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Jeremy M. Lyle and Alastair J. Morton

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Enquires should be directed to the series editor:
Dr Alan Jordan
Tasmanian Aquaculture and Fisheries Institute,
Marine Research Laboratories,
University of Tasmania
Private Bag 49, Hobart, Tasmania 7001

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J.M. Lyle and A.J. Morton

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Executive Summary

Southern rock lobster (*Jasus edwardsii*) and abalone (blacklip - *Haliotis rubra*, and greenlip - *H. laevigata*) are highly prized by recreational fishers in Tasmania. The numbers of rock lobster and abalone licences issued have increased each year since the introduction of the present recreational licensing system in 1995, with about 15,500 persons holding at least one rock lobster licence and 9,300 persons licensed for abalone during 2002/03. This represents increases of over 80% for lobster and 120% for abalone since 1995. Rock lobster are taken by a variety of methods, including lobster pots, lobster ring or hoop nets, and dive collection. Abalone are primarily harvested by divers.

The current study represents the fourth survey of the lobster fishery and the third for the abalone fishery undertaken since 1996. A random sample of licence holders was contacted by telephone in October 2002 and invited to participate in a diary survey in which fishing activity was monitored throughout the 2002/03 season (November 2002 – October 2003). Response to the diary survey was very high, with 97% (498 diarists) participating for the entire survey period.

Between November 2002 and August 2003, recreational fishers harvested an estimated 163,400 lobsters, based on 125,900 fisher days of effort. Potting was the dominant method and represented almost 80% of the lobster fishing days but only 62% of the estimated harvest. Dive collection accounted for about 18% of trips and 34% of the harvest, while ring usage contributed 2% of trips and 4% of the harvest. The overall average harvest rate for the season was 1.3 lobster per day, with harvest rates averaging 1.0 lobster per day for pots, 2.3 for dive collection, and 2.5 for rings.

Seasonally the lobster fishery exhibited three distinct phases; intense activity early in the season (November to January) that accounted for over 70% of the total harvest; a period of intermediate fishing activity (February to April) that contributed a further 25%; and finally, a phase of low activity (May to August) that accounted for less than 5% of the season's total.

The distribution of daily catches differed markedly between pot and dive methods, with almost half of all pot-days resulting in no retained catch compared with less than a third of the dive effort. The daily bag limit of five lobster was attained (or exceeded) in only a very small proportion of pot sets and contrasted the situation for divers who took at least five lobster in about one quarter of all dives.

On average, the weight of dive caught lobster were one third larger than pot caught individuals. Conversion of numbers to weights produced a total recreational harvest estimate of 148.5 tonnes for 2002/03, with catches from the south-east and east coasts accounting for 63%, the north coast 21% and the west coast 16% of the total harvest weight.

The size of the recreational lobster catch relative to the total allowable commercial catch (TACC) has been identified as a management performance indicator for rock lobster, with a trigger reached when the recreational catch equalled or exceeded 10% of the TACC. The recreational harvest represented 9.8% of the 2002/03 TACC of 1523 tonnes. Although there was statistical uncertainty surrounding this estimate (implying the true value could have been above or below the reference point), catch levels were now sufficiently close to the trigger limit to provide impetus for a review of management arrangements.

An estimated 133,700 abalone were harvested by recreational fishers between November 2002 and October 2003, based on 25,300 diver days of effort. About 64% of the total abalone harvest was taken between November and January, 30% between February and April, and 6% between May and October. In total, 40% of the catch was taken from the south-east coast, with catches from the east coast and north-west also significant.

Almost one quarter of all dives targeted at abalone resulted in no retained catch. By contrast, the daily bag limit of 10 abalone was achieved in about quarter of dives and the overall average daily harvest rate was 5.3 abalone.

The average, legal sized abalone was assumed to have a whole weight of 500 g, giving a recreational harvest estimate of 66.8 tonnes during 2002/03. The recreational harvest represented about 2.8% of the 2002 commercial catch of 2371 tonnes. There are currently no explicit performance indicators relating to the recreational fishery in the Abalone Management Plan.

Between 1996/97 and 2002/03 the recreational lobster and abalone catches have increased by around 80% and 150%, respectively, and as such highlight the need for on-going assessment to monitor future developments in the fisheries and to quantify impacts on stocks.

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1 Introduction

Rock lobster and abalone are highly prized by recreational fishers in Tasmania. Southern rock lobster (*Jasus edwardsii*) are taken by a variety of methods, including lobster pots, ring or hoop nets and dive collection. Two species of abalone, blacklip (*Haliotis rubra*) and greenlip (*H. laevigata*), are targeted by recreational divers, the former dominating the catch and the latter generally restricted to the north coast of Tasmania. In addition to recreational importance, rock lobster and abalone support major commercial fisheries in Tasmania, with both fisheries subject to quota management.

Recreational licences (first introduced in the late 1970s) are required to harvest rock lobster and abalone. The licences are method-based and prior to the mid 1990s comprised rock lobster pot and general dive licences, the latter permitted the capture of rock lobster, abalone, and scallops by diving. The licensing system was revised in 1995 and the general dive licence was split into rock lobster, abalone and scallop dive licences. In 1998, a ring net licence was also introduced, effectively closing a loophole in the legal take of rock lobster. Pot fishers are permitted to use one pot, ring net fishers up to four rings, and divers can use artificial breathing apparatus (scuba and surface air supply or hookah).

Licences are issued annually, with the licensing year extending from November to the end of the following October. Recreational fishers may hold up to three categories of rock lobster licence and/or abalone dive licences in a given fishing year[1]. In addition to licensing, minimum size limits, closed seasons, and a ban on the taking of females in berry apply to lobster. Minimum size limits apply for abalone. Recreational fishers are also subject to daily bag limits of five lobster and ten abalone and possession limits of ten lobster and twenty abalone.

Since the introduction of the present licensing system, the number of persons holding at least one recreational lobster licence has increased steadily from about 8500 to 15,500 in 2002/03, representing an overall increase of more than 80% since 1995 (Fig. 1). Increases have occurred in each of the licence categories, with about 12,300 pot, 6600 dive and 3200 ring net licences issued in 2002/03. Set against this trend was the introduction in 1998 of quota management for the commercial fishery, with objectives to reduce catches to sustainable levels and to allow for rebuilding of legal-sized biomass (Ford 2001). The total allowable commercial catch (TACC) was initially set at 1502 tonnes and effectively represented a reduction in catches which had averaged over 1700 tonnes per annum for the decade prior to 1998. The TACC was increased to 1523 tonnes in 2002.

Abalone dive licence numbers have increased by over 120% since 1995, with about 9300 issued in 2002/03 (Fig. 1). Between 1995 and 2002 the abalone TACC varied

[1] Note, the licensing system also includes net and scallop licence categories.

between 2100 – 2800 tonnes. The 2002 TACC was set at 2400 tonnes for blacklip and 140 tonnes for greenlip abalone.

The size of the recreational harvest has been identified as a management performance indicator for the rock lobster fishery. Specifically, if the recreational harvest exceeds 10% of the TACC in a year, recreational management arrangements will be reviewed (Anon. 1997). The recreational catch also represents an input into the stock assessment model developed to assess stock status and undertake risk assessments under different management scenarios (Punt & Kennedy 1997, Gardner *et al*. 2002). There are no specific management performance indicators relating to the recreational fishery for abalone.

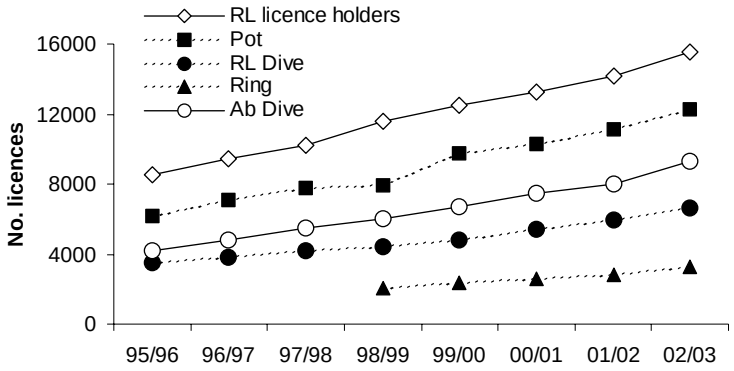

Fig. 1. Numbers of recreational rock lobster and abalone dive (Ab Dive) licences issued annually since 1995/96. RL licence holders refers to the number of persons holding at least one recreational lobster licence.

There have been few previous attempts to assess the size of the recreational lobster and abalone harvests in Tasmania. A household survey of home food production for the year ending April 1992, established that approximately 57 tonnes of rock lobster and 25 tonnes of abalone was 'home produced' in Tasmania (ABS 1994). More recently, a telephone survey of licensed fishers produced an estimated harvest of about 111,000 lobsters, approximately 5% of the commercial harvest by numbers, and 133,000 abalone, approximately 3% of the commercial harvest, for the 1995/96 fishing year (Lyle & Smith 1998). Although response rates were very high in these surveys, estimates were based on recalled information and thus subject to biases that tend to result in over-estimates of catch (Pollock *et al*. 1994).

