LIVE SEAFOOD HANDLING:

STRATEGIES FOR DEVELOPMENT

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Project 92/125.26

PACIFIC SEAFOOD MANAGEMENT CONSULTING GROUP PTY LTD
P·S·M

REPORT ON THE STATUS OF THE LIVE SEAFOOD INDUSTRY IN AUSTRALIA

NATIONAL SEAFOOD CENTRE LIVE SEAFOOD HANDLING: STRATEGIES FOR DEVELOPMENT PROJECT NO. 92/125.26 October, 1995

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Disclaimer:

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EXECUTIVE SUMMARY

Live seafood has become an increasingly important sector within Australia's seafood industry over the past decade, and if current marketing trends continue, it is likely to be the major contributor to future increased export earnings from seafood. For the year 1994/95, the value of seafood exports reached A$1.4 billion - an increase of 60% on earnings five years ago. The greatest proportion of these gains can be attributed to an increase in the value of our exports rather than an increase in volume. It is predicted that the Australian seafood industry is likely to achieve export earnings of around A$2.0 billion by the year 2000 without the need to substantially increase production volumes. Clearly, encouraging this trend will provide tremendous benefits to all Australians and to our precious environmental resources.

A major component of this value-adding process is the export of live seafood which is currently worth in excess of A$250 million. The primary goal of this project has been to identify the major needs of the live seafood industry and to propose a range of strategies which will enhance its continued growth. Most importantly, every effort has been made to relay this information to relevant government and industry bodies so that due consideration may be given to these needs.

Based on industry surveys and discussions held during the Live Seafood Industry Forum in Hobart, six issues of major concern were established. For each issue, this report presents a number of 'industry needs' which have been identified to address specific impediments.

- **Market Intelligence**

In the case of market intelligence, timely and accurate information regarding markets is required by exporters in order for them to make sound marketing decisions; better knowledge of market trends is needed to assist the airlines and freight forwarders in determining schedules required to service the demand for space; and access to market trend information should provide resource managers with an enhanced insight into the likely pressures which may be placed on specific fisheries due to market demand.

- **Resource Management**

Greater emphasis should be placed on achieving efficient vertical migration (movement towards higher value) of fisheries products; details of markets and their requirements (eg. capture and handling methods) for particular species must be known, and understood by fisheries resource managers when establishing management regimes and estimating the sustainability of specific fisheries resources; fisheries managers should aim for security of access to these resources and encourage share allocation arrangements which reflect a preference for selective fishing for value-adding purposes; and in turn, fisheries managers need to educate and encourage fishers to progress towards a strategic harvesting approach which focuses on market requirements rather than resource availability.

- **Airfreight Logistics Information**

Details of the facilities currently offered at departure and destination points for all airlines and freight forwarders should be generated and made available to

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APPENDICES

1. INTRODUCTION

The live seafood market has been recognised as having considerable potential for the Australian fishing and aquaculture industries for many years. Indeed, sales of live seafood, particularly to Asian countries, have provided lucrative returns to many seafood exporters who have identified live product as a premium value added product form. With quotas and other restrictions reducing catches, the fishing industry is able to obtain a higher return from catching less fish by selling them live. Currently, live seafood exports from Australia are worth in excess of $260 million per annum.

In recognition of the need to establish efficient and effective handling procedures which are specific to the variety of seafood species, this Live Seafood Handling Project has been commissioned by the National Seafood Centre (NSC). The primary goal of the project is to assist in the development of the industry by facilitating the process of problem solving, disseminating information to, and improving communication within, the industry and broadening opportunities for access to the live seafood market. The specific project objectives are detailed in Section 2.

Currently by value, Australia's most important live seafood exports include rock lobsters, prawns and abalone. For the most part, the export of these species is undertaken by a relatively small number of large organisations. In contrast, the live marketing of other species (such as coral trout, red emperor, spanner crabs, freshwater crayfish etc.) which are considered to have similar potential, is being undertaken by a large number of small operators who, in relative terms, lack access to the resources which are available to most larger organisations. One of the aims of this project is to enhance access for the small operator to the technology and skills required for the successful handling of live seafood products.

In addition to the buyers and end-consumers of live seafood, the fishing, aquaculture, processing and transport sectors all stand to gain from initiatives which enhance the survival of seafood during the capture, holding and transport stages of the marketing process. Section 4 defines the terms and outlines the primary steps involved in the handling of live seafood for the purposes of this report. It is also intended that operators of all sizes in these industry segments gain access to the techniques and equipment which will lead to increased survival rates and improved product quality. Benefits will also accrue from resolving problems such as air transport logistics and seasonality of supply, and by ensuring that research is correctly focussed from industry's perspective.

Two meetings to address the issues facing the live seafood handling sector have been held previously (Section 3). However, little was resolved from these meetings other than to establish a network between industry members and government and to highlight some of the problems facing the industry. In combination with the industry surveys undertaken as part of this project (Section 5), the Hobart Forum revealed a number of specific problems and proposed strategies to overcome them. This has provided a sound foundation upon which both government and industry may now comprehensively address the current and likely future impediments to the continued growth of this industry.

Details of the discussions held during the work groups and forum are provided in Section 6. The four major issues for discussion were established from the industry surveys - separate questionnaires were forwarded to researchers and commercial operators (see Appendix I and II). Based on these discussions, a range of strategies to address the industry needs were proposed. These industry needs and future directions are detailed in Section 7.

Section 8 identifies the organisations which currently support the live seafood industry. The roles and responsibilities of relevant Federal and State Government Bodies, as well as their sub-agencies have been described so as to provide a concise overview of the industry support network.

Appended to the Report are copies of the questionnaires distributed to the commercial operators and researchers, the agenda for the Hobart Forum, a list of Forum delegates (by work groups) and copies of research papers presented at the Forum.

2. PROJECT AIMS AND OBJECTIVES

This project has entailed the gathering and collating of information from commercial operators and research organisations which are involved in the live seafood industry, and the presentation of a range of practical strategies to assist its future development. The information used in this report has been obtained through industry surveys and from discussions held during the Hobart Live Seafood Forum.

Given an increased understanding of the needs of the industry, it is hoped that the range of strategies suggested to overcome its current impediments can be coordinated and implemented by government and industry.

Objective One To establish the current status of the live seafood industry including the quantity and value of species being handled, the markets into which the products are placed and the research which has been undertaken. In addition, impediments to the development of the industry will be identified.

Objective Two To prepare a Preliminary Report on the Status of the Live Seafood Industry in Australia. This report will present the aforementioned information on the status of the industry, evaluate needs and propose future directions (strategies) aimed at progressing the industry, and provide a basis for achieving desirable outcomes from the Hobart Forum.

Objective Three To assist in the facilitation of the Live Seafood Handling Forum.

Objective Four To prepare a final report on the Status of the Live Seafood Industry in Australia. In addition to the content provided in the Preliminary Report, the final report will include detail of the outcomes of this Hobart Forum and formally propose future directions for the industry.

3. LIVE SEAFOOD HANDLING FORUMS

Prior to the Hobart Forum, the National Seafood Centre (NSC) hosted two meetings to review the status of the live finfish transport (now seafood handling) industry in Australia. These meetings were held in Melbourne (1993) and Brisbane (1994). It is recognised by the NSC that whilst these meetings enabled the exchange of ideas and information between researchers and commercial operators, they failed to establish an on-going mechanism for the development of strategies addressing the specific needs of the industry.

3.1 MELBOURNE MEETING (1993)

In 1993, MOJO Australia was commissioned to develop a strategic marketing plan for the seafood industry (called the FINS study). During this study, MOJO identified the immediate need for a national tag recognised by all states identifying cargo as Australian seafood.

In November 1993, a meeting was held between the NSC, MOJO Australia, industry representatives and research scientists to discuss the need for national identification of Australian seafood cargo.

During this meeting, it was established that more than a national identification tag was required to meet the demands of the live seafood industry. As such, the Live Fish Container Standards Program was initiated with the objective being to develop a comprehensive program covering standardisation of packaging and labelling live seafood product.

A further objective was the establishment of an Advisory Register which was to provide communication links with strategy developers and representatives from all facets of the live seafood sector. It was intended that this register would streamline the communication process serving to increase the acceptance of the program and its objectives.

This program has not been implemented at this time.

3.2 BRISBANE MEETING (1994)

The FRDC/NSC meeting on the "Transport of Live Fin-fish" in Brisbane was conducted for the purpose of facilitating discussions between commercial operators and researchers concerning the transport of live fin-fish. Several major issues were discussed, including advances in packaging and identification, R&D, marketing, and a proposal to establish a Code of Practice for the transport of live fin-fish.

Discussions concerning the establishment of a Code of Practice considered all aspects of live finfish handling; from the point of capture to the market. The information gathered from these discussions identified and described current industry practices and research relevant to each stage of processing. It was intended that the acquired information was to be used as a basis for the development of a Code of Practice which would be implemented nation-wide.

It was agreed at this meeting, that development of the Code of Practice would require on-going liaison with the attendees and industry as well as the approval of an FRDC application. To date, an early draft Code of Practice for live finfish transport has been prepared, however further work is needed to develop this to the stage where it can be considered by industry.

3.3 HOBART FORUM (1995)

Approximately fifty delegates, representing all facets of the live seafood handling sector, were invited to this Hobart Forum. During the first half of the day, details of current live seafood research were presented by researchers and information collated from the industry survey were presented by PSM Consulting Group. The survey information provided a sound basis for consideration of the primary issues by the Forum.

Two workshop sessions were undertaken at the Forum. The first involved the delegates meeting in work groups (see delegate groups listed in Appendix III) to discuss four primary issues including transport logistics, equipment and technology, research direction and continuity of supply. Details of the discussions during these work groups are presented in Section 6. The second workshop involved all delegates in an open forum discussion to establish the means by which these issues would be addressed. The last session entitled "where to next?" discussed the need for the establishment of a reference group to determine future directions for the live seafood industry.

The large number of participants gathering at the Forum was an indication of the need for both researchers and commercial operators to raise personal concerns, reiterate on-going issues and strengthen communicative ties within the live seafood industry. Overall, the Forum was considered by most delegates to be a positive step towards enhancing the development of the live seafood industry.

4. LIVE SEAFOOD HANDLING DEFINITIONS

4.1 DEFINITIONS OF TERMINOLOGY USED IN THE REPORT

Live Seafood refers to fish, crustaceans and molluscs which are sold for human consumption in live form. It does not include broodstock or seedstock used in aquaculture, nor aquarium fish or animals used for re-stocking waterways.

Commercial Operators include those companies and individuals involved in the capture or purchase of live seafood for the purpose of selling to importers, domestic restaurants or consumers. These are assumed to be involved in the handling of live seafood including the holding, packing and transport of live product.

Commercial operators also include those involved in the supply of equipment and services to the live seafood handlers. (In many cases, commercial operators are also directly involved in applied research).

Researchers include those organisations, such as fisheries departments, universities, laboratories or private companies, and individuals which are involved in the research and development of systems and technology for the purpose of enhancing the survival and quality of live seafood through the handling stages.

Professional Fishers include those companies or individuals involved in the capture of seafood from the wild.

Aquaculturalists include those companies or individuals involved in the production or culture of seafood in captivity. This implies some sort of corporate ownership of the stock and/or involvement (such as feeding, predator control, etc.) in the life cycle of the organism.

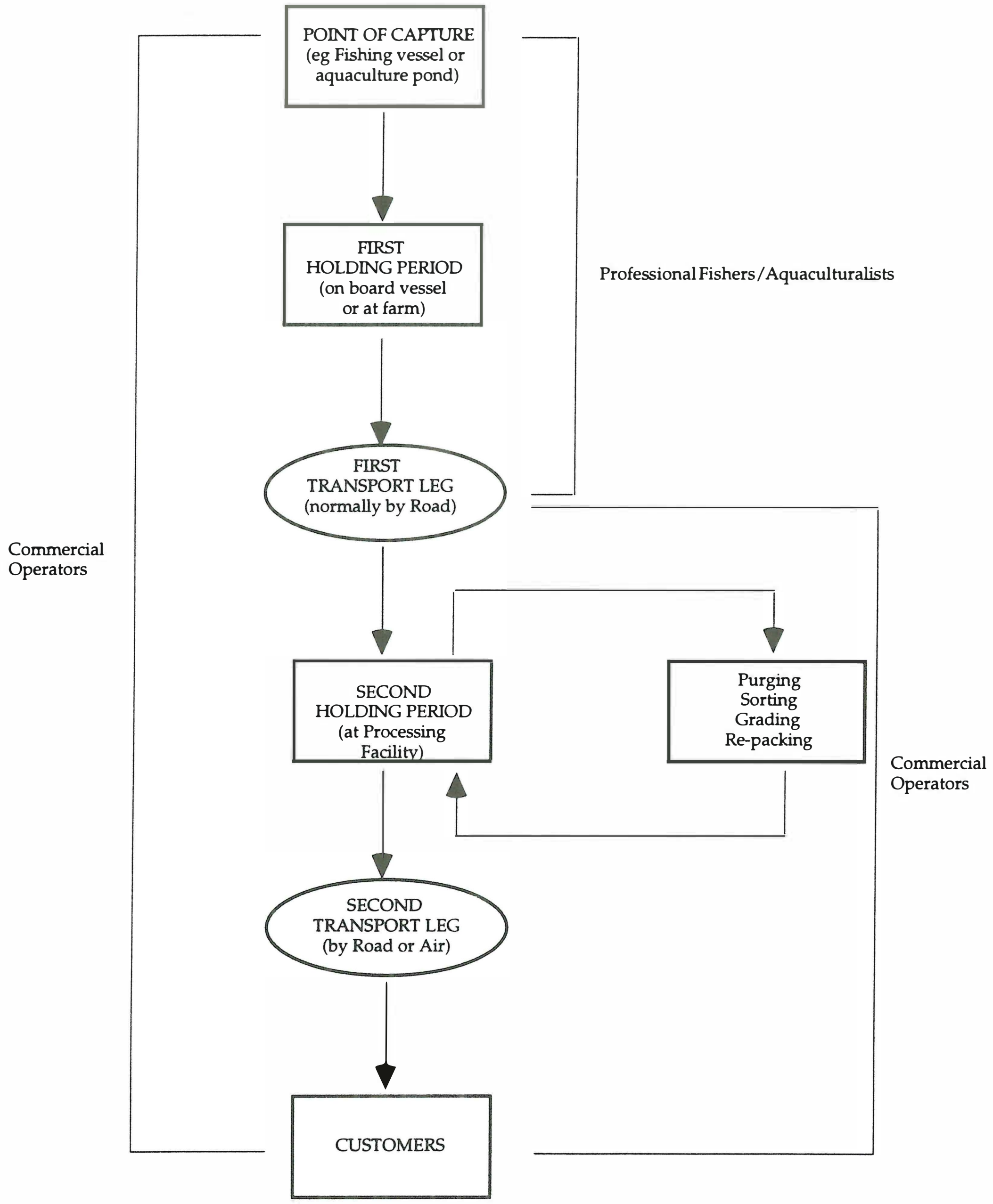
Customers include those companies or individuals involved in the purchase of live seafood, either for resale or own use.

Sorting refers to the assessment of the individual animal's suitability for live handling. Stock which is not suitable for transport due to its condition should be excluded upon sorting.

Grading refers to sorting by size or any other attribute which the customer demands.

4.2 STEPS IN THE HANDLING PROCESS

The following flow chart provides a broad overview of each of the primary steps in the handling process. Whilst it is recognised that in some cases product may flow through an alternative route, this chart identifies the major steps in the process and has been used as a basis for discussions in this report.



5. STATUS OF THE LIVE SEAFOOD INDUSTRY

Australia exported in excess of $1.4 billion worth of seafood in 1993/94. More than one third of this value was comprised of perishable seafood including fresh chilled and live product. By value, seafood was the most significant category of perishable products to be exported by airfreight totalling $480 million in 1994/95 compared to $190 million for meat, $150 million for horticulture and $50 million for dairy.

Perishable seafood is now recognised as being a major contributor to the Australian economy; its profile being elevated by the recently commissioned Federal Government study to investigate the airfreight infrastructure impediments which face exporters of perishable seafood.

5.1 ESTIMATED AUSTRALIAN PRODUCTION AND VALUE

The live seafood market has undergone rapid expansion in recent years, particularly in Asian countries, but also in Australia. Statistics collated by the Australian Bureau of Agricultural and Resource Economics (ABARE) indicate that many of Australia's high value seafood products are targeted towards the export rather than domestic market. Many low value seafood products consumed in Australia are imported, sourced from Thailand and southern Africa. The live seafood trade is currently based on products for which relatively high prices are available - predominantly in export markets.

5.1.1 'Live' shipments driving growth in export value

Although there are, as yet, few published statistics to quantify the trade in live seafood, there is evidence that this innovation in product form is now a significant contributor to the growth of our total seafood export value. For instance, of the $973 million of crustaceans and molluscs exported in 1993/94, almost 90% comprised rock lobster, prawns and abalone. In each case, the value of these exports has risen significantly in recent years despite static or declining production volumes - due in no small part to the increased proportion of product shipped live. (It is not possible to differentiate accurately between price increases for live and general market fluctuations.)

ABARE estimates that most of the $217 million in rock lobster exports for 1993/94, recorded as 'live, fresh or chilled', were live. That is, almost half of the total value, and up 17% on the previous year. Their unpublished figures for 1994/95 show further growth to $246 million - up almost 12% - recorded under that classification. ABARE also estimates that $4.5 million worth of live fish were exported while an increased proportion of kuruma prawns (shipped live) was a significant factor in the 27% increase in the value of prawn exports to markets including Hong Kong and Japan. Trade estimates put live abalone at 15% to 20% of the $70 million abalone (not canned) exported in 1993/94.

The extent of the Asian market for live seafood is not well researched. However, industry sources suggest that, for the range of species categorised as tropical fish and marine crustaceans, the market would exceed the capacity of Australian fisheries (and aquaculture) to supply in the short to medium term. This is due primarily to increased demand, and the decline in the availability of seafood from local sources. Furthermore, Australia is recognised to have a strategic potential to service this lucrative market due to its clean waters, high quality stock and proximity to the markets.

5.1.2 'Live' product extending opportunities for low/medium priced species

Government statistics also show that our seafood exports are heavily focussed on a narrow range of species which are also in demand on the domestic market (although equivalent prices would not be realised). However, export markets for live products appear to provide opportunities for a far greater range of species, especially fish, including many for which there is not significant domestic demand. Whilst the range of species suitable for live shipment has not been fully researched, it is known that several species of reef fish (amongst others) which are low to moderately priced on the domestic market in traditional forms, return sufficiently high prices as live products to support a growing industry. It is highly likely that markets are available for many other species of live fish.

ABARE estimated the value of live fish exports in 1993/94 at $5.5 million - up 16% on the previous year. Their unpublished figures for 1994/95 estimate the value at $9 million - up by almost 40%.

5.1.3 Domestic sales unknown

Domestically, the live seafood market has been driven by the Asian restaurant trade. However, there is no reliable data on the value of domestic sales of live seafood. In Sydney and Melbourne, almost all medium to high class Asian restaurants incorporate live tank facilities which are used for holding species including lobsters, abalone, coral trout and others.

Currently, the market for live finfish in Australian capital cities is estimated to be 9 tonnes per week (industry sources) with an estimated value of $6.5 million per annum (based on an average wholesale price of $15.00 per kilo). Domestic sales of live rock lobster, abalone, oysters and miscellaneous crustaceans and molluscs are difficult to estimate but would be in the order of $80 million per annum (oysters sales alone account for some $45 million). All indications are that the volume and value of this form of product will continue to increase into the future.

It is generally perceived that the realisation of the commercial potential for live seafood sales, both in the domestic and export markets is constrained principally by the suffering of high mortalities and logistic problems (sourcing stock, transportation etc), although this may not necessarily be the case. Therefore, one of the main objectives of the project is to identify the specific factors which currently constrain the development of the industry.

5.2 LIVE SEAFOOD HANDLING SURVEY RESULTS

Surveys were distributed to commercial operators and researchers to establish the current status of the industry. Copies are provided in the Appendix I.

5.2.1 Methodology and Limitations

Two surveys were prepared. The first survey was entitled 'Live Seafood Handling' and was distributed to as many commercial operators as could be identified through sources including the NSC, FRDC, AUSEAS, AQIS Exporters Database and personal communications. Surveys were sent to commercial operators in every state and territory. From the 156 surveys sent nationally, 44 were completed and returned providing a response rate of 28%. The second survey was entitled 'Live Seafood Research' and a total of 17 surveys were distributed to research organisations around Australia. With 15 surveys being completed and returned, this provided a response rate of 88%. Details of the survey distribution and response rate by state is provided in Tables 5.1 and 5.2 respectively.

Table 5.1 Survey response from commercial operators

State/Territory (Commercial Operators	Sent	Returned	Response
ACT	1	0	0.0%
New South Wales	27	10	37.0%
Northern Territory	2	1	50.0%
Queensland	30	16	53.3%
South Australia	20	4	20.0%
Tasmania	18	4	22.2%
Victoria	24	3	12.5%
Western Australia	34	6	17.6%
National	156	44	28.2%

The surveys were not designed to reveal details of every aspect of either commercial or research activities; rather they were prepared in such a way as to maximise the availability of information which would be of direct use in the development of strategies to enhance the activities of the commercial sector. Whilst it may have been desirable to obtain more information regarding the issues raised, it was recognised that in the case of commercial operators, response rates would diminish as the requirement for detail increased. Never-the-less, useful information regarding the broad issues facing the industry has been obtained.

A number of limitations in respect of the results from the surveys have been noted. Not all commercial operators received surveys due to the time constraints of the project. By comparison with the statistics provided by ABARE (see Section 5.1), respondents accounted for approximately one quarter of the total volume and value of most categories of live seafood exported. Some respondents expressed concern as to the usefulness of industry surveys. In respect of the Forum, several respondents indicated that previous attempts to assist the industry in that manner had failed to generate any useful outcomes. Specific reference was made to the failure of the previous Forum to lead to the implementation of an industry code of practice.

Table 5.2 Survey response from researchers

State/Territory (Researchers)	Sent	Returned	Response
ACT	0	0	0.0%
New South Wales	1	1	100.0%
Northern Territory	2	1	50.0%
Queensland	3	3	100.0%
South Australia	1	1	100.0%
Tasmania	5	5	100.0%
Victoria	1	0	0.0%
Western Australia	4	4	100.0%
National	17	15	88.2%

5.2.2 Source, Quantity and Value of Live Seafood Species

The quantity of live seafood handled during the past two years and forecasts for the next two years were provided by each respondent. These figures were separated for wild caught and aquaculture sources, and current price ranges for each species were obtained. Based on the quantities and maximum current prices, approximate annual values for each species has been estimated (see Tables 5.3 and 5.4).

