Misguided Claims of Overfishing in New South Wales: Comment on "Empty Oceans Empty Nets. An evaluation of NSW fisheries catch statistics from 1940 to 2000"

Robyn Forrest and Tony J Pitcher
Fisheries Centre, University of British Columbia, Vancouver, Canada

Summary
A recent report characterises New South Wales fisheries as seriously mismanaged and unsustainable. While there have undoubtedly been declines in some fish populations in New South Wales, we are unable to substantiate these claims since the report lacks both consistency and rigour, analytical methods are not clearly described, fisheries science is not appropriately applied, and there is a failure to comprehend the management systems and responsibilities in Australian fisheries. In summary, the published report is so seriously flawed that it should not be used or quoted.

Currently, there is much concern about the state of the world's marine fish stocks and the ecosystems in which they are embedded (e.g., Pauly et al. 2003). While there is no doubt that some of the world's fisheries have been poorly managed and/or overfished, statements describing failures of fisheries management programmes should be based on rigorous and defensible analysis if criticisms are to be credible. For example, a recent heavily-cited analysis of the decline of tuna populations (Myers and Worm 2003) may be based on incorrect assumptions (Walters 2003; Hampton *et al*. 2005). It is evident that careless interpretation of fisheries statistics increases confusion and may undermine the credibility of legitimate conservation efforts.

A recent anonymous report (hereafter, "the report") published in 2006 by the Hunter Community Environment Centre in New South Wales (NSW), Australia, makes strong claims of mismanagement and severe overfishing in the commercial and recreational fisheries of NSW (Hunter Community Environment Centre 2006). The report presents landings data for a selection of species fished in the state's Ocean Trawl and Ocean Trap and Line fisheries; and for some species landed in recreational fisheries. The report cites declining catches as evidence for overfishing and unsustainability of the state's fisheries. It begins with sections on catch per unit effort and target switching, then provides "assessments" of the Ocean Trap and Line Fishery; the Ocean Trawl Fishery; Recreational Fishing; other populations of fishes in serious decline; and unsustainable catches. The report ends with a set of conclusions and recommendations.

For the reasons outlined below, we contend that the data presented in the report are insufficient to substantiate the claims made therein. Our main criticisms are that the report lacks consistency and rigour and demonstrates a basic lack of understanding of fisheries science and the management of Australian fisheries. The authors have made no attempt to describe their methods or to lay out their argument in a clear and logical manner.

Before discussing specific findings of the report, we briefly outline some basic theory we believe is necessary for interpreting fisheries statistics.

1. Background: fisheries science and population dynamics

Input versus output controls as management tools
Fishery harvests are generally regulated using two approaches: those using 'input' controls and those using 'output' controls.

Input controls involve direct regulation of fishing effort rather than regulation of catch and include measures such as area closures; seasonal closures; restriction on number of fishing licenses and restriction of gear types. These are the types of control in most use in NSW.

Output controls directly regulate the catch. Because they must set quotas or allowable catches, some absolute estimate of stock biomass is required. Stock assessment is extremely data-intensive, requires expertise and, even when based on large amounts of data, can be unreliable (e.g., Myers et al. 1997). Most Australian fisheries lack resources for stock assessment for any but the most valuable species (abalone and rock lobster in NSW and the trawl fishery managed by the Commonwealth in the south of NSW). In the future, ecosystem-based modelling may provide a short cut to estimating the actual biomasses that might be used in quotas, but this technique is not yet proven. Rigorous input controls with appropriate monitoring can provide precautionary management when such assessments are unavailable, although ideally both input and output controls should be used.

Catch as an indicator of abundance
There are a number of reasons why fisheries landings are a poor indicator of abundance of fish. Principally, catches in a given location are determined by a combination of abundance of fish and fishing effort. Fishing effort is in turn driven by many factors including market demand, the price of fish and fishing costs. Changes in licensing laws may also have an effect on fishing effort, especially if there have been government buy-out programmes. Before any conclusions about declining catches can be drawn, declining effort must first be ruled out. For this reason alone, trends in landings statistics are meaningless for determining trends in fish abundance.

Changes in reporting practices also affect landings statistics. Logbook forms and reporting requirements change from time to time according to developments in management practices. Sudden changes or discontinuities in time series trends (such as the appearance or disappearance of a species or sudden change in magnitude of a trend) indicate a likely change in reporting practices that should be investigated before any conclusions are drawn.

Abundances of fish populations fluctuate naturally, as do fishing effort and targeting patterns. This is due to natural variability in environmental conditions and, in the case of fisher behaviour, contingencies such as market fluctuations, weather and fuel costs. Fisheries scientists, managers and fishers themselves are concerned with trends. Is the population increasing or decreasing over time? Very short time series are usually insufficient to distinguish trends from natural fluctuations or cycles.