The application of the telephone-diary survey method described by Lyle *et al*. (2002) largely addresses the recall bias issue and has proven robust in terms of response rates and quality and detail of information collected. This method has been applied in recreational fishing surveys in Tasmania (Lyle, 2000; Forward & Lyle, 2002) and elsewhere in Australia (Coleman 1998, Henry & Lyle 2003, McGlennon 1999, Venema *et al*. 2003). Lyle (2000) estimated that the 1996/97 and 1997/98 recreational lobster harvests[2] were about 90,000 and 70,000 lobsters, respectively. For these two seasons, the abalone harvest was estimated at 53,000 and 60,000 abalone, respectively. The 2000/01 national recreational fishing survey, which reported fishing activity for the period May 2000 to April 2001, produced harvest estimates of 87,000 lobster and 108,000 abalone for Tasmania (Henry & Lyle 2003). Forward & Lyle (2002) conducted a survey of the 2000/01 licensing season (November 2000 to August 2001) and produced a lobster harvest of about 128,000 lobster. The apparent discrepancies between the national survey and 2000/01 licensing season estimates are due to a combination factors. Firstly, the two surveys did not fully overlap in time and secondly, and importantly, the former was part of a general survey of recreational fishing and the latter a targeted survey of lobster licence-holders. As lobster fishing is a relatively specialised (rare) activity in the context of the overall recreational fishery, there was considerable uncertainty surrounding estimates. Such statistical uncertainty is reflected in the confidence interval surrounding estimates which, based on the upper 95% confidence limit for the national survey estimate (110,000 lobster) actually overlapped the lower confidence value (109,000 lobster) for the 2000/01 licensing season survey, implying that the differences in the two estimates were not statistically significant.

The objectives of the current survey were to provide a detailed assessment of the 2002/03 Tasmanian recreational rock lobster and abalone fishery in terms of participation, fishing effort and catch. Comparisons between commercial and recreational sectors based on catches were also examined.

[2] Note: these were part season surveys, conducted between December 1996 and April 1998.

2 Methods

2.1 Survey design

The survey design involved a two-stage process; an initial telephone interview to establish eligibility and collect profiling information and follow-up telephone-diary survey in which fishing activity was monitored in detail.

2.1.1 Survey sample

The survey sample was selected from the 2001/02 recreational licensing database administered by the Department of Primary Industries, Water and Environment. While the majority of licence holders in any licensing year are Tasmanian residents, a small number of interstate and overseas residents also take out licences. Commercial fishers are eligible to hold recreational licences, although restrictions controlling recreational gear and its use on commercial fishing trips apply. Persons under 10 years of age are not eligible for rock lobster or abalone licences.

All fishers with rock lobster and/or abalone licences were included in the 'population' of licence-holders. The database was then split into three strata based on licence(s) held; Stratum 1 - holders of at least a rock lobster dive licence (may or may not also possess pot, ring and/or abalone licences); Stratum 2 - all remaining rock lobster licence-holders (may or may not also possess an abalone licence); and Stratum 3 - abalone only licence holders.

A sample was randomly selected from each stratum, with higher sampling rates for strata 1 and 3, intended to improve precision in dive harvest estimates.

2.1.2 Screening survey

Respondents were contacted by telephone in October 2002 and asked to estimate the number of days fished during the 2001/02 fishing season for lobster and/or abalone (as appropriate) and the numbers of lobster and/or abalone that they personally caught and kept. In addition to providing a recall-based estimate of catch and effort, this information helped profile respondents according to previous fishing activity levels (avidity). Eligibility to participate in the diary survey was based on the respondent's intention to renew their lobster and/or abalone licences for the 2002/03 fishing season. Sampling was conducted without replacement, i.e. persons without a telephone listing or those who could not be contacted were not substituted in the sample.

2.1.3 Telephone-diary survey

All eligible respondents were invited to participate in the diary survey and those who accepted were mailed a 'memory jogger' diary. Diarists were contacted by telephone shortly afterwards to confirm receipt of the diary and to have reporting requirements

explained. Diarists were then contacted regularly by telephone throughout the diary period by survey interviewers who recorded details of any rock lobster and/or abalone fishing activity since last contact. The frequency of the contact was tailored to the needs and behaviour (fishing avidity) of individual respondents and detailed information was routinely collected soon after each fishing event, minimising recall bias problems for any non-diarised data. By maintaining regular contact, interviewers were also able to immediately clarify any misunderstandings or inconsistencies at the time of the interview, thereby ensuring overall data quality and completeness.

In practice, diarists were contacted at least once a month between November 2002 and May 2003, even if no fishing activity was planned. In June 2003, all diarists were contacted as usual and asked whether they anticipated any more fishing trips during the remainder of the season. Regular contact was maintained with those who expected to fish, whereas those not planning to fish again were not contacted again until September 2003 (after the closure of the rock lobster season) when details of any unexpected fishing activity was collected. Diarists who held abalone licences were contacted again in November 2003 to ensure that any late season abalone fishing activity was recorded. This approach to respondent management and data collection, by necessity, required highly trained and proficient interviewers, and this was achieved through careful interviewer recruitment, training and management.

Information recorded for each fishing 'event' included the date, fishing location; method used; target species for divers; start and finish times (including any significant breaks from fishing) and the numbers of rock lobster and/or abalone kept (harvested). In addition, the number of rock lobster released (or discarded) and reason(s) for release were recorded. Fishing locations were based on the eight areas used for rock lobster assessment reporting (Punt & Kennedy 1997) (Fig. 2).

By definition, a fishing event was described in terms of fishing region and method, if either changed on a given day a separate event was recorded. That is, for example, two separate events were recorded if a respondent used a pot and dived for rock lobster on the same day. Pots were generally fished overnight. In a small number of instances pots were not checked for several days, usually because of unfavourable weather conditions. The start of the fishing day was taken as the time the pot was set and the finish as the last time on a given day that it was checked or hauled. In cases where the pot was checked more than once in a day, the reported catch related to the total number of lobster taken that day. For the purposes of calculating effort, overnight sets were considered to represent a single pot-day of effort.

For rock lobster the diary enumeration period encompassed the 2002/03 fishing season (2 November 2002 to 31 August 2003) while for abalone the enumeration period was the licensing year (1 November 2002 to 31 October 2003).

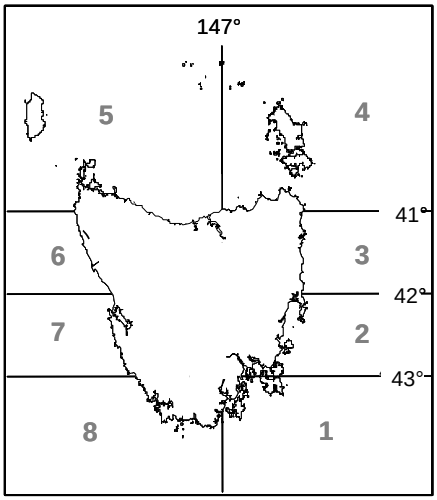

Fig. 2. Map of Tasmania showing fishing areas

2.1.4 Recall survey

An additional recall-based survey was conducted in October 2003 (the end of the recreational licensing year) with a separate sample of licence holders. Respondents were contacted by telephone and asked to estimate the number of days fished during the 2002/03 fishing season for lobster and/or abalone (as appropriate) and the numbers of lobster and/or abalone that they personally caught and kept. In this case the sample was drawn from the 2002/03 licence database, stratified and sampled in accordance with the procedures reported above for the screening survey selection. Licence holders previously selected for the screening survey were excluded from selection in the recall survey.

The recall survey sample included persons who had been licensed in 2001/02, as well as persons who had not held a licence in 2001/02 but had taken out a licence(s) for the 2002/03 season. This latter group had not been available for selection in screening and hence diary surveys.

2.2 Data analysis

2.2.1 Catch and effort

Although initial sample selection was based on the 2001/02 licence database, licence details for 2002/03 were used for data expansion. That is, the licensing status (licences held and dates of issue) for all diarists was established and expansion factors calculated as the size of the licensed population divided by the number of licensed diarists. A small number of diarists, by virtue of licences actually held in the diary survey period, changed strata for the purposes of data analysis. As initial sample selection was random these effects are not assumed to have introduced systematic biases.

Since the number of licensed fishers increased progressively during the year, the sample size (i.e. number of licensed diarists) and total number of licensed fishers changed within the diary enumeration period. About 59% of lobster and abalone licences were issued by the end of the first month (November) of the 2002/03 season, this proportion increased to 82% by the end of December and 92% by the end of January. Very few additional licences were issued after April. In order to account for this dynamic, the number of licence holders registered on the licence database and the number of licensed respondents at the end of each month provided the basis for calculating expansion factors that were applied to fishing activity for the given month.

The survey scope was confined to licensed recreational fishing activities; namely, the use of pots and rings to harvest lobster and dive methods to harvest lobster and/or abalone. Any fishing activity reported by diarists whilst unlicensed (either prior to renewing a licence or by diarists who did not renew licences) was excluded from the analyses. The base unit for catch and effort analysis was the total monthly effort and catch for each licensed respondent and this was expanded by the relevant monthly expansion factor.

An exception to this 'monthly' expansion approach was required for the recall survey data where only whole of season, rather than monthly, catch and effort data were available. In this instance a 'single' expansion, based on the overall sample fraction, was applied.

The 'bootstrap' method was used to estimate harvest and effort confidence limits, determined using the percentile method (Haddon 2001). In each instance 5000 simulations were conducted.

2.3 Size composition

Size composition information for recreationally caught lobsters was collected from on-site surveys conducted by TAFI staff at Orford, Triabunna and Tinderbox, over the opening weekend of the rock lobster season, and from information provided by a team of volunteer fishers (not diarists) located around the State. Fishing method, location, sex and carapace length (mm) were recorded.

Average weights were determined by converting lengths into weights using the following relationships:

$$W = 0.000285L^{3.114} \qquad \text{males}$$

$$W = 0.000271L^{3.135} \qquad \text{females}$$

where W is body weight (g), L is carapace length (mm) (Punt & Kennedy 1997).

