production, given documented average increases in biomass within reserves.

## **7.2 Between 30%-50% of a bioregion in sanctuary protection.**

Most of the literature on adequate proportions of Bioregions to be established as marine sanctuaries suggest between 30% and 50% as ideal.

Research by Ward *et al.* (1999) supports this position;

Habitats and species assemblages can be used as surrogates for biological diversity when designing marine reserves. However, simulations showed that the number of species protected in a reserve design increased with the levels of representation within the surrogates (e.g habitats or species assemblages). Therefore, the more habitats used as surrogates for biodiversity, the more taxa were eventually reserved. Nevertheless, to protect all the species of concern over 40% protection of all habitats was required.

### **7.2.1 Case study 1 Channel Islands – USA.**

The US Science advisory panel working for the Marine Reserve Working Group, undertaking the assessment for the dedication of the Channel Island National Marine Sanctuary in 2000, identified that between 30% and 50% of all marine habitats in the assessment area must be protected in no take zones to minimize the risk of fisheries collapse and maximize long term sustainable catches.

### **7.2.2 Case study 2 Dry Tortugas.**

Dahlgren and Sobel (2000) modeled the present biomass in fished and unfished areas of the Dry Tortugas to estimate the size of reserves required to meet management objectives. They concluded that 30-40% of the region of influence needed highest level protection to elevate overexploited stock to sustainable target levels.

### **7.2.3 Case study 3 Galapagos Islands**

Bustamante *et al.* (1999) (cited in Roberts and Hawkins, 2000) developed a reserve design for protecting coastal habitats in the Galapagos archipelago whose objective was to protect sites for tourism and sites of high biological importance. Their design included representing all coastal habitat types in each of five biogeographic zones encompassed by the archipelago in the reserve. They estimated that it was necessary to protect 36% of the region from fishing to achieve the conservation objective.

### **7.2.4 Case study 4 South Africa.**

Using data from Turpie *et al.* (2000), Roberts and Hawkins (2000) estimate that setting-aside 10-36% of the coast of South Africa would maximize long-term persistence of coastal fish species. A system covering 10% of the South African coast could be designed to represent over 95% of the species. However, this system would not represent a number of narrowly distributed, endemic species. A reserve system covering 29% of the coast would represent all species and a reserve system of at least 36% would protect all species at the core regions of their ranges (a common goal for conservation)

### **7.2.5 Case study 5 Manning Shelf – NSW.**

Greenville (in press) classified possible protected areas [sanctuary zones] of the Manning Shelf Bioregion into;

1. Small sized protected areas, which are equal to 15 to 30 percent of the total fishing grounds.
2. Medium sized protected areas, which are equal to 35 to 50 percent of the total fishing grounds; and,
3. Large sized protected areas, which are greater than 55 percent of the total fishing grounds.

This author found that the establishment of protected areas (sanctuary zones) in the Manning Shelf Bioregion has different effects on the predator and prey species.

He found that;

Small sized protected areas are less likely to yield hedge benefits to the fishery, with medium to large more likely. The reason for this is that smaller

sized protected areas do not increase biomass greatly above exploited levels, reducing the ability for biomass in the protected area to reduce normal fluctuations in populations caused through environmental stochasticity.

In conclusion Greenville (in press) suggests that for the two fisheries studied (Ocean Prawn Trawl –OPT - and Ocean Trap and Line -OTL) the creation of a marine protected area in the Manning Bioregion is likely to have different distributional effects. As these two fisheries target different trophic groups (ie OPT = prey species and OTL= predator species), the protected area is less likely to increase harvests for the OPT and fishery rent post establishment, but the Ocean Trap and Line Fishery;

...is more likely to benefit from protected area creation as increased prey and the removal of fishing pressure increased the biomass of these species in the fishery.

For the two fisheries as a whole, Greenville (in press) found that;

The creation of certain sized protected areas can yield some hedge benefits in terms of overall harvests and resource rent. However, for this to occur, a minimum size is required. Small sized protected areas are less likely to yield hedge benefits to the fishery, with medium to large [ie 35% to 50% of the Manning Bioregion] more likely.

