SUSTAINABILITY OF THE WESTERN ROCK LOBSTER FISHERY:
A REVIEW OF PAST PROGRESS AND FUTURE CHALLENGES

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ABSTRACT

The Western Rock (spiny) Lobster Fishery has 594 boats operating about 57,000 pots. The average annual catch of 11,000 tonnes is valued at around US$150 million. In addition to the commercial catch, recreational fishers take about 600 tonnes a year. Sustainability in this fishery is maintained by analysis of a comprehensive fisheries database, some of which dates back to the 1960s (e.g. catch, effort, length-frequencies, fishery-independent breeding-stock surveys, puerulus settlement monitoring, recreational catch monitoring); an extensive set of management controls (including a limited fishing season and legal minimum and maximum sizes); and an effective compliance program. Effort in the fishery is controlled by input restrictions on the number of pots allowed and number of days fishing, which are implemented after considerable consultation with industry. The principal method of ensuring the sustainability of the fishery is by monitoring the size of the breeding stock, using data from both a commercial at-sea monitoring program and an annual fishery-independent breeding-stock survey. When the breeding stock fell to low levels in the early 1990s, management initiatives succeeded in returning it to what are considered to be safe levels. Catches are currently high, but fishers have acquired sufficient scientific knowledge to understand that catches will fluctuate for environmental reasons and to take this into account in their fishing operations. Environmental effects have been shown to drive the level of settlement in a particular season. These settlement levels are in turn highly correlated with catches three to four years later, which provides a means of predicting future catches and managing the fishery accordingly. There are issues to be considered in assessing the sustainability of this fishery in the future. The fishery may be overly reliant on egg production from the Abrolhos Islands; catching

power of the commercial fleet is increasing due to improvements in gear and technological equipment; growth in catches made by the recreational sector are currently unconstrained; pueruli may be harvested for aquaculture in the near future; and regulations protecting the female brood stock more than the male population could lead to reproductive issues. These potential threats are considered to be low, but will need to be monitored. The fishery was awarded Marine Stewardship Council certification in March 2000, the first in the world to receive this imprimatur.

The western rock lobster *Panulirus cygnus* occurs on the western seaboard of Australia and is found in commercial quantities from Augusta in the south to Shark Bay in the north (Figure 1). The fishery is Australia's most valuable single-species fishery; landings are currently valued at US$150 million per annum. The commercial fishery dates back to the 1890s, when rock lobsters were caught for the local market. Before World War II, relatively small quantities by today's standards were caught and canned for export. However, the fishery expanded greatly after the war, when annual catches climbed from less than 500 tonnes to over 8,000 tonnes by the end of the 1950s (Gray 1999). Annual commercial catches since the mid-1980s have fluctuated between about 8,000 and 14,400 tonnes, but on average have yielded around 11,000 tonnes (Figure 2). Currently, 594 boats in the commercial fishery operate some 57,000 pots (traps) over the season (mid-November to the end of June), totaling an estimated 10.75 million pot lifts each season.

There is also a large recreational catch component to this fishery. Licensed recreational fishers are permitted to catch lobsters by diving, or by using up to two pots per person per day over the same season as commercial fishers and can keep up to eight legal-sized lobsters per person per day. Since the late 1990s, recreational fishers have accounted for between 450 and 750 tonnes each season (Figure 2), or 4 – 5% of the total western rock lobster catch (Figure 3). This figure has been growing in recent years as increasing numbers of recreational fishers take up the unrestricted access to the recreational fishery (Melville-Smith *et al*., 2001) (Figure 3).

Because of the long history and importance of the fishery, numerous reviews have examined aspects of the biology of the species and its management (*inter alia* Hancock, 1981, Phillips and Brown, 1989, Brown, 1991, Gray, 1992; 1999, Phillips, 1981, Phillips *et al.,* 2000, Melville-Smith and Anderton, 2000, Hall and Brown, 2000, Caputi *et al*., 2000 and Caputi *et al*., in press). The object of this paper is to build on these earlier reviews by documenting the progress that has been made in maintaining the sustainability of the Western Rock Lobster Fishery, and suggesting what challenges face the fishery in the future. The fishery's management regime today concentrates on controlling the exploitation rate via fishing effort and maintaining a specified breeding-stock size. Environmentally sustainable development (ESD) indicators in this fishery are a recent initiative and while some of these more general sustainability issues will be discussed, this review focuses on issues specific to management of the resource, rather than the effects of its fishing on the environment and socio-economic elements.

THREATS TO SUSTAINABILITY

Since at least the 1970s, management of the Western Rock Lobster Fishery has been guided by five principles formulated into actions, which can be summarized as:

- Acquiring reliable catch, effort, and length-frequency data to monitor the effects of fishing pressure on the exploited population.
- Setting a legal minimum size, protection of females, and gear restrictions with adequate inspection and legislative backing.

- Controlling fishing effort to protect the breeding stock and maximize the benefit from the resource.
- Understanding the stock/recruitment/environment relationship.
- Communicating effectively and regularly with both commercial and recreational fishers to ensure the objectives and methods of management are well understood.

The management arrangements have been developed with these principles as a guide. Together with a strongly directed and comprehensive (compared to other lobster fisheries in Australia and around the world) research program, this approach has resulted in the Western Rock Lobster Fishery achieving recognition as one of the best-managed fisheries in the world.