2.4 Commercial catch and effort data

Commercial catch and effort data was obtained from compulsory catch returns provided by rock lobster and abalone fishers. Rock lobster data were reported on a daily basis by depth and by ½ degree fishing blocks. Catches were reported in terms of numbers and weights. Abalone divers reported daily catch weights taken by fishing block or sub-block. For regional comparisons between commercial and recreational catches, if commercial fishing blocks were bisected by recreational area boundaries (defined in Fig. 2), commercial catches within such blocks were apportioned equally between the two adjacent recreational areas.

3 Results

3.1 Response rates

3.1.1 Screening survey

From a random sample of 790 licence-holders selected from the 2001/02 database, 55 (7%) either had no telephone listing or the number was disconnected. This represented sample loss and reduced the effective sample size to 735. Contact was made with 667 licence-holders, of whom 658 fully responded, representing a screening survey response rate of almost 90%. Non-contacts (despite at least ten attempts by telephone over a period of several weeks) accounted for 9% of the sample and refusals just 1% (Fig. 3).

Amongst the respondents, 96 indicated that they were not likely to renew their licence(s) in 2002/03 and hence were not eligible for inclusion in the diary survey[3]. The balance (562) indicated they were likely to renew their licence(s) in 2002/03 and almost 92% (516) agreed to participate in the diary survey (Fig. 3).

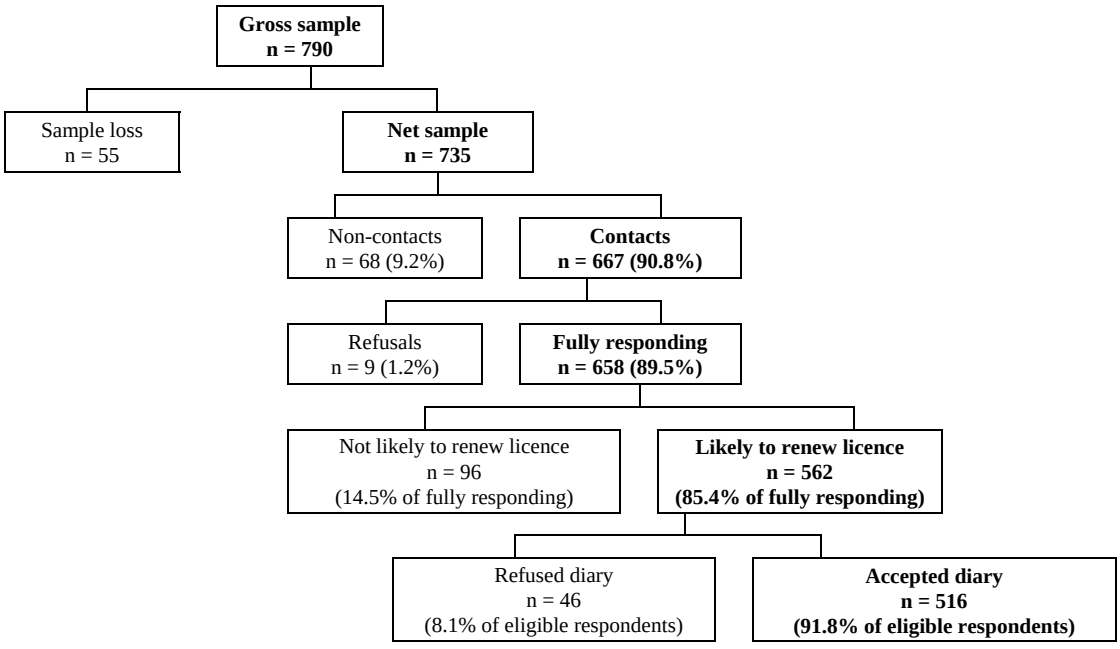

Fig. 3. Diagrammatic representation of the screening survey response profile (n is sample size).

[3] The licence status of these respondents was checked at the end of the 2002/03 season and 40 renewals were identified.

3.1.2 Telephone-diary survey

Diary response was high, with 498 diarists or almost 97% of respondents who accepted the diary participating for the entire survey period (Fig. 4). Respondents who went out of scope during the diary period (e.g. moved overseas or interstate with no intention to fish in Tasmania for the remainder of the 2002/03 season) were treated as fully responding only if complete information was collected up until the time they went out of scope. Based on the total number of eligible respondents identified in the screening survey (562), the effective response rate for the diary survey was 88.6%. Given such a high response rate, possible biases arising from non-response were not considered to be a significant problem in this study.

Data for the few diarists who partially responded (i.e. declined to participate for the full period or with whom contact was lost due to telephone disconnection) has been excluded from all analyses.

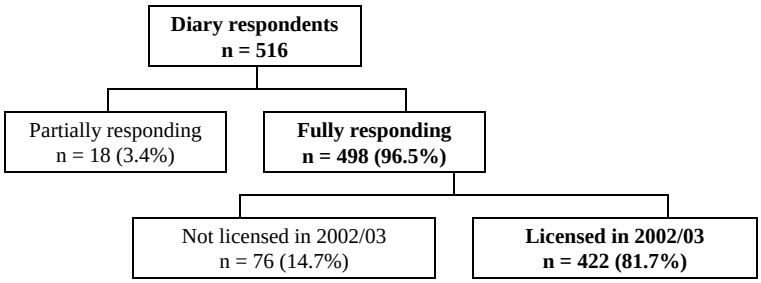

Fig. 4. Diagrammatic representation of the diary survey response profile (n is sample size).

Of the responding diarists, almost 15% did not take up a licence during the 2002/03 licensing year, despite rating themselves as 'highly' to 'very likely' to do so. Among the remaining 422 respondents, 400 held at least one category of lobster licence while 301 had abalone licences. The numbers of rock lobster and abalone licences in the licensed population and the sample of responding diarists are presented in Table 1 and indicate, as mentioned in Section 2.1.1, that dive licence holders were over sampled (through stratification). Overall, about one in 40 licence holders participated in the survey.

Table 1 Total number of 2002/03 lobster and abalone licence holders, numbers sampled (fully responding) and sample fraction by licence type.

Licence type	Licence holders	Diarists	% sampled
Rock lobster pot	12291	306	2.5
Rock lobster dive	6605	216	3.3
Rock lobster ring	3255	79	2.4
Abalone dive	9272	301	3.2
Total licences	31423	902	2.8
Total persons	16209	422	2.6

While all fishing activities for rock lobster and abalone by diary survey respondents were recorded, only those activities undertaken whilst in possession of the relevant recreational fishing licence were used in subsequent analyses. Overall, diary survey respondents reported a total of 3816 fishing events for the survey period, 3798 (99%) of which were within the scope of the survey. In total, respondents noted that details for 76% of the fishing events reported were recorded in their diaries.

3.1.3 Recall survey

A stratified random sample of 660 licence holders was selected from the 2002/03 licence database and when sample loss was discounted the net sample size was 626 (Fig. 5). In terms of non-response, non-contacts accounted for 7% and refusals a further 1%, producing an effective response rate of almost 92%, which was slightly higher than that achieved for the screening survey (refer Fig. 3).

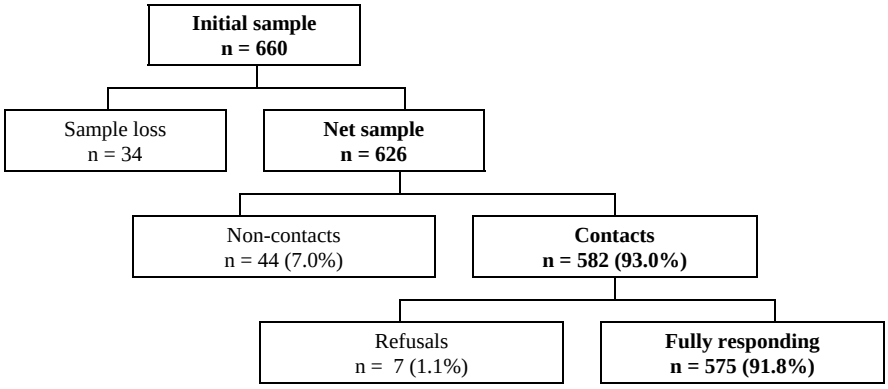

Fig. 5. Diagrammatic representation of the recall survey response profile (n is sample size).

3.2 Rock lobster

Information reported in this section relates to analyses of diary survey data provided by fully responding licence holders, and is presented as expanded estimates for the total population of recreational rock lobster licence holders in 2002/03.

3.2.1 State-wide catch and effort

During the 2002/03 fishing season an estimated 88.4% (SE 1.7%) of rock lobster licence holders (equivalent to 14,308 persons) fished for rock lobster. Estimates of total recreational effort (expressed in terms of fisher days) and harvest for the 2002/03 season are presented in Table 2. Overall, total fishing effort was estimated at 125,898

fisher days[4] for the season, yielding an estimated harvest of 163,454 lobsters, representing a mean seasonal harvest rate of 1.3 lobster per fisher day.

Lobster pots were the most popular fishing method (accounting for 62% of the total harvest) followed by dive collection (34%) and rings (4%) (Table 2). Estimated fishing effort by method indicated that over four times as many fisher days were spent using lobster pots (102,158 days) than diving (23,848 days), yielding a harvest (101,775 lobster) that was less than twice the size of the dive harvest (54,804). Lobster ring harvest and effort were low by comparison with the other methods. Mean daily harvest rates were over two times higher for dive (2.3 lobster) and ring (2.5 lobster) methods compared with pots (1.0 lobster).