Because catch alone is basically a meaningless indicator of abundance, the catch rate, or catch per unit of fishing effort (CPUE), is often used as a proxy for fish abundance when no other data are available. It is well known, however, that commercial CPUE is often also a poor indicator of abundance. Changes in spatial distribution of the fish or the fishing fleet; changes in targeting practices; changes in catching power; the way in which the CPUE index is calculated (e.g., Walters 2003); and non-random search behaviour by fishers all affect the

relationship between CPUE and abundance. These problems are compounded in multispecies fisheries, when targeting behaviour is often unknown. Interpretation of CPUE data is not done lightly by fisheries scientists, who must be able to defend their conclusions, especially when making decisions that may affect people's livelihoods. For this reason, other sources of information (e.g., information about length and age-structure) are also used wherever possible.

Simplistic interpretation of trends in landings alone, outside the context of the rest of the fishery monitoring and management process, at best, is liable to provide an incomplete picture of the status of the fishery and, at worst, will serve to perpetrate confusion and misinformation.

Catch history as an indicator of sustainability

It is a mistake to assume that catch rates lower than those observed in the first years of the fishery are an indication of unsustainability.

Two of the most important concepts in understanding the behaviour of harvested populations are those of 'standing stock biomass' and 'production'. The standing stock biomass is the quantity of stock (or the total weight of fish) that exists at a given point in time. Production is the amount of stock produced (or new fish added to the population) over a given time period. Another important concept, 'carrying capacity', describes the maximum standing stock that can be supported by the available resources (food, habitat etc.). By definition, when a population of fishes is in its virgin, or unharvested state, we assume that it is at carrying capacity and, all other things being equal, cannot grow any larger. If some of the virgin biomass is removed by harvesting, we expect that production will increase because there are more resources available for the remaining fish to grow and reproduce.

In most fish populations, the life-phase most likely to benefit from a reduction in standing stock biomass is the juvenile phase. Juvenile survival is expected to increase as intraspecific competition is reduced and this is reflected in the density dependent stock-recruitment relationships commonly used in fisheries population dynamic models. Without such density dependent effects, it would be impossible to harvest fish populations at all without driving them to extinction (Walters and Martell 2004). The degree to which juvenile survival improves as stock size is reduced depends on the life history and behavioural characteristics of the particular stock (Myers et al. 1999). Species that show a very strong improvement in juvenile survival as stock size is reduced can, in general, support higher harvest rates than species with a low improvement in juvenile survival (Schnute and Kronlund 1996).

The main goal of fisheries management is to harvest fish sustainably, i.e., at a rate that finds a long-term balance between standing stock biomass and production. It is generally understood that, for a given fish population and a given set of environmental conditions, there is some mean optimal harvest rate that will balance biomass and productivity to maximise long term catch. Harvesting at rates above this optimum rate will result in lower stock biomasses and catches in the long term. Harvesting too hard may compromise the stock's ability to reproduce itself. However, it is important to realise that any fishing at all will result in lower catch rates than at the beginning of the fishery.

Catches and catch rates in developing fisheries tend to follow a fairly well described trajectory (see Hilborn and Walters 1992). The initial exploratory phase tends to be followed by a period of high catch rates as the initial standing stock is fished down. Reduction in catches after the initial phase of a fishery is an inevitable part of fishery development and provides no evidence whatsoever as to the sustainability of a fishery. Recall that a fish population at carrying

capacity has no net production and, as the initial biomass is reduced by fishing, productivity increases. However, catches in the first few years are essentially a 'mining' exercise (as early harvests are not matched by production), and cannot be used as a benchmark for future potential of the fishery.

Trade-offs in fisheries
Fishery managers and policy-makers aim to set management goals that reflect the public's interests. There may be many conflicting views in society as to what these goals should be. Some members of the community may prefer fish stocks to be left alone in the ocean with little to no harvest (the preservationist argument). Others may prefer lower biomasses in the ocean but more fresh seafood in the markets. There is no right or wrong answer to the biomass versus production trade-off, nor is it a scientific question. Explicit acknowledgement of the trade-offs involved with managing fisheries and informed public and political debate are the keys to developing policy that find the right balance among differing public opinions.

Nobody would argue that unsustainable fishing practices are in the interest of either the public, seafood supply or the fishing industry Arguments claiming unsustainability of fisheries should, however, be based upon credible evidence if the public are to be well-informed about debates concerning conservation of marine resources.

2. Comment on chapters of "Empty Oceans Empty Nets. An evaluation of NSW fisheries catch statistics from 1940 to 2000"

In the following sections we comment on the claims made by the authors of the Hunter Community Environment Centre report, with respect to the evidence used to support their claims. At this stage, we do not comment on the sustainability of the fisheries of NSW, except when referring to published sources of information. The issue of sustainability is complex and requires careful analysis. Work is currently in progress to address these issues and we hope to be able to publish our findings in the near future.

