Report from the Mid-Year Fishery Assessment Plenary, November 2004: stock assessments and yield estimates

Compiled by

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Science Group
Ministry of Fisheries

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INTRODUCTION

1. This report summarises the conclusions and recommendations of the Mid-Year Fishery Assessment Plenary session held during November 2004. The Plenary session was held to assess the rock lobster fishery managed within the Quota Management System.

2. During the Plenary session two sources of information were considered and discussed:

   (a) A draft report from the Rock Lobster Working Group which summarised the conclusions and recommendations of the meetings of the Working Group held during 2004; and

   (b) Additional data provided at the Plenary session by NIWA (research provider).

3. Contributions to the Plenary session were made by NIWA science staff and by representatives of user groups.

4. This report addresses, for rock lobster, the points which the current Fisheries legislation requires to be considered.

5. In all cases, consideration has been based on and limited by the best available information. The purpose has been to provide objective, independent assessments of the current state of the fish stocks.

6. Where possible yields are estimated for rock lobster for the 1 April 2005 - 31 March 2006 fishing year.

7. Where possible, the status of the stocks (specifically the sustainability of current TACs and recent catch levels and whether these are at levels that will allow the stock to move towards a size that will support the MSY) have been assessed. In many cases other management measures have also been discussed. **THESE ASSESSMENTS OF THE STATUS OF ROCK LOBSTER STOCKS APPLY TO THE 2005–2006 FISHING YEAR ONLY, UNLESS SPECIFICALLY STATED OTHERWISE.**

8. Only actual TACCs are provided. The actual TACCs are the values as of the last day of the fishing year.

9. In considering Maori, traditional, recreational and other non-commercial interests, some difficulty was experienced both in terms of the data available and the intended scope of this requirement. In the absence of any more definitive guidelines, <u>current</u> interests and activities have been considered. In most cases, only very limited information is available on the nature and extent of non-commercial interests.

Approach to Yield Estimation

10. Key issues to the approaches to estimation of yield include the need to account for variability in fish stocks in conjunction with the amount and type of data available on which assessments could be based.

Sources of Data

11. A major source of information for these assessments continues to be the fisheries statistics system. The importance of maintaining and developing this system to provide adequate and timely data for stock assessments was very apparent.

Other Information

12. Draft Fisheries Assessment Reports more fully describing the data and the analyses have also been prepared. These documents will be distributed when final versions are available.

TERMS OF REFERENCE FOR FISHERY ASSESSMENT WORKING GROUPS FOR 2003–04

1. To review any new research information on stock structure, productivity, and abundance and to update the assessment of each Fishstock.

2. To estimate MSY for stocks in terms of Current Annual Yield (CAY) or Maximum Constant Yield (MCY) as defined in the "Guide to Biological Reference Points for the 2003/04 Yield Fishery Assessment Meetings". This should include an estimate of the yield and estimates of possible errors and uncertainties.

3. To determine if the stock is currently above, below, or at a level that can produce MSY.

   a) If the stock is currently above a level that can produce the MSY:

      - to determine if recent total removals (defined as commercial, recreational, and Maori customary catch, illegal catch, and all other sources of mortality combined) and the current TAC and/or TACC are at levels that will allow the stock either to be fished down to the MSY level or, after having regard to the independence of stocks, to be maintained above a level that can produce the MSY; and

      - to identify any factors relating to the interdependence of stocks of fish that would determine whether the stock should be maintained at the level rather than being fished down towards a level that can produce the MSY.

   b) If the stock is currently at a level that can produce the MSY:

      - to determine if recent total removals and the current TAC and/or TACC are at levels that will allow the stock either to be maintained at the MSY level or, after having regard to the interdependence of stocks, to rebuild the stock above a level that can produce the MSY; and

      - to identify any factors relating to the interdependence of stocks of fish that would determine whether a larger stock level is appropriate.

   c) If the stock is currently below a level that can produce the MSY:

      - to determine if recent total removals and the current TAC and/or TACC are at levels which will allow the stock to rebuild to a level that can produce the MSY or to some appropriate larger stock level;

      - to identify any factors relating to the interdependence of stocks of fish that would determine whether a stock level above that which can produce the MSY is appropriate; and

      - to determine any biological characteristics of the stock or environmental conditions that would influence the rate of rebuild.

4. To incorporate into the stock assessment information on Maori customary non-commercial and recreational interests in the stock, and all other mortality to that stock caused by fishing, which might need to be allowed for before setting a TACC.

5. To provide information and advice on other management issues (e.g., area boundaries, species designations, by-catch issues, effects of fishing on habitat, other sources of mortality, and input controls such as mesh sizes and minimum legal sizes) required for determining sustainability measures.

6. When management action is likely to be taken, or when there is a choice of management strategies for future years, to provide information on the effects on the stock of alternative strategies.

7. To determine which species will be fully assessed and discussed during the Fishery Assessment Plenary and which stocks do not warrant discussion at the Plenary. The general criterion for making this decision is that if new information has become available which alters the previous assessment, especially the yield estimates and stock status, then a full assessment should be carried out and discussed at the Plenary. This information could include:

    - New or revised estimates of biomass, MCY, CAY, or long–term yield.
    - The development of a major trend in the catch or catch per unit effort.
    - Any new studies or data which extends understanding of stock structure, fishing patterns, or non-commercial activities and which significantly affect the stock assessment.
    - Consistent over- or under- catching of the TACC.

8. To compile a list of generic assessment issues and specific research needs for the species in the Working Group.

9. To keep minutes of all Working Group meetings and distribute them to all members of that Working Group and the Chief Scientist, Ministry of Fisheries.

ROCK LOBSTER WORKING GROUP – 2004

Convenor: Kevin Sullivan

Members: Dave Banks, Nokome Bentley, John Booth, Ron Brady, Paul Breen, David Fisher, David Gilbert, Vivian Haist, Susan Kim, Malcolm Lawson, Gary Melvin, Leigh Mitchell, Ali McDiarmid, Helen Regan, Alan Riwaka, Ian Ruru, Paul Starr, Kevin Stokes, Daryl Sykes, Lance Wichman, Scott Williamson

Species: Rock lobster

GUIDE TO BIOLOGICAL REFERENCE POINTS FOR THE 2003/04 FISHERIES ASSESSMENT MEETINGS

The aim of this document is to define commonly used terms, explain underlying assumptions and describe the biological reference points used in the fisheries assessment meetings carried out during the 2003/04 fishing year (1 October 2003-30 September 2004) and their associated documents. Methods of estimation appropriate to various circumstances are given for two levels of yield: Maximum Constant Yield (***MCY***) and Current Annual Yield (***CAY***). The relevance of these to the setting of Total Allowable Catches (TACs) is discussed.

Definitions of *MCY* and *CAY*

The Fisheries Act (1996) defines Total Allowable Catch in terms of maximum sustainable yield (***MSY***). The definitions of the biological reference points, ***MCY*** and ***CAY***, derive from two ways of viewing ***MSY***: a static interpretation and a dynamic interpretation. The former, associated with ***MCY***, is based on the idea of taking the same catch from the fishery year after year. The latter interpretation, from which ***CAY*** is derived, recognises that fish populations fluctuate in size from year to year (for environmental and biological, as well as fishery, reasons) so that to get the best yield from a fishery it is necessary to alter the catch every year. This leads to the idea of maximum average yield (***MAY***) which is how fisheries scientists generally interpret ***MSY*** (Ricker 1975).

The definitions are:

> ***MCY*** – Maximum Constant Yield
> The maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass.

and

> ***CAY*** – Current Annual Yield
> The one-year catch calculated by applying a reference fishing mortality, F_{ref}, to an estimate of the fishable biomass present during the next fishing year. F_{ref} is the level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery.

Note that ***MCY*** is dependent to a certain extent on the current state of the fish stock. If a stock is fished at the ***MCY*** level from a virgin state then over the years its biomass will fluctuate over a range of levels depending on environmental conditions, abundance of predators and prey, etc. For stock sizes within this range the ***MCY*** remains unchanged (though our estimates of it may well be refined). If the current state of the stock is below this range the ***MCY*** will be lower.

The strategy of applying a constant fishing mortality, F_{ref}, from which the ***CAY*** is derived each year is an approximation to a strategy which maximises the average yield over time. For the purposes of this document the ***MAY*** is the long-term average annual catch when the catch each year is the ***CAY***. With perfect knowledge it would be possible to do better by varying the fishing mortality from year to year. Without perfect knowledge, adjusting catch levels by a ***CAY*** strategy as stock size varies is probably the best practical method of maximising average yield. Appropriate values for F_{ref} are discussed below.

What is meant by `an acceptable level of risk' for ***MCY***s and ***CAY***s is intentionally left undefined here. For most stocks our level of knowledge is inadequate to allow a meaningful quantitative assessment of risk. However, we have two qualitative sources of information on risk levels: the experience of fisheries scientists and managers throughout the world, and the results of simulation exercises such as those of Mace (1988a). Information from these sources is incorporated, as much as is possible, in the methods given below for calculating ***MCY*** and ***CAY***.

It is now well known that ***MCY*** is generally less than ***MAY*** (see, e.g., Doubleday 1976, Sissenwine 1978, Mace 1988a). This is because ***CAY*** will be larger than ***MCY*** in the majority of years. However, when fishable biomass becomes low (through overfishing, poor environmental conditions, or a combination of both), ***CAY*** will be less than ***MCY***. This is true even if the estimates of ***CAY*** and ***MCY*** are exact. The following diagram shows the relationships between ***CAY***, ***MCY*** and ***MAY***.

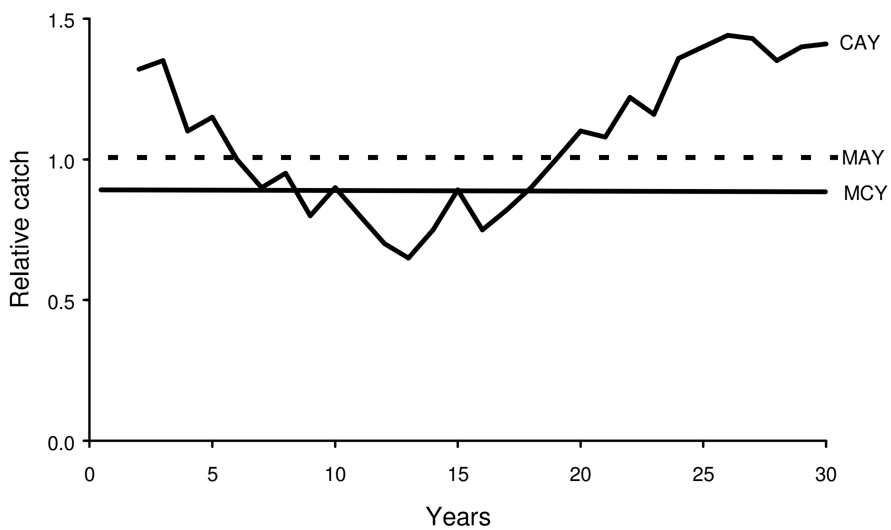

Figure 1: Relationship between ***CAY***, ***MCY*** and ***MAY***.

In this example ***CAY*** represents a constant fraction of the fishable biomass, and so (if it is estimated and applied exactly) it will track the fish population exactly. ***MAY*** is the average over time of ***CAY***. The reason ***MCY*** is less than ***MAY*** is that ***MCY*** must be low enough so that the fraction of the population removed does not constitute an unacceptable risk to the future viability of the population. With an ***MCY*** strategy, the fraction of a population that is removed by fishing increases with decreasing stock size. With a ***CAY*** strategy, the fraction removed remains constant. A constant catch strategy at a level equal to the ***MAY***, would involve a high risk at low stock sizes.

Relationship between *MCY*, *CAY*, TAC and Total Allowable Commercial Catch (TACC)

The TAC covers all mortality to a fish stock caused by human activity, whereas the TACC includes only commercial catch. ***MCY*** and ***CAY*** are reference points used to evaluate whether the current stock size can support the current TAC and/or TACC. It should not be assumed that the TAC and/or TACC will be equal to either one of these yields. There are both legal and practical reasons for this.

Legally, we are bound by the Fisheries Act (1996). In setting or varying any TACC for any quota management stock, ‘the Minister shall have regard to the total allowable catch for that stock and shall allow for –

(a) The following non-commercial fishing interests in that stock, namely –
    (i) Maori customary non-commercial fishing interests; and
    (ii) Recreational interests; and
(b) All other mortality to that stock caused by fishing.

From a practical point of view it must be acknowledged that the concepts of ***MCY*** and ***CAY*** are directly applicable only in idealised management regimes. The ***MCY*** could be used in a regime where a catch level was to be set for once and for all; our system allows changes to be made if, the level is found to be too low or too high. With a ***CAY*** strategy the yield would probably change every year. Even if there were no legal impediments to following a ***CAY*** strategy, the fishing industry's desire for stability may be a sufficient reason to make TACC changes only when the need is pressing.

Natural and Fishing Mortality

Before describing how to calculate ***MCY*** and ***CAY*** we must discuss natural and fishing mortality, which are used in these calculations. Both types of mortality are expressed as instantaneous rates (thus, over n years a total mortality Z will reduce a population of size B to size Be^{-nZ}, ignoring recruitment and growth). Units for mortalities are 1/year.

Natural mortality

Methods of estimating natural mortality, M, are reviewed by Vetter (1988). When a lack of data rules out more sophisticated methods, M may be estimated by the formula,

$$M = -\frac{\log_e(p)}{A}$$

where p is the proportion of the population that reaches age A (or older) in an unexploited stock. p is often set to 0.01, when A is the "maximum age" observed. Other values for p may be chosen dependent on the fishing history of the stock. For example, in an exploited stock the maximum observed age may correspond to a value of p = 0.05, or higher. For a discussion of the method see Hoenig (1983).

Reference Fishing Mortalities

Reference fishing mortalities in widespread use include $F_{0.1}$, F_{msy}, F_{max}, F_{mey}, and M.

The most common reference fishing mortality used in the calculation of ***CAY*** (and, in some cases, ***MCY***) is $F_{0.1}$ (pronounced `F zero point one'). This is used as a basis for fisheries management decisions throughout the world and is widely believed to produce a high level of yield on a sustainable basis (Mace 1988b). It is estimated from a yield per recruit analysis as the level of fishing mortality at which the slope of the yield-per-recruit curve is 0.1 times the slope at F = 0. If an estimate of $F_{0.1}$ is not available an estimate of M may be substituted.

F_{max} is the fishing mortality that produces the maximum yield per recruit. It may be too high as a target fishing mortality because it does not account for recruitment effects (e.g. recruitment declining as stock size is reduced). However, it may be a valid reference point for those fisheries that have histories of sustainable fishing at this level.

F_{msy}, the fishing mortality corresponding to the deterministic ***MSY***, is another appropriate reference point. F_{msy} may be estimated from a surplus production model, or a combination of yield per recruit and stock recruitment models.

When economic data are available it may be possible to calculate F_{mey}, the fishing mortality corresponding to the maximum (sustainable) economic yield. F_{mey} is always less than F_{msy}. (NB: strategies that maximise the net present value of the catch do not necessarily lead to the ***MEY***.)

Every reference fishing mortality corresponds to an equilibrium or long-run average stock biomass. This is the biomass which the stock will tend towards or randomly fluctuate around, when the reference fishing mortality is applied constantly. The fluctuations will be caused primarily by variable recruitment. It is necessary to examine the equilibrium stock biomass corresponding to any candidate reference fishing mortality. A reference fishing mortality which corresponds to a low stock biomass may be undesirable if the low biomass would lead to an unacceptable risk of stock collapse. For fisheries where this applies a lower reference fishing mortality may be appropriate.