Table 5.3 Actual and predicted quantities of fishery species handled live and current price ranges (landed). Quantities are in tonnes and values in Australian dollars.

Species	Qty (t) 1993/94	Qty (t) 1994/95	Prices [1] 1994/95	Value [2] 1994/95	Qty (t)* 1995/96	Qty (t)* 1996/97
Eastern Rock Lobster	0	4.0	$47 - 50	0.2	6.0	10.0
Southern Rock Lobster	664.5	805.7	$22 - 65	52	917.6	817.8
Western Rock Lobster	271.5	329.8	$37 - 42	14	520.0	620.0
Champagne crab	3.0	5.0	$5 - 6	0.03	15.0	20.0
King Crab	62.8	121.9	$12 - 30	4	225.8	108.8
Mud Crab	76.5	97.0	$12 - 18	2	72.0	52.5
Spanner crab	51.0	60.0	n/a	n/a	n/a	n/a
Abalone	65.0	116.5	$24 - 55	6	155.0	225.0
Coral trout	9.4	15.8	$25 - 60	0.9	30.0	53.0
Banded morwong	6.5	34.5	$6 - 36	1	38.0	48.0
Barramundi cod	n/a	0.15	n/a	n/a	n/a	n/a
Eel	78.2	106.1	$13 - 14	1	70.0	n/a
Plate size cod	n/a	0.3	n/a	n/a	n/a	n/a
Wrasse	2.6	9.1	$8 - 15	0.1	10.0	15.0

* predictions
1 A range of current prices was supplied by respondents. Prices are in A$/kg of product.
2 Based on maximum prices, the total value of each species (A$'000 000) for the 1994/95 year was estimated.

Table 5.4 ***Actual and predicted quantities of aquaculture species handled live and current price ranges (landed). Quantities are in tonnes and values in Australian dollars.***

Species	Qty (t) 1993/94	Qty (t) 1994/95	Prices [1] 1994/95	Value [2] 1994/95	Qty (t)* 1995/96	Qty (t)* 1996/97
Silver Perch	n/a	n/a	$10 - 15	n/a	1.5	10.0
Brook Trout	n/a	0.5	$13 - 24	0.01	1.0	3.0
Barramundi	11.0	7.0	$10	0.07	15.0	n/a
Yabbies	50.0	36.2	$6 - 8	0.3	40.0	110.0
Redclaw	2.0	3.5	$12 - 20	0.07	6.0	9.0
Marron	1.5	3.5	$20 - 32	0.1	3.5	6.0
Kuruma prawns	0.8	29.0	$30 - 100	3	58.0	80.0

* predictions
1 A range of current prices was supplied by respondents. Prices are in A$/kg of product.
2 Based on maximum prices, the total value of each species (A$'000 000) for the 1994/95 year was estimated.

For almost all species, annual quantities handled have increased from 1993/94 to 1994/95, and predictions are for this trend to continue. For king crabs, mud crabs and eels however, estimated quantities for 95/96 and 96/97 were not provided by some respondents. This accounts for the predicted decline in the quantities of these species and may suggest that their supplies are less reliable than for many other species. The general trend for those respondents who did provide predictions was for an increase in the quantity of live seafood that they would handle in the future.

The most significant fishery sourced species by volume and value included the southern rock lobster, western rock lobster, abalone, king crab and eel. In the case of aquaculture sourced species, yabbies and kuruma prawns were identified as the most significant species by volume and value.

Section 5.1 provided ABARE statistics for the annual production and value of selected live seafood species in Australia for the year 1993/94. Unfortunately data for the full range of live seafood species identified by the survey is difficult to obtain since the statistics are aggregated by high volume species or species groups into basic product forms such as frozen or chilled, rather than live. Data provided by ABARE when compared to those generated by the surveys indicated that respondents accounted for approximately one third of the total live seafood segment (Table 5.5).

Table 5.5 ***Comparison of ABARE estimates on live seafood production and survey returns for 1993/94. (Note: ABARE figures are assumed to refer mostly to live product).***

Species	ABARE/ Other Sources (A$million)	Survey (A$ million)	% of ABARE Total
Rock lobster	217	66	30%
Abalone	12	6	50%
Live fish (wild fishery)	4.5	3	66%
Live fish (aquaculture)	n/a	0.5	n/a
Yabbies	5	0.3	6%
Kuruma prawns	20	3	15%
Total	**258.5**	**78.8**	**30%**

- ***Implications of the survey results***

1. The respondents identified twenty-one species which are handled as live product.
2. The largest volumes were for marine crustaceans and marine molluscs (abalone).
3. Marine fish species currently represent about 15% by volume and 3% by value of the totals for all live seafood species handled by the respondents. Future trends are difficult to predict from the data, however it appears that marine fish will increase their share of the total in future years.

4. The current and predicted volumes of aquaculture species, with the exception of yabbies and kuruma prawns, appear to be relatively small. By value, kuruma prawns are likely to be the most important aquaculture species in respect of live handling.
5. Almost 60% of all commercial operators are involved in one live species rather than a wide range of species; ie. they are specialists (Figure 5.1).
6. Only 13% of respondents are involved in the capture segment of the industry.
7. Almost 30% of the respondents are involved in aquaculture (Figure 5.2).
8. More than 50% of the respondents are seafood wholesalers and seafood processors (Figure 5.2).

Figure 5.1 Number of species handled by commercial operators

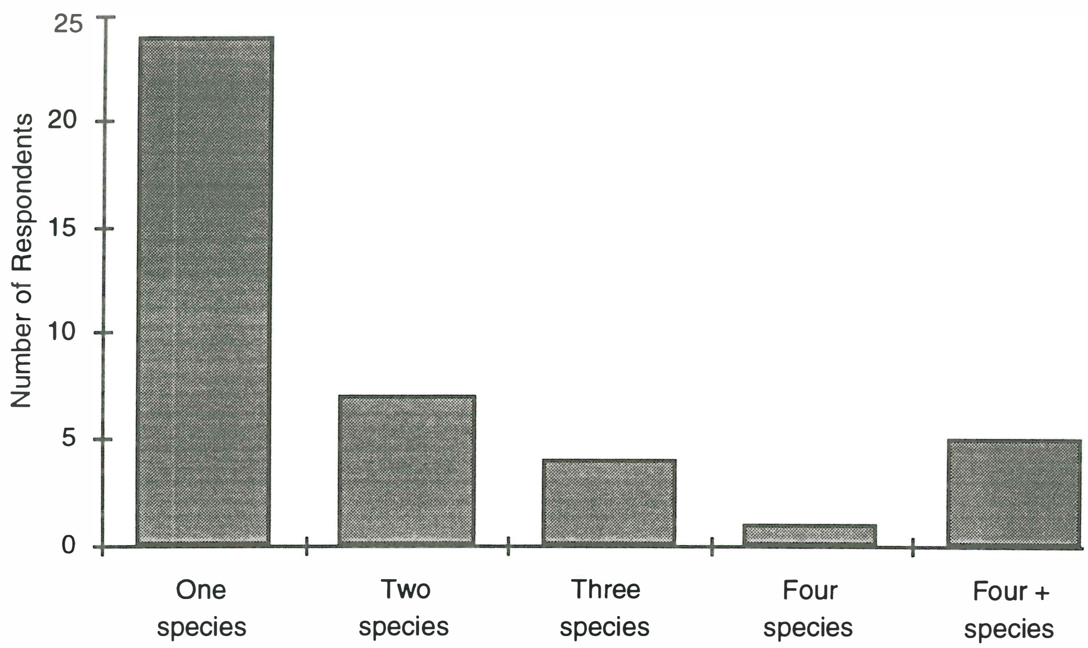
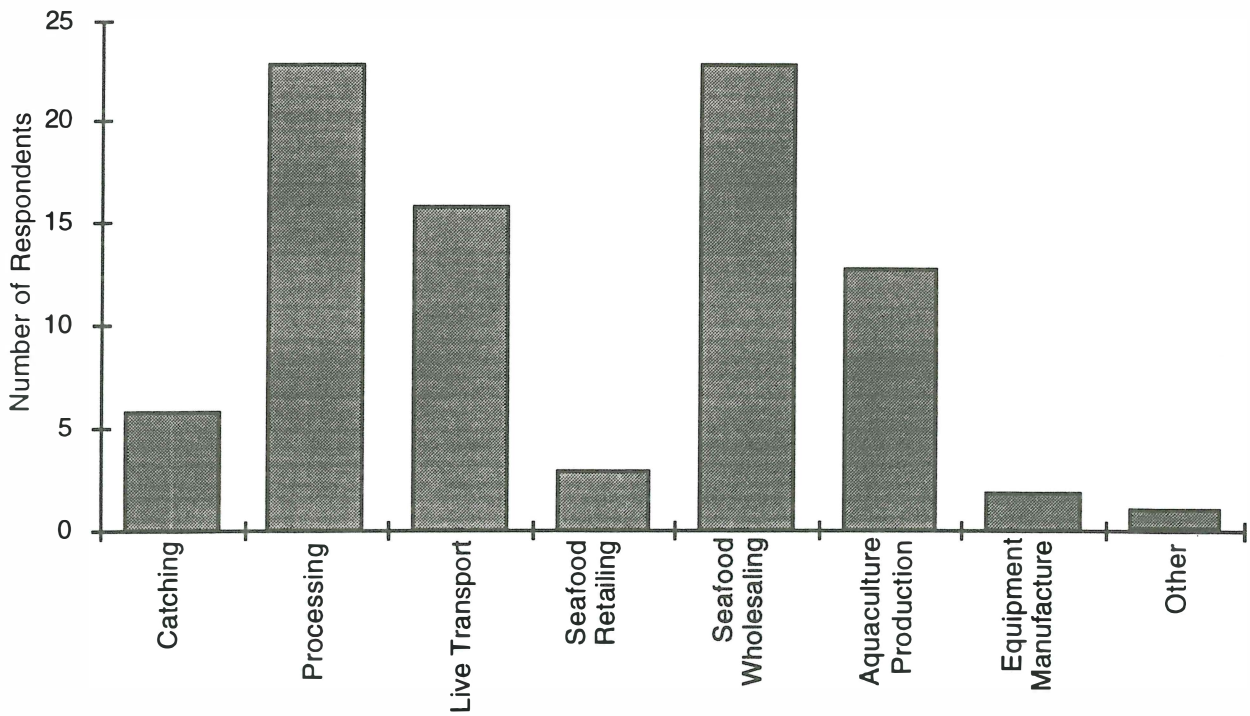


Figure 5.2 Industry segments identified by commercial operators



5.2.3 Duration of Holding and Transportation

For the range of wild fishery and aquaculture species, the average individual product weight and the average shipment weight was provided (Tables 5.6 and 5.7). The duration of holding stock prior to transport, and the duration of transport to the customer was provided.

Table 5.6 ***Average individual weights and total shipment weights, and the average duration of the Second Holding Period and Second Transport Leg for crustaceans and molluscs.***

Species	Av. Indiv. Weight	Shipment Weight	Holding Duration	Transport Duration
Eastern Rock Lobster	0.8 kg	100kg	2d	24hr
Southern Rock Lobster	0.5 - 5.0kg	20-750kg	2-20d	4-48hr
Western Rock Lobster	0.4 - 2.0kg	540-1000kg	4-7d	24-40hr
Champagne crab	1.0kg	50kg	5d	24hr
King Crab	3.0 - 6.0kg	20-300kg	2-8d	4-24hr
Mud Crab	0.9 - 1.0kg	70-600kg	0.5-7d	12-24hr
Spanner crab	0.5kg	600kg	7d	24hr
Yabbies	30 - 80gm	10-200kg	6-10d	48hr
Redclaw	80gm	50kg	5d	36hr
Marron	200gm	20kg	5d	48hr
Kuruma prawns	13 - 18gm	200-300kg	4h	14-48hr
Abalone	0.3 - 0.6kg	200-400kg	3-7d	4-48hr

Table 5.7 ***Average individual weights and total shipment weights, and the average duration of the Second Holding Period and Second Transport Leg for finfish.***

Species	Av. Indiv. Weight	Shipment Weight	Holding Duration	Transport Duration
Coral trout	0.1 - 3.5kg	100-600kg	1-6d	24hr
Banded morwong	1.1 - 1.5kg	120-400kg	2-4d	4-24hr
Barramundi cod	2.0kg	10kg	6d	24hr
Eel	0.8 - 8.0kg	600-1000kg	3-7d	24hr
Plate size cods	0.6 - 0.8kg	15kg	6d	24hr
Wrasse	0.8 - 1.0kg	60-100kg	2-5d	4-24hr
Silver Perch	0.6 - 1.0kg	100-300kg	4-14d	10-24hr
Brook Trout	1.0 - 2.0kg	1000kg	2d	7 days
Barramundi	0.7kg	500kg	3d	48-72hr

The average individual weights were mostly small (> 1 kg) although some of the rock lobsters, king crabs and marine fish (coral trout, banded morwong and barramundi cod) were larger. Shipment weights were highly variable although all were less than 1 tonne.

These responses indicate that most species are held for a period of two to seven days during the Second Holding Period. The duration of the Second Transport Leg was shown to average 24 hours for marine crustaceans and fish, and 48 hours for freshwater crustaceans.

5.2.4 Markets for Live Seafood Species

The survey revealed that Hong Kong is currently the largest market for Australian live seafood. In excess of 30% of all respondents currently export or intend to export to Hong Kong (see Figure 5.3). Hong Kong, Taiwan, Japan and other destinations in Asia were identified as the largest markets for Australian live seafood products by 84% of respondents.

Figure 5.3 Primary destinations for live seafood identified by commercial operators

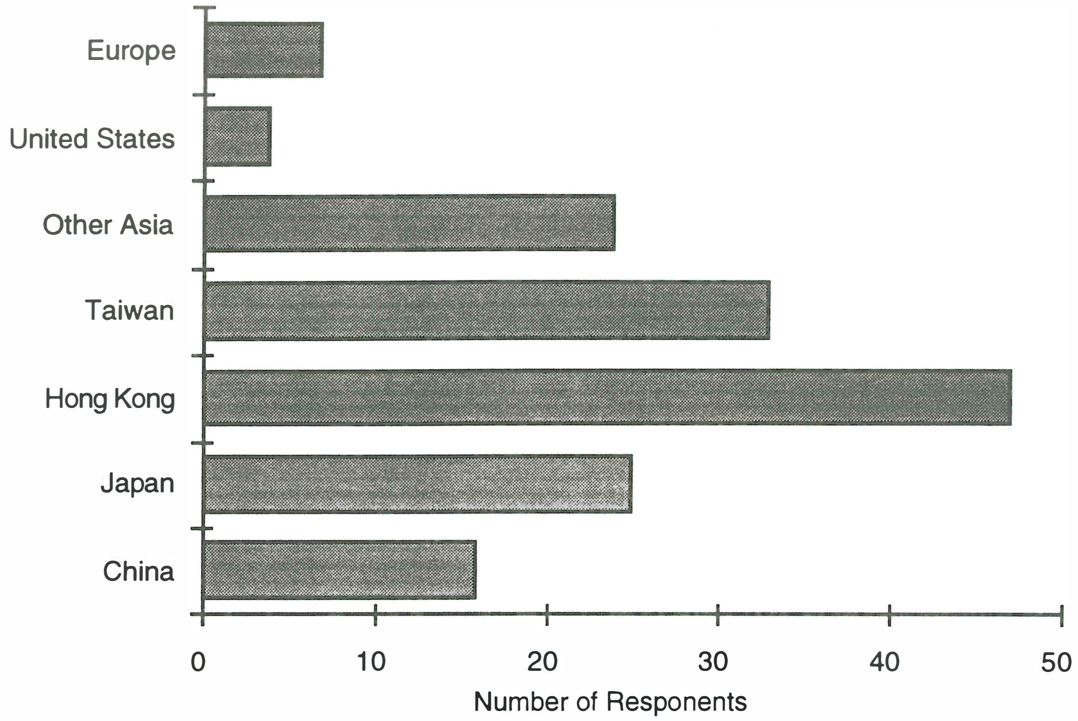
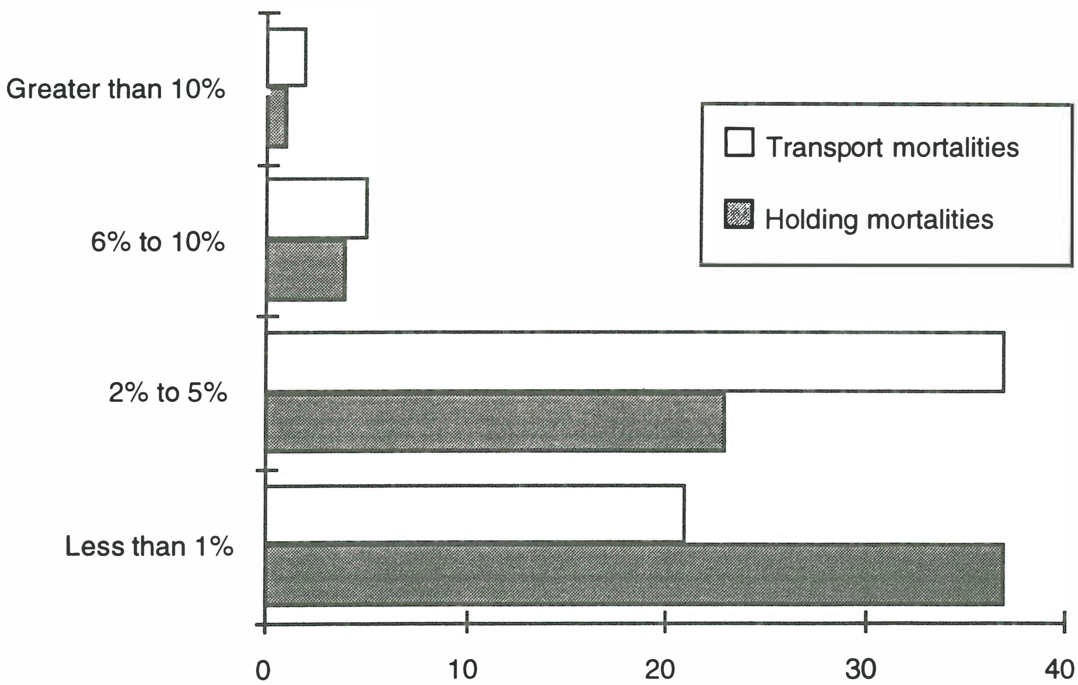


Figure 5.4 Mortalities experienced by commercial operators during the transport and holding of live seafood



5.2.5 Mortalities During Holding and Transport

Mortality is often cited as the most significant problem associated with the handling of live seafood. From the perspective of the customers of live seafood, the survey revealed that high mortality was the second most common problem, continuity of supply being their major cause for complaint. However, in the case of commercial operators, mortalities were not identified as a major concern (see Figure 5.5). Mortalities were identified as being more significant during transport rather than during holding (see Figure 5.4).

The survey did not reveal a critical level for acceptable losses. The effects of dead or moribund stock on the health of other stock held in the holding or transport system is a factor identified as one requiring further consideration and research.

Mortalities experienced by commercial operators at the time of capture or purchase of live seafood were highest (ie. in excess of 10% of stock) for western rock lobster. Species which suffered mortality rates in the order of 6% to 10% of stock included spanner crabs, parrot fish and coral trout. Reasons for above average mortalities were cited as being dependant upon:

- time of year (moulting stage)
- weather conditions
- condition of stock at time of purchase (ie. after capture)
- duration of first transport leg (ie. from vessel to holding facility)
- handling during capture
- age of catch (particularly in the case of mud crabs)

Mortalities experienced by commercial operators during the holding period and transport to customers were highest (ie. in excess of 10% of stock) for champagne crab and abalone. Species which suffered mortality rates in the order of 6% to 10% of stock included spanner crab, southern rock lobster, morwong and coral trout. Reasons for above average mortalities were cited as being dependant upon:

- weather conditions (and season)
- condition of stock at time of purchase (ie. after capture)
- water quality differences between transport and customer holding
- airport staff handling (and care during transport)
- distance from holding facility to customer
- suitability of holding tanks

5.2.6 Other Difficulties Facing Commercial Operators

The lack of continuity of supply of stock was identified as being the most significant single problem facing commercial operators (22%) as a proportion of all problems (see Figure 5.5). However, problems associated with the transport of live seafood (ie. air and road transport logistics, excessive transport time, transport techniques and equipment) were of far greater concern as a proportion of all problems (50%).

The majority of commercial operators indicated that their customers considered the major problem associated with the purchase of live seafood to be the lack of continuity of supply (see Figure 5.6). In fact, in excess of 60% of respondents considered this to be their clients' greatest concern. Mortalities during transportation and upon arrival were reported to be of concern by 25% of the respondents. Inadequate grading, unsuitable packaging and weight loss concerns were reported to be of minor concern only.