1. Catch per unit effort
In this chapter, the report presents a graph of combined catch per unit effort for all fisheries and all species in NSW since 1984 (reproduced here as Fig. 1). The authors claim that the graph provides evidence for the damage caused by "massive and unsustainable catches of many species taken in the 1980s and 1990s". The source of the data used to make the graph is not given but we make the following observations.

1. The CPUE begins to drop after 1992/3 before increasing slightly in 1996/7. A very large drop follows in 1997/8.

2. Since 1998, CPUE has actually been going up!

The authors themselves note that both 1993 and 1997 represent years in which there was a reduction in the number of licences in operation under state jurisdiction. Since 1997, the number of licenses has more than halved. Importantly, between 1991 and 1997 there were steady reductions in the inclusion of catch and effort data from the Commonwealth South East Fishery in the State's catch and effort database. These changes were finalised in 1997 along with the implementation of a new catch and effort logbook and database which addressed the limitations of previous reporting systems.

Discontinuities in the CPUE index as large as that seen in 1997 are very unlikely to be caused by a change in the underlying state of the system. This would imply that abundances of harvested species had halved in a single year whilst fishing pressure was being reduced! It is much more likely that the discontinuity seen in 1997 is an artefact of changes in the database, as well as changes to the size and structure of the fishing fleet.

The authors of the report do not acknowledge that the CPUE trend they present has been rising since 1998. While they do acknowledge large changes to the management of the fishery and the number of licences in operation, this information is given as an aside rather than suggested as the explanation for the observed trends. Notwithstanding the coarseness of this indicator (CPUE for all species in all fisheries), such an argument that selectively interprets only the evidence that supports a particular point of view is counter to the scientific method.

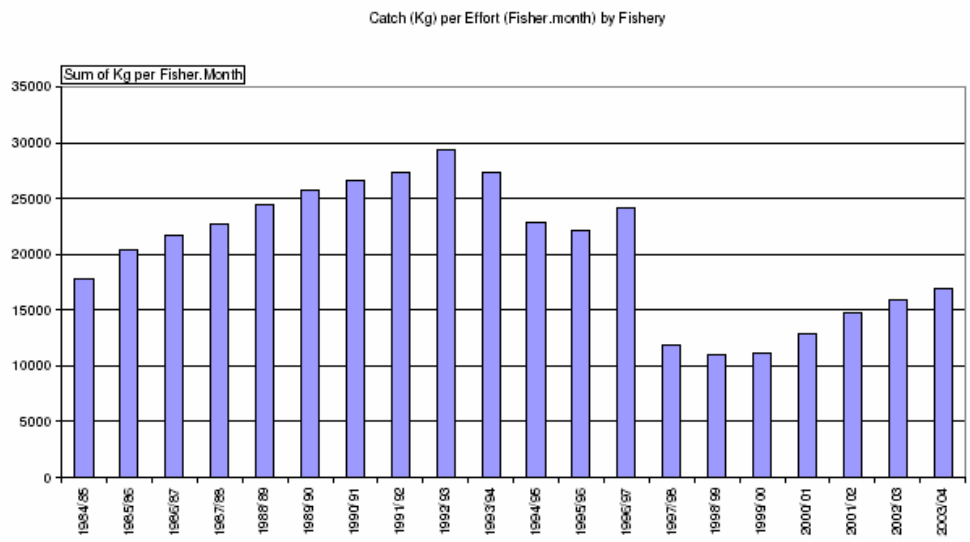

Figure 1. NSW catch per unit effort, as presented in the Hunter Community Environment Centre Report (HCEC 2006).

2. "Target switching"

This section of the report is rather garbled but it appears that the authors are citing an increase in the number of species reported as evidence for mismanagement and unsustainable fishing practices. The report makes the following observations:

i) The number of species reported has increased since the 1940s;
ii) The total catch of all finfish species increased until the mid-1980s then declined until the mid-1990s before doubling in 1994/5 then declining again;
iii) The trend in number of species reported tracked the weight of reported landings until the mid 1970s. After this, landings increased while number of species did not. During the late 1990s, landings decreased while number of species reported did not.

The data on which these observations are based are presented in Figure 2 of the report, reproduced here (Fig. 2).