Natural Variability Factor

Fish populations are naturally variable in size because of environmental variability and associated fluctuations in the abundance of predators and food. Computer simulations (e.g. Mace 1988a) have shown that, all other things being equal, the ***MCY*** for a stock is inversely related to the degree of natural variability in its abundance. That is, the higher the natural variability, the lower the ***MCY***.

The natural variability factor, ***c***, provides a way of incorporating the natural variability of a stock's biomass into the calculation of ***MCY***. It is used as a multiplying factor in method 5 below. The greater the variability in the stock, the lower is the value of ***c***. Values for ***c*** should be taken from the table below and are based on the estimated mean natural mortality rate of the stock. It is assumed that because a stock with a higher natural mortality will have fewer age-classes it will also suffer greater fluctuations in biomass. The only stocks for which the table should be deviated from are those where there is evidence that recruitment variability is unusually high or unusually low.

Natural mortality rate ***M***	Natural variability factor ***c***
<0.05	1.0
0.05–0.15	0.9
0.16–0.25	0.8
0.26–0.35	0.7
>0.35	0.6

Methods of Estimating *MCY*

It should be possible to estimate ***MCY*** for most fish stocks (with varying degrees of confidence). For some stocks, only conservative estimates for ***MCY*** will be obtainable (e.g., some applications of Method 4) and this should be stated. For other stocks it may be impossible to estimate ***MCY***. These stocks include situations in which: the fishery is very new; catch or effort data are unreliable; strong upwards or downwards trends in catch are not able to be explained by available data, (e.g., by trawl survey data or by catch per unit effort data).

When catch data are used in estimating ***MCY*** all catches (commercial, illegal, and non-commercial) should be included if possible. If this is not possible and the excluded catch is thought to be a significant quantity, then this should be stated.
The following examples define ***MCY*** in an operational context with respect to the type, quality and quantity of data available. Knowledge about the accuracy or applicability of the data (e.g., reporting

anomalies, atypical catches in anticipation of the introduction of the Quota Management System) should play a part in determining which data sets are to be included in the analysis.

As a general rule it is preferable to apply subjective judgements to input data rather than to the calculated ***MCY***s. For example, rather than saying `with the official catch statistics the ***MCY*** is ***X*** tonnes, but we think this is too high because the catch statistics are wrong' it would be better to say `we believe (for reasons given) that the official statistics are wrong and the true catches were probably such and such, and the ***MCY*** based on these catches is ***Y*** tonnes'.

Background information on the rationale behind the following calculation methods can be found in Mace (1988a) and other scientific papers listed at the end of this document.

1. New fisheries

$$MCY = 0.25\, F_{0.1}\, B_0$$

where B_0 is an estimate of virgin recruited biomass. If there are insufficient data to conduct a yield per recruit analysis $F_{0.1}$ should be replaced with an estimate of natural mortality (M). Tables 1–3 in Mace (1988b) show that $F_{0.1}$ is usually similar to (or sometimes slightly greater than) M.

It may appear that the estimate of ***MCY*** for new fisheries is overly conservative, particularly when compared to the common approximation to ***MSY*** of $0.5MB_0$ (Gulland 1971). However various authors (including Beddington and Cooke 1983; Getz et al. 1987; Mace 1988a) have shown that $0.5MB_0$ often overestimates ***MSY***, particularly for a constant catch strategy or when recruitment declines with stock size. Moreover it has often been observed that the development of new fisheries (or the rapid expansion of existing fisheries) occurs when stock size is unusually large, and that catches plummet as the accumulated biomass is fished down.

It is preferable to estimate ***MCY*** from a stochastic population model (Method 5), if this is possible. The simulations of Mace (1988a) and Francis (1992) indicate that the appropriate factor to multiply $F_{0.1}B_0$ may be somewhat higher or somewhat lower than **0.25**. This depends primarily on the steepness of the assumed stock recruitment relationship (*see* Francis 1992 for a definition of steepness).

New fisheries become developed fisheries once F has approximated or exceeded M for several successive years, depending on the lifespan of the species.

2. Developed fisheries with historic estimates of biomass

$$MCY = 0.5F_{0.1}B_{av}$$

where B_{av} is the average historic recruited biomass, and the fishery is believed to have been fully exploited (i.e. fishing mortality has been near the level that would produce ***MAY***). This formulation assumes that $F_{0.1}$ approximates the average productivity of a stock.

As in the previous method an estimate of M can be substituted for $F_{0.1}$ if estimates of $F_{0.1}$ are not available.

3. Developed fisheries with adequate data to fit a population model

$$MCY = 2/3\ MSY$$

where ***MSY*** is the deterministic maximum equilibrium yield.

This reference point is slightly more conservative than that adopted by several other stock assessment agencies (e.g. ICES, CAFSAC) that use as a reference point the equilibrium yield corresponding to 2/3 of the fishing effort (fishing mortality) associated with the deterministic equilibrium ***MSY***.

If it is possible to estimate ***MSY*** then it is generally possible to estimate ***MCY*** from a stochastic population model (Method 5), which is the preferable method. The simulations of Mace (1988a) and Francis (1992) indicate that the appropriate factor to multiply ***MSY*** varies between about **0.6** and **0.9**. This depends on various parameters of which the steepness of the assumed stock recruitment relationship is the most important.

If the current biomass is less than the level required to sustain a yield of 2/3 ***MSY*** then

$$MCY = 2/3\ CSP$$

where ***CSP*** is the deterministic current surplus production.

4. Catch data and information about fishing effort (and/or fishing mortality), either qualitative or quantitative, without a surplus production model

$$MCY = cY_{av}$$

where ***c*** is the natural variability factor (defined above) and Y_{av} is the average catch over an appropriate period.

If the catch data are from a period when the stock was fully exploited (i.e. fishing mortality near the level that would produce ***MAY***), then the method should provide a good estimate of ***MCY***. In this case, $Y_{av} = MAY$. If the population was under-exploited the method gives a conservative estimate of ***MCY***.

Familiarity with stock demographics and the history of the fishery is necessary for the determination of an appropriate period on which to base estimates of Y_{av}. The period chosen to perform the averaging will depend on the behaviour of the fishing mortality or fishing effort time series, the prevailing management regime, the behaviour of the catch time series, and the lifespan of the species.

The period should be selected so that it contains no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality). Note that for species such as orange roughy, where relatively static aggregations are fished, fishing mortality cannot be assumed to be proportional to effort. If catches during the period are constrained by a TACC then it is particularly important that the assumption of no systematic change in fishing mortality be adhered to. The existence of a TACC does not necessarily mean that the catch is constrained by it.

The period chosen should also contain no systematic changes in catch. If the period shows a systematic upward (or downward) trend in catches then the ***MCY*** will be under-estimated (over-estimated). It is desirable that the period be equal to at least half the exploited life span of the fish.

5. Sufficient information for a stochastic population model

This is the preferred method for estimating ***MCY*** but it is the method requiring the most information. It is the only method that allows some specification of the risk associated with an ***MCY***.

The simulations in Mace (1988a) and Breen (1989) provide examples of the type of calculations necessary for this method. A trial and error procedure can be used to find the maximum constant catch that can be taken for a given level of risk. The level of risk may be expressed as the probability of stock collapse within a specified time period. At the moment the Ministry of Fisheries has no standards as to how stock collapse should be defined for this purpose, what time period to use, and what probability of collapse is acceptable. These will be developed as experience is gained with this method.

Methods of Estimating *CAY*

It is possible to estimate ***CAY*** only when there is adequate stock biomass data. In some instances relative stock biomass indices (e.g., catch per unit effort data) and relative fishing mortality data (e.g., effort data) may be sufficient. ***CAY*** calculated by method 1 includes non-commercial catch. If method 2 is used and it is not possible to include a significant non-commercial catch, then this should be stated.

1. Where there is an estimate of current recruited stock biomass, ***CAY*** may be calculated from the appropriate catch equation. Which form of the catch equation should be used will depend on the way fishing mortality occurs during the year. For many fisheries it will be a reasonable approximation to assume that fishing is spread evenly throughout the year so that the Baranov catch equation is appropriate and ***CAY*** is given by

$$CAY = \frac{F_{ref}}{F_{ref} + M}(1 - e^{-(F_{ref} + M)})B_{beg}$$

Where $\boldsymbol{B_{beg}}$ is the projected stock biomass at the beginning of the fishing year for which the ***CAY*** is to be calculated and $\boldsymbol{F_{ref}}$ is the reference fishing mortality described above.

If most of the fishing mortality occurs over a short period each year it may be better to use one of the following equations:

$$CAY = (1 - e^{-F_{ref}})B_{beg}$$

$$CAY = (1 - e^{-F_{ref}})e^{-\frac{M}{2}}B_{beg}$$

$$CAY = (1 - e^{-F_{ref}})e^{-M}B_{beg}$$

where the first equation is used when fishing occurs at the beginning of the fishing year, the second equation when fishing is in the middle of the year, and the third when fishing is at the end of the year.

It is important that the catch equation used to calculate ***CAY*** and the associated assumptions are the same as those used in any model employed to estimate stock biomass or to carry out yield per recruit analyses. Serious bias may result if this criterion is not adhered to. The assumptions and catch equations given here are by no means the only possibilities.

The risk associated with the use of a particular F_{ref} may be estimated using simulations.

2. Where information is limited but the current (possibly unknown) fishing mortality is thought to be near the optimum, there are various "status quo" methods which may be applied. Details are available in Shepherd (1991), Shepherd (1984) and Pope (1983).

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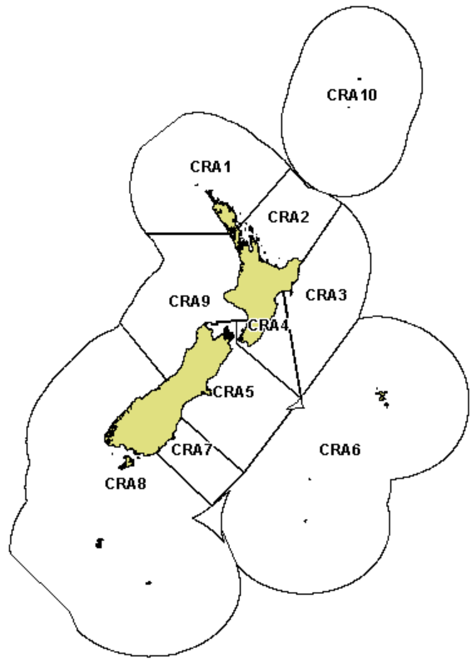
ROCK LOBSTER (CRA and PHC)

(*Jasus edwardsii*, *Sagmariasus verreauxi*)



FISHERY SUMMARY

The rock lobster fishery takes two species. The red rock lobster (*Jasus edwardsii*) supports nearly all the landings and is caught all around the North and South Islands, Stewart Island and the Chatham Islands. The packhorse rock lobster (*Sagmariasus verreauxi*) is taken mainly in the north of the North Island. Packhorse lobsters (PHC) grow to a much larger size than do red rock lobsters (CRA) and have different shell colouration and shape.

The rock lobster fishery was brought into the Quota Management System (QMS) on 1 April 1990, when Total Allowable Commercial Catches (TACCs) were set for each Quota Management Area (QMA) shown above. Before this, the fishery was managed by input controls, including minimum legal size (MLS) regulations, a prohibition on the taking of berried females and soft-shelled lobsters, and some local area closures. Most of the input controls have been retained in the fishery but the limited entry provisions were removed and allocation of individual transferable quota (ITQ) was made to the previous licence holders based on catch history.

Historically, three rock lobster stocks were recognised for stock assessment purposes:
- NSI – the North and South Island (including Stewart Island) red rock lobster stock
- CHI – the Chatham Islands red rock lobster stock
- PHC – the New Zealand packhorse rock lobster stock

In 1994, the Rock Lobster Fishery Assessment Working Group agreed to divide the NSI stock into three substocks:
- NSN – the northern stocks CRA 1 and 2
- NSC – the central stocks CRA 3, 4 and 5
- NSS – the southern stocks CRA 7 and 8

CRA 9 has not been assigned to a substock.

Time series of commercial landings and CPUE (catch per unit effort) data are provided for NSI, NSN, NSC, NSS and CHI for comparison with earlier years (Table 3). The fishing year runs from 1 April to 31 March.

The NSI stock is composed of the CRA QMAs 1–5 and 7–9, each being a separate Fishstock with a separate TACC. The sum of the TACCs for the NSI stock was set at 3275 t for the year commencing 1 April 1990. This total was reduced in each year until 1993–94 to reach 2380 t (taking into account some increases in individual ITQs resulting from appeals over catch histories by fishers). The total TACC for the NSI stock has fluctuated since, with TACC increases and decreases, and was 2325 t for the 2003–04 season. The TACC for the NSI stock was increased to 2366 t for the 2004–05 season through increases in the CRA 7 and CRA 8 TACCs from the operation of the NSS Decision Rule in 2003.

The TACC for the CHI stock (CRA 6) was set at 518 t in 1990 but increased through appeals to 530.6 t at the beginning of the 1993–94 fishing year (Table 1). The CHI TACC was subsequently reduced to 400 t in 1997–98 and to 360 t in 1998–99. CRA 10 comprises the Kermadec Islands, and has a nominal TACC of 0.086 t. The TACC for PHC increased from 27 t in 1990 to its current value of 40.3 t at the beginning of the 1993–94 fishing year following appeals.

TACs (Total Allowable Catch including non-commercial catches) were set for the first time in 1997–98 for three CRA QMAs (Table 1). Setting TACs is a requirement under the Fisheries Act 1996 and consequently TACs have been set since 1997–98 whenever adjustments have been made to the TACCs.

The MLS in the commercial fishery for red rock lobster is based on tail width (TW), except in the Otago fishery. For Otago (CRA 7), the MLS is a tail length (TL) of 127 mm, which applies to both sexes during the period 21 June to 19 November, which is the full commercial season. The female MLS in all other CRAs except Southern (CRA 8) has been 60 mm TW since mid-1992. For Southern (CRA 8), the female MLS has been 57 mm TW since 1990. The male MLS has been 54 mm TW since 1988, except in Otago (MLS described above) and Gisborne (CRA 3) where it is 52 mm for the June-August period.

Special conditions applied to the Gisborne (CRA 3) fishery after 1993–94. During June, July and August, commercial fishers are permitted to retain males at least 52 mm TW but females cannot be taken. These measures changed the commercial CRA 3 fishery to a mainly winter fishery for male lobsters after 1993, although this pattern is changing again. The fishery was then closed to all users from September to the end of November, but in 2000 it closed from 1 October instead of 1 September. In 2002 the closed season was shortened further. It now remains officially closed to commercial fishers only in May, and from mid-December to mid-January by voluntary agreement.

For recreational fishers, the red rock lobster MLS has been 54 mm TW for males since 1990 and 60 mm TW for females since 1992. The commercial and recreational MLS measure for packhorse rock lobster is 216 mm TL for both sexes.

Commercial fisheries

Table 1 provides a summary by fishing year of the reported commercial catches, TACCs and TACs by Fishstock (CRA). The Quota Management Reports (QMRs) provide the most accurate information on landings. Beginning on 1 October 2001, QMRs were replaced by Monthly Harvest Reports (MHRs). Other sources of annual catch estimates include the Licensed Fish Receiver Returns (LFRRs) and the Catch, Effort, and Landing Returns (CELRs). In recent years, landings reported by LFRRs have been close to the QMR totals.