Figure 5.5 ***Relative importance of problems faced by commercial operators***

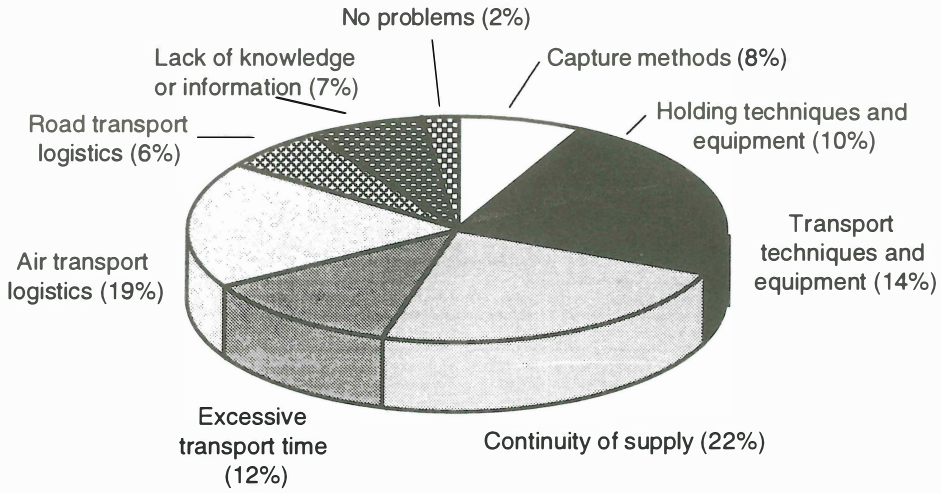
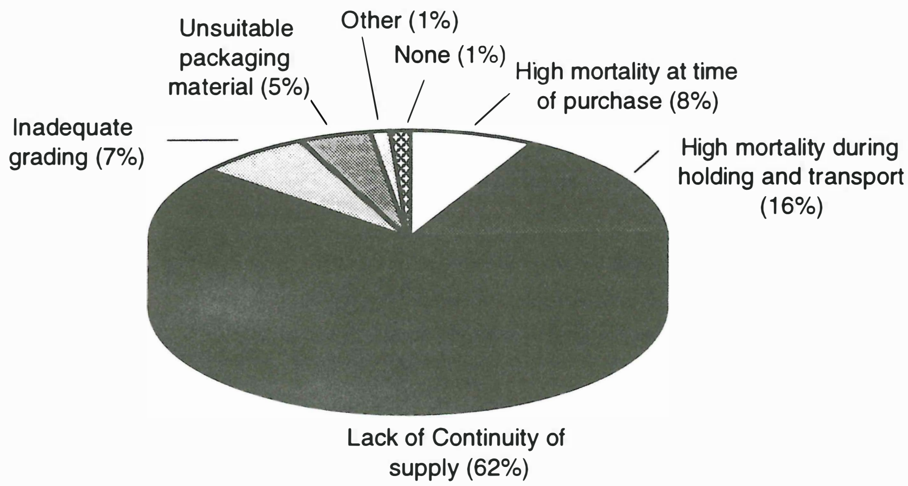


Figure 5.6 ***Relative importance of problems faced by customers according to commercial operators***



5.2.7 R&D Undertaken by Commercial Operators

Most commercial operators indicated that they had undertaken some applied research in-house. Of note was the fact that most of this research involved the development of improved filtration design and holding facilities as well as investigations into the physiological requirements of the stock (see Figure 5.7). The fact that less effort was directed towards solving problems which were identified as being of the greatest concern (eg. continuity of supply and transport logistics), provides an indication of where external (or industry based) assistance is required.

Figure 5.7 Areas of R&D undertaken by commercial operators

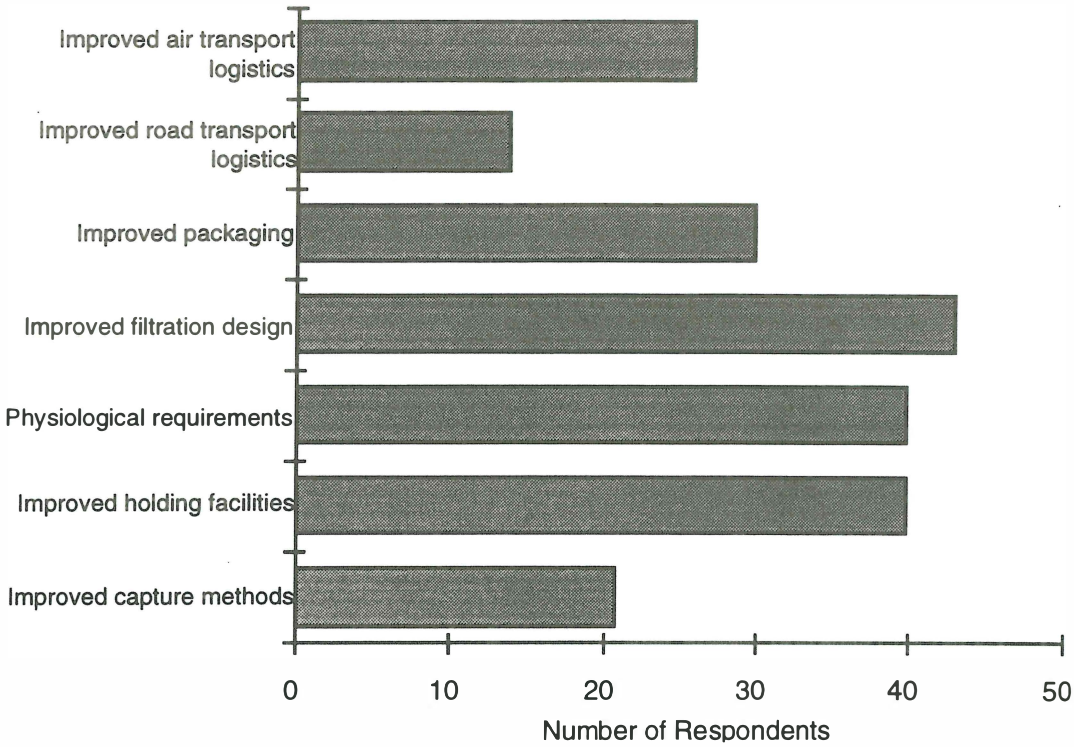
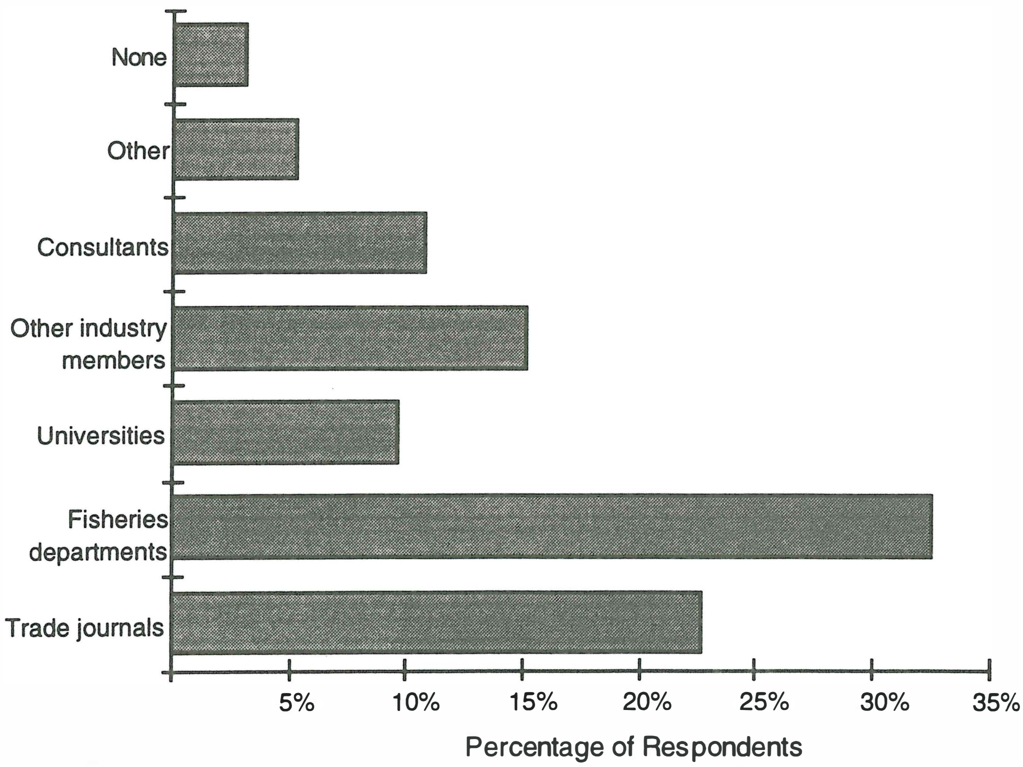


Figure 5.8 indicates the areas in which commercial operators sought information and assistance. Although over 30% of commercial operators sought information through fisheries departments (see Figure 5.8), many were critical of research currently being undertaken by university and fisheries researchers.

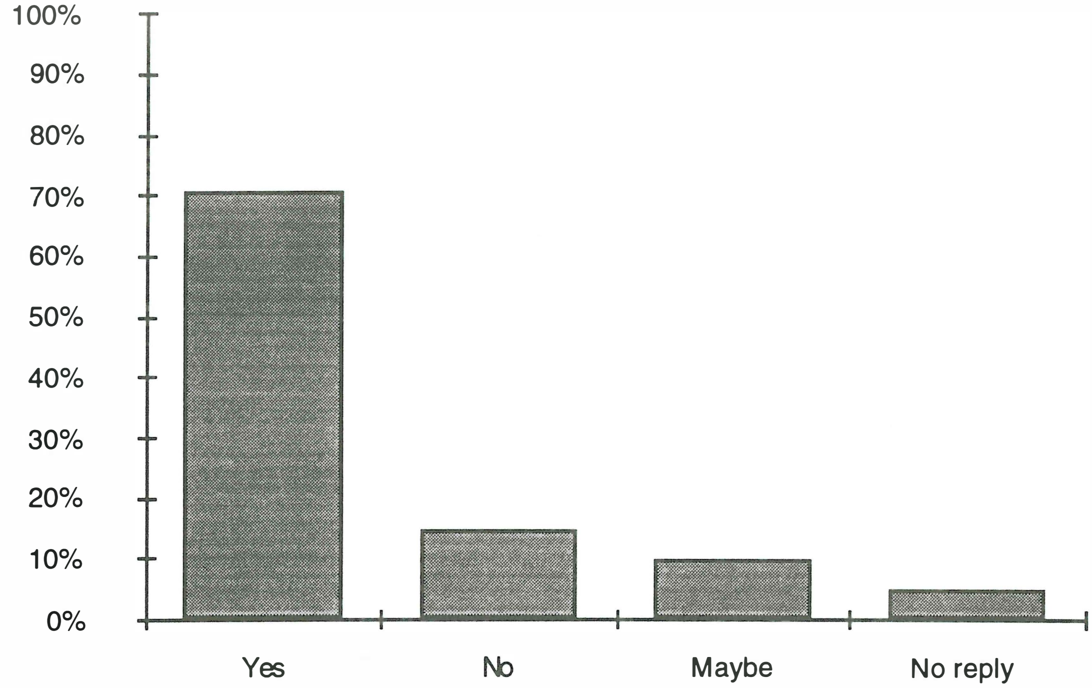
Figure 5.8 Sources of information accessed by commercial operators



5.2.8 Support For The Establishment Of A Live Seafood Industry Body By Commercial Operators

The question as to whether each of the commercial operators would support the establishment of a live seafood industry body was posed. In response, 69% indicated their support, 17% indicated that they would not support it and 14% indicated that they were unsure (see Figure 5.9).

Figure 5.9 Commercial operator support for the establishment of a live seafood industry body



In addition, a number of comments/observations were made by the respondents.

- The success of the industry body may depend upon the amount of subscription.
- The cost to industry may exceed its value.
- A large number of species and operators are involved in the industry and the problems are specific to each species and operator. This may make it difficult to achieve desirable outcomes.
- There is a perception amongst some respondents that fisheries departments already conduct the required research and that they have a role to play in ensuring that industry problems are overcome.

5.3 LIVE SEAFOOD RESEARCH SURVEY RESULTS

The research questionnaire was distributed to seventeen research organisations. A response rate of 88% resulted.

5.3.1 Methodology and Limitations

The primary purpose of the research questionnaire was to establish the types of research projects currently being conducted. In addition to structured research being undertaken by institutions such as universities, it was found that many small research projects were being conducted; some with the support of state fisheries departments. As a consequence, it quite likely that a considerable amount of R&D information is being generated outside dedicated research organisations, and that this information may be of significant value to the live seafood handling industry (see figure 5.7).

5.3.2 Description of Project Areas and Resources

A number of non-descriptive responses were provided in respect of research into live seafood handling. These included the following.

- Northern Territory Department of Primary Industry and Fisheries
  Research into the handling of *Lates calcarifer* (barramundi), *Scylla serrata* (mud crab) and *Lutjanus johnii* (snapper).
- Department of Primary Industry and Fisheries, Tasmania
  Research into the handling of banded morwong and wrasse species from an industry management perspective.
- NSW Fisheries - Fisheries Research Institute
  Research into the handling of snapper and mulloway.
- WA Fishing Industry Council
  Research into the handling of rock lobsters, freshwater crustaceans, blue crabs and finfish.

In addition, a number of descriptive responses were received.

Institution:	**University of Tasmania**
Principal:	Bradley Crear
Researchers:	2
Species:	*Panulirus cygnus* (Western rock lobster) *Jasus edwardsii* (Southern rock lobster)
Study Area:	Equipment design and holding facility sectors.
Specific Area:	Transport methods to the holding facilities, holding facility mortalities and basic respiratory physiology.
Research completed:	30%
Completion date:	August 1997
Facilities available:	Aquaria for holding lobsters, experimental rooms and apparatus, analytical laboratories.

Institution:	**University of Tasmania**
Principal:	James Findlay
Researchers:	3
Species:	*Meuschenia hippocrepis* (Horseshoe leatherjacket)
Study Area:	Fisheries catching, equipment design, holding facility and live transport sectors
Specific Area:	Capture methods, transport methods, holding facility mortalities, transport mortalities, water quality, disease and physiology.
Research completed:	25%
Completion date:	December 1997
Facilities available:	Aquaria for holding fish, experimental rooms and apparatus, analytical laboratories.

Institution:	**Australian Maritime College, Tasmania**
Principal:	Alby Steffens
Researchers:	1 to 3
Species:	*Notolabrus tetricus* (Blue throat wrasse)
Study Area:	Fisheries catching, equipment design, holding facility and live transport sectors
Specific Area:	Capture methods and physiology.
Research completed:	100%
Completion date:	Completed
Facilities available:	Temperature controlled holding facilities (4), all equipment associated with the catching sector (eg. boats, nets, etc.), analytical equipment
Publications:	(a) Determination of critical thermal minimum and incipient lethal temperature of wrasse (in press) (b) Stress of fish due to capture, handling and transport

Institution:	**South Australian Research and Development Institute**
Principal:	Patrick Hone
Researchers:	1
Species:	(1) Abalone (2) Oysters
Study Area:	Equipment design sector
Specific Area:	(1) Transport methods (to and from the holding facilities), holding facility and transport mortalities, water quality and disease. (2)Transport methods (to and from the holding facilities), and disease. (3) Capture methods, transport methods (to and from the holding facilities), transport mortalities, water quality, disease and facilities.
Research completed:	(1)25% (2)25%
Completion date:	Ongoing
Facilities available:	Temperature/humidity and light control. Program to replicate simulated air transport conditions. Flow through aquaria.
Publications:	None

Institution:	**School of Biomedical Sciences, Curtin University, WA**
Principal:	Patrick Spanoghe
Researchers:	4
Species:	*Panulirus cygnus* (Western rock lobster)
Study Area:	Holding facility and live transport sector
Specific Area:	Transport methods (to and from holding facilities), holding facility mortalities, transport mortalities and physiology
Research completed:	75%
Completion date:	December, 1995
Facilities available:	Clinical biochemistry laboratory and aquaria for live storage of a limited number of animals
Publications:	PhD thesis (in preparation) 2 reports published 1 conference communication 3 papers (in preparation)

Institution:	**Empire Bay Pty Ltd**
Principal:	Stuart Milne
Researchers:	4
Species:	*Plectropomus leopardus* (Coral trout)
Study Area:	Fisheries catching sector
Specific Area:	Capture methods, transport methods and water quality
Research completed:	25%
Completion date:	1996
Facilities available:	Curtin University and commercial fishing vessels

Institution: Department of Primary Industry and Fisheries (Tas)
Principal: Vic Epstein
Researchers: 1
Species: *Notolabrus tetricus*
Study Area: Fisheries catching sector
Specific Area: Water quality and physiology
Research completed: 25%
Completion date: 1998
Facilities available: not stated

Institution: Aquatic Science Research Unit, Curtin University, WA
Principal: Louis Evans
Researchers: (1) 5
(2) 6
(3) 2
(4) 1
Species: (1) *Plectropomus leopardus* (Coral trout)
(2) *Panulirus cygnus* (Western rock lobster)
(3) *Cherax tenuimanus* (Marron)
(4) *Acanthopagrus butcheri* (Black bream)
Study Area: Fisheries catching and live transport sector
Specific Area: Capture methods, transport methods to the holding facility, water quality and physiology of coral trout. All areas of the western rock lobster industry. Disease and physiology of marron. Physiology of black bream.
Research completed: (1) 25%
(2) 25%
(3) 75%
(4) 25%
Completion date: (1) 1998
(2) 1998
(3) 1997
(4) 1997
Facilities available: Marine aquaria, acclimation laboratory and analytical laboratory. Access to Curtin University School of Biomedical Sciences, Environmental Biology, Pharmacy and Applied Chemistry. Collaboration with the Fisheries Department.

Institution: Queensland Department of Primary Industries
Principal: Bruce Goodrick
Researchers: not stated
Species: (1) *Ranina ranina* (Spanner crab)
(2) *Penaeus japonicus* (Kuruma prawn)
Study Area: Fisheries catching, equipment design, holding facility and live transport sectors.
Specific Area: (1) Transport methods (to and from the holding facilities), transport mortalities and holding mortalities.
(2) Capture methods, transport methods (to and from the holding facilities) and transport mortalities
Research completed: (1) Proposal pending
(2) 100% and a proposal pending
Completion date: not stated
Facilities available: Live holding tanks, analytical services, technology, physiology, export registered pilot plant, live transport tank and vehicle up to 500kg
Publications: FRDC report - Kuruma prawn handling
Spanner crab workshop

Institution: Queensland Department of Primary Industries
Principal: Brian Patterson
Researchers: 5
Species: (1) *Ranina ranina* (Spanner Crab)

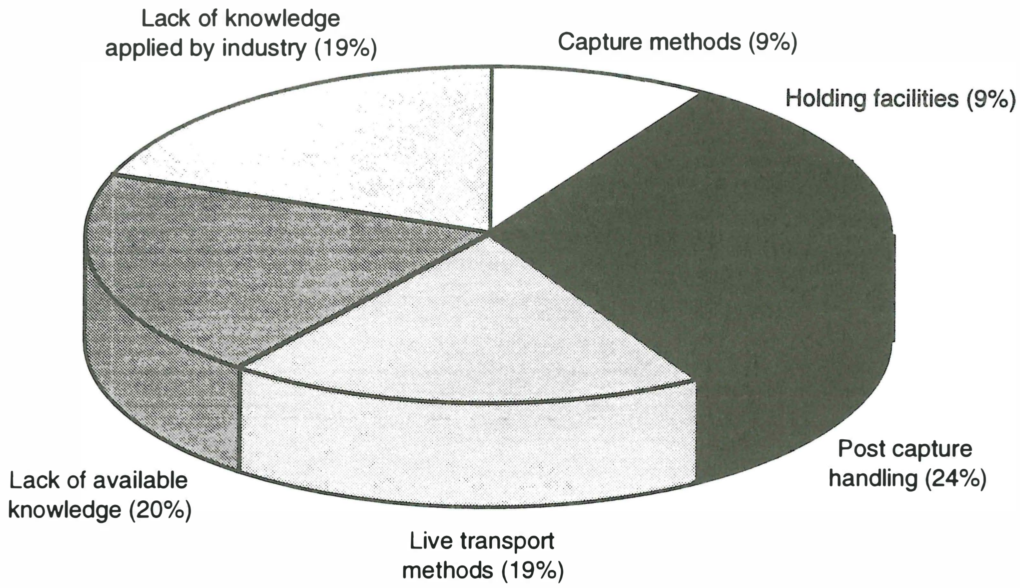
	(2) *Penaeus japonicus* (Kuruma prawn) (3) *Lates calcarifer* (Barramundi) (4) *Panulirus ornatus* (Tropical lobster) (5) *Plectropomus leopardus* (Coral trout)
Study Area:	Fisheries catching, equipment design, holding facility and live transport sectors.
Specific Area:	(1) Capture methods, transport methods (to and from the holding facilities), transport mortalities and facilities. (2) Transport methods (to and from the holding facilities), holding facility mortalities, disease and physiology. (3) Transport methods from the holding facility, transport mortalities and physiology (4) Transport methods (to and from the holding facilities), holding facility mortalities, water quality, disease and physiology (5) Transport methods (to and from the holding facilities), transport facility mortalities, water quality.
Research completed:	(1) 50% (2) 50% (3) 25% (4) 0% (5) 0%
Completion date:	Unknown
Facilities available:	Live seafood storage tanks, analytical laboratory facilities
Publications:	not stated

Institution:	**Queensland Department of Primary Industries Northern Fisheries Centre** **Southern Ocean Products** **IFIQ** **Oonoomba Veterinary Lab** **Tas. Dept. of Agriculture (Fish Health Unit)**
Principal:	Mike Rimmer (and others)
Researchers:	12
Species:	(1) *Lates calcarifer* (Barramundi) (2) *Plectropumus* spp. (3) *Cheilodactylus spectabilis* (Banded morwong) (4) *Pseudolabrus tetricus* (Wrasse)
Study Area:	Fisheries catching equipment design, holding facility and live transport.
Specific Area:	(1) Capture methods, transport methods (to and from the holding facilities), transport mortalities, water quality, disease and physiology. (2) Capture methods, transport methods (to and from the holding facilities), transport mortalities, water quality, disease and physiology. (3)Capture methods, transport methods (to and from the holding facilities), transport mortalities, water quality, disease and physiology (4)Capture methods, transport methods (to and from the holding facilities), transport mortalities, water quality, disease and physiology
Research completed:	(1) 75% (2) 50% (3) 50% (4) 50%
Completion date:	(1) June 1996 (2) June 1996 (3) June 1996 (4) June 1996
Facilities available:	Capture vessels, holding tanks, water quality testing equipment, fish physiology testing equipment, fish disease testing facilities.
Publications:	Five papers have either been published or are in press

5.3.3 Commercial Problems Identified by Researchers

A lack of knowledge either available to or applied by commercial operators was identified by researchers as a significant problem in the industry (see Figure 5.10). Methods used during live transport were also considered as significant problems. In comparison, commercial operators indicated that a lack of knowledge or information was a minor problem (7%) (see figure 5.5). Improved communications between researchers and commercial operators may overcome such misconceptions, which are clearly not the fault of either group. Indeed the opportunity for enhanced communications is a primary objective of the Hobart Forum.

Figure 5.10 The relative importance of problems facing the industry as perceived by researchers



5.3.4 Funding and Other Assistance

The primary source of funding for live seafood handling research has been the FRDC, contributing approximately 37% of the total funding requirement (see Figure 5.11). Institutional funding, through university budget allocations and fisheries budget allocations contributed approximately 35% of the funding requirement, whilst industry contributed about 9% of funds spent by researchers. It should be noted here that the contribution by industry would be far greater than 9% when all research and development is considered, since a considerable amount of research is undertaken in-house.

Principal areas in which industry does contribute significantly to institutional research include the provision of facilities and stock. Direct funding and the provision of equipment and expertise are other means by which commercial operators contribute to the institutional research effort (see Figure 5.12).