Table 2. Rock lobster effort, harvest and harvest rates for the 2002/03 season
Values in parentheses represent the 95% confidence intervals

Method	Harvest (no.)	Effort (days)	Harvest rate (no. day^{-1})
Pot	101775 (82773 – 122967)	102158 (85557 – 120690)	1.0
Dive	54804 (43292 – 67746)	23848 (20221 – 27595)	2.3
Ring	6875 (2972 – 13168)	2758 (1147 – 4358)	2.5
Total	163454 (140394 – 188670)	125898 (109231 – 144312)	1.3

The relative contribution that individual licence-holders made to the total harvest can be represented by sorting on the basis of the number of lobster harvested by each fisher and then plotting the cumulative harvest (Fig. 6). It is apparent that the harvest was not spread evenly amongst fishers, such that a small number of fishers accounted for a disproportionately large share of the total harvest. For instance, 20% of licence-holders caught two thirds of the total harvest, while 25% of licence holders harvested no lobster for the season (inclusive of the 12% who did not fish, refer above). Overall half of all licence-holders accounted for about 94% of the total seasonal harvest.

[4] A fisher day is defined as a day in which lobster was a nominated target species and/or lobsters were caught.

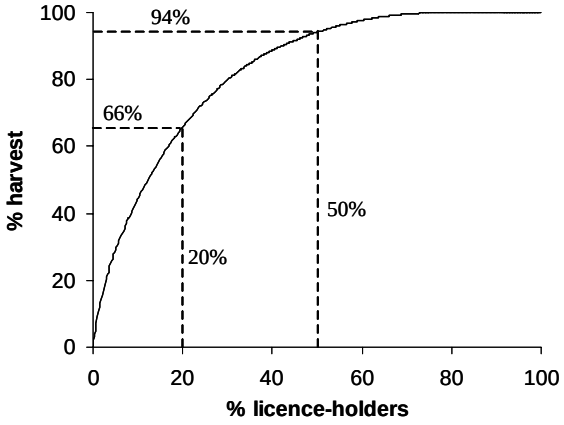

Fig. 6. Cumulative contribution to the total 2002/03 recreational lobster harvest by holders of lobster licences. Dotted lines indicate the proportions of the total harvest taken by the top 20 and 50% of licence holders (ranked according to the size of their seasonal lobster catches).

3.2.2 Seasonal catch and effort

Monthly estimates of recreational effort and harvest indicated strong seasonality in the fishery, with three distinct phases of activity (Fig. 7): high effort and harvest early in the season (November to January) followed by intermediate (February to April), and then low levels (May to August). The initial period of intense fishing activity accounted for just over 70% of both effort and harvest, the following period of intermediate activity about 25% and the final phase less than 4%. Intense fishing activity corresponded with the opening of the season and the summer holiday period, with greatest effort and harvest during January. Overall, fishing activity slowed dramatically in February but there was a slight increase in activity in April corresponding with the Easter holiday period. There was relatively limited fishing during the final four months of the season, corresponding to closure of the fishery for female lobsters and the onset of cooler and unsettled weather.

The underlying pattern of catch and effort in the fishery was influenced strongly by monthly variation in pot fishing activity, with 75% of the effort and 80% of the pot catch taken between November and January and just 22% of the effort and 18% of the pot catch between February and April (Fig. 7). Dive catch and effort was more evenly distributed between November and April, with 60% of the effort and 58% of the catch taken in the first three months compared with 34% of the effort and 38% of the catch in the following three month period.

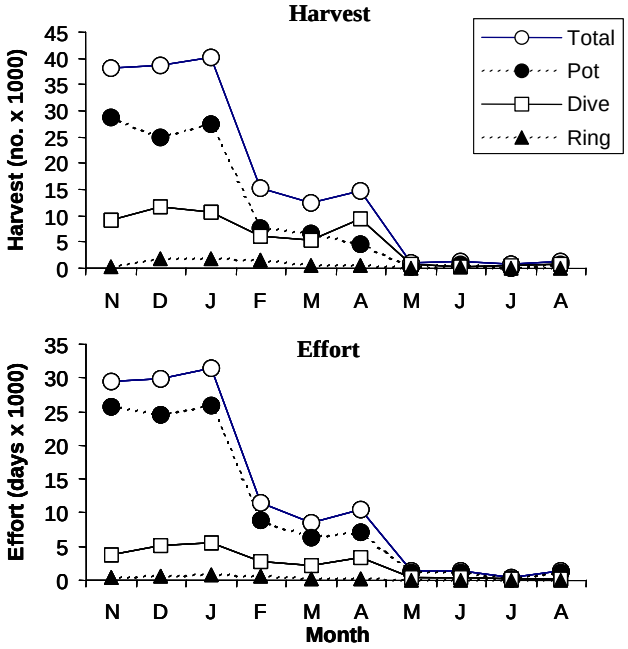

Fig. 7 Recreational rock lobster harvest (numbers) and effort (days fished) by month and method for the 2002/03 fishing season.

3.2.3 Regional catch and effort

Effort, catch and catch rates by fishing area (refer Fig. 2) are summarised in Table 3 and indicate that the fishery was centred primarily off the south-east (Area 1) and east (Areas 2 & 3) coasts. This combined region accounted for almost 70% of the total estimated lobster harvest (113,793 lobster) and attracted 77% of the total effort (96,637 fisher days) during 2002/03. Area 1 alone contributed 31% of the total harvest.

The north coast (Areas 4 & 5) accounted 14% of the total harvest (22,412 lobster) and 10% of total effort (13,073 fisher days) while the west coast (Areas 6,7 & 8) contributed 17% of the total harvest (27,248 lobster) and 13% of total effort (16,289 fisher days).

Table 3. Recreational rock lobster effort, harvest and harvest rates by fishing area for 2002/03
Values in parentheses represent the 95% confidence intervals

Area	Harvest (no.)	Effort (fisher-days)	Harvest rate (no. per fisher-day)
1	50883	42146	1.21
	(35250 – 69329)	(30885 – 55416)	
2	35547	28201	1.26
	(24271 – 47518)	(18924 – 38958)	
3	27364	26290	1.04
	(17507 – 39554)	(17621 – 36435)	
4	9996	7260	1.38
	(5155 – 16108)	(4039 – 11,080)	
5	12416	5813	2.14
	(6658 – 19384)	(3605 - 8548)	
6	13201	5780	2.28
	(6413 – 21484)	(2810 - 9610)	
7	6682	2529	2.64
	(2451 – 12101)	(1046 - 4249)	
8	7365	7980	0.93
	(3415 – 12155)	(3280 – 14741)	

Marked regional differences were evident in the proportion of rock lobster harvested by the various methods (Fig. 8). Lobster pots accounted for the bulk of the harvest from the south-east and east coasts whereas dive collection was the primary capture method off the north coast. All three methods were of significance in the fishery off the west coast. In Area 1, 59% of the harvest was taken by lobster pots with divers accounting for the vast majority of the balance. Pots accounted for 74% and 91% of the harvest in Areas 2 and 3, respectively, with the remainder taken by divers. By contrast, dive collection accounted for 68% and 80% of the harvest in Areas 4 and 5, respectively. Off the west coast, pots contributed between 32% (Area 7) and 75% (Area 8), dive collection 13% (Area 7) and 28% (Area 6) and lobster rings 5% (Area 8) and 54% (Area 7) of harvest depending on assessment area.

Mean daily harvest rates were highly variable around the State, ranging from over two lobster per day off the north-west (Area 5) and west (Areas 6 & 7) coasts to less than one lobster per day off the south-west (Area 8). Harvest rates for the south-east (Area 1), east (Areas 2 & 3) and north-east (Area 4) coasts were intermediate (Table 3). Stock abundance and total fishing pressure (including commercial activity), along with the relative mix of fishing methods used, noting significantly higher harvest rates for dive collection and rings compared with pots (Table 2), were factors that contributed to the regional variability observed in harvest rates.

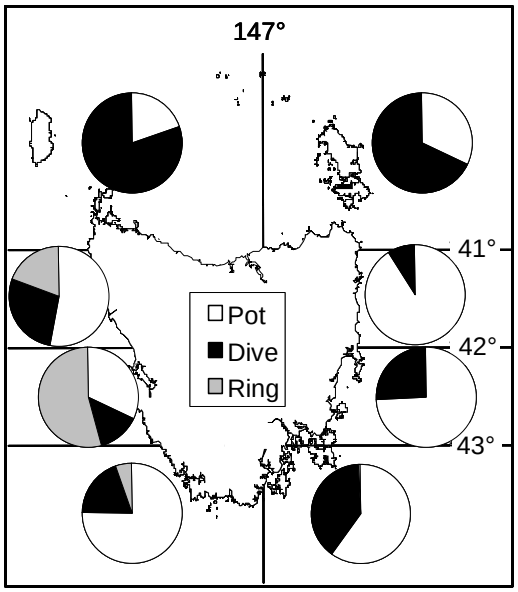

Fig. 8. Proportion of regional harvest by fishing method.

3.2.4 Daily harvest

Daily catch distributions differed markedly by fishing method (Fig. 9). Overall 47% of all pot-days yielded no retained catch compared with 39% for ring effort and 24% for dive effort. The daily bag limit of five lobster was rarely achieved (or exceeded) by pot fishers (< 3% of all fishing days) whereas as divers and fishers using rings took the bag limit on 25% and 20% of the days fished. A consequence of the vastly different success rates based on method was that pot catch rates (mean 1.0 lobster per day) were substantially lower than for rings (2.5 lobster) and dive collection (2.3 lobster).

Dive effort, which can be split into snorkel, scuba or hookah methods, revealed a strong method effect on catch rates (Fig. 9). Overall, average daily harvest rates were highest for hookah (3.0 lobster) followed by scuba (1.8 lobster) and snorkel (1.0 lobster). The bag limit was attained in 35% of hookah effort, compared with 17% of scuba and 11% of the snorkel effort. Overall, hookah proved the most popular dive method for lobster, accounting for 51% of the total dive effort and 67% of the harvest. Scuba was next in importance, representing 33% of the effort and 27% of the harvest while snorkel contributed 15% of the effort but just 6% of the dive harvest.