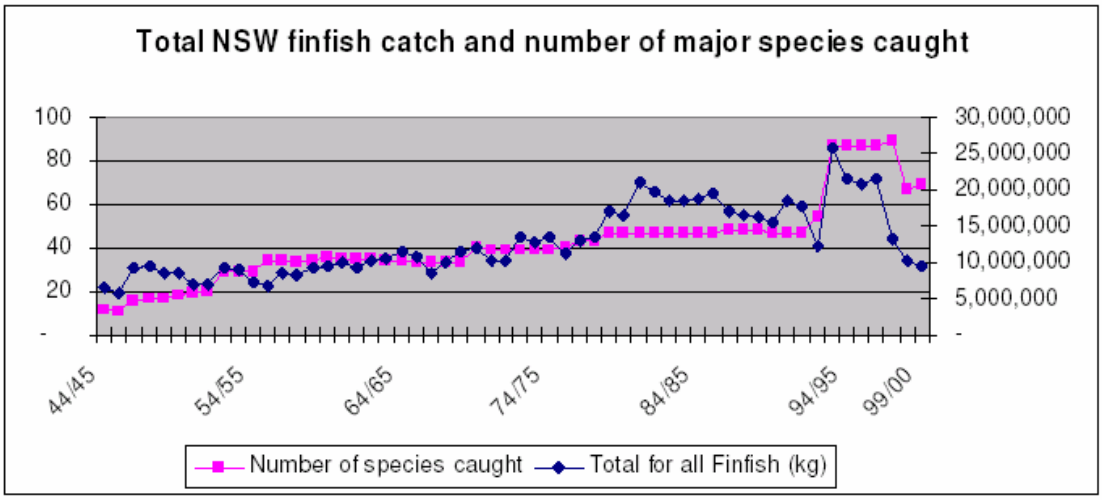

Figure 2. NSW finfish catch and number of species caught, as presented in the Hunter Community Environment Centre Report (HCEC 2006).

Following these statements, the report goes on to give an *ad-hoc* list of observations on trends in landings of a few species caught in the ocean trap and line fishery. Based on the observations listed above, the authors draw the following conclusions:

a) "Changes to reporting sheets, naming more and more species, are, in fact, testament to a history of "target switching";
b) "The unsustainability of NSW fisheries is stark";
c) "Impositions of trip limits have generally been a case of 'closing the stable door after the horse has bolted' ";
d) "A Total Allowable Catch has not been implemented";
e) "Stocks have declined and the fishing industry has continually targeted and marketed many more fish species to fill the declining catch of the more popular fish".

The data presented in Figure 2 are in no way sufficient to supports the above claims.

Composite indicators such as total catch should always be analysed further to look for the mechanisms underlying the observed composite pattern. There is a very simple explanation for the sudden jump in catch and number of reported species shown in Figure 2.

As discussed earlier, the most likely explanation for sudden changes in trends is some change in the reporting system. The x-axis of Figure 2 is not clearly labelled. Counting the data points, however, shows that the sudden jump in the number of species recorded and the weight of the total catch occurred in 1992/3. The NSW historical catch database (Pease and Grinberg 1994) ended in 1992. The new catch and effort database began in 1984. Figure 2 represents a joining together of two very different databases after 1992. The historical catch database contains data for 56 marine finfish groups (including individual species and composite reporting categories, e.g., mixed whiting); 7 mollusc groups and 12 crustacean groups. In contrast, the more recent catch and effort database that began in 1984 contains data for 227 marine finfish groups; 23 mollusc groups and 35 crustacean groups. The sudden jump in both landings and number of species reported in 1992/3 is simply an artefact of switching databases.

Figures 3a and 3b show the total weight of marine finfish landings, as reported in the current NSW catch and effort database, and the total number of finfish species reported (including composite reporting categories). We present data for all marine finfish as the authors of the HCEC report do not explain their definition of 'major' finfish species. Figure 3 shows no evidence of a doubling in landings in 1992/3, nor of a large jump in the number of species reported. The decline in landings evident in Figure 3a is almost certainly due to the removal of Commonwealth South East Fishery statistics from the State database and due to a halving of the number of active licenses in the fishery over this period.

The data in Figure 3b show a steady rise in the number of species reported during the 1980s before stabilising in the 1990s. A new database was introduced in 1997, providing the most likely explanation for the jump in the time series at this time. We caution against overinterpreting statistics such as this. Logbook reporting forms have changed a number of times over the past two decades as the number of species reported under miscellaneous categories has been reduced. There is no doubt that miscellaneous categories on reporting forms make interpretation of historical fisheries data problematic. We contend that the addition of new species to reporting forms reflects attempts by the management agency to address this problem.

The fisheries of NSW underwent several periods of expansion during the last century, including rapid expansion onto the continental slope in the mid-1970s (Tilzey and Rowling 2001). During periods of expansion, both the weight of landings and the number of species reported is expected to increase. As previously discussed, some drop in landings after the initial development of new fisheries is then expected. Since the mid-1990s, much of the capacity of the fishing fleets of NSW has been reduced. The combination of these effects could at least partly explain the observed decline in landings since 1990. There is simply not enough information contained in catch data alone to support the list of claims given in the report.