Figure 5.11 Sources of funding for researchers

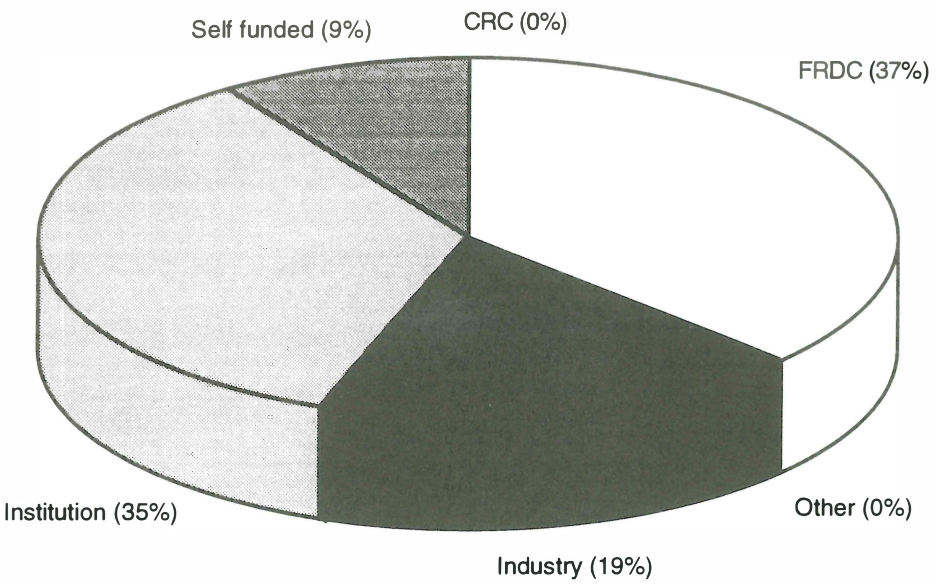
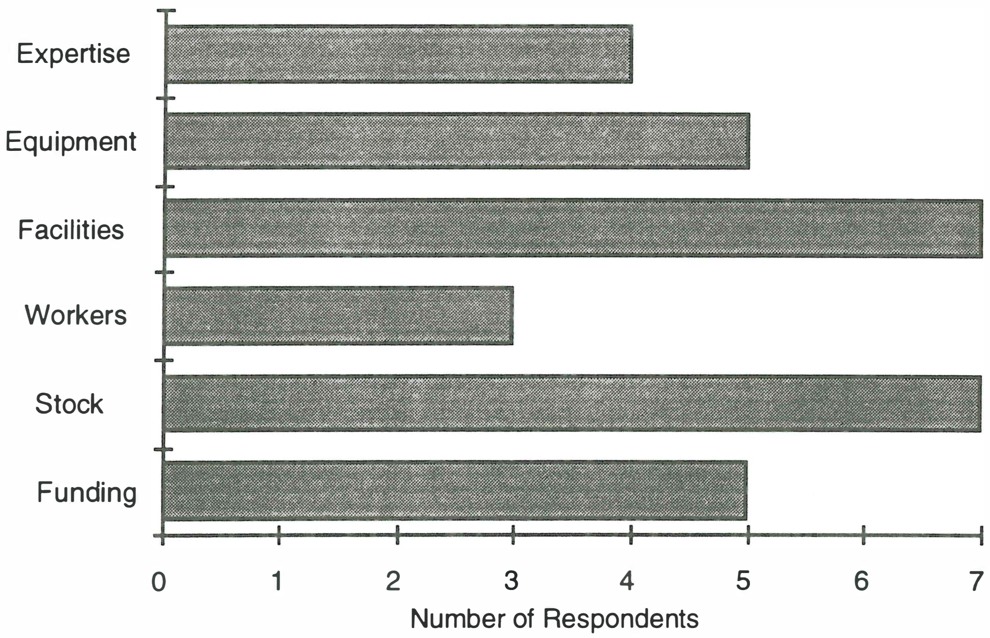


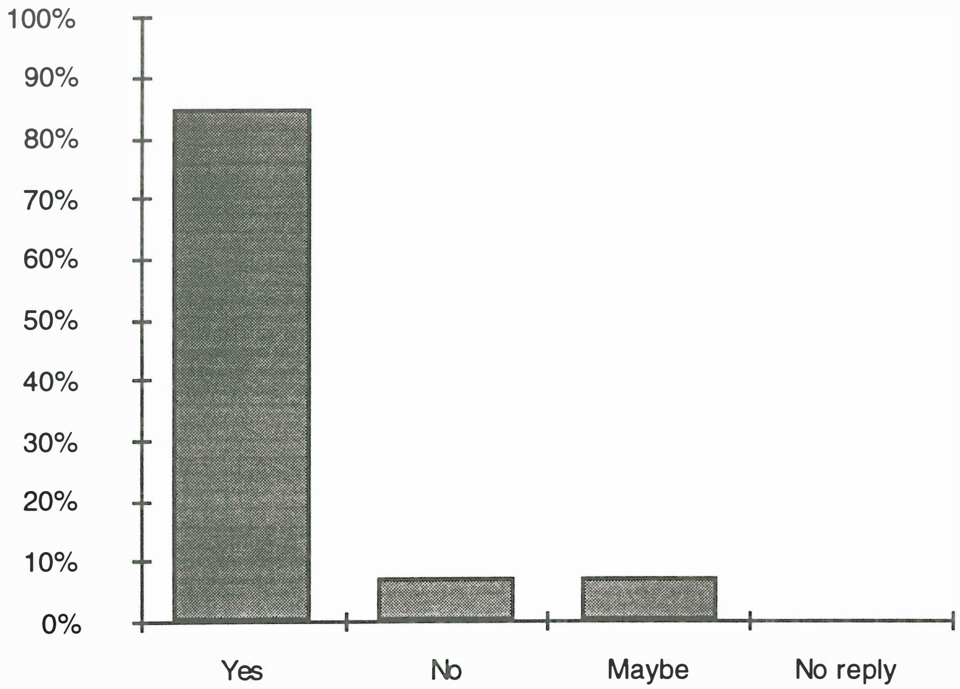
Figure 5.12 Forms of assistance provided by commercial operators to researchers



5.3.5 Support for the Establishment of a Live Seafood Industry Body

The question as to whether each of the researchers would support the establishment of a live seafood industry body was posed. In response, 84% indicated their support, 8% indicated that they would not support it and 8% indicated that they were unsure (figure 5.13).

Figure 5.13 Researcher support for the establishment of a live seafood industry body



6. MAJOR ISSUES ARISING FROM THE HOBART FORUM

The Hobart Forum provided the opportunity for delegates to discuss the four major issues of concern to the industry as identified by the industry survey. These issues included:

- Air transport of live seafood
- Equipment used for the capture, holding and transport
- The focus of current research
- Continuity in market supplies

Discussions took place in small work group sessions (to encourage input from all delegates) as well as in an open forum session. The following section provides a summary of the discussions and identifies a number of specific impediments to the development of the industry.

6.1 AIR TRANSPORT OF LIVE SEAFOOD

Perishable seafood, which includes both fresh-chilled and live product forms, is one of the major commodities exported from Australia (particularly to Asia) by airfreight. During 1994/95, seafood was ranked as Australia's major export commodity to Taiwan by value and volume and to Japan by volume. Hong Kong and mainland China were also major destinations by proportion of total commodities (ranking second and third by volume), with China showing annual growth approaching 200% by value.

Country	Value ($m)	Ranking	Growth (%)	Volume (tonnes)	Ranking	Growth (%)
China	3.4	7	198	141	3	113
Hong Kong	138.0	2	23	4720	2	14
Indonesia	1.8	15	(8)	89	12	(23)
Japan	161.0	3	29	9677	1	29
Korea	1.6	17	61	93	13	28
Malaysia	5.2	12	58	250	8	29
Singapore	21.7	9	37	967	7	34
Taiwan	101.5	1	27	5244	1	13

Figures supplied by the Department of Transport, Canberra.

In supplying these markets, the seafood industry commits tens of millions of dollars annually to airfreight expenditure. Therefore, efforts to resolve outstanding problems associated with the airfreight of perishable seafood products are likely to result in significant mutual benefit.

A number of major impediments associated with the handling and transportation live seafood were identified by the forum delegates. Of particular interest were the comments provided by representatives of our major air carriers. From the airlines perspective, there are four issues of concern when accepting live seafood cargo:

- lack of specific identification (eg live versus non-live seafood products)
- failure to comply with size and weight constraints of freight
- durability of seafood containers after multiple handling
- the high likelihood of leakage from containers which cause aircraft corrosion and the spoilage of other cargo

The recent decision by Ansett Australia to ban the carriage of live seafood from all Tasmanian terminals highlighted these issues. A representative from Ansett Australia informed the working group that aircraft frame corrosion represents a major operating cost to the airlines. On average, the overhaul cost for an aircraft is about $750,000, with up to 60% of this amount being attributable to corrosion maintenance. Whilst corrosion maintenance costs specifically due to seafood cargo vary, they are estimated to be in the order of $100,000 per aircraft. When considered over the entire Ansett fleet, this represents a cost in excess of one million dollars annually.

From the point of view of commercial operators, these issues currently constrain their ability to transport live product by airfreight.

A number of desirable criteria were suggested in respect of the design of standard live seafood containers. Those which were identified as appropriate by most delegates included:

- the availability of small space efficient disposable containers
- the availability of bulk containers
- the use of moulded plastic liners in containers
- the use of active membranes for gaseous exchange
- the use of standardised identification tape for all live seafood cargo

The work group was made aware that many commercial operators are taking it upon themselves to develop live seafood containers which may or may not be approved by the airlines. However, it was recognised that this effort has been time consuming and costly. Several delegates described their own design requirements for live seafood containers and since representatives from all sectors of the industry were represented, it was possible to discuss both the advantages and disadvantages of each design whilst simultaneously eliminating inadequate containers. Although brief, this discussion gave valuable insight into designs which may potentially be the live seafood containers of the future.

In recognition of this problem, Qantas Airways and Ansett Australia have recently prepared a document entitled "Australian Domestic Seafood Regulations and Package Approvals" to inform industry of the airlines requirements in respect of seafood carriage. This document provides details of 140 containers which have been approved by the airlines as suitable for the carriage of seafood. For the purpose of airfreighting seafood which excludes water, commercial operators may simply select the most suitable type of airfreight container for their produce. However, for instances where seafood is to be shipped with water, the choice is somewhat limited. Furthermore, whilst it was recognised that this document should provide a basis for eliminating variations in air cargo packaging requirements, cases where approved containers have been rejected for use by regional terminal managers were noted to occur. This creates considerable problems for commercial operators who may consequently face unreasonable barriers to the air shipment of their produce.

Commercial operators identified a number of other issues of concern including current aircraft scheduling (where for fresh chilled and live product, aircraft arrival times in international destinations can be critical to ensuring the freshness or survival of export product), aircraft re-scheduling (where due to a change in aircraft type alternative packaging may be required and far higher transportation costs incurred through increased labour and packaging materials), and delays in aircraft departure times (which can lead to significant losses).

It was agreed that a significant benefit (in the order of millions of dollars) could be gained by the industry through the establishment of improved communications between commercial operators and the airlines, a cooperative approach to the development of standard containers, and the establishment of effective procedures (code of practice) for the packing, handling and transport of live seafood.

It was evident from the discussions that the knowledge required for the successful transport of live seafood is currently available. However to date, a coordinated approach to solving the problems which face all sectors of the live seafood transport industry on a daily basis has not yet been adopted.

6.2 EQUIPMENT FOR THE HANDLING OF LIVE SEAFOOD

The use of suitable equipment combined with correct handling practices are critically important in ensuring good quality, live seafood, reaches the market place. Stress in particular has a major effect on live product, and may occur at any stage from capture, through holding, transport and marketing phases.

The equipment used for live seafood handling continues to evolve, and is significantly influenced by the differing requirements of each species group ie. crustaceans, fin-fish and molluscs. Some debate arose during the work group session when it was suggested that the discussion should focus on live fin-fish equipment, since handling requirements for crustaceans and molluscs are considered to be thoroughly understood. However, it was agreed following consideration of the results from the survey, that the entire live seafood industry is currently exposed to the problems under discussion, and that an integrated industry approach should be adopted in respect of all issues.

Work group participants identified few impediments to holding live seafood as a result of equipment problems. Manufacturers of live holding tanks consider the technology is well understood and has been effectively adapted to the needs of the industry. However, this is not the case with respect to equipment used to transport live seafood. Packaging and equipment (particularly reusable transport containers) are still evolving and in need of further research and development. Similarly, the design of on-board systems (wet wells, bins, coffs etc.) remains a rather inexact science.

Rather than discuss the issues of equipment use, work group participants were more interested in the use of sedatives or anaesthetics in live fish transport and the development of an industry Code of Practice. There was considerable interest in the use of *Aqui-S* as a means of preventing stress and exhaustion, particularly during the harvesting process. Work group participants expressed concern about the lack of information available about this product, and the difficulty of gaining access to *Aqui-S*.

Consensus was reached in regard of the need for an industry Code of Practice. Recognising that irregular practices prevail through all sectors of the industry (including catching, handling, holding and packaging), it was agreed that a Code of Practice would ensure some consistency and standardisation between operators during the handling and holding live fish.

The work group identified a range of issues which require consideration during the drafting and implementation of an industry Code of Practice.

- the code should include handling techniques from the point of capture (or harvest) to the customer
- the code must be supported by a comprehensive training program which seeks to educate handlers and reduce variations in handling techniques between operators
- the code should accommodate variations in fish species, geographic location, season etc
- the minimisation of stress during fish handling and storage must be the key component of the code

During discussions, some commercial operators expressed concern about the adequacy of advice and recommendations on aquaculture equipment provided by government departments and institutions. Researchers reinforced this position, indicating that recommendations are inappropriate as liability for faulty or damaged equipment may follow. Nevertheless there was a clearly demonstrated need for technical information to be available to the industry. The Australian Extension and Advisory Service (AUSEAS) provides such a service. AUSEAS was established with funding from FRDC, and provides technical information and advice which is derived from research results, trade data, industry publications and databases (including the Internet).

6.3 THE FOCUS OF CURRENT RESEARCH

Work group discussions revealed that industry considers that its research dollar should be driven further through improved definition of projects and monitoring of their success. Fortunately the gap between industry and the researchers is slowly decreasing. For example, state advisory groups (FRABs) now aim to ensure that FRDC funded research is industry driven. However, since FRDC is just one source of funds for research, further improvements can be gained through the application of this approach by other funding bodies. Support for regular forums (eg. annual workshops, newsletters, industry group meetings) was expressed as an appropriate mechanism for bringing all sectors of industry together to determine issues and their priority. It is predicted that the Live Seafood Reference Group (see Section 7) will assist in this process.

The research survey undertaken as part of this project, established that at least fifteen institutional research projects relating directly to live seafood are currently in progress in Australia. Many of these projects are multi-faceted, investigating a range of live seafood handling, capture, holding and transport issues. The survey also showed that many commercial operators undertake 'in-house' research without the assistance of research institutions. Researchers (government and university) participating in the work group, expressed a strong view that their assistance is only called upon once industry is stretched beyond its limits of knowledge and that this creates difficulties in methodology and can lead to sub-optimal results.

Researchers also suggested that industry often did not understand the scientific process; the need for replicated experiments and the time required to adequately complete projects. In response, industry members considered that they did not need to know exactly how science worked, but how the results could be incorporated into their operations. It was agreed that a greater level of interaction was required, especially on the part of the researchers who needed to 'sell' their services to industry more effectively. Work groups, such as the current forum, were considered by all participants to be an ideal opportunity for researchers to 'showcase' their results.

The level of secrecy exhibited by many commercial operators was also raised as a major concern by researchers in the work group since it was the cause of two major problems for the industry. Firstly, it makes it difficult to ascertain the validity of research in commercial situations, and secondly, it encourages a perception by commercial operators that research results are not of commercial benefit.

However, commercial operators believe that in order to establish and retain a competitive edge, it is often necessary for them to conduct 'in-house' research - the results of which are not available to industry. Whilst it was agreed by all delegates that applied research should be undertaken cooperatively, many commercial operators believe that conflicts of interest are likely to exist for researchers and consequently prefer that all information concerning their methods are kept confidential.

A number of commercial operators indicated that much of the 'in-house' research they performed involved the development of containers for transport. Since airlines have become more selective in respect of the transport containers permitted for the carriage of live seafood products, some commercial operators have begun to develop their own containers with the intention of having them individually approved by the airlines.

Commercial operators also indicated that although appropriate applied research may have been undertaken, it is often difficult to access and interpret this information. Conversely, researchers believe that much of this information is readily available but that commercial operators fail to access the information or apply it appropriately. Obviously, communication is lacking at this level and efforts must be made to rectify this problem to avoid duplication or overlap of research effort. Regular forums were considered to be the most appropriate way to overcome such problems.

The high value of 'experimental' animals was also considered as an impediment to some types of research. If industry is undertaking research and stock and holding space is required, then research may represent a significant opportunity cost to commercial operators.

Some delegates suggested that whilst research facilities have been built with industry based research in mind, industry was often not consulted about design requirements. As a consequence, many live seafood research facilities are not suitable for undertaking the type of research required by industry.

6.4 CONTINUITY OF MARKET SUPPLY

Problems associated with the continuity of live fish supplies were identified as the major concern of respondents to the industry survey. This work group identified communication regarding resource access and an entrenched industry culture as the major impediments to supply continuity.

Delegates agreed that before money and other resources can be committed to research and development, there must be some evidence that a sustainable fishery exists and that all impacts of exploitation have been considered. Clearly it is not useful for commercial operators to target fisheries for which resource allocation conflicts exist or the resource is threatened. On the other hand, it was considered that if the sustainable yield of a fishery is low, the additional value offered by the 'live' industry should take priority over other forms of capture, handling and marketing. The work group concluded that the potential value of alternative fishing methods is not sufficiently understood, or given sufficient priority, by resource management agencies. As there is not sufficient biological data on the impact of live capture methods, or on species suitable to the live trade, sufficient attention has not been given to comparing harvesting options.

It was also noted that marketing has not been given adequate consideration in fisheries resource management in Australia and that managers are not well informed about new marketing opportunities for their fisheries. It was concluded that marketing information, resource knowledge and management strategies needed to be integrated. Furthermore, the work group recognised the need to establish effective channels of communication between commercial operators and resource managers. Delegates agreed that the industry does not appear to have a strong voice in this regard and that fisheries managers should be lobbied more persistently.

The work group also concluded that achieving continuity in supply will require a shift in fishing culture, as well as fishing practices. For a more efficient vertical migration of seafood products through the distribution chain, fishers must become more involved in regulating supply, meaning that they must be encouraged to abandon the 'hunter/gatherer' approach in favour of strategic harvesting (ie. a 'just in time' approach rather than a 'fish bank' approach).

In addition to the above points, issues relating to air freight and market manipulation (ie. cancellation of orders and its effect on other markets) were raised as an impediment to continuity. Market manipulation problems typically involve delayed or postponed orders from overseas clients at critical times. Although not addressed in detail, it was felt that these situations could be mitigated by improved access to general market information, and better market intelligence.

7. INDUSTRY NEEDS AND FUTURE DIRECTIONS

In addition to providing the opportunity for communication between members of each sector of the live seafood industry, the Hobart Forum revealed a number of needs, and in response, identified a range of future directions which may assist its development. Whilst some industry needs were established through the industry surveys, discussion of these issues (see Section 6) provided additional insight which would otherwise have been lacking. As a consequence, this report provides a widely accepted foundation upon which industry development strategies may be formulated, coordinated and implemented.

The specific needs and proposed future directions of the industry are identified and summarised below. Whilst the primary goal of the forum was to discuss these issues, many other relevant points were raised and discussed, and a pathway for future communication and cooperation between industry sectors was established.

7.1 MARKET INTELLIGENCE INFORMATION

- Timely and accurate information regarding markets is required by exporters in order for them to make sound marketing decisions.
- Better knowledge of market trends will assist airlines and freight forwarders in determining schedules required to service the demand for space.
- Knowledge of market trends will provide resource managers with an insight into the likely pressures which may be placed on specific fisheries due to market demand.

7.2 RESOURCE MANAGEMENT

- Greater emphasis should be placed on achieving efficient vertical migration (movement towards higher value) of fisheries products. Details of markets and their requirements (eg. capture methods) for particular species must be known, and understood by fisheries resource managers when establishing management regimes (eg. quotas and gear restrictions) and estimating the sustainability of specific fisheries resources.
- Fisheries managers should aim to increase access to these resources and encourage share allocation arrangements which reflect a preference for selective fishing for value-adding purposes (eg. live seafood).
- In turn, fisheries managers need to educate and encourage fishers to progress towards a strategic harvesting approach which focuses on market requirements rather than resource availability.

7.3 AIRFREIGHT LOGISTICS INFORMATION

- Details of the facilities currently offered at departure and destination points for all airlines and freight forwarders should be generated and made available to exporters.
- Exporters require regularly updated information regarding airfreight services and schedules.
- Airlines and freight forwarders require market information (seasonal and trend) as an indication of future cargo space requirements.

7.4 ENHANCED COMMUNICATIONS BETWEEN INDUSTRY SECTORS

- An efficient flow of information through the vertical distribution system must be established.
- Information regarding containers permitted by the airlines for the live transport of seafood must be available to all exporters, as must access to the specified containers.
- Current details of live seafood handling facilities at departure and destination terminals and information regarding air transport logistics (flight scheduling, aircraft types etc) must be more readily available to exporters, perhaps through an industry data base system.
- Information regarding the use and availability of new survival enhancing products (eg Aqui-S) during the transport of live seafood should be available to all commercial operators.

- Details regarding completed research into the handling of live seafood should be made available to commercial operators.
- Information regarding the sustainability of specific fisheries must be relayed from fisheries resource managers to commercial operators so that they may be more certain of their capacity to service markets.

7.5 IMPROVED AIRFREIGHT FACILITIES AND HANDLING PRACTICES

- Airlines require knowledge of the needs of exporters in regard to the facilities and handling practices which are necessary for the maintenance of high product quality. Given this information, airlines will be better placed to evaluate the benefits to be gained through the provision of improved facilities and handling procedures.

7.6 COMMERCIALLY DRIVEN RESEARCH

- Improved linkages should be established between commercial operators and researchers so that problems and their solutions can be more easily identified and addressed.
- A comprehensive research program should be developed, recognising areas which require specialised scientific research and identifying commercial operators willing to act as participants in the program. Results of previous scientific work and projects currently in progress, should be considered within the framework of the program. The program must also accommodate the need for strategic research.
- A greater proportion of research effort (and funding support) should be directed towards resolving current industry problems and be focussed on those activities identified by the research program.