Table 1. Reported commercial catch (t) from QMRs or MHRs (after 1 October 2001), commercial TACC (t) and total TAC (t) (where this quantity has been set) for *Jasus edwardsii* by rock lobster CRA for each fishing year since the species was included in the QMS on 1 April 1990. –, TAC not set for QMA.

			CRA 1			CRA 2			CRA 3
Fishing Year	**Catch**	**TACC**	**TAC**	**Catch**	**TACC**	**TAC**	**Catch**	**TACC**	**TAC**
1990–91	131.1	160.1	–	237.6	249.5	–	324.1	437.1	–
1991–92	128.3	146.8	–	229.7	229.4	–	268.8	397.7	–
1992–93	110.5	137.4	–	190.3	214.6	–	191.5	327.5	–
1993–94	127.4	130.5	–	214.9	214.6	–	179.5	163.7	–
1994–95	130.0	130.5	–	212.8	214.6	–	160.7	163.7	–
1995–96	126.7	130.5	–	212.5	214.6	–	156.9	163.7	–
1996–97	129.4	130.5	–	213.2	214.6	–	203.5	204.7	–
1997–98	129.3	130.5	–	234.4	236.1	452.6	223.4	225.0	379.4
1998–99	128.7	131.1	–	232.3	236.1	452.6	325.7	327.0	453.0
1999–00	125.7	131.1	–	235.1	236.1	452.6	326.1	327.0	453.0
2000–01	130.9	131.1	–	235.4	236.1	452.6	328.1	327.0	453.0
2001–02	130.6	131.1	–	225.0	236.1	452.6	289.9	327.0	453.0
2002-03	130.8	131.1	–	205.7	236.1	452.6	291.0	327.0	453.0
2003-04	128.7	131.1	–	195.8	236.1	452.6	215.7	327.0	453.0
2004-05		131.1			236.1	452.6		327.0	453.0

			CRA 4			CRA 5			CRA 6
Fishing Year	**Catch**	**TACC**	**TAC**	**Catch**	**TACC**	**TAC**	**Catch**	**TACC**	**TAC**
1990–91	523.2	576.3	–	308.6	465.2	–	369.7	518.2	–
1991–92	530.5	529.8	–	287.4	426.8	–	388.3	503.0	–
1992–93	495.7	495.7	–	258.8	336.9	–	329.4	503.0	–
1993–94	492.0	495.7	–	311.0	303.2	–	341.8	530.6	–
1994–95	490.4	495.7	–	293.9	303.2	–	312.5	530.6	–
1995–96	487.2	495.7	–	297.6	303.2	–	315.3	530.6	–
1996–97	493.6	495.7	–	300.3	303.2	–	378.3	530.6	–
1997–98	490.4	495.7	–	299.6	303.2	–	338.7	400.0	480.0
1998–99	493.3	495.7	–	298.2	303.2	–	334.2	360.0	370.0
1999–00	576.5	577.0	–	349.5	350.0	467.0	322.4	360.0	370.0
2000–01	573.8	577.0	771.0	347.4	350.0	467.0	342.7	360.0	370.0
2001–02	574.1	577.0	771.0	349.1	350.0	467.0	328.7	360.0	370.0
2002–03	575.2	577.0	771.0	348.7	350.0	467.0	335.8	360.0	370.0
2003-04	574.5	577.0	771.0	349.9	350.0	467.0	285.8	360.0	370.0
2004-05		577.0	771.0		350.0	467.0		360.0	370.0

			CRA 7			CRA 8
Fishing Year	**Catch**	**TACC**	**TAC**	**Catch**	**TACC**	**TAC**
1990–91	133.4	179.4	–	834.5	1 152.4	–
1991–92	177.7	164.7	–	962.7	1 054.6	–
1992–93	131.6	153.1	–	876.5	986.8	–
1993–94	138.1	138.7	–	896.1	888.1	–
1994–95	120.3	138.7	–	855.6	888.1	–
1995–96	81.3	138.7	–	825.6	888.1	–
1996–97	62.9	138.7	–	862.4	888.1	–
1997–98	36.0	138.7	–	785.6	888.1	–
1998–99	58.6	138.7	–	808.1	888.1	–
1999–00	56.5	111.0	–	709.8	711.0	–
2000–01	87.2	111.0	131.0	703.4	711.0	798.0
2001–02	76.9	89.0	109.0	572.1	568.0	655.0
2002–03	88.6	89.0	109.0	567.1	568.0	655.0
2003-04	81.4	89.0	109.0	566.8	568.0	655.0
2004-05		94.9	114.9		603.4	690.4

			CRA 9		Total
Fishing Year	**Catch**	**TACC**	**TAC**	**Catch**	**TACC[1]**
1990–91	45.3	54.7	–	2 907.4	3 793.0
1991–92	47.5	50.2	–	3 020.9	3 502.9
1992–93	45.7	47.0	–	2 629.9	3 201.9
1993–94	45.5	47.0	–	2 746.2	2 912.1
1994–95	45.2	47.0	–	2 621.5	2 912.1
1995–96	45.4	47.0	–	2 548.6	2 912.1
1996–97	46.9	47.0	–	2 690.5	2 953.1
1997–98	46.7	47.0	–	2 584.2	2 844.1
1998–99	46.9	47.0	–	2 726.0	2 926.8
1999–00	47.0	47.0	–	2 748.5	2 850.2
2000–01	47.0	47.0	–	2 795.9	2 850.2
2001–02	46.8	47.0	–	2 593.0	2 685.2
2002–03	47.0	47.0	–	2 589.8	2 685.2
2003-04	45.9	47.0	–	2 444.6	2 685.2
2004-05		47.0	–		2 726.5

[1] TACC totals exclude CRA 10 (TACC=0.1 t); catch totals exclude CRA 10 and ET catches (outside EEZ).

Problems with rock lobster catch and effort data

There are two types of data on the CELR form: the top part of each form contains the fishing effort and an estimated catch associated with that effort. The bottom part of the form contains the actual landed catch, which may span several units of effort. Estimated catches from the top part of the CELR form may show differences from the catch totals on the bottom part of the form, particularly in some CRAs such as CRA 5 and CRA 8 (Vignaux & Kendrick 1998; Bentley et al. in prep.). Substantial discrepancies were identified in 1997 between the estimated and weighed catches in CRA 5 (Vignaux & Kendrick 1998) and were attributed to fishers including all rock lobster catch in the estimated total, including those returned to the sea. This led to an overestimate of CPUE, but this problem appeared to be confined to CRA 5.

After 1998, all CELR catch data were modified to reflect the actual landed catch (bottom of form) rather than the estimated catch (top of form). This resulted in changes to the CPUE values compared to those reported before 1998.

In 2003, it was concluded that this method ("Method C1", Bentley et al. in prep.) is biased because it drops trips with no landings, leading to estimates of CPUE which are too high. This bias is increasing because of the increasing trend in landings that are passed through holding pots. The current catch/effort data system operated by MFish allows landings from previous trips, held in holding pots, to be combined with landings from the active trip. This means that tracing capture from the fishing event to the landing event for the same lobster is not possible under the current system.

Therefore, the catch and effort data used in these analyses have been calculated using a new procedure. This sums all landings and effort for a vessel within a calendar month and allocates the landings to statistical areas based on the area distribution of the estimated catches. This new method assumes that landings from holding pots tend to even out at the month level. However, in some areas there are vessel/month combinations with no landings, indicating that the problem has not been completely solved by this approach. In these instances, the approach was modified by dropping all data for the vessel in the month with zero landings as well as in the following month; it was thought that a method that excludes uncertain data is preferable to one that might incorrectly reallocate landings. This method is described as "Method B4" in Bentley et al. (in prep.).

The CPUE estimates in Tables 2 and 3 have been subjected to the same error screening as those used for standardised CPUE analysis – in all cases, CPUE is calculated from the sum of catch divided by the sum of pots for each stock, sub-stock or CRA Fishstock by fishing year.

Another potential problem with assuming CPUE indices are proportional to abundance has been identified by the Working Group. Fishers may sort their catch, discarding parts not expected to provide a reasonable economic return. This "high-grading" (permitted by legislation) could lead to biases in the estimated CPUE relative to previous years when sorting did not occur. The practice has become more prevalent in recent years, especially in areas where rock lobster abundance has increased. The Working Group agreed to identify this issue for further investigation.

The 2004 Working Group report continues the decision made previously by the Working Group to report rock lobster catch and CPUE on the basis of the rock lobster fishing year.

Table 2. **Reported commercial landings (t) to 31 March 2004 and CPUE (kg per pot lift) for *Jasus edwardsii* NSI and CHI stocks, and NSN, NSC and NSS substocks, for the 1979–80 to 2003–04 fishing years. Sources of data: catch and CPUE data from 1979–80 to 1985–86 from the QMS-held FSU data; catch data from 1986-87 to 2003–04 from QMR or MHR reports held by the Ministry of Fisheries (total catches in 1986–87 and 1987–88 have been divided among substocks using the FSU data because the QMR did not report individual CRA areas in those years); CPUE data from 1986–87 to 1988–89 from the QMS-held FSU data; CPUE data from 1989–90 to 2003–04 from the CELR data held by the Ministry of Fisheries corrected for actual landings. *See* Booth et al. (1994) for a discussion of problems with the QMS-held FSU data.**

	NSI Substocks						NSI		CHI	
Fishing	NSN (CRA1 & 2)		NSC (CRA3, 4 & 5)		NSS (CRA7 & 8)		CRA1 to CRA9		CRA6	
Year	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE
1979–80	408	0.57	1 386	0.85	2 129	1.58	4 012	1.06	400	2.33
1980–81	626	0.69	1 719	0.88	1 761	1.49	4 203	1.02	356	2.18
1981–82	574	0.66	1 664	0.85	1 663	1.48	3 973	0.99	465	2.19
1982–83	549	0.59	2 213	0.91	1 632	1.35	4 453	0.96	472	1.78
1983–84	506	0.55	2 303	0.84	1 634	1.09	4 514	0.87	548	1.73
1984–85	482	0.51	2 294	0.76	1 741	1.09	4 598	0.82	492	1.35
1985–86	556	0.54	2 227	0.71	2 185	1.21	5 048	0.83	604	1.41
1986–87	486	0.48	2 144	0.72	1 927	1.07	4 650	0.79	580	1.66
1987–88	442	0.45	1 781	0.57	1 961	1.12	4 277	0.72	448	1.48
1988–89	401	0.45	1 399	0.51	1 262	0.80	3 087	0.58	450	1.40
1989–90	427	0.55	1 457	0.53	1 352	0.80	3 262	0.62	318	1.34
1990–91	369	0.55	1 156	0.46	968	0.75	2 538	0.56	370	1.38
1991–92	358	0.49	1 087	0.41	1 140	0.82	2 633	0.54	388	1.29
1992–93	301	0.44	946	0.40	1 008	0.62	2 300	0.48	329	1.14
1993–94	342	0.51	983	0.49	1 034	0.87	2 404	0.61	342	1.07
1994–95	343	0.61	945	0.59	976	0.79	2 309	0.67	313	1.07
1995–96	339	0.77	942	0.73	907	0.76	2 233	0.75	315	1.08
1996–97	343	0.87	997	0.88	925	0.74	2 312	0.82	378	1.02
1997–98	364	0.86	1 013	1.15	822	0.66	2 246	0.87	339	0.88
1998–99	361	0.95	1 117	1.22	867	0.71	2 392	0.94	334	1.17
1999–00	361	0.82	1 252	1.24	766	0.73	2 426	0.96	322	1.19
2000–01	366	0.83	1 249	1.21	791	0.81	2 453	0.98	343	1.15
2001–02	356	0.71	1 213	1.08	649	0.81	2 264	0.91	329	1.15
2002–03	336	0.58	1 215	1.01	656	0.94	2 254	0.89	336	1.16
2003–04	325	0.58	1 140	1.04	648	1.31	2 159	0.98	286	1.11

Jasus edwardsii, NSI stock

NSI landings were relatively stable from about 1960 until the late 1980s, when landings declined (Table 2). CPUE was around 1.0 kg per potlift in the late 1970s and early 1980s, and decreased slowly until the late 1980s. Catch per pot lift in NSI declined to 0.48 kg in 1992–93 and reached a peak of 0.98 kg in 2000–01 and again in 2003–04 (Table 2).

Jasus edwardsii, NSN substock

Landings in the NSN substock were high in the early 1980s but CPUE was less than 1.0 kg per potlift. Both measures gradually declined into the early 1990s. Catch per pot lift was around 0.7 kg in the early 1980s but the period from 1986–87 to 1992–93 had catch rates around 0.5 kg (Table 2). From 1994, CPUE increased to levels considerably higher than those observed at the beginning of the time series peaking in 1998–99 at 0.95 kg per potlift. Recent trends in CPUE for CRA 1 and CRA 2 differ, with CRA 1 maintaining higher catch rates since 2000–01 while CRA 2 has declined since 1998–99 (Table 3). The combined NSN catch rate in both 2002–03 and in 2003–04 was 0.58 kg per potlift.

Jasus edwardsii, NSC substock

Landings in the NSC substock were very high up to the mid 1980s, exceeding 2 000 t per fishing year for five fishing years in succession. During that time CPUE dropped from 0.9 kg per potlift to 0.7 kg (Table 2). Commercial catches then gradually decreased to below 1 000 t by the early 1990s and CPUE dropped below 0.5 kg per potlift. From 1993–94, CPUE increased to a peak of 1.24 kg/potlift in 1999–2000 (Table 2). CPUE has subsequently fallen to just above 1.0 kg per potlift since 2001–02, which is still higher than all catch rates prior to 1997–98. CPUE has increased steadily in CRA 5 since the 1995–96 fishing year and since 2001–02 in CRA 4. CPUE peaked in CRA 3 in 1997–98 but has subsequently declined (Table 3).

Jasus edwardsii, NSS substock

Catches and CPUE were high for this substock (greater than 1 500 t per fishing year and well over 1.0 kg per potlift) throughout most of the 1980s. However, both measures gradually declined during that period, dropping below 1000 t per fishing year and below 1.0 kg per potlift by the early 1990s (Table 2). CPUE remained below 1.0 kg per potlift from 1988–89, but has been increasing since 1997–98 and is now 1.31 kg per potlift (Table 2). Catches and CPUE are low in CRA 7 compared with those in other areas (Table 3), but CPUE has risen in the last 4 years.

Jasus edwardsii, Westland/Taranaki (CRA 9)

Catch per pot lift fluctuated about 0.9 kg per potlift between 1995–96 and 2001–02, but increased to 1.63 kg per potlift in 2003–04 (Table 3).

Jasus edwardsii, CHI stock

CPUE in the CHI fishery was higher than in the other New Zealand CRA areas in the 1980s (Table 2). However, CPUE has declined consistently to levels similar to those in other CRAs (Table 3). Landings were around 400 to 500 t per fishing year in the 1980s but fell below 400 t per year in the 1990s. The reasons for the decline in catch and in CPUE are unknown. Size frequencies of lobsters in the landed catch have changed little since the development of this fishery.

Table 3. Estimated CPUE (kg/potlift) for each CRA quota management area for the nine most recent fishing years. Data are from the Ministry of Fisheries CELR database and estimated catches have been corrected by the amount of fish landed from the bottom part of the form (see Section 1 in text for explanation).