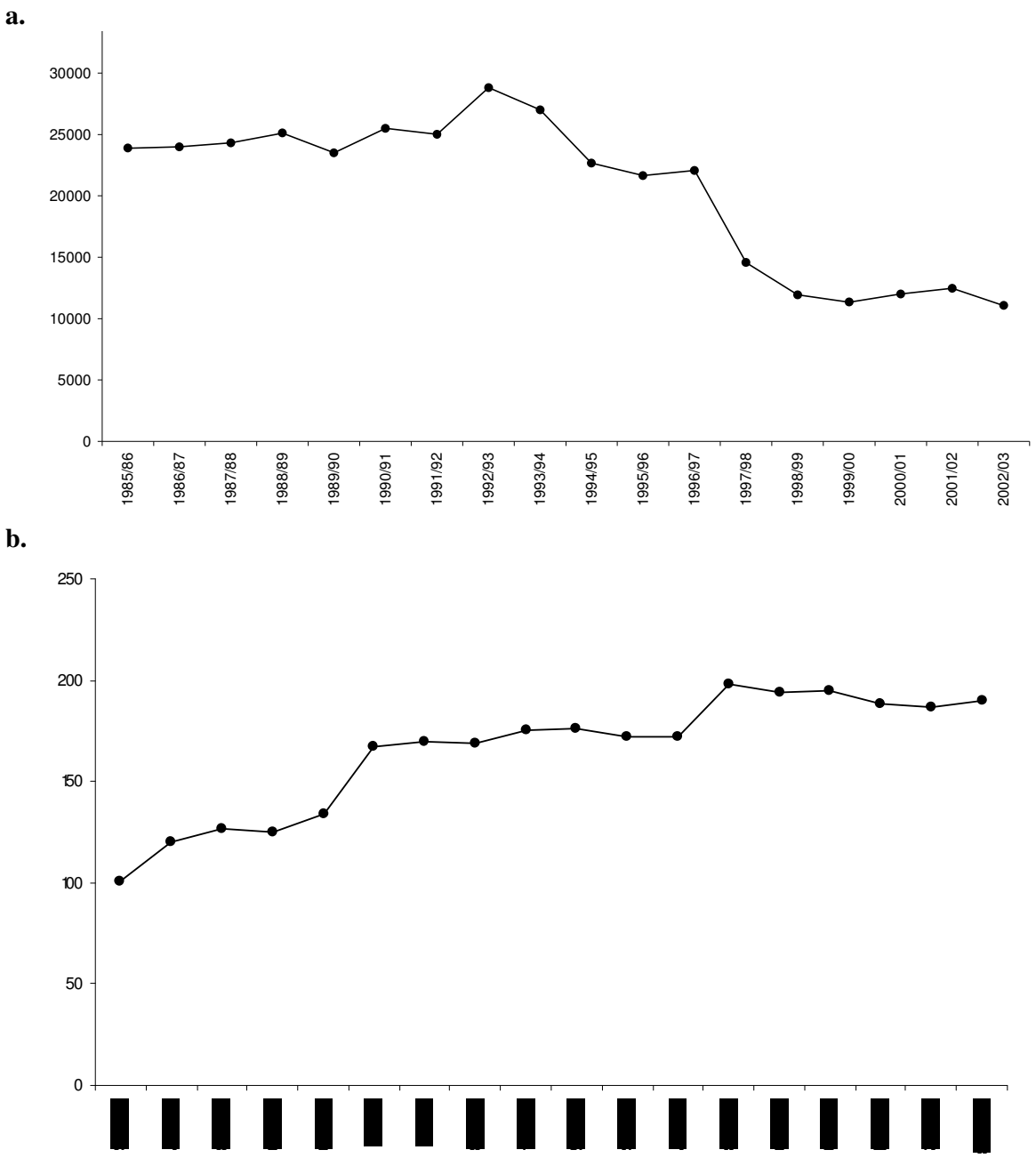

Figure 3. a. Total landings of all marine finfish species (metric tonnes); b. Total number of marine finfish species (or composite group) reported. *Source:* NSW Department of Primary Industries.

We must also note that an increase in the number of species reported, does not, *per se*, provide any indication of sustainability or otherwise. As fisheries develop, it is natural for new markets to develop for previously unmarketed species, both locally and internationally. The past two decades have seen an increasing awareness of seafood as an alternative and healthy form of protein among consumers in the western world and the Australian diet has seen a shift towards more Mediterranean and Asian types of cuisine to supplement the more traditional English-style diet. The addition of new species in landings statistics does not necessarily imply that traditionally-caught species have declined as fishers are forced to seek new markets. This has been elegantly illustrated in a recent paper (Essington et al. 2006), which showed that declines

in the mean trophic level of fisheries landings (often cited as evidence for the depletion of marine ecosystems) could, in most cases, be explained by addition of new species to fisheries landings with no associated depletion of large predatory species.

There is no logical reason why the relationship of total landings to number of species reported should have any meaning and it is unclear why the report's authors have raised this as an issue (point (iii) above), especially as the relationship changes direction in the dataset as it has been presented.