### **7.3 Between 20%-30% of a bioregion in sanctuary protection..**

From experience with the Great Barrier Reef Marine Park Zoning Plan, Ferandes *et al* (2005) suggests that due to the diverse national, cultural, political, and economic obstacles that may impede establishing large no-take reserves (eg Christie *et al.* 2003), raising the specter that calls for protection of 30–50% of marine habits in a Bioregion may be unachievable.

International experience has seen 20% of management areas or bioregions being established as sanctuary zone protection in an attempt to minimize the initial short-term impact on fishing industries.

Models developed by Mangel (2000) in the US, indicate that for stocks that are initially heavily fished ( ie 35% of their carrying capacity) reserves of 20-30% guarantee a high level of persistence for time horizons of 20-100 years and provide higher levels of cumulative catch than management with no reserves.

Although the establishment of 20% of a bioregion as marine sanctuary is criticised, anything less is unlikely to meet the objectives of the Park.

### **7.3.1 Case study 1 southern US continental shelf and coral reefs.**

In the United States, for example, the Reef Fishery Plan Development Team (RFPDT 1990) recommended the protection of 20% of the continental shelf off the southern United States.

In 2000, the US Coral Reef Task Force (USCRTF 2000) recommended 20% of coral reefs, and associated habitats receive protection in reserves.

Although 20% is widely criticised as being arbitrary and unscientific (NRC 2001), is it widely quoted (see appendix 1). The main criticisms for the reservation of 20% in marine sanctuaries is that it assumes that 20% of the target habitat is equivalent to 20% of the unfished stock, and that the stock will persist at 20% of its natural carrying capacity, which comes from a fishery model that indicated recruitment overfishing could be avoided by maintaining 20% or above of their unfished biomass (Goodyear *et al*, 1993). This model, however, remains uncertain in several areas.

1. It is difficult to determine the true size of an unexploited stock.
2. Estimates of fish mortality may be inaccurate, especially if target species are caught as a by catch in other fisheries (Guenette *et al* 1998).
3. Not all species will persist when populations are reduced to 20% of their natural carrying capacity.
4. Several studies suggest that stocks should be kept at 60-75% of their natural population size of reserves when used as the primary management measure (Hannesson 1998, Luack *et al* 1998).
5. Without other management approaches, highly mobile species and migratory species will require very large no take zones of between 70-80% of a bioregion (NRC 2001).

### **7.3.2 Case study 2 Great Barrier Reef Marine Park (GBRMP).**

In the 344,400 km<sup>2</sup> GBRMP, the network of marine reserves (no-take sanctuaries) contains at least 20% of all described “bioregions” of the Park which corresponds to 33% of the area overall.

Ferandes *et al* (2005) suggests that;

Although state-of-the-art technology and relatively good data were used to establish the GBRMP, neither was perfect or necessary to implement the conceptual approach underpinning the protective.

## **8. Conclusion.**

Clearly, no-take marine sanctuaries are effective mechanisms for the protection of biodiversity and sustainable fisheries. So too, have they been shown to be effective in introducing new economic activities and opportunities.

These benefits are all derived from the protection of biodiversity that exists in an area. The objective of the Zoning Plan for the PS-GL Marine Park must be to ensure the protection of all species represented in the Park. This objective cannot be met unless adequate representative surrogates are protected.

Although, marine sanctuaries will protect a representative portion of marine biodiversity within an area of influence, the level of representativeness will depend on the surrogates used in the process of identification and the level of detail available of the extant taxa. Limited and misleading correlations can blur the distinction between a marine sanctuary which will be effective and one which is politically expedient and easily implemented and monitored.

To allow for flexibility of reserve design within a predetermined management unit, larger reserves will contain more species and larger populations which are more likely to survive periodic disturbances.

Achieving adequate proportions of all habitat types is difficult to determine without detailed assessments of all extant taxa. This data is clearly unavailable. To avoid the risk that important species, populations and habitats

are not protected due to a lack of detail in the assessment process, large areas of the Park must be reserved in sanctuaries.

For conservation goals, the benefits of a sanctuaries increase with size. Large reserves protect more habitat and populations, providing a buffer against losses from environmental fluctuations or other natural factors that may increase mortality or reduce population. Larger marine sanctuaries provide a correspondingly larger benefit for sustainable catches and tourism.