	1995–96	1996–97	1997–98	1998–99	1999–2000	2000–01	2001–02	2002–03	2003–04
CRA 1	0.94	0.94	0.88	1.04	1.09	1.17	1.30	1.20	1.22
CRA 2	0.69	0.83	0.85	0.91	0.71	0.71	0.56	0.44	0.43
CRA 3	1.30	1.76	2.18	1.63	1.56	1.19	0.95	0.73	0.63
CRA 4	0.86	1.03	1.24	1.31	1.27	1.26	1.06	1.09	1.14
CRA 5	0.49	0.56	0.78	0.89	1.00	1.16	1.27	1.26	1.39
CRA 6	1.08	1.02	0.88	1.17	1.19	1.15	1.15	1.16	1.11
CRA 7	0.31	0.25	0.23	0.30	0.22	0.35	0.46	0.52	0.58
CRA 8	0.90	0.87	0.72	0.79	0.84	0.98	0.92	1.10	1.67
CRA 9	0.98	0.98	0.79	0.92	0.87	0.93	0.82	1.11	1.63

Sagmariasus verreauxi, PHC stock

QMS reported catches of the PHC stock have halved since 1998–99 (Table 4). Reasons for the decline and the low level of landings relative to the TACC (40 t) are unknown.

Table 4. Reported landings of *Sagmariasus verreauxi* to the QMR or the MHR since 1998—99.

Year	Landings (t)
1998–99	15.19
1999–00	11.37
2000–01	10.35
2001–02	7.75
2002–03	8.84
2003–04	16.91

Jasus edwardsii, Catch-per-unit effort by statistical area

Table 5 shows the CPUE (kg/potlift) for the most recent six years within each CRA area for each statistical area reported on CELR forms (Figure 1). The values of CPUE and the trends in the fisheries vary greatly both within and between CRA areas.

Table 5. **Estimated CPUE (kg/potlift) for each statistical area for the six most recent fishing years. Data are from the Ministry of Fisheries CELR database and estimated catches have been corrected by the amount of fish landed from the bottom part of the form (see Section 1 in text for explanation). – value withheld because fewer than three vessels were fishing.**

CRA	Stat Area	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	CRA	Stat Area	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
1	901	–	2.85	2.82	2.92	2.05	–	6	940	0.91	0.97	0.92	0.98	1.12	1.15
1	902	1.18	1.13	1.22	2.77	3.04	3.30	6	941	1.05	0.93	0.91	0.86	0.99	0.76
1	903	0.80	0.48	0.71	0.77	0.72	0.78	6	942	1.53	1.71	1.54	1.47	1.31	1.41
1	904	0.54	0.34	0.40	0.50	0.36	0.36	6	943	1.24	0.83	0.83	1.15	1.18	0.98
1	939	1.08	1.16	0.89	0.86	0.96	0.81	7	920	0.25	0.20	0.27	0.45	0.45	0.45
2	905	0.96	0.74	0.72	0.59	0.44	0.53	7	921	0.38	0.31	0.49	0.50	1.07	1.88
2	906	0.83	0.67	0.65	0.47	0.36	0.37	8	922	–	–	–	–	–	–
2	907	2.19	1.18	0.89	0.64	0.49	0.46	8	923	0.73	0.75	1.20	1.43	–	2.75
2	908	0.61	0.47	0.70	0.67	0.53	0.46	8	924	0.71	0.88	1.27	1.33	1.34	2.32
3	909	1.94	1.69	1.45	1.00	0.81	0.88	8	925	0.88	0.82	1.56	0.61	–	1.57
3	910	1.57	1.50	0.93	0.71	0.55	0.60	8	926	1.01	1.14	1.27	1.03	1.29	1.92
3	911	1.61	1.61	1.60	1.22	0.93	0.60	8	927	0.86	0.89	0.82	0.79	0.93	1.56
4	912	1.72	1.38	1.16	0.93	1.08	1.10	8	928	0.61	0.52	0.55	0.64	0.74	0.93
4	913	2.51	1.80	1.91	1.17	1.18	1.36	9	929	0.63	–	0.72	–	–	–
4	914	1.02	1.05	1.14	1.08	1.02	1.08	9	930	0.74	0.74	0.74	0.54	–	–
4	915	0.72	1.23	1.12	1.11	1.21	0.90	9	931	1.22	0.99	–	1.81	–	1.79
4	934	–	0.84	0.95	0.81	–	–	9	935	0.98	1.01	0.74	0.66	1.21	2.21
5	916	1.12	2.13	3.48	2.84	2.25	2.36	9	936	–	–	0.47	–	–	–
5	917	0.75	0.76	0.83	0.83	0.93	1.11	9	937	–	–	–	0.92	–	–
5	918	0.88	0.87	1.40	1.64	1.31	1.38	9	938	–	–	–	–	–	–
5	919	–	–	–	–	–	–								
5	932	–	–	–	–	–	–								
5	933	1.04	0.91	0.97	1.05	0.88	0.86								

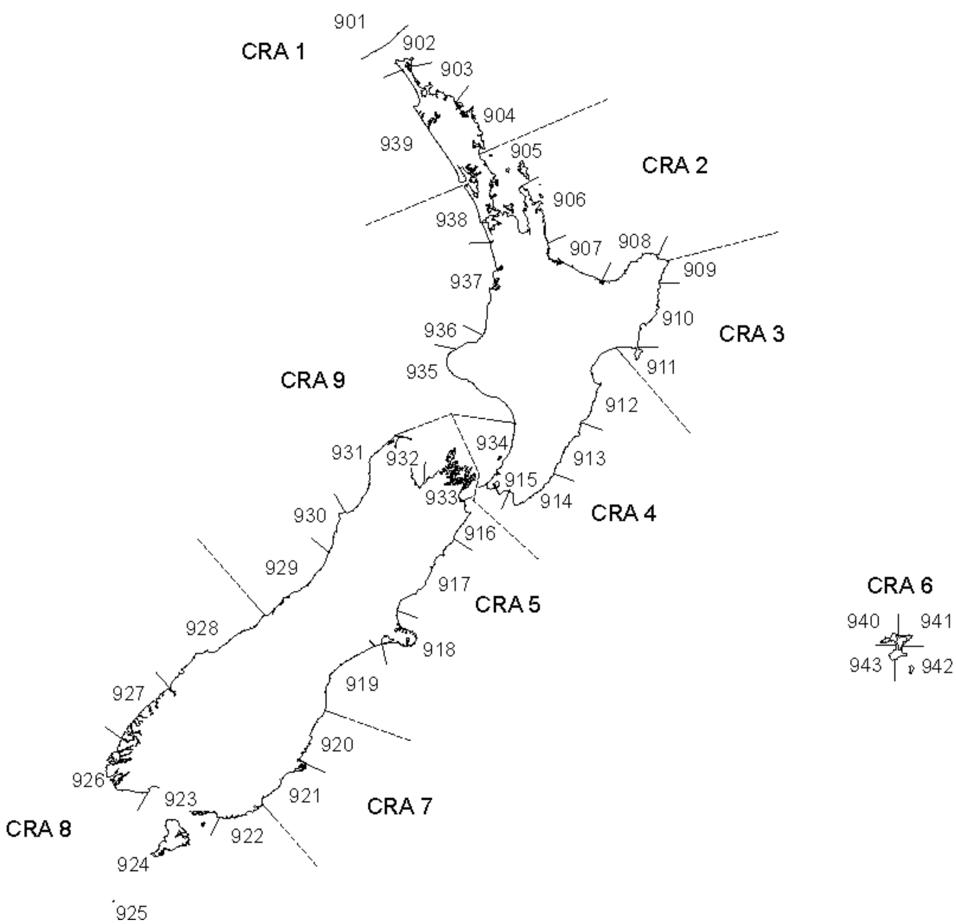


Figure 1. **Statistical areas for rock lobster as reported on CELR forms.**

Recreational fisheries

Recreational catches have been estimated from a series of regional and national telephone and diary surveys. The results from the South region (1991–92), Central region (1992–93) and North region (1993–94) are shown in Table 6 (Bradford 1997, Teirney et al. 1997). The results from the 1996 National Diary Survey (Table 7) were reported by Bradford (1998). The total New Zealand recreational catch was estimated by scaling up the reported catch by diarists by the ratio of diarists to the total estimated New Zealand population. The catch in numbers was then converted to catch in weight using mean weights of recruited lobsters observed in the appropriate catch sampling or voluntary logbook programs during the survey years (Table 6).

Estimates from the more recent national survey (1999–2000) are higher than those from the earlier surveys, but the Working Group, in the absence of documented acceptance of these results from MFish, followed its previous practice of setting these aside for the assessments. However, higher levels of recreational catch were considered in a sensitivity test to the basecase runs for CRA 3. For the base case CRA 3 assessment, it was assumed that recreational catch in each year from 1945 to 2003–04 was 20 t. A sensitivity run was performed where the recreational catch in each year was doubled to 40 t. The Working Group had little confidence in the estimates of recreational catch.

Table 6. Estimates of the recreational rock lobster harvest (t) from regional telephone and diary surveys in 1992, 1993 or 1994 (–, not available). For CRA 1 and CRA 2, two estimates of catch in tonnes are presented based on two sources of mean weight: from the diary survey and from the Industry Logbook Program for CRA 2 (Bradford 1997). Mean weights used in the other CRA areas are based either on weights reported in the diaries or from boat ramp surveys (Teirney et al. 1997).

Fishstock	Estimated number of lobsters	Mean weight (g)	Estimate (t)
CRA 1	56 000	871[1] or 674[2]	48 or 38
CRA 2	142 000	871[1] or 674[2]	123 or 95
CRA 3	8 000	–	2 to 8
CRA 4	65 000	–	25 to 60
CRA 5	67 000	–	23 to 117
CRA 7	6 000	–	1 to 6
CRA 8	32 000	–	15 to 60
CRA 9	6 000	–	2 to 6

[1] diary estimate of mean weight
[2] logbook estimate of mean weight

Table 7. Estimates of the recreational rock lobster harvest (t) from the 1996 National telephone and diary survey (–, not available). Because the sex of the sampled lobster was not determined when measured in the boatramp surveys, the mean weight is based on the average size measured assuming a 50–50 sex ratio (Bradford 1998).

Fishstock	Estimated Number of lobsters	Mean weight (g)	Estimate (t)
CRA 1	74 000	686	51
CRA 2	223 000	618	138
CRA 3	27 000	–	–
CRA 4	118 000	618	73
CRA 5	41 000	858	35
CRA 7	3 000	–	–
CRA 8	22 000	700[1]	16
CRA 9	26 000	–	–

[1] assumed

Maori customary fisheries

The Ministry of Fisheries provided estimates of the Maori customary catches for some Fishstocks for the 1995–96 fishing year. Updates of these estimates are not available.

The estimates for the 1995–96 fishing year were CRA 1 (2.0 t), CRA 2 (16.5 t), CRA 8 (0.2 t), CRA 9 (2.0 t) and PHC 1 (0.5 t). The CRA 3 assessment assumed a constant level of customary catch of 20 t per year from 1945 to 2003–04, not knowing what the real level was.

Illegal catches

For the years 1945−1973 and 1981–82 to 1989–90, illegal catch is estimated based on the average ratio of exports of rock lobster to the reported catch observed for the period 1974 to 1980. This ratio (1.16) is applied as a constant mulitplier to the reported legal catch in each of these years.

The Ministry of Fisheries Compliance staff supplied updated illegal catch estimates for CRA 3 from 1994–95 to 2003–04 (Table 8). There are existing estimates for CRA 3 from 1990–91 and 1992–93 that continue to be used (Table 8). These estimates are used in the assessment model from 1990–91 onwards. Values for 1991–92 are obtained by interpolation because no estimates have been provided for this fishing year.

In the past, MFish Compliance has provided estimates of the amount of illegal catch that subsequently was reported against quota (see Annala & Sullivan 1999). An estimate of this quantity is required to avoid counting the same catch twice. The catch listed in Table 8 as "Illegal Commercial Take" was assumed to be an estimate of the commercial catches that eventually were reported through legal channels. The average proportion of this catch relative to the total illegal catch is about 0.045 and this fraction was used to separate all historical illegal catches for the CRA 3 assessment.

Table 8. Estimates of illegal catches (t) for CRA 3 used in the 2004 assessment. The estimates by category from 1994–95 onwards were provided by MFish Compliance. Estimates for 1990–91 and 1992–93 are historical estimates provided previously by MFish.

	Illegal Recreational Take	Illegal Customary Take	Illegal Commercial Take	Poaching	Total
1990–91					288
1992–93					250
1994–95	24	13	5		42
1995–96				63	63
1996–97			20	64	84
1997–98			4	60	64
1998–99	7.5	9	4	70	90.5
1999–00	8			128	136
2000–01	5		3	70	78
2001–02	5			70	75
2002–03	5			70	75
2003–04	5		0	84.5	89.5

The Working Group members have little confidence in the estimates of illegal catch, as the estimates cannot be verified.

Other sources of mortality

Other sources of mortality include handling mortality caused by the return of under-sized and berried female lobsters to the water, and predation by *Octopus* and other predators within pots. Although these cannot be quantified, the assessment assumes that handling mortality is 10%.

BIOLOGY

Although they cannot be aged, rock lobsters are thought to be relatively slow-growing and long-lived. *J. edwardsii* and *S. verreauxi* occur both in New Zealand and southern Australia. The following summary applies only to *J. edwardsii* in New Zealand.

Sexual maturity in females is reached at about 34–77 mm TW (about 60–120 mm carapace length), depending on locality. Mating takes place in autumn, and the eggs hatch in spring into the short-lived naupliosoma stage. Most of the phyllosoma development takes place in oceanic waters tens to hundreds of kilometres offshore over a period of at least 12 months. Near the edge of the continental shelf the final-stage phyllosoma metamorphoses into the settling stage, the puerulus. Puerulus settlement takes place mainly at depths less than 20 m, but not uniformly over time or between regions. Settlement indices measured on collectors can fluctuate widely from year to year.

Most females in the south and southeast of the South Island do not breed before reaching MLS. Some rock lobsters undertake long-distance migrations in some areas. During spring and early summer, variable proportions of usually small males and immature females move various distances against the current from the east and south coasts of the South Island towards Fiordland and south Westland.

Values used for some biological parameters in the stock assessment are shown in Table 9.

Table 9. Values used for some biological parameters.

1. Natural mortality (M) [1]

Area	Both Sexes
NSS, CRA 1, 2 ,3, 4, 5	0.12

[1] This value was used as the mean of an informative prior; *M* was estimated as a parameter of the model.

2. Fecundity = a * TW^b^ (TW in mm) (Breen & Kendrick 1998)[2]

Area	a	b
NSN	0.21	2.95
CRA 4 & CRA 5	0.86	2.91
NSS	0.06	3.18

[2] Fecundity was not used by post-1999 assessment models.

3. Weight = a TW^b^ (weight in kg, TW in mm) (Breen & Kendrick, Ministry of Fisheries unpublished data)

	Females		Males	
Area	a	b	a	b
CRA 1, 2, 3, 4, 5	1.30 E-05	2.5452	4.16 E-06	2.9354
NSS	1.04 E-05	2.6323	3.39 E-06	2.9665

Growth modelling

Before the 1999 assessment, growth increments from tagging data collected in the late 1970s and early 1980s were used to estimate growth rates for *J. edwardsii*. Growth rates were estimated from the estimated frequency of moulting by size and sex and the estimated increment-at-length for each sex. In assessments before 1998, these estimates were converted to a von Bertalanffy equation, then size data from catch sampling were used in length-converted catch curves to estimate total mortality. This procedure did not address the variability of growth.

The 1998 assessment moved from an age-structured model to a length-based model (Starr et al. 1999; Breen & Kendrick 1999). The length-based model has been refined for each subsequent assessment. Growth-at-size is represented stochastically by growth transition matrices for each sex. The growth increments at size are assumed to be normally distributed with means and variances determined from a growth model. The transition matrices contain the probabilities that a lobster will move into specific size bins given its initial size.