1. Reliable catch, effort, and length-frequency data

The Western Rock Lobster Fishery has a database extending over more than 30 years that includes commercial catch returns, voluntary logbooks, processor returns, and abundance estimates of pre-recruits and breeding stock from on-board monitoring of the commercial catch and recreational catch surveys.

Extensive databases such as these were vital components to Walters *et al.'s* (1993) spatio-temporal model and in more recent times Hall's (2000) and Hall *et al*.'s (2000) size-structured model. The models have been used at different times to assess the status of the stock and to forecast the impact of proposed management strategies on the breeding stock.

2. A legal minimum size and gear restrictions with adequate inspection and legislative backing

2.1. Legal size

The legal minimum size for the fishery was set in 1900 at 76 mm Carapace Length (2.75 inches). It has essentially remained unchanged since that time, although after the 1993/94 season it was increased by 1 mm to 77 mm for the first two-and-a-half months of the seven-and-a-half month fishing season, as one of a number of management measures introduced in the early 1990s, aimed at reducing fishing mortality so as to improve the state of the brood stock (Hall and Chubb, 2001).

2.2. Compliance

A very obvious threat to the sustainability of any commercial fishery, namely compliance with regulations, was addressed early on in the development of the fishery. In the 1960s, effort limitations were introduced; it was probably not a coincidence that illegal fishing activity became pandemic. At that time there is much evidence of blackmarket sales being rife on the local market and in markets on the eastern states of Australia, and of undersized animals and egg-bearing lobsters stripped of their brood being processed (Gray, 1999, Caputi *et al*., 2000).

Management introduced measures to counteract the problem: legislation was brought in to restrict processing to licenced establishments; more inspectors were appointed; fines for rock lobster fishing offenses were increased; convictions were recorded against the vessels rather than their skippers; and licenses could be cancelled after the third offense — the measures helped to make this a highly compliant industry. Even today, much effort goes into ensuring that compliance and research into improving the efficiency of compliance in the industry is at the forefront of this field (McKinlay and Millington, 1999). Currently as few as 1 to 2 animals are illegal in every 1000 checked by enforcement officers (John McKinlay, Western Australian Department of Fisheries, *pers. comm*.). An attempt has been made to adjust the less reliable historic catch data for illegal activities and under-reporting of catch (Caputi *et al*. 2000).

2.3. Damage and mortality to the discarded catch

During the 1980s it was recognized that large numbers of undersized lobsters were being killed unnecessarily, exposed to predation, or having their growth affected by poor handling practice on board fishing vessels. These practices involved needlessly exposing undersized animals to the air for lengthy periods before sorting them from the catch, excessive handling that resulted in limb loss, and release away from their home reefs often on unsuitable benthic substrate (Brown and Caputi, 1983; 1984; 1986, Brown and Dibden, 1987). In response to this a minimum of three escape gaps (formerly only one) were required to be fitted on each pot from 1986/87 onwards. Furthermore, codes of fishing practice have been introduced into the industry (Stevens *et al*., 1995) and are continually being updated and communicated at every opportunity.

Despite the progress that has been made, it is recognized that there is still room for improvement with regard to loss of appendages by lobsters through poor or prolonged handling. Researchers are exploring the possibility of stunning the catch with cold water for a few seconds before it is sorted, so as to minimize appendage loss durng capture and post-harvest handling (Davidson and Hosking, 2001).

3. Fishing-effort control systems

Effort in the fishery has been controlled since 1963, when a maximum was fixed for total pot numbers (for a comprehensive review of catch and effort in the fishery, including regulations and controls used to limit effort, see Phillips *et al*., 2000). These effort units are transferable. In more recent years, when other lobster fisheries in Australasia turned to output controls, such as quotas, management considered adopting that approach (Bowen, 1994). However, both fishers and managers of the fishery have strongly supported retention of input control in the form of total allowable effort (TAE) and transferable effort units; it seems unlikely, therefore, that this form of management will change in the foreseeable future.

The reasons for output controls being rejected by western rock lobster fishers are outlined by Fitzharding (1999). He lists the quota system's inability to deal adequately with natural variations in abundance, problems with enforcing quotas, lower economic returns, higher costs of administration, less flexibility in the management rules to capitalize on market changes, and centralization of ownership resulting in owners of the quota placing unacceptable controls on the fishers.

4. The stock/recruitment relationship

Although there are very significant peaks and troughs in the annual catch (Figure 2), they are not due to fishing pressure. Rather, they are mainly due to environmental perturbations that drive the success or otherwise of settlement of the puerulus (the settling stage of rock lobsters). This in turn affects recruitment levels into the fishery.

4.1. Catch prediction

Studies in the 1980s of the levels of puerulus settlement on collectors at sites along the coast of Western Australia showed a good correlation between the numbers settling and the catches in the fishery three and four years later (Phillips, 1986, Caputi *et al.*, 1995a, 1995b). This has been developed into a comprehensive regional and seasonal predictive system that is recognized by industry, government and the community as being a reliable indicator of future catches (Sharp 2000). This is separate from the models that have been developed for the fishery (Walters *et al*., 1993 and Hall *et al*., 2000) which are not used to predict catches.

The strength of the Leeuwin Current (which is influenced by ENSO events), as well as the frequency and strength of westerly winds, have been established as key factors responsible for determining the level of puerulus settlement in a particular season (Pearce and Phillips,1988, Caputi *et al*., 1995c).

One of the major benefits of this ability to predict catches up to four years in advance, is that management changes can be made before fishing takes place on a year class which has yet to recruit to the fishery. By contrast, other fisheries without this ability can only react to the effects of a poor year-class passing through the fishery, after it has been fished.