The report's authors imply that Total Allowable Catches (TACs) should have been implemented in the State's fisheries. Setting of TACs involves using modelling to determine estimates of absolute stock size. Setting TACs without reliable estimates of absolute abundance is extremely prone to risk. Estimating absolute abundance is data- and resource-intensive and has failed even in some of the world's most data-rich fisheries (e.g., the northern cod fishery; see Hutchings and Myers 1994; Myers et al. 1997). Methods to reduce fishing effort, through reducing the number of licenses and implementation of spatial and temporal closures are a sensible approach to fisheries management where there are not enough data to support stock assessment and are within the guidelines of the precautionary approach.

3. Assessments: ocean trap and line fishery (OTLF); ocean trawl fishery (OTF); recreational fishing; other populations of fishes in serious decline; unsustainable catches.
The next five sections in the report present an *ad hoc* set of graphs showing historical landings of various species. We do not attempt to evaluate the authors' conclusions species by species, but make the following general observations:

i) As we have already noted, landings are a very poor indicator of stock status. Large decreases in effort and removal of Commonwealth data from the State's fisheries statistics after 1992 can explain many of the trends.

ii) Catch rates (and following on from this in many cases, catches) will always be higher in the first years of a fishery's development as the unfished standing stock biomass is initially fished down. Large catches at the beginning of time series for some species can be viewed as normal for developing fisheries.

iii) Some of the landings time series presented are simply too short to infer a trend.

iv) While most of the time series presented show declining trends, some of them show increasing trends. The authors do not clearly state their methods of interpretation and have not made it clear how they interpret trends going in opposite directions to support the same argument.

v) The final figure presented (Figure 41; total landings of all species) shows the opposite trend to most of the figures presented. Landings of all species increased continuously and gradually until the mid-1990s before dropping off. Again, we stress that there was a large decline in effort during the 1990s and Commonwealth data were removed from the database.

The arguments presented are, in general, inconsistent, poorly supported by the data presented and are not laid out clearly or logically. The report makes almost no mention of trends in estuarine landings, despite the Estuary General Fishery being the largest fishery in the state in terms of landings. If the report was intended to focus on offshore oceanic fisheries (most of the

data presented is for species caught offshore), then emphasis on recreational fisheries should have been removed, as most of the recreational catch occurs in estuaries and nearshore coastal areas (Henry and Lyle 2003). As the report claims to provide evidence of broadscale mismanagement, this distinction should at the very least have been clarified.

The errors discovered in the previous section lead us to question the care with which the report's authors compiled the data.

4. Conclusion
The authors do not make any general conclusion from their findings but make four recommendations:

1. Reduce latent effort (rarely used fishing licences);
2. Phase out trawling and passive line methods (except for whiting);
3. Set a total allowable catch for whiting of 600 tonnes per year; and
4. Close 20% of each marine bioregion to fishing.

We make brief comments on each recommendation before making broader comment below.

1. We agree that latent effort should be reduced as much as possible in input controlled fisheries. As far as we are aware, NSW DPI has already made efforts to reduce latent effort in its fisheries by imposing licence transfer conditions that result in a decrease in the number of fishing endorsements. The Commonwealth government, responsible for most of the finfish fisheries on the continental shelf and slope off NSW, has also just announced a major restructuring of its fisheries that should see a reduction of fishing effort and improvements in management (www.afma.gov.au/information/publications/newsletters/afma_update/docs/update_0224/update_0224.htm).

2. We agree that trawling is a potentially destructive fishing method that has been shown to alter the structure of some marine ecosystems (e.g., Sainsbury et al. 1997). However, we cannot comment on the effects of trawling on benthic habitats in NSW. We do not support the claim that trawling removes larval fish, which can easily pass through the mesh of a net and are often spatially separated from adult populations. Localised studies and evaluation of the actual extent of trawling in NSW should be cited before such a broad and costly recommendation is made. We note that much of the state's fresh seafood comes from trawl and line fisheries and suggest that the debate over the extent of trawling and line fishing in NSW should also incorporate public opinion on this issue.

3. It is unclear to which species of whiting the report's authors refer, although we assume it to be school whiting (*Sillago flindersi)*. The authors have cited no sources to support their recommendation of a 600 tonne total allowable catch for whiting and we view this recommendation to be baseless.

4. Marine protected areas are widely cited as a precautionary management method to buffer against the effects of fishing (e.g., Allison et al. 1998). Their efficacy will be determined by a wide range of localised factors, particularly the degree to which fish move and the spatial structure of fished populations. Marine protected areas will also be more effective if they have the support of local communities (Hilborn 2004). Blanket recommendations for the necessary area to be protected are therefore meaningless. The size and location of spatial closures should

be determined on a case-by-case basis if costly, unpopular and ineffective protected areas are to be avoided.

We do not question that there are conservation concerns for many species in NSW, for example gemfish and several demersal sharks. Concerns for these and other species have been raised by scientists within NSW Department of Primary Industries itself (e.g., gemfish: Rowling 1997; demersal sharks: Graham et al. 2001; demersal slope species: Andrew et al. 1997). Their arguments have been supported by careful analysis of available scientific evidence and have been presented in a rigorous, logical manner, free of distracting hyperbole. As such, they have been accepted by the scientific and fisheries management community.