7.7 DEVELOPMENT OF ONGOING STRATEGIES

During the Forum it was suggested that fulfilling these industry needs will be fundamental to maintaining the growth which has been achieved by the industry in recent times.

The establishment of a **Live Seafood Industry Reference Group** which could reflect the broad views of participants in the industry, (fishing, science, airlines, exporters and Government) was considered as a first step in developing and coordinating a set of strategies to address these needs.

The role of this group would be primarily to provide an on-going forum of experienced advisers to assist organisations or individuals engaged in R&D and related projects. That is, to provide an identifiable group with the broad capability and willingness to undertake an advisory role and comment on (and perhaps participate in) relevant projects. The group would also provide a basic networking structure as a starting point for enhanced communication within the industry. Communication within the group (linking the broad interests of their own fields) with identified contact points for external linkages, would provide an immediate benefit to dozens of companies and researchers. It is envisaged that this role would evolve to link with future communication strategies and systems, in due course. It is not intended that this group become involved in lobbying or peak body activities, nor would it provide the basis for such a representative body.

As a consequence of the Forum agreeing to this approach, a Steering Committee was nominated to undertake the task of promoting the function of the Reference Group and to solicit qualified, interested members. Members of the steering committee include:

Deon Mahoney	National Seafood Centre
Mike Rimmer	Queensland Department of Primary Industries
Dale Bryan	Seablest Pty Ltd
Brian Hughes	Southern Ocean Products Pty Ltd
John Vietz	Ansett Australia
Bruce Goodrick	International Food Institute of Queensland
Malcolm Shelley	Commercial Aquariums Pty Ltd
Bruce Trewavas	Satellite Seafoods Pty Ltd

* For full contact details, please refer to Appendix IV.

It was also agreed that a **Live Seafood Code of Practice** should be developed as soon as possible. The potential industry benefits to be derived from such a code were noted to include:

- establishment of a basis for the safe and humane handling of live animals
- clarification of details regarding the specific requirements of air and road transport companies for the safe carriage of live seafood
- development of strategies for gaining accreditation for ISO and other standards
- establishment of standard handling procedures from the point of capture to harvest
- coordinated training and extension
- coordinated research and development programs

Whilst some progress towards this has already been made by Prof Nigel Forteath of the University of Tasmania, additional work is required.

8. SUPPORT ORGANISATIONS FOR THE INDUSTRY

This section details the Commonwealth and State Government activities which impact upon the live seafood industry. Each government level has a number of departments and agencies with responsibilities and functions which influence the activities of most sectors of the industry. In addition, a number of inquiries which are currently underway are of relevance to the industry.

8.1 AUSTRALIAN FISHERIES MANAGEMENT AUTHORITY

The Australian Fisheries Management Authority (AFMA) is a Commonwealth statutory authority responsible for fisheries governed by Commonwealth jurisdiction. In some cases joint management arrangements exist between State Governments and AFMA.

8.2 DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Of particular influence on the live seafood industry is the Department of Primary Industries and Energy. Amongst other responsibilities, DPI&E has responsibility for the formulation of fisheries and aquaculture policy.

The DPI&E has a number of divisions, branches and committees, including:

- Australian Quarantine and Inspection Service (AQIS)
- Fisheries and Aquaculture Branch
- Australian Bureau of Agricultural and Resource Economics (ABARE)
- Bureau of Resource Sciences (BRS)
- Office of Food and Safety
- Rural Division

8.2.1 AQIS

The Australian Quarantine Inspection Service (AQIS) is responsible for regulating quarantine standards for the import and export of food products. In order to enact these responsibilities within Australia and New Zealand, AQIS has established two industry committees:

- **Fishing Industry Advisory Council (FIAC)**; its main task being to liaise between AQIS and the fishing industry on such matters as seafood inspection requirements.

- **Australian Shellfish Sanitation Advisory Committee (ASSAC)**; which is primarily concerned with shellfish safety and inspection.

8.2.2 Fisheries and Aquaculture Branch

This branch liaises closely with the Rural Division, ABARE, BRS and other agencies, providing policy advice to the Federal Minister of Resources on fisheries and aquaculture management and industry development issues.

8.2.3 ABARE

The Australian Bureau of Agricultural and Resource Economics undertakes independent research and provides advice on issues including:

- economics and commercial viability
- marketing prospects
- environment and pollution impacts

ABARE is also responsible for publishing current trade and production statistics.

8.2.4 BRS

The Bureau of Resource Sciences is a part of the DPI&E which is further divided into three areas relevant to live seafood. These areas and their responsibilities are as follows:

- **National Residue Survey**; responsible for the residue testing of exported products.

- **Animal Plant and Health Branch**; providing technical advice on fish diseases.

- **Fisheries Resources Branch**; providing management related advice on fisheries, the marine environment and pollution matters.

8.2.5 Office of Food Safety

The Office of Food Safety liaises with AQIS to develop risk assessments for exported food commodities as well as develop contingency plans to combat potential food contamination incidences. Through the **Food Safety Management Committee (FSMC)** issues concerning the food safety trade implications of food commodities (including live seafood) are addressed.

8.2.6 Rural Division

The Rural Division of the DPI&E operates the Agribusiness and Clean Food Programs from which the live seafood industry seeks assistance.

8.2.7 Animal Health and Welfare Committee (AHWMC)

The Animal Health and Welfare Committee (AHWMC), is a high level DPI&E committee which coordinates animal health and welfare issues within the DPI&E.

8.3 FISHERIES RESEARCH AND DEVELOPMENT CORPORATION

The Fisheries Research and Development Corporation (FRDC) is a national research institution which aims to increase the economic and social benefits to the Australian fishing industry.

FRDC is responsible for the planning, funding and management of R&D programs as well as facilitating the dissemination, adoption and commercialisation of the R&D results. A key priority of FRDC is to encourage development of the seafood industry in areas including:

- Aquaculture
- Health and safety
- Information delivery
- Market development
- Quality assurance
- Technology
- Value adding

In order to accomplish these goals, FRDC in conjunction with the Queensland Department of Primary Industries, has created three organisations of direct relevance to the live seafood industry. These include:

- National Seafood Centre (NSC) - in conjunction with the Qld. Department of Primary Industries
- AUSEAS - in conjunction with the Qld. Department of Primary Industries
- Fish MAD - in conjunction with the Technisyst Group

8.3.1 National Seafood Centre

The National Seafood Centre (NSC) provides funds for research and development for value-adding and product development within the post-harvest sector of the Australian seafood industry. The NSC processes funding applications from all sectors of the live seafood industry; grants being allocated specifically to those research programs which will benefit the Australian seafood industry.

8.3.2 AUSEAS

Australian Seafood Extension and Advisory Service (AUSEAS) deploys a range of resources to accommodate the seafood industry with technical information. AUSEAS is in close contact with the NSC, as well as the International Food Institute of Queensland (IFIQ) which employs seafood technologists with experience in post-harvest seafood research and development. In addition, AUSEAS has access to the INTERNET and an electronic database of external experts.

8.3.3 FishMAD

Fish MAD, or the Fish Market Analysis Database, provides the live seafood industry with easy access to current market surveys and trends within the live seafood industry. The database is continually updated, with information as diverse as trends in the fast-food outlets to institutional buyers being available.

8.4 MINISTERIAL COUNCIL ON FORESTRY, FISHERIES AND AQUACULTURE

The Ministerial Council on Forestry, Fisheries and Aquaculture (MCFFA) is a consultative council which provides a link between Commonwealth and State/ Territory Governments and the New Zealand Government. The Minister of Resources chairs the council, which is comprised of the Commonwealth and State/Territory Ministers responsible for forestry, fisheries and aquaculture issues, as well as the Minister for Fisheries (New Zealand) and other invited non-member participants.

8.4.1 Standing Committee on Fisheries and Aquaculture

Reporting to the MCCFA on issues of relevance to fisheries and aquaculture, is the Standing Committee on Fisheries and Aquaculture (SCFA); a committee comprising of State/Territory Senior Directors. The SCFA is concerned with the research, planning, management and development of both fisheries and aquaculture industries. The SCFA is divided into five sub-committees, three of which have direct impact on the live seafood handling industry.

- **Aquaculture Committee (AC)** is dedicated to the development of the aquaculture industry through a coordinating function which is concerned with administration, legislation and the dissemination of management and research information between Governments. The AC considers the development of consistent translocation policies within the aquaculture industry as a priority.
- **Fisheries Environment and Health Committee (FEHC)** has a number of functions, all of which involve aspects of the export and import of live fish and fish products in Australia and New Zealand. Tasks of the committee include:
    - collaboration of the FEHC and the National Regulation Authority (NRA) to identify and regulate chemicals of use in the aquaculture industry
    - establishment of a consistent approach to national seafood translocation and live fish transport
    - establishment of the Fish Health Coordinating Group (FHCG) and the preparation of a fish health emergency response mechanism
- **Research Committee (RC)** advises on key national research issues and oversees the Working Group on Fisheries Statistics. Each of the committees under the SCFA propose research priorities to the Research Committee for consideration.
- **Management and Compliance Committees (MC and CC)** although not specifically relevant may have indirect impacts on the live seafood industry.

Both the AC and FEHC have been established to deal with issues of direct relevance to the live seafood industry and in particular live fish transport and translocation. They have acknowledged chemical registration in aquaculture as a priority issue, and as a result, both committees have undertaken further steps to develop a coordinated approach to the registration of chemicals. The AC has established a Taskforce to mediate discussions between the aquaculture industry and the NRA concerning the development of guidelines for the use of chemicals in aquaculture, and the FEHC has undertaken to incorporate live fish transport chemicals into this process. In order to achieve this, the FEHC has distributed a number of surveys to industry members to establish the types of chemicals which require definition and registration within the live fish transport sector. The FEHC has also established the FHCG for the purpose of dealing with issues related to fish health and disease and to oversee the development of a "fish health emergency management model" directed at identifying the departmental bodies involved in animal and fish health. It has also undertaken to collate regional translocation policies to facilitate a national approach to translocation and live fish transport. It is intended that through the coordination of these policies a "noxious species list" will be developed.

8.5 AGRI-FOOD COUNCIL

The Agri-food Council is the focal point of the Federal Government's Agri-food Industry Strategy, launched in 1992. It is a council comprised of both private and government representatives and is involved in a number of activities which may influence the live seafood industry. The main objective of the Agri-food Council is to provide a cooperative and coordinated approach between industry, unions and government, with respect to food producers, processors and marketers. Core priorities of the Council with particular significance to the live seafood industry include:

- Market access and export development
- Regulatory reform
- Transportation and distribution
- Packaging
- Workplace reforms and strategies

The Agri-food Council is divided into several working groups each with a specific task. The **Airfreight Working Group**, which has one seafood industry representative, has recently developed a draft code of best practice for the airfreight export of perishable items.

8.6 SEAFOOD INDUSTRY ASSOCIATIONS AND JOINT INITIATIVES

There is one major industry organisation directly concerned with the development and activities of the live seafood industry.

8.6.1 ASIC

The Australian Seafood Industry Council (ASIC) is the national peak body representing the Australian fishing industry; including aquaculture and post-harvest sectors. ASIC is comprised of representatives of each state/ territory fishing industry council with a number of sub-committees covering environment, aquaculture, training and management.

The primary objective of ASIC is to ensure access of resources for its 7,000 members, emphasising sustainability through sound harvesting practices and protection of the marine environment. ASIC has a high government profile and instigates cooperative industry planning.

ASIC manages **SeaQual**, which is a joint initiative with FRDC and DPI&E. It was recently established for the specific purpose of increasing the rate and spread of adoption of quality management systems in the seafood industry. In so doing, SeaQual will examine the costs and benefits of adopting quality management systems and develop a framework identifying factors which determine adequate levels of quality management. By promoting the importance of quality management, it is intended that SeaQual will create an environment through which all sectors of the live seafood industry may remain internationally competitive.

8.7 CURRENT GOVERNMENT INITIATED INQUIRIES

Indirectly impacting the live fish industry, is the **National Taskforce on Imported Fish and Fish Products**. This project, initiated by the Minister for Primary Industries and Energy, aims to develop a national quarantine framework for the importation of aquatic animals for aquatic use. It was initially established following the recent pilchard kill in South Australia in 1995. This Taskforce will be investigating current translocation policies including interstate trade in fish and fish products.

The **House of Representatives Standing Committee on Transport, Communications and Infrastructure**, has been requested to investigate systemic deficiencies in Australia's air freight export infrastructure and report on the impediments facing exporters and the capacity of the airfreight sector to service them.

A **Study of the Impediments to the Development of Export Markets for Perishable Products** is being undertaken by the DPI&E, Department of Transport, and Department of Prime Minister and

Cabinet to complement the Air Freight Review inquiry. The Working Group's aim is to examine all steps of the air freight export chain for perishable products and to determine actions required to eliminate any impediments. The results of this study will be used to target specific areas for action and act as a catalyst for the more rapid growth of exports of perishable products. In particular, the group is considering major issues which face exporters operating outside the main air freight forwarding centres of Sydney and Melbourne.

8.8 STATE GOVERNMENT BODIES

For each State of Australia, State Government Departments and Institutions are responsible for state based fisheries and aquaculture issues. Whilst each of these organisations vary in their responsibilities, the broad issues dealt with on a daily basis include:

- Management and administration of licenses, permits, policy implementation and regulation, general enquiries
- Liaison between industry, State Government and the Commonwealth Government.
- Research and Development activities both in fisheries and aquaculture
- Training
- Quality assurance
- Promotion and extension services
- Conservation and recreation

Specifically, State Governments oversee domestic issues of relevance to the live seafood industry including state translocation and quality assurance. Issues of national significance (eg. exports, quarantine, use of chemicals and fish transport) are the responsibility of Commonwealth departments and institutions as discussed above.

exporters; exporters require access to regularly updated information regarding airfreight services and schedules; and airlines and freight forwarders require market information (seasonal and trend) as an indication of future cargo space requirements.

- **Communication Between Industry Sectors**
An efficient flow of information through the vertical distribution system must be established; information regarding containers permitted by the airlines for the live transport of seafood must be available to all exporters, as must access to the specified containers; current details of live seafood handling facilities at departure and destination terminals and information regarding air transport logistics (flight scheduling, aircraft types etc) must be more readily available to exporters, perhaps through an industry data base system; information regarding the use and availability of new survival enhancing products during the transport of live seafood should be available to all commercial operators; details regarding completed research into the handling of live seafood should be made available to commercial operators; and information regarding the sustainability of specific fisheries must be relayed from fisheries resource managers to commercial operators so that they may be more certain of their capacity to service markets.

- **Improved Airfreight Facilities and Handling Practices**
Airlines require knowledge of the needs of exporters in regard to the facilities and handling practices which are necessary for the maintenance of high product quality; and given this information, airlines will be better placed to evaluate the benefits to be gained through the provision of improved facilities and handling procedures.

- **Commercially Driven Research**
Improved linkages should be established between commercial operators and researchers so that problems and their solutions can be more easily identified and applied; a comprehensive Program should be developed, recognising areas which require specialised scientific research and identifying commercial operators willing to act as participants in the Program; the results of previous scientific work and projects currently in progress should be considered within the framework of the Program which must also accommodate the need for strategic research; and a greater proportion of research effort (and funding support) should be directed towards resolving current industry problems and be focussed on those activities identified by the Program.

As a first step towards initiating strategies to address these needs, a steering committee was elected (during the Hobart Forum) to form an industry reference group. The role of this group would be primarily to provide an on-going forum of experienced advisers to assist organisations and individuals engaged in R&D and related projects, and to provide a basic networking structure as a starting point for enhanced communication within the industry. Communication within the group (linking the broad interests of their own fields) with identified contact points for external linkages, would provide an immediate benefit to the industry. It is envisaged that this role would evolve to link with future communication strategies and systems, in due course.

APPENDIX I

Live Seafood Handling Survey Questionnaire

LIVE SEAFOOD HANDLING QUESTIONNAIRE

Please tick the appropriate boxes. Some questions require a written answer and you may wish to expand on some aspects. If insufficient space is available, please attach a separate sheet to the end of the questionnaire. Please return to:

Please return questionnaire to:

PSM Consulting Group Pty Ltd
PO Box 243, MOWBRAY TAS. 7248
Phone: (003) 347 005 • Mobile: (018) 130 595 • Fax: (003) 347 007

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1.1 Company Name ....

1.2 Respondents Name ....

1.3 Which industry sector best describes your operations area?
(you may tick more than one box)

Fisheries Catching Sector ☐	Seafood Processing Sector ☐	Live Transport Sector ☐	Seafood Retailing Sector ☐
Aquaculture Production Sector ☐	Seafood Wholesaling Sector ☐	Equipment Manufacturer ☐	Other .... ☐

1.4 What species and quantity of live seafood have you handled in the past and expect to handle in the near future?

	Species (please be precise)	1993/94	1994/95	1995/96	1996/97	Estimated Current Value
1.	....	......................kgs	..................kgs	......................kgs	..................kg	$........../kg to $ ..../kg
2.	....	......................kgs	..................kgs	......................kgs	..................kg	$........../kg to $ ..../kg
3.	....	......................kgs	..................kgs	......................kgs	..................kg	$........../kg to $ ..../kg
4.	....	......................kgs	..................kgs	......................kgs	..................kg	$........../kg to $ ..../kg
5.	....	......................kgs	..................kgs	......................kgs	..................kg	$........../kg to $ ..../kg

List species here ...	Species 1	Species 2	Species 3	Species 4	Species 5
	....	....	....	....	....

1.5 Which industry sector best describes your customer base for each species?

Domestic Processor	☐	☐	☐	☐	☐
Domestic Wholesaler	☐	☐	☐	☐	☐
Domestic Retailer	☐	☐	☐	☐	☐
Export Wholesaler	☐	☐	☐	☐	☐
Export Retailer	☐	☐	☐	☐	☐

1.6 If you are involved in export, which regions or countries comprise your major markets?

Mainland China	☐	☐	☐	☐	☐
Japan	☐	☐	☐	☐	☐
Hong Kong	☐	☐	☐	☐	☐
Taiwan	☐	☐	☐	☐	☐
Other Asia	☐	☐	☐	☐	☐
United States	☐	☐	☐	☐	☐
Europe	☐	☐	☐	☐	☐
Other	....	....	....	....	....

1.7 From which source does each of the live species that you handle originate?

Wild Fishery	☐	☐	☐	☐	☐
Aquaculture	☐	☐	☐	☐	☐

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2.	Species 1	Species 2	Species 3	Species 4	Species 5
2.1 Please provide estimates for the following:					
Ave. size of product (kg)	....	....	....	....	....
Ave. quantity per shipment (kg)	....	....	....	....	....
Ave. time for holding (days)	....	....	....	....	....
Ave. time for transport (days)	....	....	....	....	....

2.2 On average, what mortality rate do you experience at the time of capture /or purchase of your live product?

	Species 1	Species 2	Species 3	Species 4	Species 5
Less than 1%	❑	❑	❑	❑	❑
2% to 5%	❑	❑	❑	❑	❑
6% to 10%%	❑	❑	❑	❑	❑
Greater than 10%	❑	❑	❑	❑	❑
How does this rate vary?	....	....	....	....	....
	....	....	....	....	

2.3 On average, what mortality rate do you experience during the period that you hold or transport your live product?

	Species 1	Species 2	Species 3	Species 4	Species 5
Less than 1%	❑	❑	❑	❑	❑
2% to 5%	❑	❑	❑	❑	❑
6% to 10%	❑	❑	❑	❑	❑
Greater than 10%	❑	❑	❑	❑	❑
How does this rate vary?	....	....	....	....	....
	....	....	....	....	

2. cont...

	Species 1	Species 2	Species 3	Species 4	Species 5

2.4 What best describes the problems that you face in respect of handling each species of live product?

	Species 1	Species 2	Species 3	Species 4	Species 5
Unsuitable capture methods/equipment	❑	❑	❑	❑	❑
Unsuitable live storage techniques/equipment	❑	❑	❑	❑	❑
Unsuitable live transport techniques/equipment	❑	❑	❑	❑	❑
Lack of continuity of supply	❑	❑	❑	❑	❑
Excessive time involved during transport	❑	❑	❑	❑	❑
Logistics problems with air transport	❑	❑	❑	❑	❑
Logistics problems with road transport	❑	❑	❑	❑	❑
General lack of knowledge and information	❑	❑	❑	❑	❑

2.5 What areas of R&D have you undertaken or consider are necessary in respect of live seafood handling?

	Species 1	Species 2	Species 3	Species 4	Species 5
Improved capture methods	❑	❑	❑	❑	❑
Improved holding tank design/construction	❑	❑	❑	❑	❑
Determination of species specific physiological requirements (eg. optimal pH, DO, Temp)	❑	❑	❑	❑	❑
Improved filtration design/construction	❑	❑	❑	❑	❑
Improved packaging materials	❑	❑	❑	❑	❑
Improved road transport logistics	❑	❑	❑	❑	❑
Improved air transport logistics	❑	❑	❑	❑	❑
Other	....	....	....	....	....
	....	....	....	....	....

2. cont...	Species 1	Species 2	Species 3	Species 4	Species 5

2.6 What best describes the problems that your customer relays to you in regard to your live product?

	Species 1	Species 2	Species 3	Species 4	Species 5
High mortality rate at time of purchase	☐	☐	☐	☐	☐
High mortality rate during subsequent storage or transport	☐	☐	☐	☐	☐
Lack of continuity of supply	☐	☐	☐	☐	☐
Inadequate grading of product	☐	☐	☐	☐	☐
Unsuitable packaging material	☐	☐	☐	☐	☐

3.

3.1 What sources of information do you access.

Trade Journals	☐	Fisheries Departments	☐	Universities	☐	Other industry members	☐
Aquaculture consultants	☐	Other (please specify)	☐	....			

3.2 Would you support the establishment of a Live Seafood Industry Body? (The purpose of this body would be to promote research in areas which would directly meet the needs of the industry and to disseminate research outcomes and other relevant information to industry.)

Yes ☐ No ☐

If you would like to expand on any of the above, please attach a separate sheet. Any additional comments will be appreciated.