4.2. Protecting egg production

One of the most serious threats to the fishery in the past — and one that still requires vigilant attention — is that the brood stock should become over-exploited. Western rock lobsters live along many hundreds of kilometers of coastline (Figure 1). Although a single stock, they do have regional differences in their biological characteristics; for example, females (and probably also males) mature at a much smaller size at the offshore Abrolhos Islands than at the coast, and even on the coast there are substantial differences in size at maturity (Table 1).

Fishing a population below or around the size at maturity during the rapid somatic growing phase generally optimizes the catch that season. However, unless properly managed, this is a risky management strategy because it could overexploit the parent stock, which in turn could lead to overfishing of recruits.

The size of the brood stock of the western rock lobster in the early 1990s was estimated to have shrunk to very low levels (Walters *et al*., 1993). The postulated reasons for the decline were that exploitation rates were higher because licences were being fished more intensively and efficiently, and that fishers could target isolated deepwater reefs in the offshore breeding grounds more efficiently when electronic fishing aids (particularly GPS) were introduced (Brown *et al*., 1995, Caputi *et al*., 2000). Modeling results (using the model of Walters *et al*. (1993)) suggested that egg production had been reduced to 15-20% of pristine levels (Anon., 1993). Furthermore, a decline in Abrolhos Island puerulus settlement from 1984 was considered to possibly be due to the reduction in spawning stock as it could not be explained by environmental effects. The first signs of recruitment overfishing appeared to be emerging in the fishery (Caputi *et al*., 1995c).

Scientists, industry and managers were unified in their concern about the state of the brood stock and the signs that recruitment was possibly being affected. This led management to introduce of a suite of measures aimed at rebuilding the brood stock to the levels of the 1980/81 season. These management changes, which were supported by industry, were introduced in the 1993/94 season.

The changes were:

(i) An 18% reduction in the number of pots allowed to be used in the commercial fishery. Nominal fishing effort had increased through the 1980s with uptake of latent effort in the fishery, combined with greater efficiency targeting lobster reefs using electronic and other fishing aids. Consequently, fishing mortality had increased substantially. A 10% pot reduction was imposed through the mid- to late-1980s at a rate of 2% per season, but this stabilized the increase in effort over this period rather than significantly decreasing it. The 18% 'temporary' (although nine seasons on there has been no lifting of its temporary status) pot reduction was aimed at reducing that additional fishing effort and the pressure on the breeding animals.

(ii) The introduction of what has become known as the 'setose rule', which required fishers to return to the sea any female lobster bearing ovigerous setae and/or a tar-spot (i.e. carrying an external spermatophore). This was additional to existing legislation that required fishers to return egg-bearing animals back to the sea. The commercial and recreational fishing seasons start in mid-November. Mature females, while not necessarily carrying eggs, generally have ovigerous setae during the spawning season (September – December) and until February or March, when many moult into a non-setose phase. They remain non-setose until May or June, when they moult back into the setose state in preparation for the breeding season, which starts around September. Therefore, while the setose rule has not excluded all mature females from capture, it has largely limited their exploitation to the proportion that moult to the non-setose stage in the period between February and May.

(iii) The introduction of a legal maximum size for female lobsters: 115 mm carapace length (CL) in the southern zone (south of 30^{o}S; see Figure 1) and 105 mm CL in the northern (including the Abrolhos Islands) zone of the fishing grounds. This rule was aimed at protecting the large females in the population. Although these animals make up only a small part of the population, they are thought to make a large contribution to egg production. Chubb (1991), for example, showed that large female western rock lobsters are capable of producing multiple broods each season and can carry hundreds of thousands more eggs than small females.

(iv) An increase in the legal minimum size by 1 mm CL from 76 to 77 mm from November 15 – January 31 (i.e. for the first two-and-a-half months of the seven-and-a-half month fishing season, which extends from November 15 to June 30). Most western rock lobsters around the legal minimum size migrate offshore around the start of the commercial fishing season in December and January. They are targeted by the commercial fishery, which takes large numbers of them. Once in the deeper offshore waters, fewer are caught, and it was therefore expected that increasing the minimum size during the migrating phase would enable more animals to survive to ultimately become part of the breeding population.

The obvious question to follow from these management changes is to ask how successful they have been in rebuilding the brood stock.

The state of the brood stock is currently measured by two different methods. The first, described by Chubb *et al*. (1995), uses commercial monitoring data from the northern and southern coastal management zones of the fishery. The shortfall of this index is that it does not automatically take increases in fishing efficiency, which are inherent in the use of commercial catch-and-effort data, into account. Although these data can be adjusted to make up this deficiency (as described by Brown *et al*., 1995), there is inevitable uncertainty about the modified figures. In the case of the western rock lobster fishery the monitoring data are adjusted by about 1 to 2 percent per annum to take into account efficiency increases.

The fishery-independent method of establishing an egg-production index was established for the western rock lobster fishery in the early 1990s (Melville-Smith *et al*., 1998). In brief, a survey is conducted each year at the same GPS positions on a number of sites covering the full extent of the commercial fishery. Standardized fishing gear, bait and lunar phase are used to limit the variables that could influence catch rates. Regional egg production is calculated from the number and size of breeding females caught in the pots, taking into account size-fecundity relationships. The short-fall of this approach is that uncontrolled environmental factors such as temperature and swell at the time of sampling can affect the catch rates.