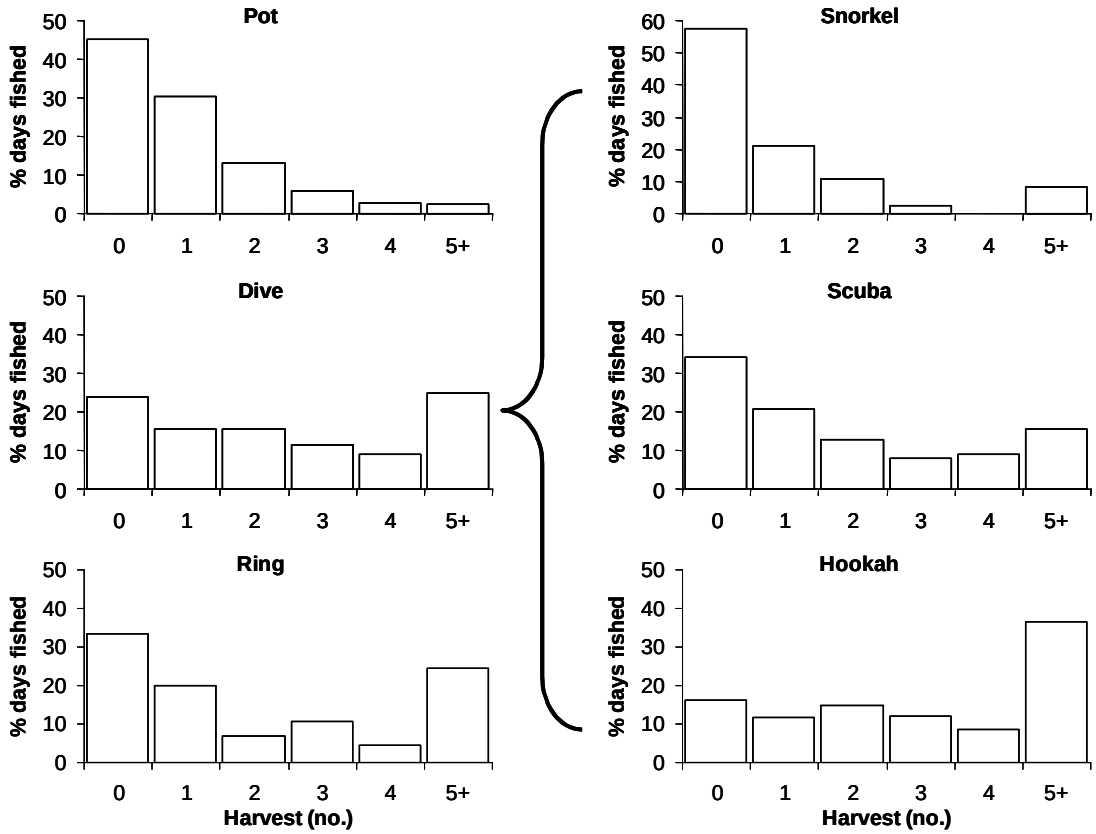

Fig. 9. Distribution of daily lobster harvest by fishing method for 2002/03 licence holders.

3.2.5 Released catch

In total, an estimated 152,971 lobsters (95% confidence interval [CI]: 135,846 – 185,598) were estimated to have been released or discarded during 2002/03, equivalent to 0.9 lobster for every individual retained. Not unexpectedly, pots accounted for the majority of releases, the method involving passive collection as opposed to active selection of individual lobsters by divers. During the fishing year an estimated 110,831 lobster (95% CI: 88,305 – 123,691) were released or discarded from pots. That is, for every retained pot-caught lobster, 1.1 lobster were released or discarded. The seasonal pattern of lobster releases from pots (Fig. 10) indicated that highest quantities of lobsters were released early in the season when effort was high. The ratio of released to retained lobster tended to fluctuate around 1.0 (range 0.8 – 1.5) up to April after which it increased and remained above 1.2 (Fig. 10). The increased ratio of released lobster from May onwards was influenced largely by the closure of the fishery to the taking of females (see below).

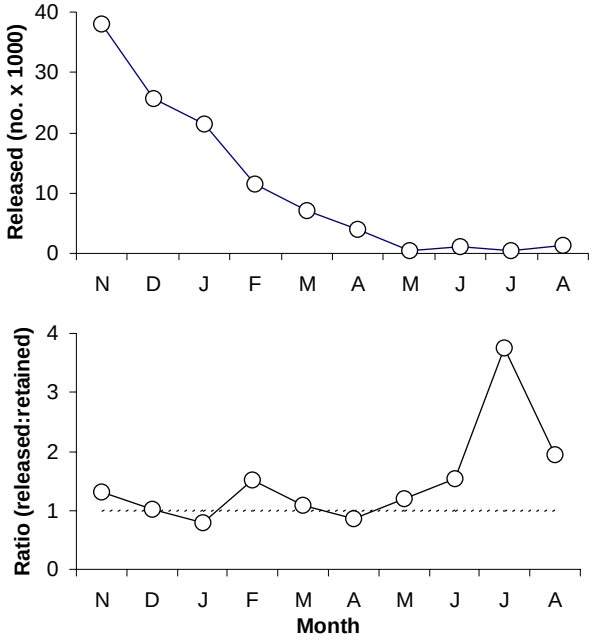

Fig. 10. Numbers of rock lobster released (top) and ratio of released to retained catch (bottom) by month for recreational pot fishing during the 2002/03 season. The dashed line represents a ratio of 1.0 (i.e. one lobster released for each lobster retained).

About 91% of pot releases were reported to be due to undersized lobsters, about 6% were berried females and 2% because lobsters were dead or damaged. Just under 1% of all released lobster were as a result of over bag limit catches. Between November and April, 93% of the pot releases were reported as being under the legal minimum size, 4% were berried females and 2% were discarded because they were dead or damaged. In the latter part of the season, May to August, berried females and the closure of the fishery to females (effectively the same thing) were the most significant reasons for release, representing 47% of all released lobsters. Most of the balance (41%) was due to undersized individuals. Although divers may release lobsters, i.e. the catch is landed and then sorted, most of this sorting occurs underwater and therefore a similar analysis of reasons for release by divers has not been attempted.

3.2.6 Size composition

Lengths were collected for 491 dive and 251 pot caught lobster from the south-east and east coasts of Tasmania (Fig. 11). Two-way analysis of variance of carapace length against sex, method, and sex × method demonstrated highly significant (P<0.001) method and sex effects and a significant sex × method interaction (P=0.002). Dive caught lobster were significantly larger than pot caught lobster, averaging 124 mm and 114 mm respectively, with males larger than females. The estimated average weight for dive caught lobster was 1006 g, 33% greater than that for pot caught lobster (757 g). Contingency table analysis of sex ratio by method produced a highly significant result (χ^2 = 36.4; P<0.001), with male to female ratios of 1.71:1 and 0.66:1 and for dive and

pot collection, respectively. Differences in sex ratio by method are largely attributable to divers targeting larger fish, which were more likely to be males.

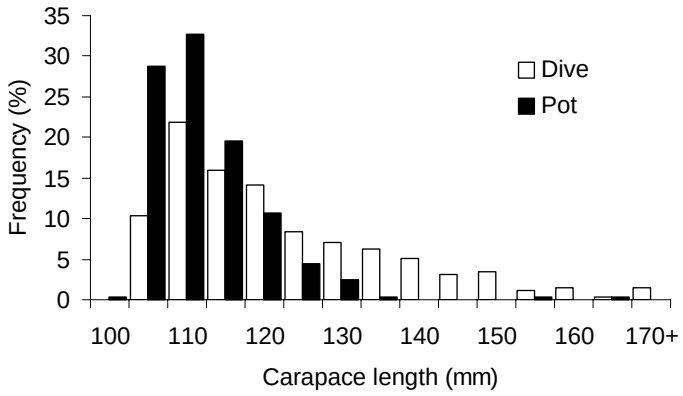

Fig. 11. Length frequency distributions by 5 mm size class for recreationally caught lobster taken by dive and pot fishing methods in Tasmania.

3.2.7 Estimated harvest weights

The weight of the 2002/03 recreational harvest was approximated by applying mean lobster weights (by method) determined from size composition data to catches for Areas 1-3 and 8. In the absence of size information for the other areas, mean lobster weights based on commercial catch returns (based on catches from depths < 20 m) have been used, with an adjustment factor of 1.33 for dive-caught lobster (Table 4). Lobsters caught by ring nets were assumed to have the same mean weight as pot-caught individuals.

The state-wide harvest was estimated to be 148.5 tonnes, with regional harvests ranging between 43.5 tonnes (Area 1) and 5.5 tonnes (Area 7) (Table 4). As a proportion of the total harvest, the south-east and east coast (Areas 1, 2 & 3) accounted 63%, the north coast (Areas 4 & 5) 21% and the west coast (Areas 6, 7 & 8) 16%. The combined effects of dive collection and presence of large lobsters off the north coast was particularly evident, with this region accounting for just 14% of the numbers (refer Table 3).

Table 4. Average lobster weight (g) by method and total estimated harvest (kg) by area
* av. weight is based on commercial catch weights.[1] av. weight calculated by multiplying av. pot weight by 1.33 (conversion ratio between pot and dive weights).