APPENDIX II

Live Seafood Research Survey Questionnaire

LIVE SEAFOOD RESEARCH QUESTIONNAIRE

Please tick the appropriate boxes. Some questions require a written answer and you may wish to expand on some aspects. If insufficient space is available, please attach a separate sheet to the end of the questionnaire. Please return to:

Please return questionnaire to:
PSM Consulting Group Pty Ltd
PO Box 243, MOWBRAY TAS. 7248
Phone: (003) 347 005 • Mobile: (018) 130 595 • Fax: (003) 347 007

URGENT AND CONFIDENTIAL

1. Organisation ....

2. Respondents Name ....

3. Which industry sector best describes your research area?
(you may tick more than one box)

Fisheries Catching Sector	☐	Equipment Design Sector	☐
Holding Facility Sector	☐	Live Transport Sector	☐

4. What species of live seafood do you research (please be precise)?

	Species 1	Species 2	Species 3	Species 4	Species 5
List species here ...	....	....	....	....	....

5. From which source does each of the live species that you handle originate?

Wild Fishery	☐	☐	☐	☐	☐
Aquaculture	☐	☐	☐	☐	☐

	Species 1	Species 2	Species 3	Species 4	Species 5
6. What specific area(s) are you researching?					
Capture methods	❑	❑	❑	❑	❑
Transport methods (to the holding facility)	❑	❑	❑	❑	❑
Transport methods (from the holding facility)	❑	❑	❑	❑	❑
Holding facility mortalities	❑	❑	❑	❑	❑
Transport mortalities	❑	❑	❑	❑	❑
Water quality	❑	❑	❑	❑	❑
Disease	❑	❑	❑	❑	❑
Physiology	❑	❑	❑	❑	❑
Other	....	....	....	....	....
7. How much of your research have you completed?					
0%	❑	❑	❑	❑	❑
25%	❑	❑	❑	❑	❑
50%	❑	❑	❑	❑	❑
75%	❑	❑	❑	❑	❑
100%	❑	❑	❑	❑	❑
8. When is your research expected to be completed?					
(month/year)	....	....	....	....	....
9. How many people are involved with your research?					
	....	....	....	....	....

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	Species 1	Species 2	Species 3	Species 4	Species 5
10. What do you think is the major problem areas in the live transport of the animal(s) you are studying?					
Capture method	❑	❑	❑	❑	❑
Setup of holding facilities	❑	❑	❑	❑	❑
Post-capture handling	❑	❑	❑	❑	❑
Live transport methods	❑	❑	❑	❑	❑
Lack of knowledge available	❑	❑	❑	❑	❑
Lack of knowledge applied by industry	❑	❑	❑	❑	❑
Other	....	....	....	....	....
11. Who are you funded by?					
FRDC	❑	❑	❑	❑	❑
CRC	❑	❑	❑	❑	❑
Industry	❑	❑	❑	❑	❑
Institution	❑	❑	❑	❑	❑
Self	❑	❑	❑	❑	❑
Other	....	....	....	....	....

12. What facilities are available?

....

....

....

....

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13. Do you do research in conjunction with an industry group? If so do they provide:

Funding	❑	Facilities	❑
Animals	❑	Equipment	❑
Workers	❑	Expertise	❑

14. Have you published or are you intending to publish any reports/papers on your present research or any previous research on live transport?

....

....

....

....

15. Would you support the establishment of a Live Seafood Industry Body? (The purpose of this body would be to promote research in areas which would directly meet the needs of the industry and to disseminate research outcomes and other relevant information to industry.)

Yes ❑ No ❑

If you would like to expand on any of the above, please attach a separate sheet. Any additional comments will be appreciated.

APPENDIX III

Hobart Forum Agenda

Time Allocation	Subject	Speaker/Facilitator
09:00 to 09:15	**Welcome and Introduction**	Peter Dundas-Smith Michael White
09:15 to 11:15	**Presentations by Researchers** (see Appendix IV for papers)	
	Overview of FRDC live fish transport project	Mike Rimmer
	Commercial applications of current research in live fish transport	Peter deGuingand
	An Overview of current packaging and transport techniques	Brian Franklin
	Stress fish experience during capture and transportation to holding facilities	Alby Steffens
	Live transport of horseshoe leatherjackets	James Findlay
	The oxygen requirements of rock lobsters in holding facilities	Brad Crear
	Investigations of on-boat handling in the Queensland live coral trout fishery	Louis Evans
	Barramundi or moribundi: Interactions between water quality changes and fish physiology during live transport	Brian Paterson
	How to live longer and suffer less - if you are a fish on the move	Bruce Goodrick
11:15 to 11:30	**Morning Tea**	
11:30 to 12:00	Presentation of the Preliminary Status of the Live Seafood Industry in Australia.	David (DOS) O'Sullivan
12:00 to 13:00	**Lunch**	
13:00 to 13:45	**Workshop Session - What needs fixing?** (Four industry workshop sessions to discuss issues raised from survey questionnaires - see Appendix III)	David O'Sullivan Michael White Norm Grant Deon Mahoney
13:45 - 15:15	**Industry Forum - How do we make a difference?** (Reports on industry workshop sessions - Section 6)	Peter Dundas-Smith Rosemary Clarkson Nigel Forteath Helen Rapp
15:15 to 15:30	**Afternoon Tea**	
15:30 to 16:30	**Future Directions - Where to next?** (Discussion of primary outcomes -Section 7)	Norm Grant

APPENDIX IV

List of Forum Delegates (by working group)

WORK GROUP NO. 1

Michael White F	PSM Consulting Group	Suite 6, 51-55 City Rd. STH MELB Vic 3205
Tania Kiley F	PSM Consulting Group	Suite 6, 51-55 City Rd. STH MELB Vic 3205
Rosemary Clarkson N	IFIQ	GPO Box 46 BRISBANE Qld. 4001
Graeme Morrisby T	Ansett Australia	Ansett Airfreight HOBART Tasmania
Dale Bryan C	Seablest	Unit 2 / 5 Gladstone St HOBART Tas 7000
Ken Smith C	S.E.A. Food International	13 Bright water Rd. HOWDEN Tas 7054
Brian Franklin C	Southern Ocean Products Pty Ltd	8 Lovett St BICHENO Tas 7215
Bruce Trewavas C	Satellite Seafoods	17E Quay St BUNDABERG Qld 4670
Ross McDonald T	Cathay Pacific Airways	PO Box 812 HAMILTON CENTRAL Qld 4007
John Vietz T	Ansett Australia	Engineering Base MELBOURNE AIRPORT Vic 3043
Jayne Gallagher	DPIE	Edmund Barton Building Canberra ACT 2601
Steve Percival R	AMD	PO Box 37 DOVER Tas 7117
Bruce Bird C	Moana Pacific Fisheries Limited	PO Box 37 DOVER Tas 7117

WORK GROUP NO. 2

Deon Mahoney F	National Seafood Centre	19 Hercules St HAMILTON Qld 4007
Brad Crear F	University of Tasmania	PO Box 1214 LAUNCESTON Tas 7250
Dave Shields C	Moana Pacific Fisheries Limited	PO Box 37 DOVER Tas 7117
Helen Rapp R	NSC Advisory Committee	Watts Gully Rd. KERSBROOK SA 5213
Brian Paterson R	IFIQ	19 Hercules St HAMILTON Qld. 4007
Teri Hanrahan E	Austmarine Pty Ltd	4/316 Brisbane Rd. LABRADOR Qld.
Richard Carson E	AQUASONIC	PO Box 134 Inglebum NSW 2565
Peter de Guingand R/C	Southern Ocean Products Pty Ltd	8 Lovett St BICHENO Tas 7215
John Seccombe E	AQUAHORT	52 Maraetal Heights Rd AUCKLAND N.Z.
Peter Dundas - Smith N	FRDC	PO Box 222, DEAHIN WEST ACT 2600
Dominic O' Brien R/C	AMD	PO Box 37 DOVER Tas 7117
Malcolm Shelley E	Commercial Aquarium Services	1582 Peats Ridge Rd PEATS RIDGE NSW 2250
Alan Freedman E	Aquatic Freight Transport Systems	PO Box 243 BOTANY NSW

WORK GROUP NO. 3

David O'Sullivan F	PSM Consulting Group	Suite 6, 51-55 City Rd. STH MELB Vic 3205
Nigel Forteath F/R	University of Tasmania	PO Box 1214 LAUNCESTON Tas 7250
Stuart Milne R	Curtin University of Technology	GPO Box U1987 PERTH W.A. 6001
Stephen Thrower R	AUSEAS	19 Hercules St HAMILTON Qld 4007
Mike Rimmer R	Northern Fisheries Centre - QDPI	PO Box 5396 CAIRNS Qld 4870
Bruce Goodrick R	IFIQ	19 Hercules St HAMILTON Qld 4007
Trevor Dix C	Tassal	5 Franklin Wharf HOBART Tas 7000
Alby Steffans R	AMC	PO Box 21 BEACONSFIELD Tas 7270
Louis Evans R	Curtin University of Technology	GPO Box U1987 PERTH W.A. 6001

WORK GROUP NO. 4

Norm Grant F	PSM Consulting Group	Suite 6, 51-55 City Rd. STH MELB Vic 3205
James Findlay F	University of Tasmania	PO Box 1214 LAUNCESTON Tas 7250
Dan Liszka R	NSW Fisheries	Locked Bag 9 PYRMONT NSW 2009
Phillip Walsh N	NSC Advisory Committee	55 Pandora Dve City beach PERTH WA
Ross Heather C	Aquatas	PO Box 156 KINGSTON Tas 7051
John Sumner O	M&S Food Consultants Pty Ltd	The Moorings DEVIOT Tas 7275
Brian Hughes R/C	Southern Ocean Products Pty Ltd	8 Lovett St BICHENO Tas 7215
Trevor Newnham		Unit 1 / 44 Stanley Terr. TARINGA Qld 4068

Notes:

F= Facilitator	E= Equipment Supplier	O= Other
R= Research	T= Transport Industry	
C= Commercial Operator	N= NSC/FRDC member	

APPENDIX IV

Scoping Papers for work groups

Live Seafood Handling Forum
Scoping Paper-"The flying fish crisis"
Workgroup No. 1

Facilitator : Michael White

The transport of live seafood is considered by most commercial operators as a major impediment to the operation of their business. How do we overcome the flying fish crisis?

In particular, air transport poses a number of problems. Currently, uncertainty exists in respect of the equipment and materials which are permitted for the carriage of live seafood, and the systems and strategies required to meet the physiological needs of individual species given the requirements of the airlines. Furthermore, enquires by many operators have revealed inconsistencies in the requirements between airlines. The following issues have evolved.

Problems facing the airlines

1. Leakage of containers has occurred in the past - creating serious problems in respect of airframe corrosion.
2. Some containers are more suited to manual or automated handling than others - this being dependent upon aircraft type and airport facilities.

Problems facing the commercial operators

1. Specifications of the containers and supporting equipment permitted for use by the airlines cannot be confirmed.
2. 'Preliminary' specifications vary between airlines.
3. The use of reusable (environmentally and airline(?) friendly) containers may not be economical due to the high costs associated with their return. Is the backloading rate calculated by weight or volume?
4. The urgency associated with the transport of live seafood may not be considered by airlines when scheduling shipments.

Strategies and mechanisms to overcome the problems

Live Seafood Handling Forum
Scoping Paper-"Equipment for Capture/Holding/Transport"
Workgroup No. 2

Facilitator : Deon Mahoney

Equipment used for the capture, holding and transport of live seafood must meet several important criteria, including:

minimise stress
minimise the potential for physical damage
promote the survival of fish; and
ease of handling by fork lifts and other transport equipment.

During discussions, delegates should review the following topics, and suggest additional factors which impact on the choice and usage of equipment.

What fish capture techniques and equipment are the most acceptable / efficient for the live seafood trade?

What are the important variables associated with live seafood holding equipment? How much do they vary between species? Is this type of information readily available?

Is packaging equipment currently used for the transport of live seafood effective? Is further development needed to improve closed or open systems?

Live Seafood Handling Forum
Scoping Paper-"Is Current Research Correctly Focussed?"
Workgroup No. 3

Facilitator : Dos O'Sullivan

Industry requires that its research dollar must be driven further. It must be carefully directed and its success and benefits monitored. Fortunately the gap between industry and the researchers is slowly decreasing. For example, the state advisory groups (FRABs) initiative by the FRDC assists in ensuring that the research is industry driven. However, FRDC is just one source of funds. can there be further improvements? This requirement for focussed research will be the centre of discussions for the workshop.

The discussions may attempt to answer the following questions, or delegates may have some topics of their own. How can research become more focussed on industry issues? Can ore funds be sourced for research on live seafood projects? What opportunities are there for collaborative research within the industry (ie. between commercial companies) as well as between and within university and government scientists? Should there be an inventory of research facilities? Should all research projects contain industry and research partners? How should the research results be disseminated? Can publicly funded projects result in proprietary information?

To be effective, R&D investment must be carefully directed and its success / benefits monitored. R&D can't be directed effectively in isolation from industry.

Coordinating R&D and communicating industry needs, success and benefits, requires regular input from an industry based advisory group. That input then needs to be effectively disseminated to the appropriate R&D organisations.

An appropriate and tried method of accomplishing this is to establish an R&D body/ industry advisory group. However, as there are clearly other needs of the 'live' industry (eg. communication with resource manager) a joint 'policy council' approach sounds more effective.

It is not necessary to conceive such a body with all the necessary detail known. Another approach is to form a 'steering committee' to investigate the appropriate structure and scope of a policy group.

Live Seafood Handling Forum
Scoping Paper - "Continuity of Supply"
Workgroup No. 4

Facilitator : Norm Grant

'Continuity' driven by both availability and demand (ie. incentive to exploit a resource).

Availability

Before money and resources are committed to R&D and, indeed, before private investment is committed, there must be some evidence that a sustainable fishery exists and that all of exploitation - particularly those unique to the 'live' trade, including methods of capture - have been considered.

It is certainly not useful for traders to target fisheries where conflicts of resource allocation are unresolved, or the resource is threatened. On the other hand, if the sustainable yield of a fishery is low, perhaps the additional value offered by a 'live' industry should take priority over other forms of capture, handling and marketing.

Marketing has not been a strength in fisheries resource management in Australia and perhaps managers need to be encourages to consider the role of 'live' industry. At the same time, private investors should be encouraged to seek advice from resource managers prior to investment. To support this entire process, it may be necessary for additional biological information to be researched or compiled.

Does the live industry have a voice in resource management? Is there sufficient biological data on the impact of capture methods, and on species suitable to live trade (including markets), to support good resource management? Are there effective channels of communication between live fish entrepreneurs and resource managers?

Demand

Prior to R&D investment there should be some evidence of viable markets (ie. compatible with the size of the investment) exist.

Many of Australia's export targeted fisheries are driven by the live trade (eg. lobsters, spanner crabs) and these are subject to export demand / price fluctuations which can cause havoc in domestic trade. This is extremely damaging to both local fisheries and traders alike.

Is there sufficient marketing information to support live fish investment (both private and Government)? Is there an effective marketing communication process to guide potential investors (particularly newcomers such as those involved in small scale aquaculture)? What other issues affect continuity?

APPENDIX V Research Papers

Mike Rimmer
Queensland Department of Primary Industries
Northern Fisheries Centre

DEVELOPMENT OF LIVE FISH TRANSPORT TECHNIQUES

Live Fish Transport Workshop
October, 1995

DEVELOPMENT OF LIVE FISH TRANSPORT TECHNIQUES

FRDC Projects 93/184 and 93/185

PARTICIPATING ORGANISATIONS

- Queensland Department of Primary Industries (QDPI), Northern Fisheries Centre, Cairns.
- Southern Ocean Products, Bicheno, Tasmania.
- QDPI, International Food Institute of Queensland, Brisbane.
- QDPI, Oonoonba Veterinary Laboratory, Townsville.
- Tasmanian Department of Agriculture, Fish Health Unit, Launceston.

INTRODUCTION

There is increasing interest in the transport of live finfish, to both export and domestic markets. Marketing live finfish is regarded as a 'value adding' process since live fish bring higher prices than frozen or fresh chilled product. Both wild caught and farmed fish species are in demand for live markets.

This research project was developed by amalgamating two FRDC proposals, one put forward by the Queensland Department of Primary Industries and another by Southern Ocean Products of Bicheno, Tasmania. Research results from this project are subject to the intellectual property arrangements of FRDC projects 93/184 and 93/185.

OBJECTIVES

To develop cost-effective techniques for transporting live Australian tropical and temperate finfish.

DURATION

1 July 1993 to 30 June 1996

RESEARCH

The live fish transport project has been divided into 3 major areas of research:

1. Capture and maintenance prior to transport;
2. Transport;
3. Post-transport maintenance.

Capture and Pre-transport Maintenance

Capture

Research into capture techniques is being undertaken to improve survival of finfish destined for live markets. We are investigating the effects that modifications to existing capture techniques such as gill-netting, line fishing and trapping have on survival and stress in the captured fish.

For example, coral trout (*Plectropomus* spp.) are captured using heavy monofilament lines. We are investigating the effects that capture depth, degree of barotrauma (i.e. overinflation of the swim bladder) and swim bladder puncture have on survival of coral trout.

An important component of the live fish transport project is to extend information which already exists, for use by fishers and processors involved in the live fish trade. Two articles have been published on improving survival by adopting capture and handling techniques based on techniques used by the aquaculture industry. These articles were published in the June 1994 issue of 'Australian Fisheries' (Rimmer *et al.* 1994), and in the June-July 1994 issue of Tasmanian fishing industry magazine 'Fishing Today' (de Guingand 1994).

Pre-transport Maintenance

Maintenance of fish in good condition prior to transport is essential in providing premium quality live fish to markets. We have looked at several aspects of pre-transport maintenance, such as the design of holding tanks, design and operation of recirculating systems, and coff design and construction.

An article on holding system design and operation has already been published (de Guingand *et al.* 1995) and another article, on the design and operation of recirculating systems for live fish holding facilities, is to be published in the October 1995 issue of 'Professional Fisherman'. These articles provide processors with information to set up holding facilities suitable for the maintenance of live finfish, and to operate these facilities under commercial conditions.

In conjunction with Associate Professor Louis Evans (Curtin University, WA) we are investigating methods to improve water quality in live fish holding systems aboard capture vessels.

We have also investigated coff design, and based on our experimental results, have constructed a prototype coff that dramatically improves survival and reduces external damage to live fish.

Transport

Our research has shown that fish shipped live are subject to rapid and extremely adverse changes in water quality, associated with the production of metabolic by-products. The most dramatic change in water quality occurs within the first 1-2 hours after the fish are packed. Subsequent changes in water quality are relatively minor.

Typical changes that occur during live fish transport are:

- reduction in dissolved oxygen levels due to respiration
- increase in carbon dioxide levels due to respiration
- increase in ammonia levels due to excretion
- decrease in pH due to carbon dioxide accumulation

The consumption of oxygen and the build up of metabolic by-products can be reduced by reducing the metabolic rate of the fish. There are two ways in which the metabolic rate of fish can be lowered:

1. Anaesthesia. There are a number of anaesthetics available for use in fish transport applications. Several fish anaesthetics, such as MS222 (ethyl m-aminobenzoate) and benzocaine(ethyl p-aminobenzoate), are believed to be in use at the present in live fish transport applications. However, no anaesthetic is currently registered for use in food fish in Australia; thus, the use of anaesthetics with fish for human consumption in Australia is illegal. In the event that anaesthetics are registered for use with finfish in the future, it is likely that a withholding period will be required following use of the anaesthetic, and that this withholding period (several weeks to several months) will exceed the duration that live fish are normally held following transport (c. 1 week). Because of the legal problems associated with the use of anaesthetics for live food fish, this project is not investigating the application of anaesthetics for live fish transport.
2. Cooling. Because fish are poikilothermic, lowering the temperature of their environment will reduce body temperature and hence metabolic rate. Temperature reduction is currently widely used in live fish transport, but without any real data as to the optimal transport temperature for each species and the optimal rate of temperature change. Our research is investigating the best methodology for reducing temperature, and the optimal temperature for transporting a range of commonly transported finfish species.

Packaging

Existing live fish packaging has a number of deficiencies, particularly the relative delicacy of the containers and the resultant spillage due to damage in transit.

One aspect of our research into improved packaging for live fish transport has been the development of a prototype insert for standard polystyrene boxes which provides the following advantages over existing packaging:

- puncture proof (unlike plastic bags),
- dark colour and opaque (unlike standard polystyrene seafood boxes),
- greater water height:volume ratio to improve submergence of fish,
- solid lid to incorporate gel coolant pack.

Our prototype packaging systems are not designed to fully commercial standards, but are instead designed to test the biological aspects obtained from the present study. For example, the box insert described above has been constructed from PVC, which is not a viable material for commercial use. However, it serves to test the principles on which a commercial insert would be based. The Australian packaging company RMax have examined our prototype insert and have indicated an interest in cooperating with ongoing studies related to live seafood packaging. Preliminary discussions have also been held with QANTAS regarding their requirements for improved packaging for live fish.

The issue of packaging development will become increasingly important as the live finfish trade continues to grow and as the results of the present study provide data for improved transport procedures. We intend to test our biological results with prototype systems, but the development of a fully commercial live finfish (or live seafood) transport system is outside the purview of this project. Project personnel are liaising with the National Seafood Centre (NSC), and it is proposed that the NSC act as the lead agency for the development of commercial live fish packaging systems. It is expected that this would involve the collaboration of various individuals representing researchers, fishers, processors, and seafood packaging companies.

Road Transport

At the previous workshop on live fish transport, held in Brisbane in May 1994, industry representatives stated that most domestic transport of live fish would be undertaken using road transport, rather than air freight. Industry representatives further stated that there was a lack of readily available information on setting up and running road transport operations dedicated to hauling live fish.

Mike Rimmer, the Principal Investigator for this project, visited the US in the first half of 1995 to undertake collaborative research on development of aquaculture techniques for marine finfish. Because road transport of live fish is a thriving industry in the US, this trip provided an ideal opportunity to look at commercial live fish transport operations in detail. The results of this work have been compiled in a report to FRDC (the funding body for this segment of the trip) that will be available in

October 1995. This report provides full details on all design and operational aspects of road transport of live fish. Because it is based largely on discussions with commercial live fish transport operators, the information in it is directly applicable to commercial road transport of live fish in Australia.

Post-transport Maintenance

We are investigating aspects of post-transport maintenance associated with both fish health and human health. We are examining the incidence of ectoparasites on fish subjected to transport, and then held for 1 day and 1 week after transport. This simulates the typical holding period after fish are transported to wholesalers or restaurants. We are also examining the possible proliferation of pathogens that may affect human health, such as the bacterium *Vibrio parahaemalyticus*.

Our results indicate that there is little or no proliferation of ectoparasites following live fish transport. In addition, we have not recorded any problems with proliferation of any bacterial pathogens that are implicated in human health problems.