The overall impact of the above management measures on the state of the brood stock since their introduction in the 1993/94 season can be seen from the fishery-dependent and fishery-independent egg production indices in Figures 4a and b. Irrespective of which index is used, the results suggest a substantial increase in egg production within the last decade.

At the time the management changes were introduced, there was little doubt they would increase egg production in the fishery, but the extent of protection they would offer could not be accurately predicted. The effectiveness of these 1993/94 changes have since been assessed by way of an age-structured model (Hall and Chubb, 2001). The model suggests that, by 1999/2000, egg production in the fishery was 134% of the target level (i.e. egg production in the 1980/81 season). It also estimates that the catch in 1999/2000 was 90.5% of what might have been taken had the management measures discussed above not been in place. Furthermore, the model calculates that, if each of the four management measures had been applied separately and singularly, egg production in the 1999/2000 season would have been 76, 84, 94 and 102% of the target level for the minimum size, maximum size, pot reduction and setose regulations, respectively (Hall and Chubb, 2001).

While management measures such as those introduced in the 1993/94 season are in place to protect the brood stock, there seems to be little likelihood of recruitment to the fishery declining in the future due to overfishing. Managers have no wish to increase the size of the brood stock beyond the target level (of egg prodution levels at the beginning of the 1980s (Figure 4a)). When landings in the 2001/02 fishing season were predicted to be below average, an outcome that was subsequently born out (Chubb, 2002), one of the 1993/94 management measures — the maximum size rule for females — was rescinded for that one season only, to bolster catches because the markets, principally in Asia, require a consistent level of supply. The effect of this management change was not considered to pose unacceptable risks to the fishery (Department of Fisheries, Western Australia, 2002). With the breeding stock at levels which are considered adequate for the fishery, it is considered that environmental effects will be the major factor driving future variation in catch abundance.

5. Effective and continuing communication with stakeholders

The principal method of consultation in the fishery is through the Rock Lobster Industry Advisory Committee (RLIAC), a statutory Ministerial Advisory Committee. The Committee includes fishers, processors, conservation and recreational fishing representatives and managers The functions of the RLIAC, as set out in the *Western Australian Fish Resources Management Act 1994,* are:

- to identify issues that affect the rock lobster fishery;
- to advise the Minister on matters relating to the management, protection and development of the rock lobster fisheries; and
- to advise the Minister on matters relating to rock lobster fisheries on which the advice of the Advisory Committee is sought by the Minister.

Since its establishment in 1965, RLIAC has made communication and consultation with industry its first priority. RLIAC has been the forum in which issues (particularly those related to sustainability) have been debated and recommendations made to the Minister. The committee takes problems that affect the fishery and the industry generally, such as the dangerous decline in the size of the breeding stock before 1993/94, and by way of discussion and management papers and meetings with industry, initiates ways to resolve them.

The fishery management group has a very successful process of communicating with stakeholders by way of an annual coastal tour, which is a series of public meetings for to fishing communities and the general public, and by way of Western Rock Lobster Commercial Fisheries Production Bulletins, which are produced three times a year). Commercial fishers involvement in the management of the fishery, which has until recently been by way of RLIAC and the West Australian Fishing Industry Council, was enhanced in 2002? by the creation of an industry peak body known as the Western Rock Lobster Council.

3. Issues to be resolved

With egg production in the fishery being monitored, and with the previously described ways of adjusting exploitation rates to maintain breeding stock levels, the main biological threat to sustainability of the resource is under control. However, there are always other issues arising that, if left unattended, could cause problems for the fishery in the future.

3.1. Regional contributions to egg production

One of the risks associated with the management of egg production in this fishery, is the disproportionate contribution to egg production that is believed to be made by

Comment [C1]: What is meant by an obscure threat? Does it mean unlikely or one that is not generally recognised? Some clarification would be desirable.

lobsters at the Abrolhos Islands. Chubb (1991) calculated this offshore group of islands contributed between 45 and 60% of the stock's egg production in the 1984/85 to 1988/89 seasons — a direct result of the high densities of lobsters and their small size at maturity in that region (Table 1). The large quantities of eggs produced in this relatively small and isolated region, and therefore the presumed dependence of the fishery on that part of the brood stock, does leave the fishery vulnerable in the unlikely event of a serious disaster (e.g. a major oil spill or localized disease outbreak).

3.2. The impact of increases in fishing efficiency

The effect of effort creep — the increase in the catching power of a rock lobster pot due to improvements in fishing technology — will need constant vigilance in this input-regulated fishery. The use of nominal fishing effort to plot changes in catch per unit effort over time (Caputi et al., 2000), indicates this index to be stable since the 1970s. However, when catch rates are adjusted for increases in fishing efficiency due to gear technology improvements (colour echo sounders, GPS, better designed and faster boats etc), the catch rates with standardised effort have gradually declined.

Caputi *et al.* (2000) showed, using the Walters *et al.*'s (1993) model for the fishery and without taking account of the management package introduced in 1993 to improve egg production, that a considerably more favourable scenario of the state of egg production in the fishery emerged when nominal fishing effort was used than when standardised effort was used. Furthermore, modelled future projections showed egg production to stabilise at about 20% of virgin biomass production using nominal fishing effort, but to steadily decline and ultimately affect recruitment when standardised effort was used.

While there are no plans in the immediate future to reduce the number of pots in the western rock lobster fishery, the efficiency of the fleet will inevitably increase in the future (previously estimated as being 0.5-2% per annum in shallow-water and 1-4% in deep-water (Brown *et al*., 1995)). There is little doubt, therefore, that some form of adjustment will be necessary in the medium to long term to maintain egg production at the target level.