From the 2003 stock assessment, the sex-specific growth models have been parameterised with two parameters representing the expected growth increment of lobsters of 50 mm TW and the difference between the increment at 50 and 80 mm TW. Another two parameters describe the CV of the increment for each sex, one describes the minimum standard deviation and one describes the magnitude of observation error. The model is over-parameterised when all parameters are estimated, so the last two parameters are fixed. A shape parameter for each sex can also be estimated. It is assumed, based on analysis of the tag-recapture data, that males moult twice yearly and that females moult once yearly, in autumn. Growth rates are estimated simultaneously with other parameters of the assessment model, so that growth estimates are affected by all the data including the size frequency and CPUE data, as well as the tagging data.

(b) Settlement indices

Annual levels of puerulus settlement have been estimated for periods ranging from 9 to 22 years at 6 sites from Gisborne to Otago, on the northeast of Stewart Island, and at Chalky Inlet in

Fiordland. A new site was recently established at Jackson's Bay on the west coast of the South Island.
The settlement data for NSC to the end of 2003 (based on the sites Gisborne, Napier, Castlepoint, Wellington, and Kaikoura) show that there was a strong settlement pulse during the period 1991–92 (and into 1993 at some sites). Settlement since then declined markedly (except for a moderate year in 1998), in 1999 reaching the lowest seen. From 2000 there has been a recovery in settlement levels, with 2001–03 near the long-term average. Dive observations carried out in Wellington showed high abundance of juveniles following the high settlement of pueruli in the early 1990s (Booth et al. 2000). Recruitment to the fishery of lobsters from the high 1991 to 1993 settlements may have contributed to the increase in CPUE in the NSC fishery in the mid to late 1990s.

The years 1981, 1983, 1987, 1991, 1992, and 1993 were high settlement years, and 1999 a very low settlement year, over broad areas of the east coast. The extent of these areas suggests that factors that drive larval recruitment are widespread. This is also the case in other rock lobster fisheries such as Western Australia.

For the east coast of NSS (settlement sites Moeraki and Halfmoon Bay), puerulus settlement on collectors has been low since the relatively high values of the early 1980s, except for a marked increase at Moeraki (and to a less extent Halfmoon Bay) starting in 2000, and continuing into 2003. For the west coast (Chalky Inlet), settlement since sampling began in 1987 has been high compared with the east coast of NSS, but variable from year to year.

STOCKS AND AREAS

There is no evidence for genetic subdivision of lobster stocks within New Zealand based on biochemical genetic and *mt*DNA studies. The observed long-distance migrations in some areas and the long larval life probably result in genetic uniformity among areas. Gene flow probably also occurs to New Zealand from populations in Australia (Chiswell et al. 2003).

Subdivision of the NSI stock on other than genetic grounds has been considered (Booth & Breen 1992; Bentley & Starr 2001). There are geographic discontinuities in the frequency of antennal banding, size at onset of maturity in females, migratory behaviour, some fishery catch and effort patterns, phyllosoma abundance patterns, and puerulus settlement levels. These observations have led to division of the NSI stock into three substocks (NSN, NSC, and NSS) for assessment. Cluster analysis based on similarities in CPUE trends between rock lobster statistical areas provides support for the current stock definitions (Bentley & Starr 2001).

Although considered separately for stock assessment purposes, the CHI stock (CRA 6) also appears to be genetically the same as the NSI stock. It may depend upon the NSI stock as a source of recruitment, but changes in abundance within the CHI stock are unlikely to affect the NSI stock.

Sagmariasus verreauxi forms one stock centred in northern New Zealand, and may be genetically subdivided from populations of the same species in Australia.

DECISION RULES AND MANAGEMENT PROCEDURE

An evaluation for the 2003–04 fishing year of the rock lobster decision rules and management procedure was made based on CPUE data extracted at the end of August 2004.

Data preparation procedures

The data used in all the CPUE evaluations, including the NSN and NSC decision rules and the NSS management procedure, were extracted from the CRACE database using procedures described in

Bentley et al. (in prep). All error checks were set to “Level 1”, which effectively screens out all obvious data errors. Corrections were made to the catch estimates provided in the effort section of the form based on the landing information provided at the end of the trip on the bottom part of the catch/effort form. Problems with previous correction methods were documented in the 2003 Plenary Report (Sullivan 2003). The correction method used in this analysis is the method agreed by the Rock Lobster Fishery Assessment Working Group as being the most reliable to deal with the holding pot problem (“Method B” – see Bentley et al. (in prep.). This method sums all landings and effort for a vessel within a calendar month and allocates the landings to statistical areas based on the distribution of the estimated catches. This method assumes that landings from holding pots tend to even out at the level of a month. However, in some areas, there are vessel/month combinations with no landings, indicating that the problem has not been completely solved by the vessel/month approach. In these instances, the approach was modified by dropping all data for the vessel in the month with zero landings as well as in the following month; a method that excludes uncertain data is thought preferable to one that might incorrectly reallocate landings.

Method “B” probably has little effect on the operation of the NSN and NSC decision rules because they are defined in relative terms. For the NSS, problems created by keeping lobsters in holding pots, and the associated positive bias created, were discussed thoroughly in 2003. The Minister accepted a revision to the decision rule, extending the rebuild period to maintain the existing slope of the CPUE target trajectory (Sullivan 2003).

For decision rule analyses, the data are aggregated by fishing year, month, rock lobster statistical area, and vessel. The standardisation procedure, described by Maunder & Starr (1995), uses month, statistical area and fishing year as explanatory variables. The data were restricted to the appropriate QMAs for each analysis and all data were used except for one vessel, which has been consistently dropped from the NSN analysis. The decision rule comparisons for the NSN and NSC are based on the exponents of year coefficients calculated by the regression model, which uses ln(catch/potlifts) as the dependent variable, and uses the calculated standard error for each coefficient to test for a significant change. The coefficients in these regressions are calculated relative to the fishing year with the smallest standard error.

The NSS management procedure uses the data from CRA 8. The analysis follows the suggestion of Francis (1999) and calculates “canonical” coefficients and standard errors for each fishing year. These coefficients are standardised with respect to the geometric mean of the entire series. This procedure allows calculation of standard errors for every coefficient, including the base year coefficient. A further refinement is to scale each standardised index by the geometric mean of the simple arithmetic CPUE indices. The arithmetic index is the summed mean of the total catch and effort for each fishing year:

$$\left(\beta_{year} = \sum catch_{year} \Big/ \sum potlifts_{year} \right).$$

The geometric mean CPUE is preferred to the arithmetic mean because it is less affected by outliers.

Because the canonical process scales the standardised series to a geometric mean of one, this refinement scales the standardised indices to CPUE levels consistent with those observed by fishers.

Decision Rule for NSN and NSC

The decision rule described by Breen et al. (1994) was modified by the National Rock Lobster Management Group (NRLMG) for the NSN and NSC substocks to allow consideration of TAC increases. The original decision rule required that a substock be assessed whenever a “standardised CPUE analysis” (Maunder & Starr 1995) showed a “significant” decrease in the CPUE for a given year relative to the CPUE estimate for 1992–93. A year index would be considered “significantly different” from the 1992–93 year index if the standard error bars of the two years did not overlap.

Table 10. Decision rule indices for 1992–93 and 2003–04 fishing years (1 April to 31 March) for the NSN and NSC substocks from a standardised CPUE analysis. The table also shows the upper and lower bounds, which are the index plus and minus one standard error respectively. The final column indicates the significance of change between the two years (* = significant increase).

Substock	1992–93 Index	1992–93 Lower	1992–93 Upper	2003–04 Index	2003–04 Lower	2003–04 Upper	Result
NSN	0.974	0.942	1.008	1.233	1.184	1.284	*
NSC	0.394	0.386	0.401	1.197	1.167	1.228	*

NSN

The standardised CPUE for the NSN stock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 2). There were four consecutive years of decrease between 1998–99 and 2002–03. However, the standardised index for 2003–04 is still above the levels registered in the late 1980s and the early 1990s and is nearly unchanged compared with the 2002–03 index. Figure 3 shows that both the standardised index and the simple arithmetic mean show similar trends and that both are still above the low abundance of the late 1980s and early 1990s. Under the NSN decision rule, the 2003 CPUE is significantly above the 1992 CPUE (Table 10).

NSC

The standardised CPUE for the NSC stock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 4). There have been several consecutive years of decrease since 1998–99. However, the degree of decline for the NSC stock (about 25%) is less than the comparable decline for the NSN stock (about 35%). The standardised index for 2003–04 is well above the lowest level, which was observed in 1992–93. Figure 5 compares the standardised index with the simple arithmetic mean, and shows a similar trend. The unstandardised index is lower than the standardised index for this stock, probably reflecting the switch to a winter fishery with generally lower catch rates. It is likely that the standardisation model interprets the relatively high catch rates in these winter months as indicative of higher abundance. Under the decision rule, the 2003 CPUE is significantly above the 1992 CPUE (Table 10).

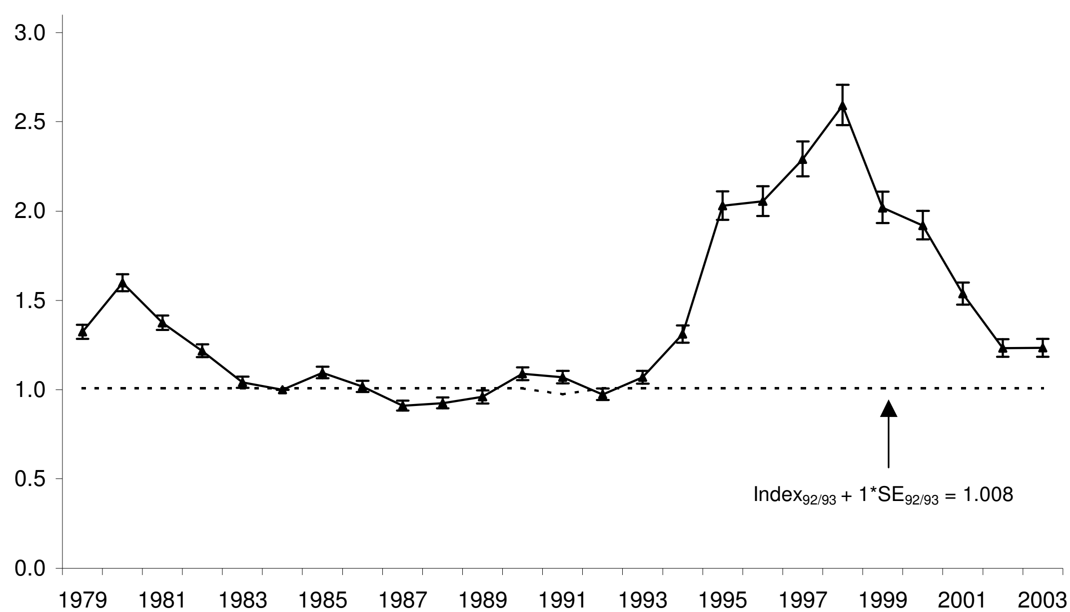


Figure 2. Values of the year index from the standardised CPUE analysis for the NSN substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative to the 1984-85 fishing year (the year with the lowest standard error).

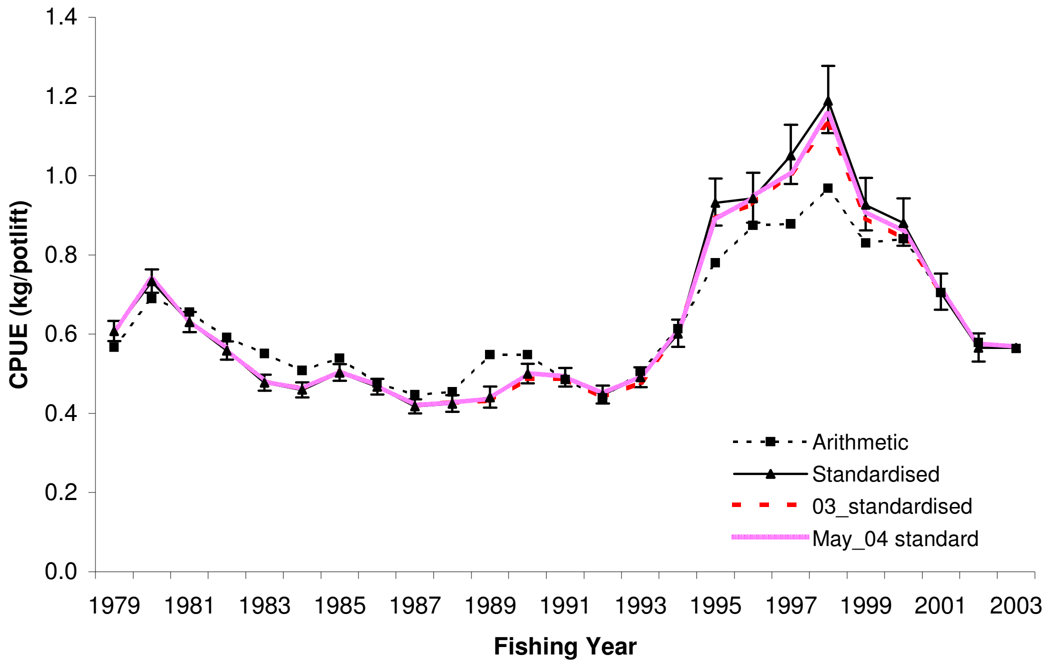


Figure 3. Values for the NSN standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown are the standardised series calculated in September 2003 and in May 2004.

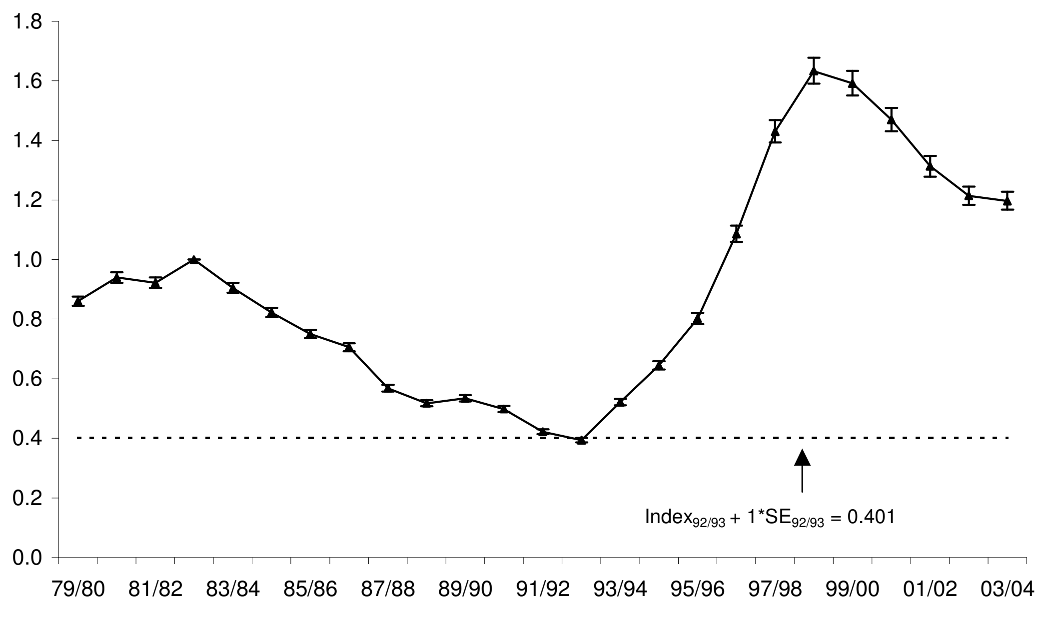


Figure 4. Values of the year index from the standardised CPUE analysis for the NSC substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative to the 1982-83 fishing year (the year with the lowest standard error).