	Av. weight (g)		Total
Area	Pot/Ring	Dive	harvest (kg)
1	757	1006	43596
2	757	1006	29211
3	757	1006	21318
4	1105*	1468[1]	13506
5	1122*	1490[1]	17595
6	823*	1094[1]	11866
7	788*	1047[1]	5497
8	757	1006	5937
Total			148526

3.2.8 Comparison with commercial fishery

The recreational harvest relative to the 2002/03 quota year commercial catch of 1510 tonnes[5] was estimated to be 9.8%, though there was marked regional variability, ranging from 35% in the south-east (Area 1) to just 3% in the south-west (Area 8) (Fig. 12A). An alternative approach is to compare shallow water (< 20 m) catches, since this recognises that the majority (here assumed to be all) of the recreational catch was taken from shallow coastal waters. On this basis, the recreational harvest represented 26% of the shallow water commercial catch of 570 tonnes. In Area 1, the recreational catch was almost equal (95%) to the shallow water commercial catch. The recreational harvest was about half the size of the commercial catch in Areas 2 & 3 and was also important (31%) in Area 6. Elsewhere, recreational catches were comparatively small (<15%) by comparison with the commercial catches.

[5] The quota year covered the period March 2002 to February 2003.

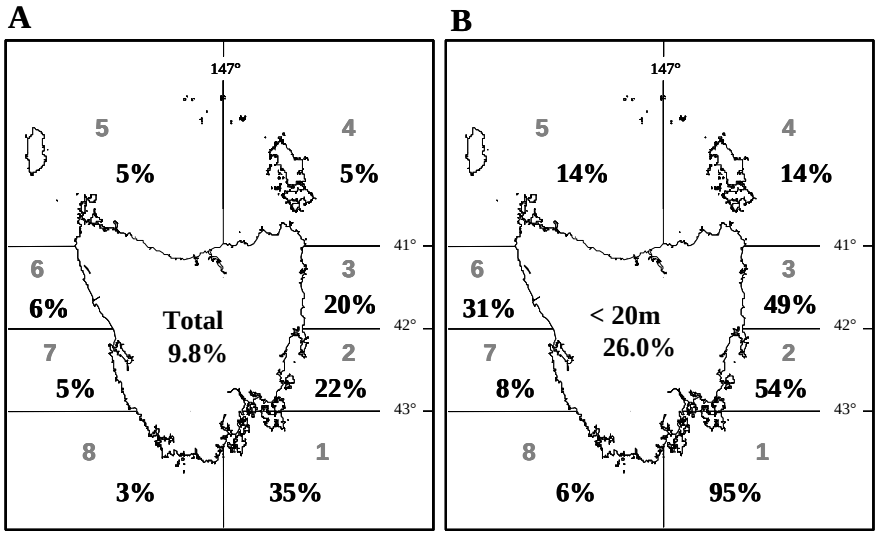

Fig. 12 2002/03 recreational lobster harvest (weight) expressed as a percentage of the commercial rock lobster catch by area: (A) based on total catches; and (B) based on catches from shallow water (< 20m).

3.3 Abalone

Information reported in this section relates to analyses of diary survey data provided by fully responding licence holders, and is presented as expanded estimates for the total population of recreational abalone licence holders during 2002/03.

3.3.1 State-wide catch and effort

An estimated 63.5% (SE 2.4%) of abalone licence holders (equivalent to 5864 persons) actually fished for abalone during 2002/03, harvesting 133,711 abalone (95% CI: 112,469–160,451) for 25,342 fisher days[6] (95% CI: 21,752-29,559) of effort. This represented an average harvest rate of 5.3 abalone for each day fished. The catch was taken almost exclusively by dive collection methods, though a very small quantity (<0.1%) was taken by hand collection (wading).

The relative contribution that individual licence-holders made to the total harvest is presented in Fig. 12 and revealed a pattern similar to that observed for lobster (refer Fig. 6). Overall, 20% of abalone licence-holders accounted for 69% of the total harvest while 98% of the harvest was taken by just half of all licence-holders. A comparatively high proportion of fishers (40%) actually harvested no abalone during 2002/03 (inclusive of the 36% who did not fish for abalone).

[6] A fishing day was defined as one in which abalone was a nominated target species and/or abalone were caught.

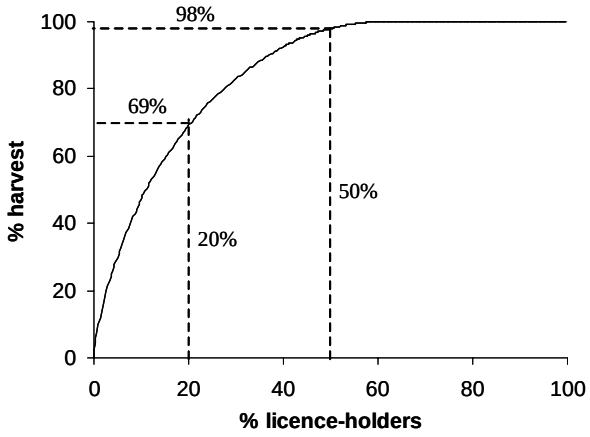

Fig. 12. Cumulative contribution to the total 2002/03 recreational abalone harvest by licence holders. Dotted lines indicate the proportions of the total harvest taken by the top 20 and 50% of licence holders (ranked according to the size of their seasonal abalone catches).

3.3.2 Seasonal catch and effort

The fishery for abalone exhibited a strong season pattern, with a marked increase in effort between November and January and peak catches in December and January (Fig. 13). The first three months of the licensing year accounted for 64% of the harvest and 62% of the effort. There was a sharp decline in effort and harvest in February and a minor increase in the level of fishing activity during April, mainly due to Easter fishing. The February to April period contributed 30% of the harvest and 32% of the effort. There was very limited fishing for abalone during the final six months of the licensing year, which accounted for just 6% of the annual harvest and effort.

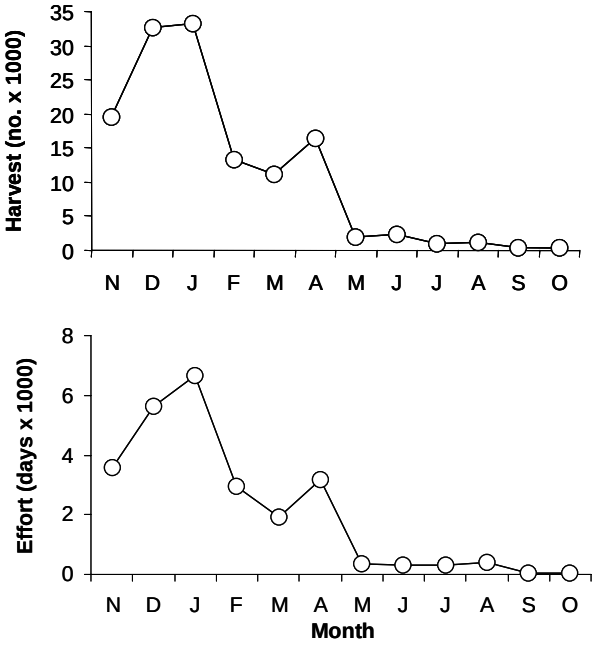

Fig. 13 Recreational abalone harvest (numbers) and effort (days fished) by month for the 2002/03 fishing season.

3.3.3 Regional catch and effort

Regional catch, effort and harvest rates for abalone are presented in Table 5. Recreational effort and harvest was concentrated in the south-east of the State, with 40% of the effort and harvest reported from Area 1. The east coast (Areas 2 & 3) accounted for a further 24% of the effort and 22% of the harvest, the north coast (Areas 4 & 5) represented 27% of the effort and harvest and the west coast (Areas 6, 7 & 8) 9% of the effort and 12% of the harvest. Daily harvest rates ranged between 4.5 and 7.4 abalone per day and were consistently higher than 5.0 in all areas apart from the east and north-east coasts (Areas 2, 3 & 4). The highest catch rates were recorded off the west coast (Areas 6 & 7).

Table 5. Recreational abalone effort, harvest and harvest rates by fishing area for 2002/03
Values in parentheses represent the 95% confidence intervals, * based on an average whole weight of 0.5 kg per abalone

Area	Harvest (no.)	Effort (fisher days)	Harvest rate (no. per fisher day)	Harvest (kg)*
1	53154 (39534 – 70947)	10241 (7879 – 13122)	5.2	26577
2	19463 (11185 – 29966)	4115 (2357 – 5889)	4.7	9732
3	9405 (4686 – 15341)	1966 (1039 – 2954)	4.8	4703
4	11,259 (5402 – 18,459)	2526 (1297 – 3471)	4.5	5630
5	24,553 (13085 – 39629)	4209 (2568 – 5970)	5.8	12277
6	10010 (4818 – 16342)	1349 (671 – 2115)	7.4	5005
7	1306 (0 – 3493)	230 (0 – 517)	5.7	653
8	4560 (1763 – 8109)	703 (260 – 1255)	6.5	2280

3.3.4 Daily harvest

Hookah represented 39% of the total abalone dive effort, yielding 44% of the harvest. Snorkel effort was far more prominent for abalone than for lobster, accounting for 37% of the abalone dive effort and 40% of the harvest. By contrast, scuba contributed 24% of the effort and just 16% of retained catch.

Daily abalone catches indicated that 27% of the overall dive effort targeted at abalone resulted in the bag limit being achieved (or exceeded) whereas 22% of dives resulted in no harvest (Fig. 14). Catch distributions for snorkel and hookah were very similar, with over 30% of dives resulting in catches of at least ten abalone and catch rates of 5.8 and 5.9 abalone per day for snorkel and hookah dive methods, respectively. The average daily catch rate for scuba was 3.5 abalone, with 35% of dives resulting in no catch, and at least ten abalone taken on only 12% of the days dived.