3.3 Recreational fishing sector

One of the issues that has yet to be addressed, is the expansion of the recreational fishery. Since the 1986/87 season, recreational licence sales have increased roughly 150% (Figure 4), and the increase in the recreational catch's share of the total landings over that period has been even greater (Figure 3). Over 90% of the recreational rock lobster catch is made in the shallow inshore grounds in depths of less than 20 m (Melville-Smith and Anderton, 2000) — well outside of the depths in which the brood stock of the coastal regions of the fishery are found. Therefore, while recreational fishers are competing with commercial fishers for a greater share of the inshore catch, particularly around large metropolitan areas, they are not directly affecting the brood stock.

The increase in the recreational catch is not just a catch-sharing issue between the two user groups. Although recreational fishers are subject to the same regulations as commercial fishers with regard to legal minimum size, prohibition of retaining setose animals etc., it is more difficult to enforce them in the recreational sector, which land catch almost anywhere along the wide stretches of coastline over which the species occurs.

Strategies for developing an integrated approach for managing the recreational, aboriginal, conservation and commercial rock lobster catching sectors were developed by a Ministerially appointed Integrated Fisheries Management Committee; whos recommendations were released in mid-2003. These recommendations included the establishment of an Integrated Fisheries Allocation Council which would determine the allocation issues between groups, such as the recreational and commercial sectors of the Western Rock Lobster Fishery.

3.4. Harvesting pueruli for aquaculture

The propagation of *P. cygnus* lobsters from egg to marketable-sized animals seems unlikely in the short-term, given the long and complicated larval life of rock lobsters. However, harvesting of pueruli and growing them on is a relatively simple operation that has been successful in a number of countries, most notably Vietnam (Tuan *et al*., 2000).

The future possibility that western rock lobster pueruli will be harvested from the wild fishery for commercial-sale for on-growing at sea or ashore is, if not adequately controlled, seen as a potential threat to both the sustainability of fishery and the economics of fishing operations. These concerns have led to a modeling study of the impact of removing different numbers of pueruli on the subsequent catch in the wild fishery (Phillips *et al.*, in press). The model has estimated that effects are likely to be slight unless many millions of pueruli are removed, but any potential losses to the wild fishery could be countered by effort reductions linked to the number of pueruli harvested and the puerulus settlement strength. Methods for capturing the pueruli for aquaculture have ben developed (Phillips *et al.*, 2001).

Research developing rock lobster aquaculture in Australasia is receiving substantial funding through the Fisheries Research and Development Corporation, an Australian Federal funding body. Licenses to capture and grow-on pueruli of rock lobsters have been issued in New Zealand and Tasmania; we believe it is only a question of time before western rock lobsters are farmed.

3.5 Reproductive biology issues

The western rock lobster catch has become more male-dominated since females have received greater protection with the maximum size and setose rules. To this point there has been no evidence of sperm limitation (as described by MacDiarmid and Butler, 1999 for *Jasus edwardsii*) or of other reproductive biology issues related to strongly biased sex ratios in the population caused by the setose rule. Research to monitor these issues is undertaken as part of the fishery independent breeding stock survey and the at-sea commercial monitoring program Chubb, 1991; Chubb et al., 1995).

4. Widening the awareness of sustainable fisheries management

The western rock lobster fishery was the first fishery in the world to be awarded certification as a well managed fishery by the Marine Stewardship Council (MSC), an international organization set up to assess and certify sustainable fisheries.

Accreditation in March 2000 followed an extensive review conducted by an independent panel into the way that the fishery operated, taking into account its sustainability and its general impact on the marine environment (Phillips, *et al.*, 2003). The MSC assessment is based on a document entitled "Principles and Criteria for Sustainable Fishing". These form the basis for qualifying fisheries as certified and able to utilize the MSC eco-label. For the purposes of MSC certification, a sustainable fishery is defined as one that is conducted in such a way that:

- it can be continued indefinitely at a reasonable level;
- it maintains and seeks to maximize ecological health and abundance,
- it maintains the diversity, structure and function of the ecosystem on which it depends, as well as the quality of its habitat, minimizing the adverse effects that it causes;
- it is managed and operated in a responsible manner, in conformity with local, national and international laws and regulations;
- it maintains present and future economic and social options and benefits;
- it is conducted in a socially and economically fair and responsible manner.

The certification is a positive indication of the quality of the management of this fishery.

A new development in Australia is a Federal Government initiative concerned with sustainability of fish stocks. The Department of the Environment and Heritage, (the Federal Department responsible for environmental issues) has determined that, from December 2003, only marine products from fisheries that are environmentally sustainable may be exported. The assessment of such fisheries is a similar process to the MSC assessment. The Western Rock Lobster Fishery has already received export certification.

There are recommendations to establish marine national parks in several regions of Western Australia that will directly impact on western rock lobster fishing operations (Report of the Marine Parks and Reserves Selection Working Group, 1994). Some recommendations of this working group have been promulgated (e.g. the creation of a Marine Reserve at Jurien Bay), and other Marine National Parks or refuge areas, which may affect fishing areas and activities, are likely to be created in the future.

5. Code-of Practice

A Code-of-Practice has been adopted by the fishery. This includes safety on board the vessels (including gear handling, diving for lost pots, chemicals control, and personal handling), handling of lobsters, bait disposal, waste collection and disposal on shore.