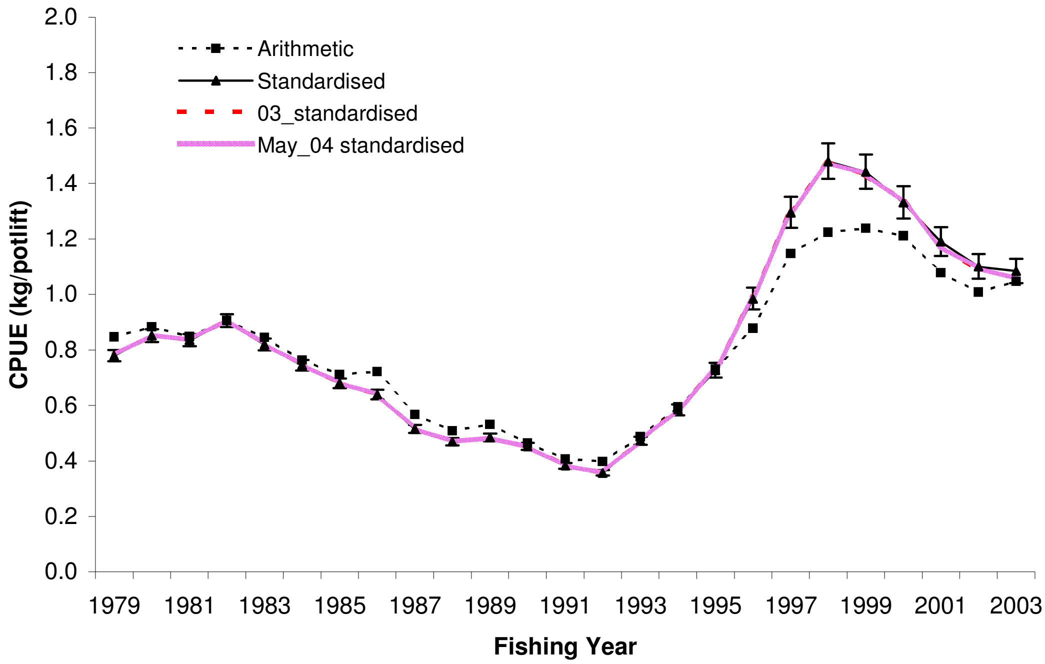


Figure 5. Values for the NSC standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown are the standardised series calculated in September 2003 and in May 2004.

Management Procedure for NSS

A management procedure was proposed by the National Rock Lobster Management Group and accepted by the Minister of Fisheries in 1996. This resulted in TAC and TACC decreases in 1999 and 2001. A revised management procedure was proposed and accepted in 2002. Evaluation of the revised procedure, documented in Bentley et al. (2003), considered a number of different stock and recruitment hypotheses across a series of management strategies for the two NSS QMAs. A family of "harvest control rules" based on variable control parameter values were used to set the TAC. Both the old and new management procedures are rebuilding rules designed to achieve a specific target CPUE within a specified number of years.

This rule was revised again in 2003 to reflect a change in the CPUE standardisation procedure, in turn made necessary by the increasing practice of landing lobsters to holding pots (discussed above). Recent CPUE estimates were decreased by the change, but the target CPUE was unchanged because it is based on early data unaffected by the holding pot problem. The Minister agreed to extend the projected rebuilding time and to retain the original slope of the rebuilding trajectory.

The new management procedure currently applies to the entire NSS stock but is based entirely on data from the CRA 8 QMA. The CRA 7 quota holders wanted the option of adopting a different management procedure at a later date, but in the interim, have agreed to abide by the functioning of the CRA 8 management procedure.

The harvest control rule evaluates how well the observed CRA 8 CPUE tracks the rebuilding trajectory (through a "status" indicator) and how well the CPUE trend compares with the increasing target trajectory (through a "gradient" indicator). The parameter values selected for the harvest control rule represent a compromise between higher fishery harvest and lower stock risk while attaining rebuilding targets within the specified time frame. The criteria used to select this specific harvest control rule, and its performance relative to all the other evaluated rules, are presented in Bentley et al. (2002).

Revised target biomass level

Legislation requires that New Zealand fisheries be managed to maintain stocks at or above B_{MSY}, the recruited biomass associated with the maximum sustainable yield (*MSY*). However, B_{MSY} is not defined in the legislation and Francis (1999) has observed that B_{MSY} will vary depending on the harvest strategy adopted, which is frequently undefined. A workshop on the use of B_{MSY} in New Zealand fisheries management held in 2001 suggested that

> "*a more pragmatic management approach, consistent with the Purpose of the Act, is to ensure that stocks are managed above, for example, the lowest observed stock size that has been known to give rise to good recruitment*" (Stokes et al. 2001).

Following this suggestion, a target level of CPUE based on the history of the fishery is being used . This approach continues the use of commercial CPUE as an index of abundance in rock lobster fisheries and uses the average of the standardised CPUE indices from CRA 8 from 1979–80 through 1981–82. These are the first three years for which reliable CPUE data are available, and the average CPUE for these years was higher than at any subsequent time. A target CPUE that is nearly twice the recent level should serve as a reasonable and achievable reference biomass target.

Description of the harvest control rule

The rule acts by calculating a multiplier that determines the new catch from the existing catch:

$$TAC_{t+2} = Z_t \, TAC_{t+1}$$

The Z_t is calculated from observed and target values for CPUE in any year and from the three parameters of the rule:

- *N*, the number of years used for averaging CPUE in the rule;
- *W*, relative weight given to the distance between observed and target CPUE, relative to the difference between target and observed gradients; and
- *S*, a scaling or sensitivity parameter used to determine the rule's response.

These three parameters define a family of candidate harvest control rules and the rule selected by the NRLMG is shown in Table 11. In the control rule, the difference between the target and the observed CPUE is calculated for a "status indicator" :

$$A_t^s = I_t^{obs} / I_t^{pred} - 1$$

where I_t^{obs} and I_t^{pred} are the observed and predicted (target) CPUE in year *t*, respectively.

Similarly, the difference between the target and observed gradient is calculated for a "gradient indicator:

$$A_t^g = \left(\left(I_t^{obs} - I_{t-1}^{obs}\right) / I_{t-1}^{obs}\right) - \left(\left(I_t^{pred} - I_{t-1}^{pred}\right) / I_{t-1}^{pred}\right)$$

The indicators are averaged for *N* years:

$$\overline{A}_t^s = \frac{1}{N} \sum_{d=t-N+1}^{d=t} A_d^s$$

and similarly for A_t^g to obtain $\overline{A}_t^g$. Then mean gradient and status indicators are combined, using the relative weight *W*:

$$A_t^* = W\overline{A}_t^s + (1-W)\overline{A}_t^g ,$$

and the combined mean indicator is used with a scalar *S* to determine a response:

$$R_t = SA_t^*$$

Then this response is used to determine the multiplier Z_t , taking into account the sign of R_t and limiting the magnitude with minimum and maximum thresholds (Table 11).

$Z_t = 1$	for $-Minimum \le (R_t) \le Minimum$
$Z_t = 1 + R_t$	for $-Maximum \le (R_t) < -Minimum$ and
	for $Minimum < (R_t) \le Maximum$
$Z_t = 1 - Maximum$	for $(R_t) < -Maximum$
$Z_t = 1 + Maximum$	for $(R_t) > Maximum$

As in the previous NSS management procedure, a "latent year" is specified, prohibiting changes to the TAC in two consecutive years.

Table 11. Parameters of the new NSS harvest control rule.

Parameter	Value
N (number of years in running average for both the "status" and "gradient" indicators)	3
W (relative weight for the "status" indicator)	0.40
S (scalar for management decision)	0.75
Minimum (minimum management action accepted)	0.05
Maximum: (maximum management action accepted)	0.25

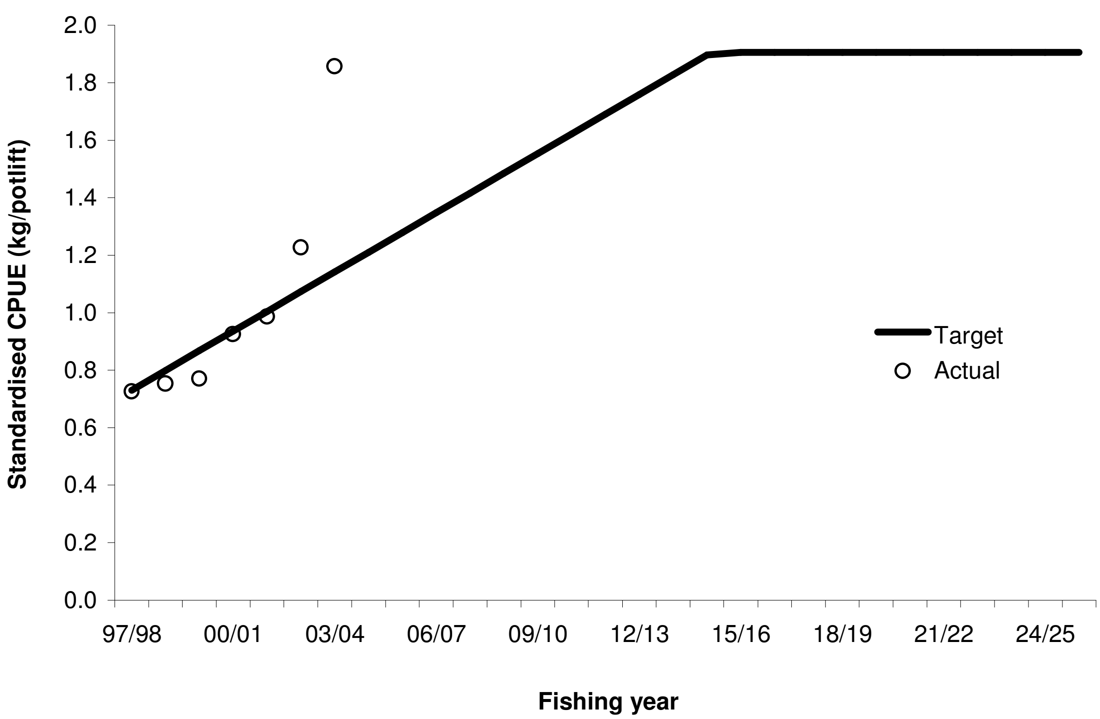


Figure 6: Operation of the NSS harvest control rule for 2004. The target biomass trajectory for CRA 8 is generated by plotting a straight line from the observed starting value in the 1997–98 fishing year to the mean [1979–80 to 1981–82] CPUE, which is to be achieved in 2015–16 using a constant slope of 0.06857 kg/potlift/year. Observed CPUE is generated from the standardised CPUE analysis for CRA 8 multiplied by the geometric mean of the arithmetic (sum of annual catch divided by sum of potlifts) CPUE indices.

Table 12: Implementation of NSS decision rule for 2004, based on a constant slope of 0.06857 kg/potlift/year –: not required for the evaluation.

Fishing year	Target Rebuild CPUE	Observed Standardised CPUE	Status Indicator	Gradient Indicator	A_t^*	R_t	Z_t
2000–01	0.936	0.926	–	–			
2001–02	1.005	0.986	-0.019	-0.008			
2002–03	1.073	1.228	0.143	0.177			
2003–04	1.142	1.858	0.627	0.450			
Mean	–	–	0.250	0.206	0.224	0.168	1.168

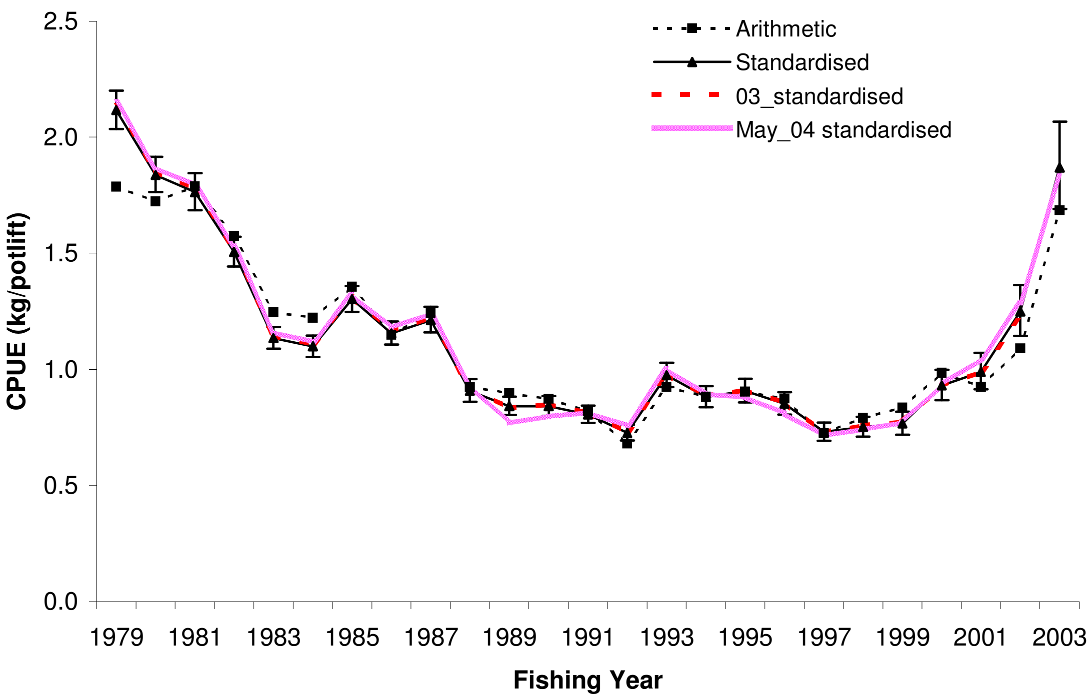


Figure 7: Values for the CRA 8 standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown are the standardised series calculated in September 2003 and in May 2004.

Implementation of NSS harvest control rule for 2004

A plot of the observed standardised CPUE indices compared with the agreed CRA 8 rebuilding trajectory is provided in Figure 6. The overall CPUE trend shows a strong increase, with the 2003 value being the second highest in the series, although there is more uncertainty in this index value than for earlier indices (Figure 7). The status indicator measures the amount that the observed CPUE indices deviate from the target trajectory. The mean value for this indicator over the last three years is 0.250 (Table 12). The gradient indicator measures the degree to which the slope of the observed CPUE differs from the slope of the rebuilding trajectory. The mean value for this indicator over the last three years is 0.206. When these two indicators are combined using the weighting parameter *W* (0.4), the resulting value $\left(A_t^*\right)$ is 0.224 (Table 12). This value is scaled by the scaling parameter *S* (0.75) to create a response value $\left(R_t\right)$ of 0.168 (Table 12). This value is greater than the agreed minimum change value (0.05) and is not greater than the agreed maximum change value for the management procedure (0.25), so the value of Z_t is set to 1.168 (Table 12). However, according to the terms of the NSS management procedure because a TACC increase was granted for the 2004–05 fishing year, the 2005–06 year is a latent year with no scheduled change in TACC.

STOCK ASSESSMENT

This section reports a new assessment for *J. edwardsii* for CRA 3 from the NSC substock.

CRA 3 (Gisborne)

The CRA 3 fishery extends from East Cape south to the Wairoa River. The current TAC of 453 t, set in 1998, comprises 20 t allowances for amateur catch and customary harvest, 86 t for illegal removals and a TACC of 327 t, distributed amongst 35 quota share owners. An estimated 36 commercial vessels reported CRA 3 landings in the 2003-04 fishing year.