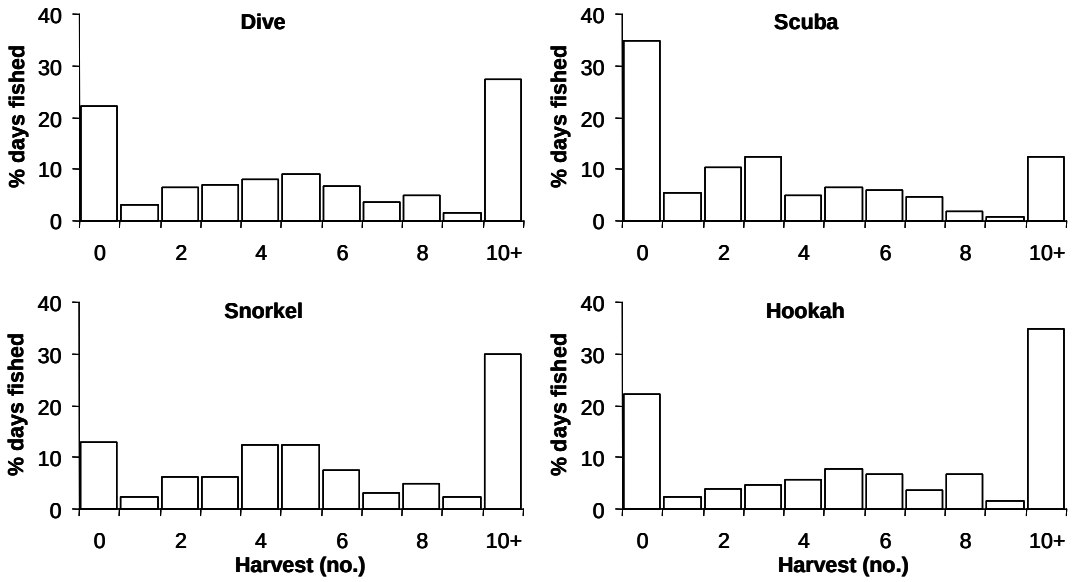

Fig. 14. Distribution of daily abalone harvest by dive methods for 2002/03 licence holders

3.3.5 Estimated harvest weights

Size composition information was not available for recreationally caught abalone. However, based on research sampling, the average, legal sized abalone has been estimated to have a whole weight equivalent to 500 g (D Tarbath, pers. comm.), giving an estimated recreational harvest of about 66.8 tonnes during 2002/03. Regionally, harvest estimates ranged from 26.6 tonnes in Area 1 to just 0.7 tonnes in Area 7 (Table 5). The catch for the combined south-east and east coasts (Areas 1-3) was 41 tonnes, the north coast (Areas 4-5) 17.9 tonnes, and the west coast (Areas 6-8) 7.9 tonnes.

3.3.6 Comparison with the commercial fishery

The 2002 commercial abalone catch was 2371 tonnes[7], indicating that the recreational harvest was less than 3% of the commercial catch. Regionally, the size of the recreational catch ranged from almost 14% of the commercial catch in Area 3 to less than 0.3% for Areas 7 & 8 (Fig. 15). Despite the importance of Area 1 to the recreational fishery, the recreational catch was only equivalent to 4% of the commercial catch. This clearly reflected the significance of this region to the commercial abalone fishery.

[7] Based on estimated weights (verified landed weight was 2397 tonnes of blacklip abalone) (Tarbath *et al.* 2003).

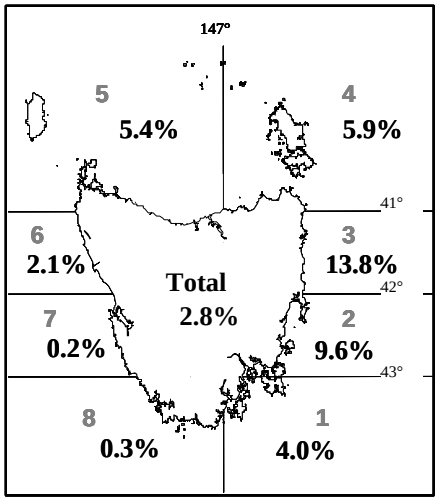

Fig. 15 2002/03 recreational harvest (weight) of abalone expressed as a percentage of the commercial catch by area.

3.4 Recall survey estimates

Rock lobster and abalone harvest, effort and harvest rate estimates derived from diary and recall surveys are compared in Table 6. Recall estimates of effort and harvest were consistently higher than those for the diary survey, exceeding diary totals by factors of 1.27 and 1.40 times, respectively for lobster and 2.24 and 2.19, respectively for abalone. These comparisons clearly indicate the impact of recall biases, resulting in overestimates of catch and effort. Based on the lack of overlap in 95% confidence limits, differences between recall and diary estimates were significant for lobster effort and abalone harvest and effort but not for lobster harvest.

The substantially greater overestimation of abalone catch and effort compared with rock lobster was probably linked to the fact that lobster are a more 'memorable' and highly prized catch and, as a general rule, were taken in smaller numbers than abalone (note also the influence of the different bag limits and ease of capture, as implied by the frequency that daily limits were achieved by fishers). Interestingly, however, derived harvest rates were generally consistent between recall and diary estimates.

Table 6. Recreational lobster and abalone effort, harvest and harvest rates based on diary and recall surveys, 2002/03.

Values in parentheses represent 95% confidence limits

	Harvest (no.)	Effort (days)	Harvest rate (no. day $^{-1}$)
Rock lobster			
Diary survey	163454 (140394 – 188670)	125898 (109,231 – 144,312)	1.29
Recall survey	207709 (179539 – 236664)	175721 (155894 – 197190)	1.18
Ratio: Recall/Diary	1.27	1.40	0.91
Abalone			
Diary survey	133711 (112469 – 160451	25342 (21752 – 29559)	5.3
Recall survey	299 259 (238192-374409)	55563 (47817-64353)	5.4
Ratio: Recall/Diary	2.24	2.19	1.02

4 Discussion

The current study represents the fourth survey of the lobster fishery and the third for the abalone fishery undertaken since 1996 using the telephone-diary method. Between 1996/97 and 2002/03 there has been a substantial increase in the number of licensed recreational lobster and abalone fishers in Tasmania, 64% for rock lobster and 93% for abalone. Although harvest estimates for the 1996/97 licence year did not include November 1996 catches (Lyle 2000), it is clear that the recreational harvest has increased significantly over this period, by around 80% (from 90,000 to 163,000) for lobster and about 150% for abalone (from 53,000 to 134,000). Significant growth in licence numbers and catches highlight the need to take account of the recreational component of the fishery in resource management and assessment.

The comparatively low level of abalone licence usage (63% licence holders) compared with lobster (88%) presumably reflected the relative esteem with which recreational fishers held the different species. Furthermore, the licensing system, whereby a base fee applies for the first licence category and a small extra charge applies for each additional licence category, may act to encourage fishers to take out additional licences as a form of speculation about the types of activities they may actually undertake. As such, licence numbers did not necessarily reflect licence usage but did imply that there was some latent capacity within the recreational sector.

Rock lobster and abalone fishing activity was highly seasonal, being most intense immediately following the opening of the season (or licensing year) and over the summer holiday period, with peaks in effort during January and highest catches taken in December and January (Lyle 2000, Forward & Lyle 2002, present study). During 2002/03, around 70% of the lobster and over 60% of the abalone harvest and effort were accounted for during the first three months of the season. This was followed by a sharp fall in catch and effort for both lobster and abalone in February and then slight increases during April, largely attributable to fishing activity over the Easter holiday period. Activity levels from May to the end of the season (or licensing year) typically remained low and contributed very little in terms of harvest (around 5% in 2002/03) for both lobster and abalone.

The lobster and abalone fisheries were concentrated off the south-east and east coasts of Tasmania (Lyle 2000, Forward & Lyle 2002, present study). In 2002/03, about 31% of the lobster and 40% of the abalone harvest (by numbers) was taken off the south-east (Area 1), with a further 38% and 22%, respectively, derived from the east coast (Areas 2 & 3 combined). Lobster catches were comparatively low from the north coast (Areas 4 & 5), about 14% of the total numbers, whereas this region was more significant to the abalone fishery with 27% of the harvest. The west coast (Areas 6, 7 & 8) produced about 17% of the lobster and 12% of the abalone harvest. The intensity of the fishing activity off the south-east and east coasts reflected a combination of factors, including sheltered and accessible waters and proximity to major population and holiday centres. Factors such as limited availability of suitable reef habitat off the north coast (apart from around the Bass Strait islands), and exposure to unfavourable sea conditions and limited access points off the west coast, contributed to the lower levels of recreational

fishing pressure observed in these regions. By comparison, the west coast represents a very significant region for both the commercial rock lobster and abalone fisheries (Gardener et al. 2003, Tarbath et al. 2003).

The majority of the recreational lobster harvest was taken by pots, the method accounted for 62-64% of the total numbers in 1996/97, 1997/98 and 2002/03 and 55% in 2000/01 (Lyle 2000, Forward & Lyle 2002, present study). Dive methods typically accounted about one third of the total harvest in each of the years apart from 2000/01, when divers took 44% of the total. The reason for the apparent increase in the dive harvest proportion in 2000/01 was unclear but was not evident in the most recent season. In absolute terms, while there was a substantial increase in the pot catch between 2000/01 and 2002/03 (from 70,000 to 102,000 lobster), dive harvests were very similar (around 55,000 lobster) over this period. Overall, lobster rings represented a minor fishing method.