The procedures for handling of lobster ensure that they are delivered to the factories on the shore, alive, and missing as few limbs as possible, and therefore in the best condition for live export. Waste collection proceedures, safety plans and other similar activities have enhanced the status of the industry in the community.

6. Discussion and Conclusions

The attention of managers of the western rock lobster fishery is shifting away from the fishery's biological sustainability, which was believed to be under threat in the late 1980s, towards increasing the value of the catch and/or reducing the costs of taking the catch. A number of strategies are being considered; for example mechanisms to reduce within-and between-season variability in catch levels caused by different catchabilities within seasons and by inter-annual pulses of recruitment strength. An example of this was the removal of the maximum size ahead of the 2001/02 season, when that season was predicted to have a well below average catch. Other mechanisms being considered are temporary closures in the fishery during periods of low catch, such as for a few days each month over the full moon, and/or in that part of the season when a synchronized molt takes place.

As noted by Rogers (2000), the shift in focus towards maximizing economic returns has generated new controversies around the question of whether industry management committees should be advising Government to change management arrangements for short term market benefits, rather than concentrating on stock sustainability issues alone.

The Standing Committee on Ecologically Sustainable Development (ESD) of the Legislative Council of the Western Australian Parliament recently undertook an examination of the management and sustainability of the western rock lobster fishery. The committee concluded that this fishery "is a major success story in terms of sustainability of its yield and the infrastructure managing the fishery is operating within ESD principals" (Sharp, 2000 p.1). The Committee's only criticism of research efforts was that “to date, it has focused primarily on sustainable yields rather than on the ecosystems supporting the western rock lobster resource” (Sharp, 2000 p. 2). That gap in research is currently being addressed as part of this fisheries ongoing MSC accreditation obligations.

Morgan (2001) considers that this fishery has become an economic victim of its biological success; he suggests that the high catch volumes of recent years, which he implies might have resulted from the stock-rebuilding program begun in 1993/94, have begun to have a significant affect on the marketing and wholesale prices received for the product.

In more recent times, fallout from the events of September 11th in the USA, a slow economic turnaround in prime Far Eastern markets, and most recently the SARS virus, raised concerns for the economic status of the fishery and stimulated attempts to develop new markets for the lobsters (Department of Fisheries, Western Australia, 2001). However, the concerns have proved to be illusionary and the catch has continued to be sold, and at high prices (Tony Gibson, Western Rock Lobster Development Association (Inc.), Perth Australia. *pers. comm.*)

The fishery is well positioned through the efforts of many years of collaborative management between stakeholders, supported by well-directed research and monitoring programs, to be able to enjoy future prosperity. Managing fisheries sustainably is a dynamic process. While some future questions in the western rock lobster fishery have been identified here, it is inevitable that other unforeseen ones will arise. The challenge for fisheries researchers, managers and industry, is to have the foresight to identify these potential problems and to have the continued means and ability to address them. However, at this stage the sustainability of the stock is not in doubt as the 2003/2004 catch is predicted, based on the level of puerulus settlement four years ago, to be at least 13,000 tonnes, near to the highest catch ever recorded.

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TABLES

Table 1. Size at 50% maturity (in mm carapace length) of western rock lobsters sampled at five sites in the fishery. Female maturity is identified by proportions in different size categories carrying eggs and male maturity by the state of their gonads (data adapted from Grey 1979 and Chubb 1991).

	Size at maturity (mm)				
	Fremantle	Two Rocks	Dongara	Geraldton	Abrolhos Is.
Female	97	97	93	96	66
Male	99	no data	no data	102	no data