We also do not question that recreational fisheries in NSW are large and are likely to impact the abundance of a number of marine species. However, it must be acknowledged that angling is an important part of life for many Australians and maintenance of viable recreational fisheries is a management goal of NSW DPI (e.g., NSW Fisheries 2001). Recreational fisheries should be managed to ensure sustainability, as should commercial fisheries. The public has generally been slow to realise that recreational harvests may, in some cases, equal or exceed commercial harvests (e.g., Pollock, 1980; West and Gordon, 1994, Henry and Lyle 2003) and there is often resistance to introduction of new policy to manage recreational fishing. The introduction of a saltwater licence fee in 2002 following intensive public consultation was at least a first step in the right direction. Education programmes may be the key to help anglers and the public understand why management measures are necessary.

There have been major changes to the ways in which fisheries in NSW have been managed over the past decade, many of these to address concerns about continued sustainability of the state's marine resources. There have been two major government buy-outs of commercial fishing licenses (both acknowledged in the HCEC report), the most recent in concert with the closure of 30 estuarine areas to commercial fishing. Management Advisory Committees (MACs), made up of a broad range of representative stakeholders are now a feature of all the fisheries of NSW. Data quality issues are gradually being addressed and practical methods to assess the complex fisheries in NSW are being developed (e.g., Scandol 2004).
NSW DPI has also entered into collaborative partnership with two major institutions (Fisheries Centre, University of British Columbia; and the Australian Commonwealth Scientific and Industrial Research Organisation) to help clarify the issues of ecosystem-based fisheries management through data analysis and computer simulation. Both of these projects involve bringing together all available data for the fisheries of NSW so that questions about sustainability and ecosystem-based fisheries management can be addressed in a rigorous and defensible way.

In Australia, as in the rest of the world, there are legitimate concerns for conservation of our marine environments and sustainability of seafood resources. In many of the world's collapsed fish stocks, fishing pressure was not regulated at a constant or near constant rate and harvest rates continued to rise as stock biomass decreased (e.g., Hutchings and Myers 1994). The main problems that have been identified with collapsed fisheries have been failure to control fishing capacity (allowing fishing fleets to become too large); too much trust placed in stock assessments; and management systems that either cannot or will not adapt to new information about the state of the fishery (Walters and Maguire 1996; Cochrane 2000). We would argue that NSW DPI has made efforts to address these types of problems and is at least moving in the right direction towards greater sustainability of its fisheries. Fisheries are managed by input controls that include a highly regulated licensing system; small-scale area closures to protect

specific spawning stocks; gear restrictions; and substantial reduction in capacity. Management advisory committees meet regularly to discuss and address issues within each fishery. NSW DPI employs a public consultation process whenever major decisions are made (e.g., placement of the Recreational Fishing Havens). Considerable efforts have been made to improve access to fisheries dependent data to inform decisions.

For the reasons outlined in the previous sections, we believe the Hunter Community Environment Centre report is poorly formulated, lacks rigour and provides no evidence to support its claims, except (for some species known to be of conservation concern) citation of works already published by NSW DPI. As already noted, oversimplistic interpretation of trends in landings alone, at best, is liable to provide an incomplete picture of the status of the fishery and, at worst, serves to perpetrate confusion and misinformation. Publication of the report's findings in the *Sydney Morning Herald* (April 14, 2006), which announced that the state's fisheries are "on the edge of collapse", sparked accusatory responses from members of the public accusing different sectors of irresponsible fishing practices (*SMH* April 17, 2006). The report's credibility was not questioned. Not surprisingly, the public are not, in general, well-informed about the details of fisheries science and should not be expected to be able to distinguish between reliable and unreliable sources.

The Australian public deserves to be properly informed on the issue of marine conservation. Many peoples' livelihoods depend on fishing; fresh seafood is an important part of the diet of many Australians; and recreational angling is an important and economically valuable past-time. Conservation of the marine environment is also an important public concern. Care needs to be taken that genuine concerns for sustainability are not obscured by value-laden rhetoric masquerading as science. Talk is cheap. The real solutions to problems within fisheries management should involve setting and communication of clear management goals; careful and honest analysis of all available data; and consultation with the public, industry and other interest groups. Implementation of major changes may be costly and require extensive public consultation and may therefore move more slowly than some groups would like.

References

Allison, G.W., J. Lubchenco and M.H. Carr. 1998. Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications* 8, Suppl.1, 79–92.

Andrew, N. L., K. J. Graham, K. E. Hodgson and G. N. G. Gordon. 1997. *Changes after twenty years in relative abundance and size composition of commercial fishes caught during fishery independent surveys on SEF trawl grounds*. FRDC Project No. 96/139, 106pp.