During 2002/03 pot catches dominated the harvest (>59% of numbers by area) off the south-east and east coasts, whereas dive collection was the dominant method off the north coast (>74% of numbers). Pots, dive collection, and rings were each locally important in the west coast areas. Such regional differences based on fishing method were consistent with patterns observed in previous surveys (Lyle 2000, Forward & Lyle 2002) and have important implications for regional catch rates. For instance, the average daily harvest rate for pots was less than half that for dive and ring methods. Thus, in areas where pots dominated the catch, overall harvest rates were comparatively low (1.0-1.3 lobster for Areas 1,2 & 3), and conversely where dive or ring methods were significant, harvest rates were substantially higher (>2 lobster for Areas 5,6,& 7). Since divers selectively harvested larger lobsters (biased towards males) than those taken by pots, the relative mix of methods also influenced the size structure of the catch taken from an area.

Average daily lobster harvest rates in 2002/03 for pots (1.0 lobster) and diving (2.3 lobster) were intermediate between those determined for previous seasons (i.e., 0.9-1.2 for pots and 2.1-2.6 for dive) while the average harvest rate for abalone (5.3 abalone) was lower than for either 1996/97 or 1997/98 (6.0 and 6.6 abalone, respectively) (Lyle 2000, Lyle & Forward 2002).

Bag limits represent the primary management strategy to constrain recreational lobster and abalone catches in Tasmania. In practice, being restricted to a single pot, pot fishers rarely (<5% days fished) attained the bag limit of five lobster and thus this management measure had little direct impact on the overall pot catch. By contrast, bag limits had a more obvious impact on lobster and abalone dive catches, with about one quarter of the dive effort for either species resulting in the bag limit being achieved.

Artificial breathing apparatus (hookah and scuba) conferred a clear advantage when targeting lobster (reflected in catch rates and incidence of the bag limit being achieved) but was less of a factor for abalone, where catch rates for snorkel divers were almost as high as those for hookah. This is not unexpected given that abalone are sessile and often common in shallow waters. Of the dive methods, harvest rates were highest for divers using hookah, an observation that has been noted in previous surveys (Lyle 2000, Forward & Lyle 2002). Potentially, hookah gear provided competitive

advantages through increased accessibility to confined spaces and longer bottom times but catch rate differences may also reflect diver motivation. That is to say, hookah divers may be more motivated to harvest target species than incorporating other activities in a dive. To some extent, this is borne out by the observation that around one third of all hookah dives resulted in the bag limit(s) being achieved for the target species. In fact divers in general often targeted both rock lobster and abalone on a dive. Out of the total dive effort during 2002/03 for lobster and/or abalone, both species were targeted in over half (56%) of all dives. This 'combined' dive effort accounted for 66% of the abalone harvest and 70% of the dive harvest of lobster. Recognition of this fishing behaviour has implications for the management of the fishery, especially in terms of the possible impacts of management change for one or other species.

Primarily as a consequence of regulation (e.g., seasonal closures, size, and bag limits), fishers were required to release some of their lobster catch. For pot fishers approximately one lobster was released for every one kept, the fate of these released individuals (i.e. survival rates) is unknown. Divers may also release some of their catch but there is also potential for handling damage (e.g., broken antennae and limbs) as a result of attempted capture or removal from dens before size, sex or condition could be accurately assessed. The implications of such damage on subsequent growth, reproduction and survival in rock lobster are unclear. Abalone may also be subject to some handling impacts since individuals maybe removed from the substrate prior to measuring. Although not recorded as 'releases', the act of removing abalone using knives can cause lacerations to the foot. As abalone lack blood coagulant they are unable to stop bleeding thus increasing the possibility of incidental handling mortality. Furthermore, abalone not returned directly to suitable habitat may not reattach and/or may be more vulnerable to predation. The fact that a proportion of the catch is released is an important management tool used to conserve rock lobster and abalone stocks, however, the fate of these released individuals is unknown and warrants investigation.

Relative to the commercial lobster catch, the recreational harvest had more than doubled since the late 1990s to just under 10%, reflecting the combined effects of increased recreational catches and the introduction of catch limits (quota) on the commercial sector. Comparisons based on state-wide catches, however, underestimate regional impacts. This was particularly evident off south-east Tasmania where, in 2002/03, the recreational catch exceeded one third of the commercial take but was comparatively small (<6%) in areas such as the north and west coasts. Furthermore, depth limitations on diving and practicalities of hauling pots and ring nets imply that the recreational rock lobster fishery operates primarily in shallow waters, presumably at depths of less than about 20 m. By contrast, commercial fishers operate over wider areas, including deeper offshore reefs and typically only about one third of their harvest is taken in depths of less than 20 m. Thus in areas where the sectors overlap the recreational proportion of the catch was higher than implied by comparison of total catches. In fact, if only shallow-water catches were considered, then the recreational catch was just over one quarter of size of the commercial take in 2002/03. In the south-east it was almost equivalent to the commercial catch while the recreational catch was about half the size of the commercial catch for the remainder of the east coast.

The recreational abalone harvest in 2002/03 was equivalent to less than 3% of the 2002 commercial abalone catch. Regionally, as a proportion of the commercial harvest the

recreational catch was most significant (around 10% or greater) off the east coast, in Areas 2-3 (equivalent to abalone fishing blocks 23-30). Significantly, recent assessments of fishery dependent information has indicated that abalone stocks on the east coast (including blocks 23-30) have declined and a reduction in commercial catches was recommended (Tarbath *et al*. 2003). If stocks are depressed as indicated by commercial catch and catch rate trends, the impacts of (growing) recreational fishing pressure may become a significant factor that will need to be explicitly factored into stock assessments. This situation is likely to be exacerbated since recreational fishers may continue to fish an area even when abalone densities are reduced to below what are typically classed as commercially viable levels by industry.

The size of the recreational rock lobster harvest relative to the total allowable commercial catch (TACC) has been identified as a management performance indicator, with a trigger reached when the recreational catch equals or exceeds 10% of the TACC. Based on the 2002/03 TACC of 1523 tonnes, the estimated recreational catch of 148.5 tonnes represented 9.8% of the TACC. Although there was statistical uncertainty surrounding this estimate (implying the true value could have been above or below the reference point) catch levels were now sufficiently close to the trigger limit to provide the impetus to review management arrangements. There are no management performance indicators relating to the recreational fishery in the Abalone Management Plan.

The expansion of the recreational rock lobster and abalone fisheries in Tasmania, particularly over the past decade, clearly highlights the need for on-going assessment to monitor future developments and to quantify impacts on stocks. Although simple recall based surveys are cheap and easy to conduct, considerable caution is required in interpreting the results, especially if accuracy, rather than simply trends, in catch or effort are required. As demonstrated in this and previous surveys (Lyle 2000, Forward & Lyle 2002) recall based estimates were substantially (often significantly) higher than those arising from the telephone-diary estimates, a difference arising largely from the impacts of recall bias (Pollock et al. 1994). The telephone-diary survey methodology has been designed to minimise this bias along with impacts of non-response and thus represents a viable and cost-effective approach to provide detailed and reliable fishery information at state-wide and regional levels.

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References

ABS (1984). Household fish consumption and non-commercial fishing activities, Tasmania. Australian Bureau of Statistics, Hobart.

Anon. (1997). Rock lobster fishery policy document. Unpublished report of the Rock Lobster Working Group, Tasmanian Department of Primary Industry and Fisheries.

Coleman, A.P.M. (1998). Fishcount: A survey of recreational fishing in the Northern Territory. NT Department of Primary Industry and Fisheries. Fishery Report No. 43.

Ford, W. (2001). Restructuring the Tasmanian rock-lobster fishery – the effect of two years of management under individual transferable quotas. *Marine and Freshwater Research* **52**: 1641-1648.

Forward, J., and Lyle, J.M. (2002). A survey of the 2000/01 Tasmanian recreational rock lobster fishery and options for future assessment. Tasmanian Aquaculture and Fisheries Institute Final Report to the Marine Recreational Fishery Council, 36p.

Gardner, C., Frusher, S., Eaton, L., Haddon, M., and Mackinnon, C. (2002). Tasmanian rock lobster fishery 2000/2001. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report, 96p.

Haddon, M. (2001*). Modelling and Quantitative Methods in Fisheries*. Chapman and Hall/CRC, Florida, 406p.

Henry, G.W., and Lyle, J.M. (2003). The national recreational and indigenous fishing survey. Final Report to FRDC, Project 99/158. NSW Fisheries Final Report Series No. 48, 188p.

Lyle, J.M. (2000). Assessment of the licensed recreational fishery of Tasmania (Phase 2). Tasmanian Aquaculture and Fisheries Institute Final Report to FRDC, Project 1996/161.

Lyle, J.M., Coleman, A.P.M., West, L., Campbell, D., and Henry, G.W. (2002). New large-scale survey methods for evaluating sport fisheries. pp207-226. In *Recreational Fisheries: Ecological, Economic and Social Evaluation*. Ed T.J. Pitcher & C.E. Hollingsworth, Blackwell Science.

Lyle, J.M., and Smith, J.T. (1998). Pilot survey of licensed recreational sea fishing in Tasmania - 1995/96. Marine Research Laboratories Technical Report 51.

McGlennon, D. (1999). Survey of the licensed recreational rock lobster fishery in South Australia 1998/99. South Australian Research and Development Institute. Final Report.

Pollock, K.H., Jones, C.M., and Brown, T.L. (1994). Angler survey methods and their applications in fisheries management. *American Fisheries Society Special Publication* **25**. 371p.

Punt, A.E., and Kennedy, R.B. (1997). Population modelling of Tasmanian rock lobster, Jasus edwardsii, resources. *Marine and Freshwater Research* **48**: 967-980.

Tarbath, D., Mundy, C., and Haddon, M. (2003). Tasmanian abalone fishery. Tasmanian Aquaculture and Fisheries Institute Fishery Assessment Report, 144p.

Venema, S., Boxall, V., and Ward, T.M. (2003). Survey of recreational rock lobster fishing in South Australia during 2001/02. Unpublished report South Australian Research and Development Institute, 42p.