PUBLICATIONS

de Guingand, P. (1994). Keeping fish in top nick. Fishing Today 7(3), 16-17.

de Guingand, P., Rimmer, M., Brouwer, R. and Meikle, G. (1995). Live fish 'on hold' - system design is the key to success. Australian Fisheries 54(2), 14-18.

de Guingand, P., Rimmer, M. and O'Brien, J. (1995). Recirculating system design for live fish facilities. Professional Fisherman, October 1995, in press.

Rimmer, M., Paterson, B. and de Guingand, P. (1994). A guide to live fish capture and handling. Australian Fisheries 53(6), 19-21.

Participating organisations and personnel in FRDC Projects 93/184 and 93/185.

Organisation	Personnel	Role
QDPI, Northern Fisheries Centre, Cairns	G. Meikle*, M. Rimmer, M. Pearce, G. Semmens	Project coordination (M. Rimmer) ; water quality experiments; transport procedures; packaging development.
Southern Ocean Products, Bicheno	P. de Guingand*, B. Franklin, B. Hughes	Capture and maintenance techniques; water quality experiments, transport procedures; packaging development.
QDPI, International Food Institute of Queensland, Brisbane	B. Paterson	Stress analyses: lactate, ADP, blood ions.
QDPI, Oonoonba Veterinary Laboratory, Townsville	I. Anderson, A. Thomas	Fish health analyses; microbiology; human health pathogens.
Tasmanian Department of Agriculture, Fish Health Unit	J. Handlinger, J. Carson	Fish health analyses; microbiology.

* Full time technical staff employed on FRDC funding.

Contact details for participating organisations in FRDC Projects 93/184 and 93/185.

Queensland Department of Primary Industries (QDPI), Northern Fisheries Centre

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Southern Ocean Products

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QDPI, International Food Institute of Queensland

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QDPI, Oonoonba Veterinary Laboratory

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Tasmanian Department of Agriculture, Fish Health Unit

Postal Address:	Fish Health Unit, Mt Pleasant Laboratories, Tasmanian Department of Agriculture, PO Box 46, Kings Meadows, Tas. 7249
Phone:	(003) 41 5389
Facsimile:	(003) 44 4961

Peter de Guingand
Southern Ocean Products
QDPI
Northern Fisheries Centre Cairns

COMMERCIAL APPLICATIONS OF CURRENT RESEARCH IN LIVE FISH TRANSPORT

Live Fish Transport Workshop
October, 1995

Commercial applications of current research in live fish transport: Peter de Guingand

FRDC Projects 93/184 and 93/185
Major Participating Organisations
Southern Ocean Products, Bicheno, Tasmania.
Queensland Department of Primary Industries (QDPI), Northern Fisheries Centre, Cairns.

Introduction

Markets for live finfish have escalated continuously over the past five years and this trend is expected to continue in the future. In 1993 the above participating organisations applied for funding to develop techniques that would be commercially applicable to industry. These applications were amalgamated and a joint project resulted.
The project was divided into 3 major areas of research as follows:

1. Capture and maintenance prior to transport;
2. Transport;
3. Post transport maintenance.

The purpose of this presentation is to outline some of the research being undertaken in this project and the implications for industry.

Capture and maintenance prior to transport
It was evident when the project first commenced that there were major problems in the techniques being used during the capture of target species. As traditionally fishers have provided for different markets where product was not required to be live some training was needed to alert fishers of the needs of the processor. Southern Ocean Products provided an outline to fishers mentioning some relevant areas that could be improved on. Following is a list of some of the areas that were thought to be easily adapted by the fisher, whilst keeping expenses at a minimum so as to remain commercially applicable:

Species caught by gill net were being left entangled for long periods of time, up to 12 hours. As a result fish were exhausting themselves during attempts to escape. It is also thought that fish gills were being restricted making respiration difficult. Scales were also being dislodged, particularly in the tail region. Fishers were encouraged to decrease ësoak timesí to a maximum of approximately 3-6 hours. Other areas of general handling that Southern Ocean Products focussed on with local fishers in the form of catcher training workshops included net types used on dip nets; reduction of ëdryí time during unloading to processors; methods of handling of fish and boat well requirements, design and construction.

An article was published in the Tasmanian Fishing Industryís magazine ëFishing Todayí outlining various general handling techniques that could be easily adopted by fishers (de Guingand, 1994). Other articles published in various issues of ëAustralian Fisheriesí also offer fishers and processors information previously available in the aquaculture industry that enables fish to be held in better condition (see references).
In northern waters coral trout (*Plectropomus* spp.) are caught using heavy monofilament lines, and are brought rapidly to the surface in order to avoid sharks, which readily attack the captured fish. This rapid ascent causes the swim bladder to over inflate (a condition termed ëbarotraumaí), placing stress on the internal organs of the fish, and in extreme cases, causing the oesophagus and rectum to extrude from the mouth and

anus of the fish. A similar condition occurs in southern waters during fishing for blue throat wrasse (*Notolabrus tetricus*).

At the Northern Fisheries Centre in Cairns, and at Southern Ocean Products in Tasmania we have arbitrarily divided barotrauma into 3 categories, based on the degree of swim bladder inflation resulting from capture, with stage 1 being normal and 3 severe. Results show that the degree of barotrauma shown by fish directly affects survival. Further work will investigate the relationship between the degree of barotrauma exhibited and the capture depth of fish.

Whilst the popular method of dealing with barotrauma by commercial fishers is to prick extruded part of the gut with a knife or fish hook, or using a knife to puncture the swim bladder through the gut wall, our own research uses the method of puncturing the swim bladder with a heavy gauge hypodermic needle. In our research puncturing the swim bladder only improves survival marginally, from 10-30%. Due to these results it is worth considering the value of fishing in deeper waters when a large number of the fish caught have a high probability of dying.

An important aspect of pre-transport maintenance in Tasmania is the holding of fish in small sea cages called ëcoffsí in sheltered bodies of water. This is done so that processors can wait until a large enough number of fish are caught to make the journey to collect them from the fisher worthwhile. A fish coff is usually a rigid frame enclosed in mesh. Commercial fishers use materials ranging from welded steel mesh to plywood with holes drilled in it. At Southern Ocean Products four different mesh types have been assessed to quantify the impact that material choice has on fish condition. The material types chosen were: salmon growers mesh, 50 mm trawl mesh, chicken wire and plastic oyster growers mesh.

A three stage classification system was designed in order to assess the impact of the different materials on fish condition with respect to scarring and scale loss. Banded morwong (*Cheilodactylus spectabilis*) were placed in coffs at similar densities. Results of this study showed that using salmon growers mesh is the preferred alternative whilst the oyster growers mesh also showed good results. The results of this work have allowed us to design a prototype coff to show commercial fishers as a workable and cost effective alternative that will result higher quality fish.

Transport

Much of our research in this area has focussed on experimental evaluation of techniques to reduce the metabolic rate of fish as this has the advantage of a reduction in oxygen consumption, carbon dioxide production which will result in a more stable pH value, and also a reduction in ammonia production. As no anaesthetics are currently registered for use on food fish in Australia we have adopted various chilling strategies as a means of reducing the metabolic rate of fish.

We have selected two rates at which to reduce fish body temperature: rapid and slow; at the rapid rate fish are immersed in pre-chilled water, whilst the slow rate requires that fish be placed into ambient water and then chilled. Fish are cooled to either 5, 8, or ten degrees below ambient, dependent on species. The species being worked with are banded morwong (*Cheilodactylus spectabilis*), barramundi (*Lates calcarifer*), and blue throat wrasse (Notolabrus tetricus).

Our research indicates that cooling as a means of reducing metabolism is an effective strategy and has practical applications for live fish transport. Survival is greater then controls for most cooling strategies but care must be taken not to go past species minimum tolerances. In our work it has been more effective to work with low levels of anaesthesia as when working with deeper levels it is relatively easy to induce a thermal shock resulting in death.

Throughout the project many chemicals have been passed on to us as having uses during live fish transport. The project has tested some of these chemicals with limited success. Amongst these are oxygen producing tablets, pressurised oxygen generating bottles, oxidising chemicals, ammonia removing liquids, exchange resins, activated carbines and synthetic polymers.
Other areas of research within our project have been covered by other speakers.

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Brian Franklin
Southern Ocean Products

AN OVERVIEW OF CURRENT PACKAGING AND TRANSPORT TECHNIQUES

Live Fish Transport Workshop
October, 1995

AN OVERVIEW OF CURRENT PACKAGING AND TRANSPORT TECHNIQUES

Brian Franklin, Southern Ocean Products.

1. ROAD TRANSPORT

Economics:

The economics of road transport are very good for a number of reasons. With a reasonable system incorporating temperature control, aeration, and oxygen good water to fish ratios can be achieved. The truck has the advantage of being able to pick up product in remote locations, and deliver product to the customers door.

Mortalities:

Mortalities can be a big problem with road transport as there are a large number of animals in the one container. If there is a problem even with a small number of fish resulting in death, this can trigger very high mortalities in the other wise healthy animals.

Government Regulations:

There have already been confirmed cases of prohibited species being transported between states in live fish trucks. State Governments are already aware of the risk of introducing unwanted species in transport water, and it is only a matter of time before regulations are introduced to prohibit unregulated road transport.

Code of Practice:

At the last live fish packaging conference a group was formed to develop a code of practice. Nothing has been done so far. If industry does not develop its own code then it is likely that Governments will act to regulate the industry. Realising the concerns of animal rights lobbyists and the other problems already mentioned it is unlikely that industry would be happy with a code of practice imposed by Governments.

2. AIR TRANSPORT

Mainstream Commercial Airlines:

Ansett Freight in Hobart is one of the biggest movers of live seafood in Australia, but due to recent leaking from live fish packages they have suspended all shipments of live finfish in Australia. The current polybox and plastic bag method of packing live fish obviously needs to be improved, and any developments need to involve all participants in the industry.

Small Aircraft:

Small non-mainstream aircraft are playing an ever increasing role in transporting live fish in Australia. For many of the same reasons that live fish trucks are successful so are these aircraft. They can handle non standard larger sized packaging and devote more care to the specific system. Through the use of oxygen and more suitable containers they are able to reduce water fish ratios. Transit, loading and unloading times are also reduced because of the more flexible nature of the operation. The limitation is that they can only be used in Australia and not for overseas exports.

3. PACKAGING

Current standard methods:

Even if the problems of leakage could be overcome there are still a number of unsatisfactory features with the current packaging system. To actually put the bags, the foams, the water, and the fish in the box and seal it is quite difficult and labour intensive. This system is only moderately successful in keeping the fish alive, and as we all know there are frequent leakages.

Possible improvements:

There will probably always be a need for a package of the size of the current poly box. With some basic improvements this could provide a satisfactory package. By modifying the standard poly box with coatings or strong inserts , and using oxygen generators and aerators this system could be OK.

Larger modules:

Larger modules have evolved through the improvements in truck and light aircraft transport. Their limited acceptance by some international airlines have caused considerable interest. The larger sized modules offer advantages with the opportunities of more sophisticated water quality control. One off larger modules have been used in the international aquarium trade for some time and a commercial approach to these systems will undoubtably have benefits for this industry.

4. FUTURE DIRECTIONS

Coordinated approach:

There a number of reasons why the Australian live fin fish industry should have a coordinated approach to developing an effective packaging and transport system. We have national resources. We are already major exporters of live seafood. We have a good name for clean green produce. We have as sophisticated technology as our competitors. We have the mechanism through the FRDC for coordinated funding. We all want to make a dollar.

Without criticising the scientific community to harshly, there is definitely an embarrassing amount of ëresearchí. This is definitely unproductive.

Working group:

Hopefully something will eventuate from this conference. The last conference in Brisbane formed a group to develop a code practice. I was a part of that group. I understood that funding was approved for that group to develop a code of practice with Nigel Forteath as the convenor.

Funding:

Southern Ocean Products has been developing prototypes of a number of different packaging options as part of our joint project with QDPI and FRDC The commercialisation of the successful prototypes is outside the scope of this project. SOP will be making application to NSC and FRDC for further funding to develop these commercial options.

Alby Steffens
Australian Maritime College

Stress: The Invisible (and Forgotten?) Factor in Live Fish Transport

Live Fish Transport Workshop
October, 1995

Stress: The Invisible (and Forgotten?) Factor in Live Fish Transport

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Introduction

(i) Size of the Australian Live Fish Market

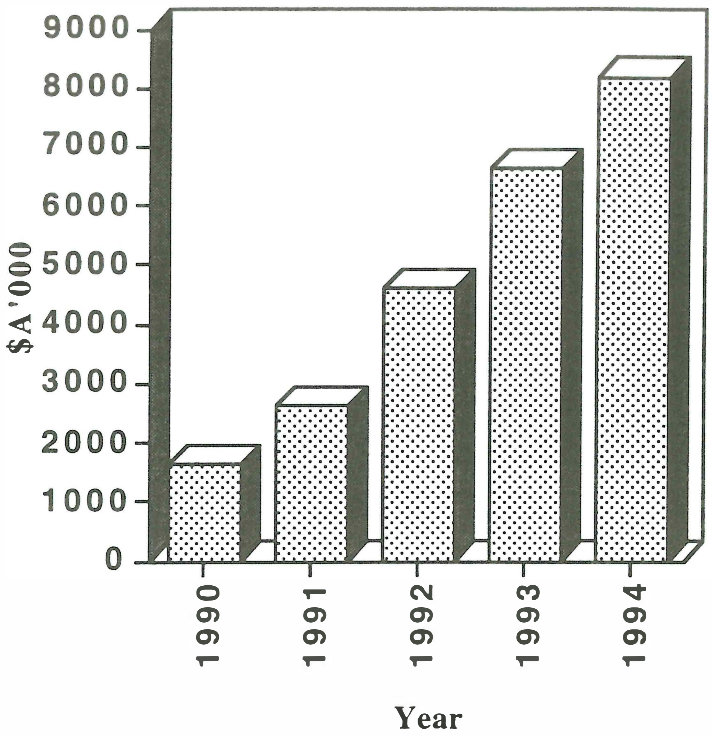
The size of the Australian live fin fish market has increased from approximately $1.8 million in 1990 to $8.5 million in 1994 (source Australian Bureau of Statistics; Figure 1). The live fin fish market in both South-east Asia and within the Asian ethnic communities of Australia is the major source of the growth. Recently it was reported that coral trout (*Plectropomus maculatus*) were fetching between $A200 and $A300 a kilo on the Hong Kong market (A Current Affair). Whilst this is exceptional, a considerable premium is available for many other species of live fish sold into South-east Asia and Hong Kong. The humble blue-throat wrasse (*Notolabrus tetricus*), a species avoided by most Australians of European background, sells live for approximately $20.00 per kilo on the Sydney fish Market, yet fetchs between $6.00 and $9.00 chilled. Many enquires continue to be received from potential market players by AMC for information as to the materials and methods to successfully transport fish alive.

(ii) Concept of Stress

The literature on stress in fish is volumous and a comprehensive review is beyond the scope of this paper. Only corticosteroid involvement is discussed and it should be remembered that catecholamines (adrenalin and noradrenaline) play an important role also.

The common theme throughout the literature is the "premise of a stimulus acting on a biological system and the subsequent reaction of the system" (Pickering, 1981). However there is a fundamental difference between various workers in the definition of the term 'stress'. Some define stress as the response of the animal to a stressor (e.g., Mazeaud and Mazeaud, 1981) while others consider stress as the applied stimulus (e.g., Fevolden *et. al.*, 1991). The term 'strain' has also been used however it is considered that this is the mechanical consequence of stress. Pickering (1981) concluded that it is really a matter of semantics and an author (s) should specify clearly the manner in which the term is used. Pickering lamented in 1993 that consensus had still not been reached. In this paper stress is defined as the applied stimulus to which the fish responds.

Figure 1. Value of Australian Fish Species Exported Live for the years 1990 to 1994



It is conventional to classify stress responses as primary (neural and neuro-endocrine responses e.g., raised corticosteroid and catecholamine levels), secondary (the physiological consequences of such primary responses e.g., reduced number of circulating lymphocytes, changes in osmotic and ionic regulation) and tertiary (changes in behaviour, decreased growth rate and increased susceptibility to diseases) (Pickering, 1981). On the population level the cumulative effect may result in significant mortality (Barton and Iwama, 1991). This 'pigeon holing' of response is really a system of convenience; in reality fish undergo response encompassing all the levels. The response may be described as adaptive or maladaptive (Figure 2) (Barton and Iwama, 1991). Table 1 details the effects of corticosteroids (especially cortisol) in fish and similar vetebrates.

Cortisol is considered the most important corticosteroid in fish, principally because of the quantities produced and the range of biological activities mediated by this hormone (Balm *et. al.*, 1989). Pickering (1992) states "plasma cortisol elevation, as a direct result of stress-induced activation of the hypothalmic-pituitary-interrenal axis is a major factor responsible for the damaging effects of stress on survival, growth and reproduction". Schreck (1981) and Donaldson (1981) have described the stress response to various stressors by elevation of cortisol; the change in levels of this hormone is recognised as a reliable indicator of the degree of stress the fish experienced. Table 5 reproduces selected examples (mainly dealing with capture, handling and transport) from Barton and Iwama (1991) and for a complete list (including references) the reader is referred to that

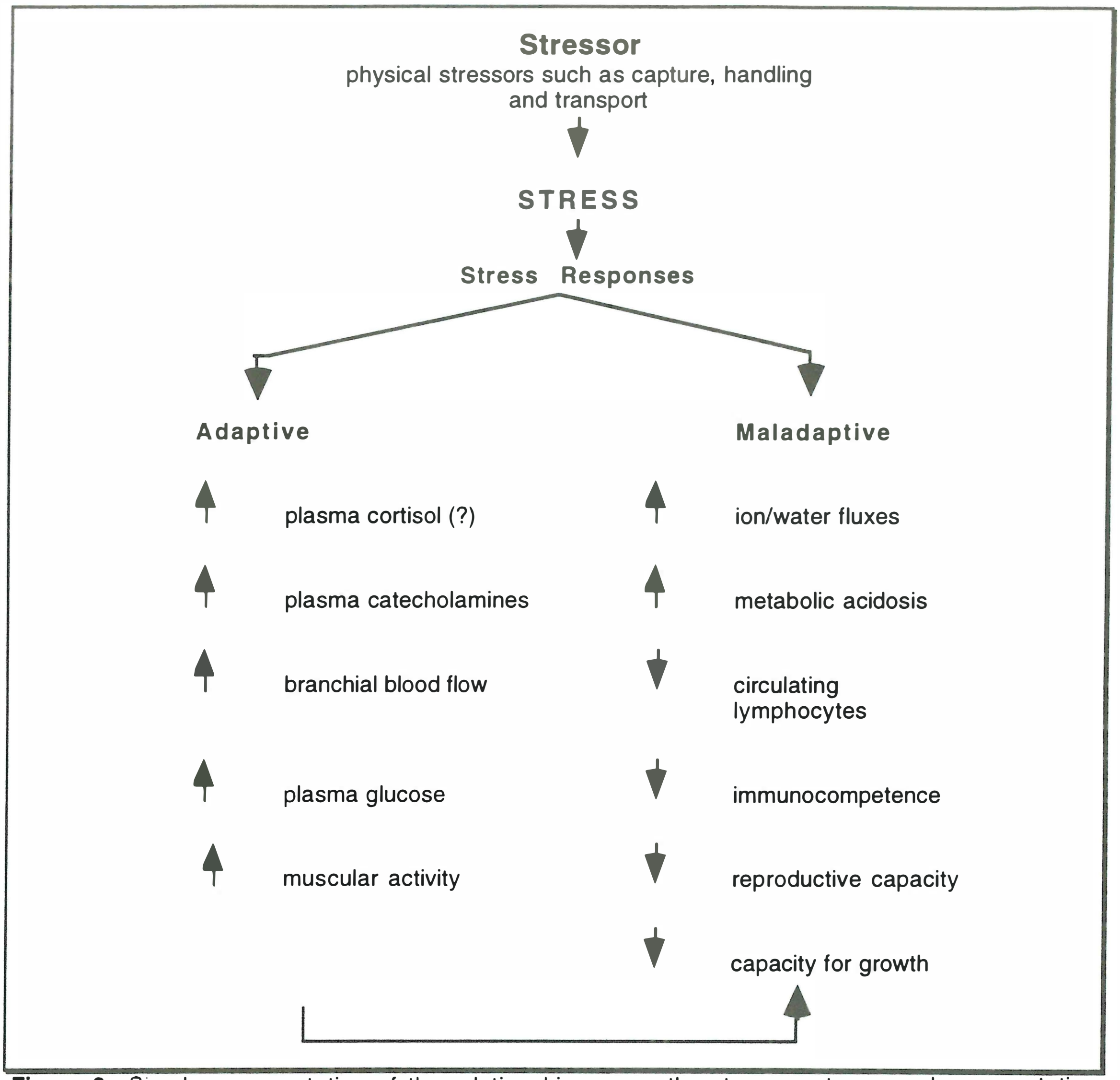


Figure 2. Simple representation of the relationship among the stressor, stress, and representative adaptive and maladaptive stress responses in fish. Although the elevation in plasma cortisol may be considered as an 'adaptive response because of its possible gluconeogenic action, this role for cortisol under stressful conditions for fish has not been confirmed conclusively. (After Barton and Iwama, 1991).

paper.

Resting or unstressed levels are highly variant and appear to be in two categories, under 10 ng mL^{-1} and between 25 and 40 ng mL^{-1}. This suggests that many of the 'unstressed' fish were suffering a chronic stress stimulus or that the sampling procedure produced a stress response. Pankhurst and Sharples (1992) attribute the higher basal levels to "differences in conditions of husbandry and handling protocols by different workers". Many workers are under the impression that using anaesthetics reduces the stress response however Thomas and Robertson (1991) and Strange and Schreck (1978) proved that when the anaesthetic is MS-222® (ethyl *m* -aminobenzoate

Table 1. Effects of increased corticosteroids (especially cortisol) in fish and similar vertebrates (After Smith, 1982) Data from Barton and Iwama, 1991; Borski *et al*, 1991 and Smith, 1982.