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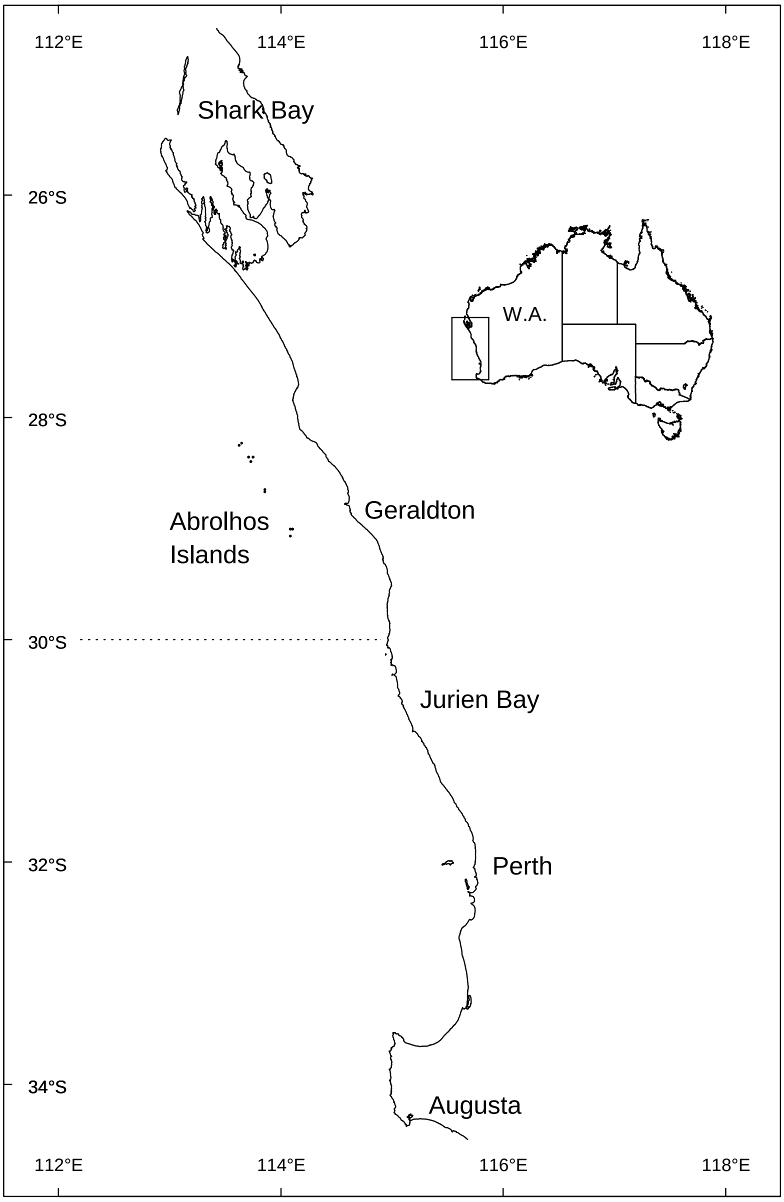
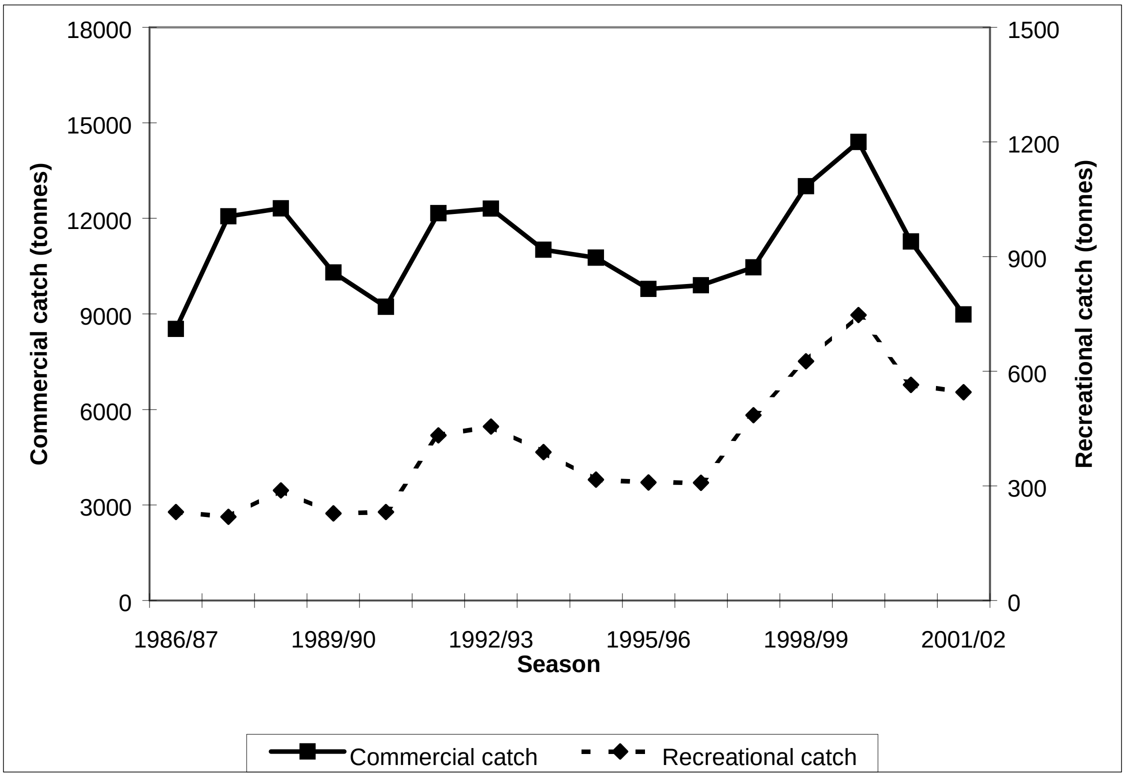
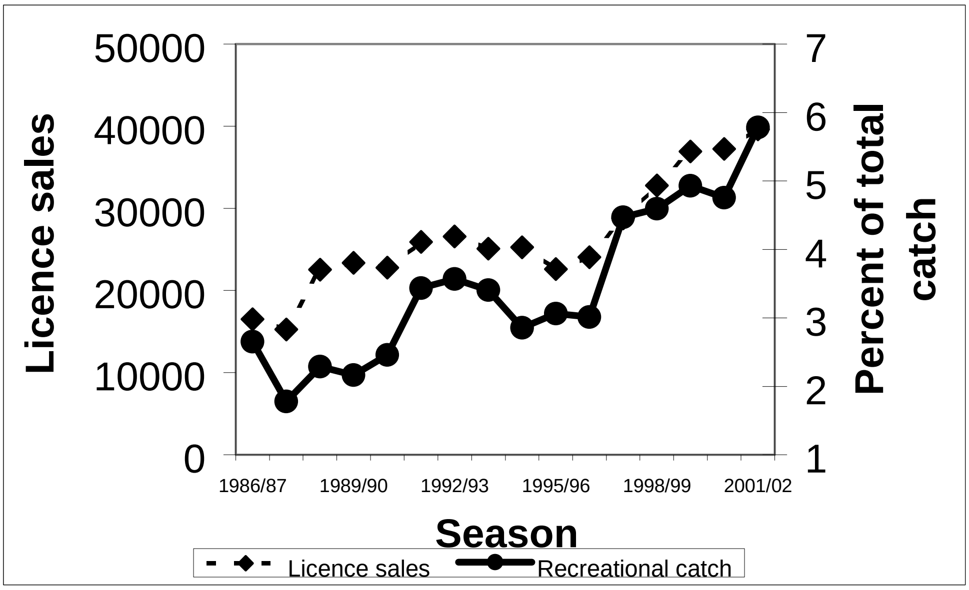
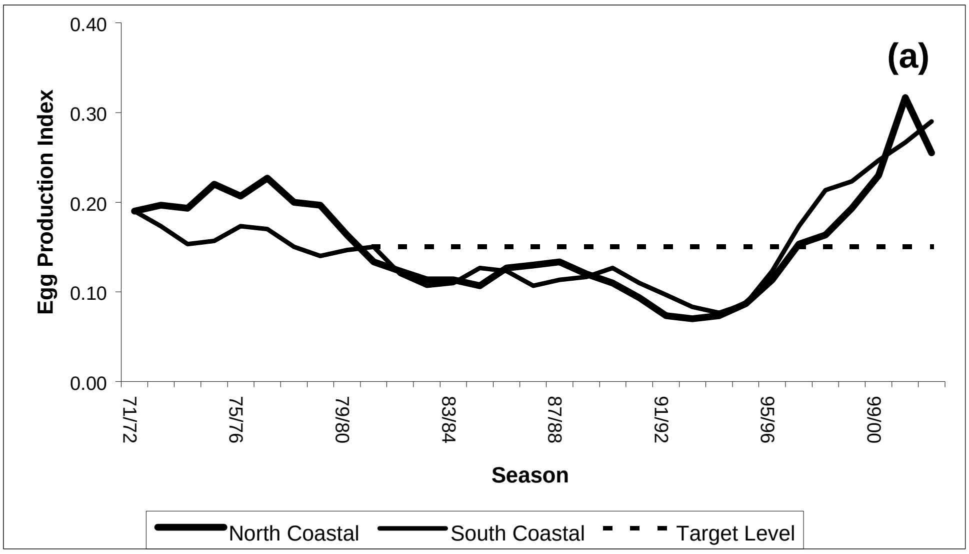
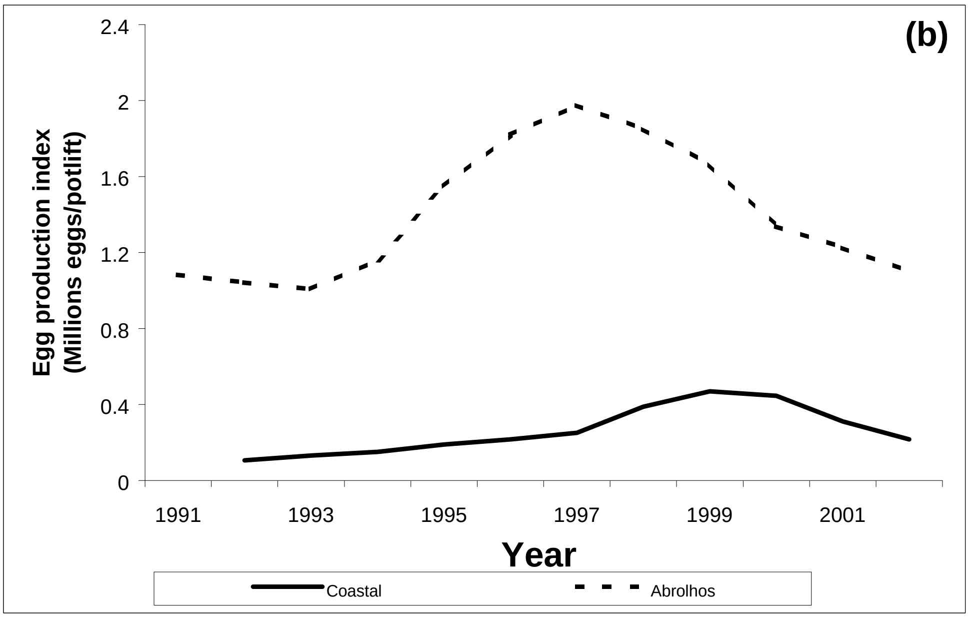

112°E
114°E
116°E
118°E
Shark Bay
26°S
W.A.
28°S
Geraldton
Abrolhos
Islands
30°S
Jurien Bay
32°S
Perth
34°S
Augusta
112°E
114°E
116°E
118°E


18000
15000
12000
9000
6000
3000
0
Commercial catch (tonnes)
1500
1200
900
600
300
0
Recreational catch (tonnes)
1986/87
1989/90
1992/93
1995/96
1998/99
2001/02
Season
Commercial catch
Recreational catch


50000
40000
30000
20000
10000
0
Licence sales
7
6
5
4
3
2
1
Percent of total catch
1986/87
1989/90
1992/93
1995/96
1998/99
2001/02
Season
Licence sales
Recreational catch

.


0.40
0.30
0.20
0.10
0.00
(a)
Egg Production Index
71/72
75/76
79/80
83/84
87/88
91/92
95/96
99/00
Season
North Coastal
South Coastal
Target Level


2.4
2
1.6
1.2
0.8
0.4
0
(b)
Egg production index
(Millions eggs/potlift)
1991
1993
1995
1997
1999
2001
Year
Coastal
Abrolhos