In 2003 the CRA 3 Industry Association, after taking advice from fisheries research and management service providers consulted with industry members to determine a response to ensure a rebuild of stock abundance. With assistance and advice from FishServe, the NZ RLIC has coordinated a programme to shelf ACE in the CRA 3 fishery that limits the commercial catch to 210 t in the 2004–05 fishing year.

Revised size-based model

The length-based model, used in 2002 (Starr et al. 2003) and revised for the 2003 assessment (Kim et al. 2004), was revised again for the 2004 assessment. Revisions included: ·

- consideration of the effect of the Te Tapuwae o Rongokako Marine Reserve established in 1999
- changing the prior for the common component of error from uniform in arithmetic space to uniform in log space, following a suggestion made by Dr. Andre Punt when he reviewed the length- based paua model

In addressing the Te Tapuwae o Rongokako Marine Reserve, the Working Group discussed three possible effects of the marine reserve:

a) a stock-recruit effect, through which increased egg production in the reserve might lead to increased recruitment in CRA 3;

b) a yield-per-recruit effect, through which reduced fishing mortality in CRA 3, as a result of a partial refuge, could increase yield-per- recruit through interchange of animals between the fished stock and the marine reserve; and

c) removal from the fishery of a portion of the stock and the ground it occupies.

The Working Group saw no basis for modelling hypothesis a) given the wide dispersal of larvae and the small area of the reserve relative to the areas of settlement. The Working Group noted that b) implicitly assumes growth over-fishing and that significant interchange of lobsters occurs between the remaining fished stock and the new reserve. There is no evidence for the first assumption, and movement data collected by DoC (D. Freeman, DoC, pers. comm.) do not support the second. The Working Group agreed to implement the third effect, which is the simplest of the three hypotheses and possibly the most conservative, by removing an agreed percentage (10%) of the stock from the fishery in 1999 and assuming that recruitment to the model drops by that same percentage in subsequent years. Effectively, this hypothesis assumes that the stock has become smaller as a result of establishing the marine reserve.

Model structure

The model is fitted to three series of catch rate indices from different periods, and to size frequency and tag-recapture data.

In the model, a year is divided into two seasons: autumn-winter (AW): April through September, and spring-summer (SS): October through March. This captures several biological processes: a) season- and sex-specific moult patterns; b) possible differential vulnerability between the two seasons (and also between sexes); and c) a reduction in the vulnerability of mature females greater than the MLS in the autumn-winter season because of their egg-bearing status. Seasonal structure is important to incorporate because several fisheries have changed from predominantly spring/summer fisheries to autumn/winter fisheries that catch mostly male lobsters.

Significant catches occurred in the early part of the time series for CRA 3. Different MLS regulations existed in the past and escapement regulations have changed. We therefore incorporated historical information for CRA 3: a time series of sex-specific MLS regulations, time series of catch per day estimates for the 1960s and early 1970s, and some early size frequency data, including market sampling data. These data and their sources are listed in Table 13.

The initial population in 1945 is assumed to be in equilibrium with base recruitment and with no fishing mortality. Each season the number of male, immature female and mature female lobsters within each size class is updated as a result of:

a) **Recruitment**. Each year, new recruits are added equally for each sex and both seasons, into the smallest size classes, beginning with the autumn-winter season. The proportion of individuals recruiting to each size class is modelled as a normal distribution with a mean of 32 mm and a standard deviation of 2 mm. The distribution is truncated at the smallest size class in the model (30 mm). Recruitment in a specific year is the product of a parameter for base recruitment level and a parameter representing the deviation from base recruitment for that year. The vector of recruitment deviations is assumed to be normally distributed. The years for which recruitment deviations were estimated were 1945 to 2000.

b) **Mortality**. Natural, fishing and handling mortalities are applied to each sex category (male, immature female and mature female) in each size class. Estimated natural mortality is assumed to be independent of sex, year and length. Fishing mortality is determined from observed catch and model biomass, modified by legal sizes, sex-specific seasonal vulnerabilities and size-specific selectivity curves.

   Fisheries that respect size limits (SL fisheries – legal commercial and recreational) are differentiated from those which do not (NSL fisheries – part of the illegal fishery plus the Maori traditional fishery). It is assumed that size limits and the prohibition of taking berried females apply only to the SL fisheries. Otherwise, the selectivity and vulnerability functions are the same for the SL and NSL fisheries. Relative vulnerability is calculated by assuming that a specified sex in a specified season has the highest vulnerability and estimating the relative vulnerability for other sex/season combinations. Mature females have no legal vulnerability in the autumn-winter, when all are assumed to be ovigerous. The annual rate of SL fishing mortality is calculated as the ratio of catch to the SL biomass, where catch includes both the legal catch and the portion of NSL catch taken from the SL biomass. SL biomass is defined as the weight of males and females in the size classes above the MLS limits, adjusted for their relative vulnerability as defined above. Handling mortality rate is assumed to be proportional to legal fishing mortality at 10% of all lobsters that are released.

c) **Fishery selectivity curves:** A three-parameter fishery selectivity function is assumed, with parameters describing increasing vulnerability from the initial size class to a maximum, followed by decreasing vulnerability. The three parameters describe the shapes of the ascending and descending limbs and the size at which vulnerability is maximum. Changes in regulations over time (for instance, changes in escape gap regulations) can be modelled by estimating separate selectivity parameters appropriate to each period of the fishery). For the CRA 3 assessment, the size at maximum selectivity and the shape of the right-hand part of the curve were assumed.

d) **Growth and maturity**. For each size class and sex category in a season, a transition matrix specifies the probability of an individual remaining in the same size class or growing into each of the other size classes. Maturity for females can be estimated as a two-parameter logistic curve from the maturity-at-size information in the size frequency data, but for the CRA 3 assessment there were few immature females in the data, reflecting a small size at maturity, and the maturity parameters were assumed.

Model fitting

A total negative log likelihood function was minimised using AD Model Builder™. The model was fitted to standardised CPUE indices estimated by season from the 1979–80 to 2003–04 fishing years. The model was also fitted to an additional seasonal catch rate index based on daily catch and effort data for the period 1963 to 1973 (Annala & King 1983) and a pre-recruit index series from the catch sampling. A lognormal error structure was assumed for abundance indices and a normal error structure for tag-recapture data and proportions-at-length.

The model was fitted to size data (proportions-at-length) taken from commercial pots. These data were available either from research sampling conducted on commercial vessels or from voluntary logbooks maintained by rock lobster fishers. Estimates of the seasonal size frequency were obtained by collating data that had been summarised by area/month strata and weighted by the commercial catch taken in each stratum, the number of lobsters measured and the number of days sampled. Size data from each source (research sampling or voluntary logbooks) were fitted separately. A fundamental assumption is that the size frequency data are representative of the commercial lobster catch. The size proportions within each season summed to one across all three sex categories: males, immature females, and mature females. This provides the model with seasonal estimates of the relative proportion by sex category in the catch.

Market sampling data were also used in the fitting procedure. These data are available only as carapace lengths from males and females, without maturity information. The carapace lengths were converted to tail width, and the model made predictions for the size classes beginning at one size class above the MLS.

A summary of the data used in each assessment, the data sources and the applicable years is provided in Table 13. For this assessment it was observed that few tag-recapture data involved larger lobsters. Data from the adjoining areas CRA 2 and CRA 4 were examined: CRA 2 data gave substantially different (higher) growth estimates; data from CRA 4 were too sparse to be useful. Data from CRA 5 gave similar growth estimates when we restricted the size range of data to that seen in CRA 3, so we added half the available CRA 5 tag-recapture data (selected randomly) to the CRA 3 data.

Table 13. Data types and sources for the 2004 assessment for CRA 3. Year codes apply to the first 9 months of each fishing year, *viz* 1998–99 is called 1998. MFish - NZ Ministry of Fisheries; RLIC – Rock Lobster Industry Council.

Data type	Data source	Begin year	End year
Historical catch rate	Annala & King (1983)	1963	1973
CPUE	FSU & CELR	1979	2003
Pre-recruit index	MFish and RLIC	1993	2003
Historical proportions-at-size	Various	1961	1983
Observer proportions-at-size	MFish	1986	2003
Logbook proportions-at-size	RLIC	1993	2001
Tag recovery data	RLIC & MFish	1974	2003
Historical MLS regulations	Annala (1983), MFish	1945	2003
Escape gap regulation changes	Annala (1983), MFish	1945	2003

The parameters estimated and the priors used are provided in Table 14. Fixed parameters and their values are given in Table 15.

CPUE, the historical catch rate, pre-recruit data, the proportions-at-length and tagging data were weighted directly by a relative weighting factor, and the assessment attempted to obtain standard deviations of standardised residuals for each data set that were close to one.

Table 14. Parameters estimated and priors used in basecase assessments for CRA 3. Prior type abbreviations: U– uniform; N – normal; L – lognormal.

	Prior Type	Lower bounds	Upper bound	Mean	CV
Log R_0 (ln mean recruitment)	U	1	25	–	–
M (natural mortality)	L	0.01	0.35	0.12	0.1
Recruitment deviations	N [1]	-2.3	2.3	0	0.4
LogqI	U	-25	0	–	–
LogqCR	U	-25	2	–	–
LogqPRI	U	-25	0	–	–
Increment at TW=50 (male & female)	U	1	20	–	–
Difference between increments at TW=80, TW=50	U	0.001	30	–	–
CV of growth increment (male & female)	U	0.01	5	–	–
Shape of length-growth increment relation	U	0.1	10	–	–
Relative sex/season vulnerability: [2]	U	0	1	–	–
Shape of ascending limb of vulnerability ogive	U	1	50	–	–

[1] Normal in logspace = lognormal (bounds equivalent to – 10 to 10).
[2] Relative vulnerability of immature females in autumn-winter was fixed at one.

Table 15. Fixed values used in basecase assessment for CRA3.

Quantity	CRA 3
Log of common component of error	-0.809
TW at 50% probability female maturity	45.7
(TW at 95% probability female maturity) – (TW at 50% probability female maturity)[2]	5.86
Shape parameter for biomass-CPUE relation	1
Minimum std dev of growth increment	1
Std dev of observation error of increment	0.5
Size at max selectivity before 1993, males	52
Size at max selectivity before 1993, females	56
Size at max selectivity after 1993, males	52
Size at max selectivity before 1993, females	60
Shape of descending limb of vulnerability ogive	50
Std dev of historical catch per day	0.30
Std dev of pre-recruit index	0.30
Maximum exploitation rate per season	95%
Handling mortality	10%
Process error for CPUE	0.25
Process error for historical catch rate	0.3
Process error for pre-recruit index	0.3
Year of selectivity change	1993
Current male size limit (AW) 54 in SS	52
Current female size limit	60
First year for recruitment deviations	1945
Last year for recruitment deviations	2000
Relative weight for length frequencies	7
Relative weight for CPUE	1
Relative weight for CR	0.5
Relative weight for PRI	0..45
Relative weight for tag-recapture data	0.4
Projected SL catch (t)	226
Projected NSL catch (t)	110
Percentage stock in marine reserve	10%

Model projections

Bayesian estimation procedures were used to estimate uncertainty in model estimates of current biomass, and in future projections. This procedure was conducted in the following steps:

a) Model parameters were estimated by AD Model Builder™ using maximum likelihood and the prior probabilities. These point estimates represent the mode of the joint posterior distributions of the parameters, and are called the MPD estimates;

b) Samples from the joint posterior distribution of parameters were generated using a Markov chain – Monte Carlo procedure (MCMC) and the Hastings-Metropolis algorithm;

c) For each sample of the posterior, 3-year projections (encompassing the 2004–05 to 2007–08 fishing years) were generated by assuming the catches indicated in Table 16. Future annual recruitment was randomly sampled with replacement from the model's estimated recruitments from the period 1991–2000;

d) A marginal posterior distribution was found for each quantity of interest by integrating the product of the likelihood and the priors over all model parameters; the posterior distribution was described by the mean, median, and 5th and 95th percentiles.

Table 16. Catches (t) used in the 3-year projections. Projected catches are based on the currently unshelved part of the TACC and the current estimates of recreational, customary and illegal catches. The four tonnes of "reported illegal" catches are subtracted from the 210 t of legal commercial catch. Total projection catches are 226 t of size-limited catch and 110 t of catch taken without reference to the size limit or berried female regulations.

Population Modelled	Commercial	Recreational	Reported illegal	Unreported illegal	Customary
CRA 3	210	20	4	85	20

Performance indicators

The assessment used several performance indicators based on biomass, all using the mid-season biomass (after removal of half the catch) legally available and vulnerable to the fishery (e.g. above MLS and non-berried females) in the autumn-winter season (index biomass). The stock was estimated to be at its lowest level in 1992, so the minimum biomass indicator, Bmin, is taken from the autumn-winter season of 1992. Current biomass, Bcurr, is taken from the autumn-winter season of 2004. Projected biomass, Bproj, is taken from the autumn-winter season of 2007.

The mean biomass in the autumn-winter period between 1974–79 was used as a reference level for the2000 and 2001 CRA 3 stock assessments. This period was selected for a reference level because it was a period with a demonstrable degree of productivity and apparent safety. The choice of this reference period is perforce arbitrary and open to debate. In 2004, the fishing industry in CRA 3 collectively agreed on a target CPUE for the fishery of 0.75 kg/potlift. This level was selected because it represented a desirable and economically sustainable catch rate for the fishery. The CRA 3 fishing industry, recognising that current catch rates were below this reference level, has organised the shelving of ACE in 2004–05 to a level of 210 t to begin a rebuild of biomass and consequently of catch rates to this higher level.

For this assessment a new reference biomass (B_{ref}) is defined: the biomass associated with a CPUE of 0.75 kg/potlift. This catch rate represents a higher biomass level than the previously agreed reference biomass level associated with the period 1974–79. The WG accepted this new reference level as an appropriate current target for the fishery, and noted the lower associated risks inherent in this choice of target catch rate compared to the previous reference biomass level. The mean biomass in the 1974-79 period would equate to an equivalent mean CPUE of about 0.57 kg/potlift. Both reference biomass levels were calculated from the model biomass estimates and the model parameter estimate of the CPUE q.

Four exploitation rate indicators are the recent (autumn-winter 2003) and projected (autumn-winter

2006) exploitation rates on the legal (USL) and sublegal (UNSL) sectors of the population. The final indicator is the percentage of runs for which the index biomass decreased in the 3-year projections.

Stock assessment results - *Jasus edwardsii*, CRA 3

The base case assessment for CRA 3 was obtained by trying to obtain standard deviations of normalised residuals (sdnr) from all data sets that were close to 1 by adjusting the relative weights for each data set, while at the same time obtaining an MPD estimate of *M* that was not near its upper bound of 0.35 and obtaining a reasonable fit to the recent CPUE. The base case defined by Tables 14 and 15 was accepted after examining approximately 200 candidate runs.

Base case results suggested that the index biomass decreased to its nadir in 1992, then increased strongly to a peak in 1996 to 1998, then declined after 1998. Exploitation rate peaked (at the model's upper bound) in the spring-summer seasons of 1984 through 1986 and in 1991. Recent exploitation rates are near 60% for the catch limited by size limit and berried female restrictions in both seasons.

A series of sensitivity trials on the MPD estimates showed that results were most sensitive to the proportion-at-age data and tag-recapture data sets and much less sensitive to the abundance indices. MPD sensitivity trials that explored the effects of some modelling choices suggested that the results were generally robust to these choices.