Initial benefit to fisheries does not, however, necessarily increase with the size of the reserve. The maximum short to medium term benefit of no take zones for fisheries, in terms of sustainability and yield, occurs when the reserve is large enough to export sufficient larvae, and small enough to minimize the initial economic impact to fisheries. Despite these initial impacts to fishers, to maximize the medium to long term benefit, it is necessary to protect a larger area.

To alleviate this short term impact on commercial fishers, more funding is required to provide compensation to commercial fishers who necessarily must be bought out of their fishing businesses. As recreational fishers will be one of the main beneficiaries of a larger marine sanctuary, they must shoulder more of the financial cost of these buyouts. The \$10 million in expected recreational licence sales generated over the past 12 months must be directed to the buyout of commercial fishing in the PS-GL Marine Park. Other arrangements can be established to augment the contribution of recreational fishers to the buyouts of commercial fishers. This would include a levy on commercial operators within the Marine Park (including commercial fishers, tour operators etc) which could repay a low interest government loan over the next 15 years.

An adequate proportion of all representative habitats in the Bioregion has been suggested by marine scientists and resource economists as between 20% and 50%. This equates to a minimum 50% in area of all habitat types identified in the Port Stephens –Great Lakes Marine Park. We consider this as the minimum sanctuary protection to achieve the objectives of the Park.

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### Appendix 1. Table 2. Commercial Fisher Fees as at 1 July 2003

(see [http://www.fisheries.nsw.gov.au/\\_data/assets/word\\_doc/5315/licencing-policy.doc](http://www.fisheries.nsw.gov.au/_data/assets/word_doc/5315/licencing-policy.doc))

Purpose	Elements	Amount (\$)	Notes
Commercial fishing licence			
New licence	Fee	443	
	Research	122	
	Fishery	221	
	Total	\$786	
	Fee for unlicensed crew members, per person	+\$56	

Purpose	Elements	Amount (\$)	Notes
Licence renewal	Fee	221	The late fee applies for applications received more than 30 days after licence expiry date.
	Research	122	
	Fishery	221	
	Total	\$564	
	Fee for unlicensed crew, per crew person	+\$56	
	Late fee	+\$111	
Conditional skipper's endorsement		\$33	
Fishing boat licence			
New licence OR Boat replacement	Maximum boat length:		
	3 metres	\$155	
	4 metres	\$178	
	5 metres	\$201	
	6 metres	\$224	
	7 metres	\$247	
	+1 metre max. length	+\$23	
Fee for unlicensed crew, per crew person	+\$56		
Licence renewal	Maximum boat length of:		The late fee applies for renewal applications received more than 30 days after licence expiry date.
	3 metres	\$44	
	4 metres	\$67	
	5 metres	\$90	
	6 metres	\$113	
	7 metres	\$136	
	+1 metre max. length	+\$23	
Late fee	+\$111		
Boat licence transfer		\$277	Fee per licence transferred
Boat registration		\$111	
Crew registration		\$111	Person is registered for 2 years
Net registration		\$23	
Duplicate licence		\$11	GST included
Abalone & lobster fisheries			
Registration of share transfer and other dealings.		\$214	
Registration of share mortgage		\$375	
Fisher nomination		\$321	
Quota transfer		\$161	
Fishery management charge, per share	Abalone fishery	\$250	Charge applies per share held in each fishery
	Lobster fishery	\$58	
Sea urchin and turban shell (SUTS) fishery			
Fisher nomination		\$321	
Fishing business charge			
Environmental assessment charge	1 fishery	\$159	The number of fisheries in which the business is
	2 fisheries	\$318	

Purpose	Elements	Amount (\$)	Notes
	3 fisheries 4 fisheries 5 fisheries  +1 fishery	\$425 \$532 \$639  +\$107	endorsed determines fee.
Fisheries Resource Conservation & Assessment Council		\$85	Fee applies once per business
Share management rental charge		\$107	Fee applies once per business.
Total fishing business charge	1 fishery 2 fisheries 3 fisheries 4 fisheries 5 fisheries  +1 fishery	\$351 \$510 \$617 \$724 \$831  +\$107	