Cochrane, K.L. 2000. Reconciling sustainability, economic efficiency and equity in fisheries: the one that got away? *Fish and Fisheries* 1, 3-21.

Essington, T.E., A.H. Beaudreau and J. Wiedenmann. 2006. Fishing through marine food webs. *Proceedings of the National Academy of Science* 103, 3171-3175.

Graham, K. J., N. L. Andrew and K. E. Hodgson. 2001. Changes in relative abundance of sharks and rays on Australian South East Fishery trawl grounds after twenty years of fishing. *Marine & Freshwater Research* 52(4), 549-561.

Hampton, J., Sibert, J.R., Kleiber P., Maunder, M.N. and Harley, S.J. (2005) Decline of Pacific tuna populations exaggerated? *Nature* 434: E1-E2.

Henry, G. W. and J. M. Lyle, Eds. 2003. *The National Recreational and Indigenous Fishing Survey*. NSW Fisheries Final Report Series. NSW Fisheries, Cronulla.

Hilborn, R. 2004. Ecosystem-based fisheries management: the carrot or the stick? *Marine Ecology Progress Series* 274: 275-278.

Hilborn, R. and C. J. Walters. 1992. *Quantitative Fisheries Stock Assessment. Choice, Dynamics and Uncertainty*. Chapman and Hall, 570pp.

Hunter Community Environment Centre. 2006. *Empty Oceans Empty Nets. An evaluation of NSW fisheries catch statistics from 1940 to 2000.* Hunter Community Environment Centre, Newcastle, 31 pp.

Hutchings, J.A. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, Gadus morhua, of Newfoundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 51(9), 2126-2146.

Larkin, P. A. 1977. An epitaph for the concept of maximum sustained yield. *Transactions of the American Fisheries Society* 106(1), 1-11.

Myers, R. A., J. A. Hutchings and N. J. Barrowman. 1997. Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological Applications* 7(1), 91-106.

Myers, R. A., K. G. Bowen and N. J. Barrowman. 1999. Maximum reproductive rate of fish at low population sizes. *Canadian Journal of Fisheries and Aquatic Science* 56, 2404-2419.

Myers, R.A. and Worm, B. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423: 280-283.

NSW Fisheries. 2001. *Estuary General Fishery Environmental Impact Statement*. Cronulla, NSW Fisheries.

Pauly, D., J. Alder, E. Bennett, V. Christensen, P. Tyedmers and R. Watson. 2003. The future for fisheries. *Science* 302, 1359-1361.

Pease, B. C. and A. Grinberg. 1995. *New South Wales Commercial Fisheries Statistics 1940-1992*. NSW Fisheries, Cronulla, 351pp.

Pollock, B.R. 1980. Surprises in Queensland angling study. *Australian Fisheries* 39 (4), 17-19.

Rowling, K. R. 1997. The collapse of the eastern Australian gemfish stock - issues for management and the role of fisheries science. *Proceedings of the 2nd World Fisheries Congress, Brisbane, 28 Jul-2 Aug 1996*. CSIRO Publishing, Collingwood, Vic, Australia.210-214pp.

Sainsbury, K. J., R. A. Campbell, R. Lindholm and W. Whitelaw. 1997. Experimental management of an Australian multispecies fishery: examining the possibility of trawl-induced habitat modification. In: (eds E.K. Pikitch, D.D. Huppert and M.P. Sissenwine) *Global Trends: Fisheries Management. American Fisheries Society Symposium* 20 American Fisheries Society Bethesda, Maryland. Pp. 107-112.

Scandol, J. P. 2004. *A Framework for the Assessment of Harvested Fish Resources in NSW*. Cronulla, NSW Department of Primary Industries: 96 pp.

Schnute, J. and A. Kronlund. 1996. A management oriented approach to stock recruitment analysis. *Canadian Journal of Fisheries and Aquatic Science* 53, 1281-1293

Tilzey, R. D. J. and K. R. Rowling. 2001. History of Australia's South East Fishery: a scientist's perspective. *Marine and Freshwater Research* 52, 361-375.

Walters, C. J. 2003. Folly and fantasy in the analysis of spatial catch rate data. *Canadian Journal of Fisheries and Aquatic Science* 60, 1433-1436.

Walters, C. and J.-J. Maguire. 1996. Lessons for stock assessment from the northern cod collapse. *Reviews in Fish Biology and Fisheries* 6(2), 125-137.

Walters, C. J. and S. J. D. Martell. 2004. *Fisheries Ecology and Management*. Princeton University Press Princeton, 399pp.

Walters, C. J. and A. M. Parma. 1996. Fixed exploitation rate strategies for coping with effects of climate change. *Canadian Journal of Fisheries and Aquatic Science* 53, 148–158.

West, R.J. and G.N.G. Gordon. 1994. Commercial and recreational harvest of fish from two Australian coastal rivers. *Australian Journal of Marine and Freshwater Research*. 45 (1), 1259-1279.