Four MCMC sensitivity trials were made. For the "domed" trial, the parameter value for the variance of the right hand limb of the selectivity curve (SelectVR) was fixed at 20 (base case 50) based on a run in which it was estimated, and the size at maximum selectivity (SelectMax) for males at 49 (base case 52). This trial allowed a low selectivity for larger fish, and thus allowed the model to create a cryptic population. For the "free M" trial, the prior on M was altered to have a c.v. of 0.3 (base case 0.1) and the upper bound was increased to 0.50 (base case 0.35). This trial relaxes the prior belief that *M* is low. For the "fixed growth" trial, the model was not fitted to the tag-recapture data simultaneously with the other data sets. Rather, growth parameters were estimated from model fits to tag-recapture data only, and then fixed. The "fixed growth CRA 3" trial was similar but used growth parameters obtained from model fits to the CRA 3 tag-recapture data only.

These trials produced very similar estimates of the index biomass for the periods for which there are data while there were some differences among these trials in estimates of early population size and projected population performance.

A retrospective trial using data up to 2001 showed a large difference in the model estimate of biomass in 2001 from the basecase estimate. This difference is explained by the continuing decline in CPUE since 2001.

The assessment results (Table 17) are based on the posterior distributions of indicators. These were obtained from the MCMC simulations – a single chain of 15 million was made and 7505 samples were taken. They suggest that the index biomass is currently about twice Bmin (0.05 and 0.95 quantiles were 57% to 63% higher than Bmin) and 40% less than Bref (23% to 53% less). At the 2003–04 level of catches and using historical recruitments sampled from 1991–2000, the median expectation is that biomass will increase by about 19% over three years, but with considerable uncertainty (40% to 281% of current biomass). The index biomass increased in 59% of projections over 3 years. A sensitivity trial using future recruitment sampled from the model's estimated recruitments from 1959–2000 showed biomass increases in 48% of projections.

The projections rely on an assumption that recruitment would be similar, on average, to that in the 1991–2000 period and with variability as seen in those ten years.

Table 17. Summary statistics for performance indicators from posterior distributions from CRA 3. Biomass indicators are shown

in t.

	0.05	median	average	0.95
$UNSL_{AW,03}$	8.90%	10.00%	10.00%	11.10%
$USL_{AW,03}$	45.70%	51.20%	51.30%	57.10%
$UNSL_{AW,06}$	4.30%	8.10%	9.20%	17.50%
$USL_{AW,06}$	18.80%	41.50%	49.50%	98.90%
Bmin	90	98	98	106
Bref	312	329	330	348
Bcurr	154	199	202	257
Bproj	70	237	280	620
Bcurr/Bmin	156.9%	203.3%	206.3%	262.9%
Bcurr/Bref	47.3%	60.3%	61.1%	77.1%
Bproj/Bcurr	39.9%	118.9%	134.6%	281.2%
Bproj/Bmin	72.4%	243.5%	286.4%	636.8%
Bproj/Bref	21.4%	72.0%	84.8%	187.6%
%decrease		41.2%		

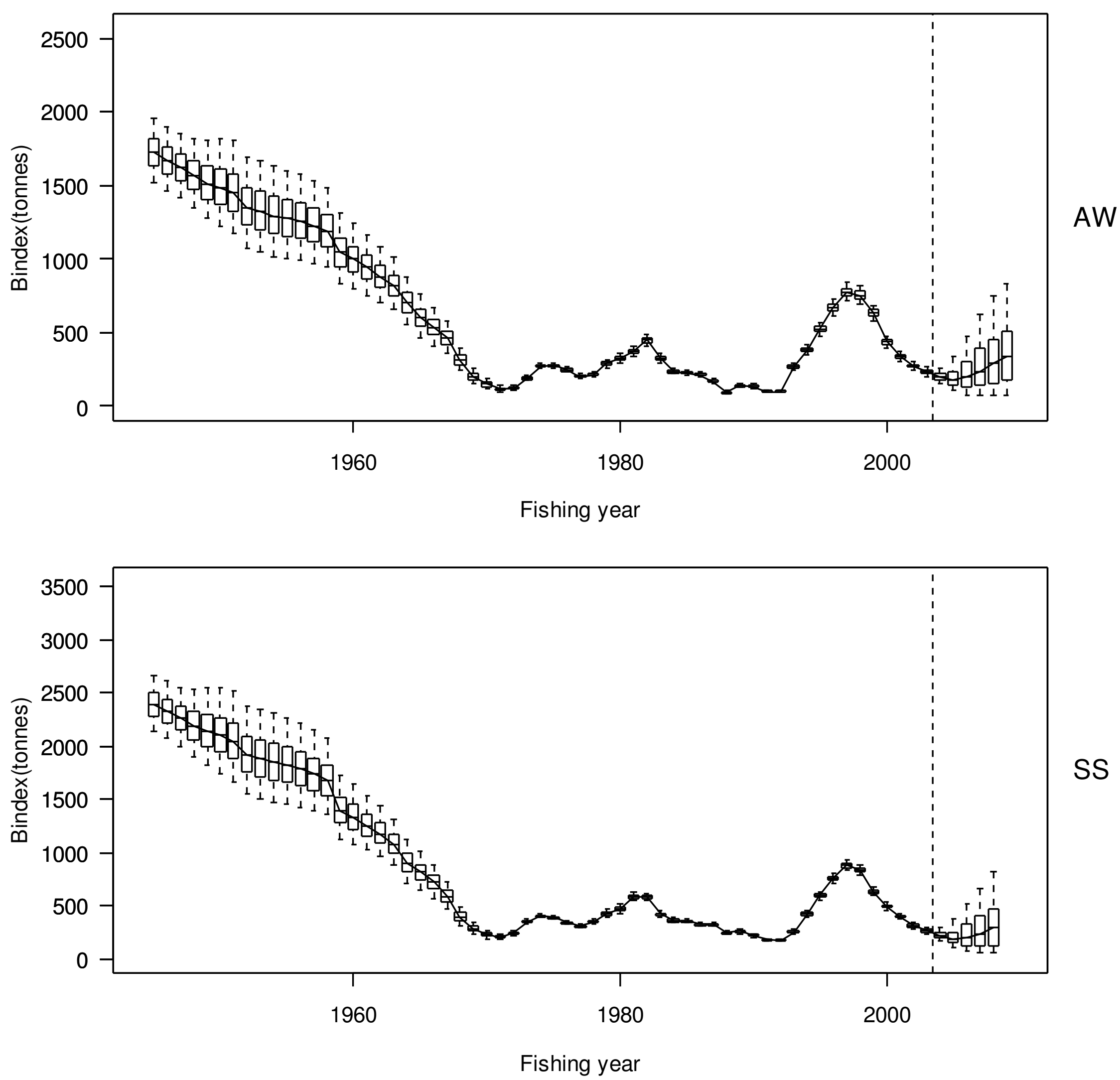


Figure 8. Posterior trajectories of vulnerable biomass, for the AW (top) and SS (bottom) seasons, from the CRA 3 base case MCMC simulations. For each year the horizontal line represents the median, the box spans the 25th and 75th percentiles and the dashed whiskers span the 5th and 95th percentiles.

YIELD ESTIMATES

Estimation of Maximum Constant Yield (MCY)

***Jasus edwardsii*, all stocks**

MCY was not estimated.

***Sagmariasus verreauxi*, PHC stock**

MCY was estimated using the equation $MCY = cY_{av}$ (Method 4). Mean annual landings for 1979–96 were 20.0 t. The best estimate of M is 0.1, so the value of c was set at 0.9.

$$MCY = cY_{av} = 0.9 * 20 = 18 \text{ t}$$

It is not possible to assess the level of risk to the stock of harvesting the population at the estimated MCY value.

Estimation of Current Annual Yield (CAY)

***Jasus edwardsii*, all stocks**

CAY was not estimated for any stock.

***Sagmariasus verreauxi*, PHC stock**

CAY was not estimated because no biomass estimates are available for this stock.

STATUS OF THE STOCKS

***Jasus edwardsii*, NSN substock**

CRA 1

The stock assessment of CRA 1 was not updated in 2004. The 2002 model results suggest that 2001–02 stock abundance was higher than in the 1979–88 reference period, with low exploitation rates under levels of catch used in the assessment. Those levels of catch appear to be sustainable, because model projections at the end of the 5-year projection period have a median expected biomass near the 2001–02 biomass.

However, the projections showed increasing uncertainty on an annual basis and should not be considered reliable much beyond two to three years. Because the projections are made under the assumption of constant catches fixed at levels used in the assessment (commercial 129.2 t, amateur 47.2 t; customary 10 t; unreported illegal 72 t.), an increase in future catch levels would result in an increased probability of a decrease in biomass.

Model results seemed robust to the range of assumptions examined in the sensitivity trials, and also showed good retrospective performance. In particular, the effect of assuming a higher non-commercial catch history in the model resulted in similar current and projected stock status.

CRA 2

The stock assessment of CRA 2 was not updated in 2004. The 2002 model results suggested that 2001–02 stock abundance was higher than in the 1979–88 reference period, with exploitation rates of 20–25% in each season under catch levels used in the assessment. Model results seemed robust to the range of assumptions examined in the sensitivity trials. In particular, the effect of assuming a higher non-commercial catch history in the model resulted in similar current and projected stock status.

The 2001–02 levels of catch as used in the assessment (commercial 225 t, amateur 122.6 t, customary 10 t, illegal 88 t.) appeared to be sustainable, because model projections at the end of the 5-year projection period have a median expected biomass near the 2001–02 biomass. However, in this stock, the projections should be considered less reliable than for CRA 1, as the uncertainty of future recruitment has more impact short-term on projected biomass. Because the projections were made under the assumption of constant catches fixed at the levels used in the assessment, an increase in future catch levels would result in an increased probability of a decrease in biomass.

***Jasus edwardsii*, NSC substock**

CRA 3

The stock assessment of CRA 3 was updated in 2004 with a revised length-based model. The assessment suggests a stock that increased sharply from 1992 to 1998 and then decreased. The 2004 index biomass is about 60% of the biomass corresponding to a reference catch rate of 0.75 kg/pot lift. CPUE rose steadily from 1993, peaked in the 1997–98 season and has declined since.

The projections assume current levels of non-commercial catch and 210 tonnes of commercial catch in the next 3 years. The current TACC is 327 tonnes but The CRA 3 fishing industry have agreed to shelve down to 210 t for 2004–05.

The base case assessment showed a median expectation that the stock would increase by 20% in three years at these levels, but the 5th and 95th percentiles of future stock level were 40% and 280% of the 2004 level, so the stock could increase or decrease, given the recruitment assumptions made for the projections. Uncertainty in the projections comes from several sources, particularly given that levels of recreational, illegal and traditional catches are poorly determined. These catches, especially historical illegal catches, may have been substantial in some years and errors in estimation translate directly into uncertainty in the projections. Further, these non-commercial catches could change, with unpredictable effects on the stock.

The projections rely on an assumption about future recruitment (at 32 mm TW in the model) – it was assumed that recruitment would be similar, on average, to that in the period 1991–2000 with variability as seen in those ten years. However, recruitment in these ten years is not necessarily a good basis for prediction of future recruitment.

The settlement data for NSC to the end of 2002 show that there was a strong settlement pulse in the early 1990s, followed by lower settlement up to 1999. From 2000 there has been a recovery in settlement levels, with 2001–03 near the long-term average.

CRA 4

The stock assessment of CRA 4 was updated in 2003. The 2003 model results suggest that 2002–03 stock abundance was higher than in the 1979–88 reference period. Exploitation rate peaked in the late 1980s to early 1990s at the model's maximum of 90% for the spring-summer fishery, and recent exploitation rate is near 60% for the catch limited by size limit and berried female restrictions in the autumn-winter under the 2002–03 levels of catch assumed in the model. Those levels of catch would produce a median 30% reduction in model biomass over five years to a level slightly below reference levels. Projections are sensitive to the assumed level of non-commercial catch.

These projections show increasing uncertainty on an annual basis and should not be considered reliable much beyond two to three years. Because the projections are made under the assumption of constant catches fixed at 2002–03 levels used in the assessment, an increase in future catch levels would result in an increased probability of a decrease in biomass and likely lower future biomass.

Model results seem robust to the range of assumptions examined in the sensitivity trials, and also show reasonable retrospective performance. In particular, the effect of alternative higher non-commercial catch histories in the model resulted in similar current stock status, but more pessimistic projections.

CRA 5

The stock assessment of CRA 5 was updated in 2003. The 2003 model results suggest that 2002–03 vulnerable biomass is higher than in the 1979–88 reference period, with moderate exploitation rates under levels of catch used in the model. With the 2002-03 assumed levels of catch, model projections at the end of the 5-year projection period show a median biomass smaller than the 2002–03 biomass, but still well above the reference levels. The 2002–03 vulnerable biomass is estimated to be greater than at any time in the last 20 years and the decrease is expected to be modest.

These projections show increasing uncertainty on an annual basis and should not be considered reliable beyond two to three years. Because the projections are made under the assumption of constant catches fixed at 2002–03 levels, an increase in future catch levels would result in an increased probability of a decrease in biomass and likely lower future biomass.

Model results seem robust to the range of assumptions examined in the sensitivity trials, and also show reasonable retrospective performance. The effect of higher alternative non-commercial catch histories in the model resulted in similar current stock status but quite different projected stock status.

***Jasus edwardsii*, NSS substock**

There was no new assessment of the NSS stock in 2004. However, a revised management procedure was accepted by the Minister of Fisheries in July 2002 and was adjusted in October 2003 to accommodate biases in the CPUE series used to evaluate the procedure. This procedure is used to determine any annual changes to the existing TACC (see Section 4 above). The outcome of the management procedure was a 5.4% increase in the 2004–05 TACs for CRA 7 and CRA 8.

***Jasus edwardsii*, CHI stock**

The stock assessment for this substock has not been updated since 1996. The status of this stock is uncertain. Catches have been less than the TACC since 1990 and CPUE showed a declining trend from 1979/1980 to 1997/1998 but has remained stable since. These observations suggest a declining standing stock which may now have stabilised. However, size frequency distributions in the lobster catch have not changed, with a continuing high frequency of large lobsters. Large lobsters would have been expected to disappear from a stock declining under fishing pressure. This apparent discrepancy could be caused by immigration of large lobsters into the area being fished. The models investigated assume a constant level of annual productivity which is independent of the standing stock.

Commercial removals in the 2003–04 fishing year (286 t) were below the range of estimates for *MSY* (300–380 t), and were 15% less than the previous year's landings. The current TAC (370 t) lies within the range of the estimated *MSY*.

***Sagmariasus verreauxi*, PHC stock**

The status of this stock is unknown.

Summary of yield estimates (t), TACCs and TACs (t), and reported 2003-04 commercial landings. The yield estimates for CRA 6 are the range of yield estimates from a simple production model. (–, not available).

Fishstock	QMA	Yield estimate	2003–04 TACC	2003–04 Commercial landings	2004–05 TACC	2004–05 TAC
CRA 1	Northland	–	131.1	128.7	131.1	
CRA 2	Bay of Plenty	–	236.1	195.8	236.1	452.6
CRA 3	Gisborne	–	327.0	215.7	327.0	453.0
CRA 4	Wairarapa–Hawke's Bay	–	577.0	574.5	577.0	771.0
CRA 5	Canterbury–Marlborough	–	350.0	349.9	350.0	467.0
CRA 6	Chatham Islands	300–380	360.0	285.8	360.0	370.0
CRA 7	Otago	–	89.0	81.4	94.9	114.9
CRA 8	Southern	–	568.0	566.8	603.4	690.4
CRA 9	Westland–Taranaki	–	47.0	45.9	47.0	
CRA 10	Kermadec	–	0.1	0.0	0.1	
Total			2685.3	2444.6	2726.6	
PHC 1	All QMAs	18	40.3		40.3	

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