Target Organ(s) or Functions	Effects
General	
Protein Metabolism	Increased protein synthesis via enhanced activity of messenger RNA; the proteins synthesised seem to be mostly proteolytic. Inhibition of growth Mobilisation of protein from thymus, spleen and liver.
Carbohydrate Metabolism	Reduced utilisation of carbohydrate. Increased glucose production from tissue protein. Deposition of glycogen in the liver.
Circulatory System	Mobilisation of leucocytes.
Immune System	Initial suppression, then transient stimulation followed by long term immunosuppression.
Reproductive System	Suppression of reproductive steroids.
Growth	Stress imposes a metabolic load and so an energy expense. Inhibition of prolactin
In Freshwater	
Gills	Increased retention of ions.
Kidney	Increased reabsorption of Na^{+} by kidney tubules.
Testes	Precocious sexual maturity in downstream migrant smolts (males only)
In Seawater	
Gills, Intestine	Increased production and activity of Na-K-ATPase, giving enhanced salt absorption in gut and enhanced salt excretion by the gills.

methanesulfonate) or quinaldine sulfate the response is both dose and stress severity related. Metomidate did not affect cortisol titer. Because benzocaine does not illicit a stress response it is the preferred anaesthetic.

In many fish there exists a diurnal and/or seasonal variation with regard to cortisol titer (Audet and Claireaux, 1992; Thorpe *et.al.*, 1987; Audet *et.al.*, 1986; Kuhn *et.al.*, 1986; White and Fletcher, 1984; Noeske and Spieler, 1983; Pickering and Pottinger, 1983; Bry, 1982; Rance *et.al.*, 1982; Steffens, unpublished data) and this also may be a part explanation for the variance in levels in Table 2. Photoperiod, temperature and sexual condition all affected cortisol level in the goldfish (*Carassius auratus*) with 'mature ' females having the lowest levels, maturing females the highest levels, regressed fish having similar levels to maturing females in warm conditions and low levels under cool conditions (Peter, *et.al.*, 1978). Barton and Schreck (1987) reported that the higher the acclimation temperature the greater the stress response and mortality in Pacific salmon (*O. tshawytscha)* following a confinement stress.

The period of holding fish prior to transport can be highly variable and is usually dictated by the purchasers requirements. A minimum of 72 hours has been considered by many operators sufficient time required for fish to purge, thereby greatly reducing the volume and toxity of excretement during transport. However this time frame may not be enough for fish to overcome the stress sustained from capture, transport and holding prior to packing for the market. Periods of ten days to two weeks have been suggested as the minimum time required for complete recovery and a return to normality after an acute handling stress (Pickering *et.al.*, 1982, Schreck, 1981) Adjustment to psychological-behavioural factors may require longer.

This study aimed to quantify the level of stress attributable to capture, on board handling, transport to, and storage in a recirculating holding facility. The results would provide baseline data for an Australian species transported live. However, more inportantly, the study was undertaken using the fish as an indicator species to identify potential problem areas in the event-line from capture to packaging for transport to market.

Materials and Methods

Capture and Blood Sampling

Blue-throated wrasse (*Notolabrus tetricus*) were captured by angling from boats drifting over reefs in water less than 10 metres deep.

One fish was sacrificed for each blood sample. Fish were killed with a sharp blow to the back of the head and blood was sampled by cardiac puncture using a 20 gauge needle. Approximately 1 mL of whole blood (for haematocrit and haemoglobin analyses) was stored in tubes coated with lithium hepron (anti-coalulant). Approximately 1 mL was centrifuged for five minutes and the plasma removed. Plasma was frozen (-20°C) up to several weeks until cortisol analysis was undertaken.

Transport

Transportation to the holding facility was in a 1000 L fish transporter. Compressed oxygen was continually passed through the water. The trip to the holding facility took 45 minutes. Fish were then transferred into holding systems. Substantial, yet unavoidable physical handling of the fish occurred durng the time fish were transported from the boat to the holding system.

Holding Facilities

Design

A recirculating holding system consisted of a 2000L reservoir, two 4000L litre Rathburn tanks , a UV filter and a biofilter. Temperature was held at 10°C +/- 1°C. Photoperiod was 14 hours light, 10 hours dark. The water exchange rate was approximately 50 litres per minute.

Maintenance

At the time of transfer of the fish to the holding system an ectoparasite prophylactic consisting of 3.2 mg malachite green in a litre of 37% formaldehyde was added. The dose rate was 0.25 mL per 10 litres of water (Needham and Cross, 1988). The system was maintained on a daily basis. Faecal matter was removed. Partial water exchanges

Table 2. Summary of documented changes in plasma cortisol (or corticosteroids) in fish resulting from the aquaculture related stressors of handling, confinement (including crowding), exercise, transport, and stocking. Species are listed alphabetically within families, which are arranged phyletically. Data within species are listed chronologically; many of the values were estimated from graphs and, in some cases, converted from molar values. Many 'prestress' values listed may not be representative of actual resting conditions because of experimental protocol used. (*BL/s: body lengths per second)
Reproduced from Barton and Iwama, 1991.

	Corticosteroids ($ng\ mL^{-1}$)		
Family and species	Prestress	Poststress	Stressor and conditions
Polyodontidae	11	72	2 h transport
Polyodon spathula			
Lepisosteidae	9	58	30 min confinement
Lepisosteus oculatus	15	19	2 h transport
Amiidae	7	21	2 h transport
Amia calva			
Anguillidae	2	78	15 min emersion
Anguilla anguilla	5	108	15 min emersion and handling
Clupeidae	42	265	2 h transport
Dorosoma cepedianum			
Salmonidae	544	643	4 h swimming
Oncorhynchus mykiss	120	900	2 h mild agitation
	20	35	transport and stocking
	10	200	30 min confinement plus transport
	<2	43	handling and 90 sec confinement
	<2	70	1 h agitation
	<2	213	continuous severe confinement
	<2	50	6 h transport
	76	250	2 h swimming, 1 BL/s*
	72	300	2 h swimming, 2.6 BL/s*
	70	326	2 h swimming, 5 BL/s*
	3	65	8 h transport
	<2	35	8 h transport, salt
	45	100	8 h transport, chilled water
	45	85	8 h transport, chilled plus salt
	35	205	6h confinement
	9	140	30 s handling, pH 6.6
	-	18	sampling without anaesthetic
	-	27	sampling with 125 mg/L tricane
	-	45	sampling with 62,5 mg/L tricane
	20	70	6 h confinement
Salmo salar	40	190	5 min chasing
Cyprinidae	66	203	continuous mild agitation
Carassius auratus	58	97	capture
	73	93	60 s handling
Cyprinus carpio	43	260	pond-tank transfer
	46	315	handling
	55	340	2 h transport
Sciaenidae			
Cynoscion nebulosus	6	51	after hook and line capture

were effected daily until the water quality (as measured by ammonia and nitrite concentrations) stabilised at acceptable values. Fish were offered food from day two (fresh squid, mussels, fish) and any uneaten food remaining was removed after a hour.

Sample analysis

Haematocrit (Hct), (Packed Cell Volume), Haemoglobin Count (Hb),

Haematocrit was determined by a Clements microhaematocrit centrifuge and the standard reading scale. The cyanmethaemoglobin method as described by Darcie and Lewis (1975) was used for haemoglobin concentration determination. All samples were analysed in duplicate and the mean thereof is used in further analysis.

Cortisol Determination

Orion Diagnostica Cortisol (^{125}I) radioimmunoassay kits manufactured by Orion Corporation, Finland and supplied by Australian Laboratory Supplies, Sydney were used to determine plasma cortisol titers. The kit instruction insert states "The assay involves the use of a cortisol antiserum which has negligible cross-reactivity with other endogenous corticosteroids and cortisol metabolites. Binding of cortisol to serum proteins (mostly cortisol binding globulin) is inhibited by the inclusion of hormone analogs in the tracer solution. Final separation of free and antibody-bound hormone is performed by precipitating the latter with polyethylene glycol."

All samples were analysed in duplicate and the mean thereof is used in further analysis.

Mean Cell Haemoglobin Concentration (MCHC)

The Mean Cell Haemoglobin Concentration (or Mean Cell Corpuscular Haemoglobin Concentration) is the haemoglobin content of Red Blood Cells (RBC). The Mean Cell Haemoglobin Concentration is calculated as:

$$MCHC = \frac{Hb(g100mL^{-1})}{Hct(\%)}$$

Results

Cortisol

Wrasse on capture had plasma cortisol concentrations ranging from 3.73 to 4.44 ng mL^{-1} (mean value 4.02 ng mL^{-1}; se. 0.13). Subsequent plasma cortisol levels were significantly ($P<0.05$) elevated at all sampling times (Figure 3).

Plasma cortisol levels of fish held on board boat peaked 30 minutes after capture (268.8 ng mL^{-1}; se. 14.02) and three hours after capture plasma cortisol levels had fallen significantly ($P<0.05$) to 51.31 ng mL^{-1}; se. 20.53. Transportation and handling procedures (seven hours post capture at University) significantly ($P<0.05$) increased plasma cortisol concentration from the three hour level to 184.99 ng mL^{-1}; se. 11.95).

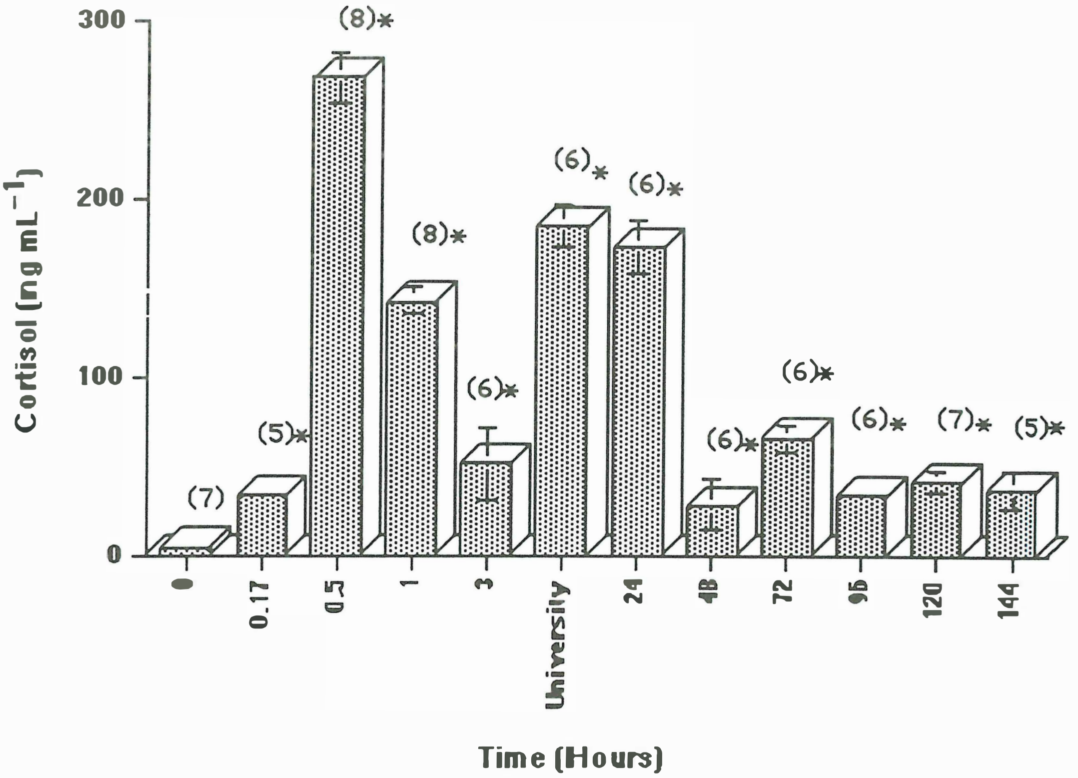


Fig. 3 Changes in plasma cortisol concentration (mean +/- s.e. (*n*) ng mL^{-1} in line caught wrasse held in confinement on board boat, transported to the university and placed in recirculating holding systems. *, Different from value at Time zero (time of capture)($P<0.05$) (University = 7 hours).

Twenty four hours after being confined in the holding system levels had not altered significantly (172.98 ng mL^{-1}; se. 15.64)($P<0.05$). Forty-eight hours after confinement levels had fallen significantly ($P<0.05$) from both the confinement and the twenty-four hour levels but was still significantly higher the level of freshly captured fish. Plasma cortisol levels rose significantly ($P<0.05$) at seventy-two hours post confinement relative to the 48 hour level. In fact the 72 hour sample was significantly different from the 96, 120 and 144 hour levels. There was no difference between the 48, 96, 120 and 144 hour levels ($P>0.05$).

Poor water quality (Total ammonia level > 3.5mg L^{-1}) is considered the likely cause. Figure 4 gives a comparison between cortisol titer during confinement and the water quality and exchange rates of the recirculating system.

Haematocrit (Hct), Haemoglobin (Hb) and Mean Cell Haemoglobin Concentration (MCHC)

Only the Hct value for one hour sample was significantly ($P<0.05$) different from any other sample (Figure 3). Table 3 compares haematocrit values with cortisol means. Hb and MCHC values were not significantly different at any time sampled from any other time sampled.

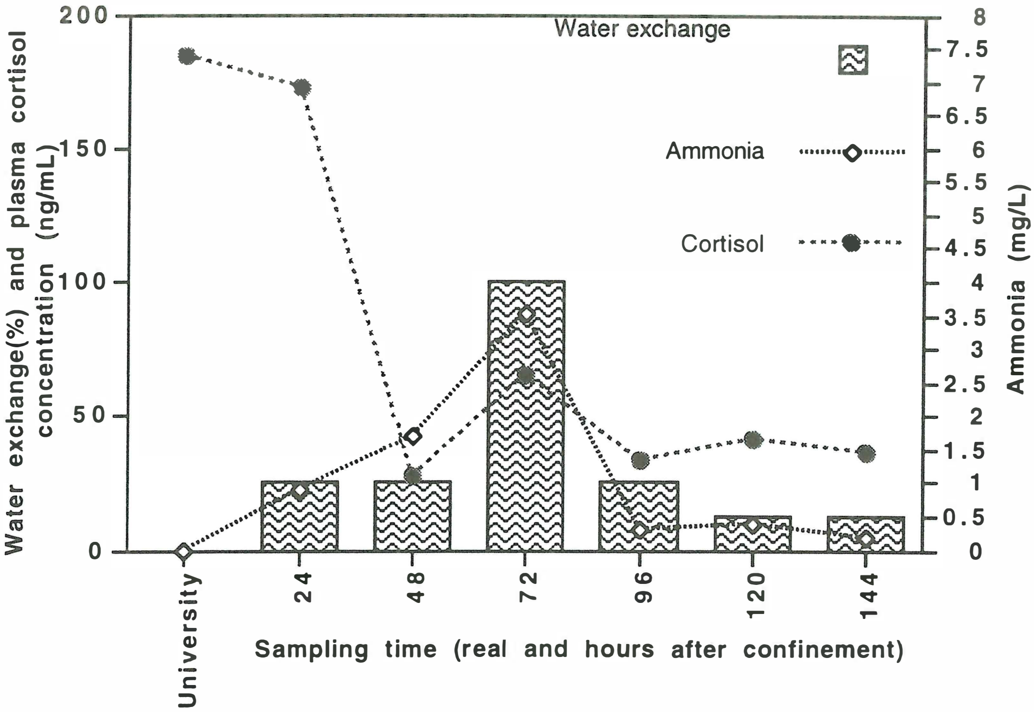


Fig. 4. Comparison between wrasse cortisol titer (ng mL-1) during confinement and the water quality (Total NH3, mg L-1) and water exchange rates (%) of the recirculating system.

Table 3. Haematocrits (Hct) Of Blue Throated Wrasse immediately after capture, held on board boat, following transportation and confinement in a recirculating system. Values are means +/- SE. Mean cortisol (F) levels (ng mL^{-1}) are shown for comparison.

	Sampling time											
	0	10min	30min	60min	3hr	uni	24hr	48hr	72hr	96hr	120hr	144hr
(*n*)	7	5	8	8	6	6	6	6	6	6	7	5
Hct	28.1	29.1	28.5	30.0	27	27.5	27.92	27.4	25.6	27.7	28.1	27.6
se.	0.67	0.7	0.49	0.71	0.45	0.42	0.39	0.62	0.48	1.01	0.59	1.14
F	4.1	33.3	268.8	142.7	51.3	185.0	173.0	27.8	65.5	33.7	41.5	36.5
se.	.13	.87	14.02	6.76	20.53	11.95	15.64	14.36	7.37	3.74	6.54	10.9

Discussion

Cortisol

The plasma cortisol levels of fish sampled at capture (or resting levels) were similar to those reported for other teleosts by Pankhurst *et. al.* (1992); Pankhurst and Sharples (1992); Pottinger.and Pickering (1992); Waring *et. al.* (1992); Pickering *et. al.*, (1991); Thomas and Robertson (1991); Schreck *et. al.*, (1989) and Robertson *et. al.*, (1988). Table 4 displays the results of this study in context with the mentioned reports.

The stress response (as measured by cortisol titer), associated with capture, handling (fish had to be physically removed from the hook by either hand or with the aid of a hook remover) and confinement peaked thirty minutes after capture. The response latency of cortisol elevation is well known and described (e.g., Smith, 1982). Other studies dealing with the stress response due to transport, handling and confinement on marine (Pankhurst *et. al.*, 1992; Waring *et. al.*, 1992; Thomas and Robertson, 1991; Robertson *et. al.*, 1988; Robertson *et. al.*, 1987) and freshwater teleosts (Pickering *et. al.*, 1991; Barton *et. al.*, 1980) have reported similar time delays before cortisol levels peaked. Strange, (1980) found cortisol levels peaking one hour after a confinement stress, however there does not appear to have been a blood sample taken at 30 minutes. Pankhurst and Sharples (1992) also found that cortisol levels peaked 60 minutes after capture, however the method of confinement (held under water in a cage) is considered to be less stressful and is therefore probably the reason for the delay. Three hours after capture cortisol levels had declined substantially (from 268.8 ng mL^{-1} to 51.31 ng mL^{-1}). That cortisol levels decline in such a short space of time is also reported by other workers (Waring *et. al.*,1992; Thomas and Robertson, 1991; Flos *et. al.*, 1988; Pickering *et. al.*, 1982; Barton *et. al.*, 1980; Strange and Schreck, 1978) and is considered evidence that the fish is commencing to cope with confinement.

Table 4. Plasma cortisol concentrations (ng mL^{-1}) in teleost fish captured from the wild and sampled immediately, (W) or captured from the wild and acclimatised for a period before sampling (W & Ac), or fish from aquacultural establishments (Aq). Values preceded by either ~ or < are approximate having been determined from a graph. Data from Pankhurst *et.al.* (1992); Pankhurst and Sharples (1992); Pottinger.and Pickering (1992); Waring *et.al.* (1992); Pickering *et.al.*(1991); Thomas and Robertson (1991); Schreck *et.al.*(1989).

Species	Status	Cortisol	Source
Snapper, (*Pagus auratus*)	W	1.7 - 8.0	Pankhurst and Sharples (1992)
Blue Mao Mao, (*Scorpis violaceus*)	W	3.3	Pankhurst *et. al.* (1992)
Flounder, (*Platyichthys fleus*)	W	10.4	Waring *et. al.* (1992)
Atlantic Salmon, (*Salmo salar*)	W&Aq	~ 5.0	Waring *et. al.* (1992)
Red Drum, (*Sciaenops ocellatus*)	Aq	~ 8.0	Thomas and Robertson (1991)
Rainbow Trout, (*Oncorhynchus mykiss*)	Aq	~ 5.0	Pickering *et. al.* (1991)
Coho Salmon, (*Oncorhynchus kisutch*)	Aq	< 10.0	Schreck *et. al.* (1989)
Red Drum, (*Sciaenops ocellatus*)	Aq	< 5.5	Robertson *et. al.* (1988)
Blue-throated Wrasse, (*Notolabrus tetricus*)	W	4.1	Present study

Handling and transportation to the holding facilities resulted in a second cortisol peak (184.99 ng mL^{-1}) and twenty-four hours later the levels had only slightly declined (172.98 ng mL^{-1}). This inability of the fish to lower cortisol levels suggests that a second major acute stress in a short period has a prolonged affect in the ability to re-establish homeostasis quickly and in this study the delay would appear to be at least twenty-four hours. Pankhurst and Sharples (1992) found that snapper took at least 48 hours before plasma cortisol levels fell from the post transport peak. The possibility also exists that the chemistry of the water in the holding system differed to the area from where the fish were caught and that the confinement within the holding system both produced chronic stress.

The rise in levels from forty-eight hours to seventy-two hours (27.76 ng mL^{-1} to 65.47 ng mL^{-1}) is directly attributable to water quality (Figure 4). Marine fish do not normally encounter ammonia and nitrite levels of any consequence in their natural environment. As protein undergoes catabolism for energy generation the nitrogen component is excreted largely as ammonia (NH_3), therefore ammonia is the principal metabolic waste of fish The vast amount of ammonia produced is excreted via the gills (e.g., 56% in the carp, *Cyprinus* , Lagler *et. al.*, 1977). Acute ammonia toxicity will cause death from decreased oxygen carrying capacity and interference with neural function, osmoregulation and pH levels. Chronic ammonia toxicity will cause hyperplasia of the gill epithelium and gas exchange will be reduced. The levels present in the holding system seventy-two hours post-confinement were sufficiently high enough (Total NH_3 > 3.5 mg L^{-1}) to cause the fish distress. Following a 100% water exchange the 96 hour plasma cortisol sample was not significantly different ($P < 0.05$) from the sample of forty-eight hours. Donaldson, (1981; quoting unpublished data from Donaldson *et. al.*) found that increasing ammonia levels had an effect in elevating cortisol titers.

The final three readings reveal fish under ongoing chronic stress. This suggests that the fish are unable to come to terms with their new environment. One factor that may have an influence is stocking density. The number of fish in each holding tank is considered higher than would be found for a prolonged period in the natural environment. Donaldson, (1981; quoting unpublished data from Sandercock and Stone (1979)) reports that the authors describe a significant difference between the size of interrenal nuclear diameters of fish (coho smolts, *Oncorhynchus kisutch*) reared at two different densities (56 000 per pond compared to 104 000 per pond). In contradiction to this finding Schreck, (1981) was unable to demonstrate any relationship between stocking density and cortisol level for yearling coho (*O. kisutch*).

A final recovery time was not concluded from this study, however Pickering *et. al.*, (1982) concluded a minimum of two weeks was required for complete recovery and a return to normality after an acute handling stress. Schreck, (1981) hypotheses ten to fourteen days but adds that adjustment to psychological-behavioural factors may require longer.

Haematocrit (Hct), Haemoglobin (Hb) and Mean Cell Haemoglobin Concentration (MCHC)

The 60 minute haematocrit value was significantly higher from all others and this suggests erythrocyte swelling resulting in increased haematocrit values (Swift, 1981). The swelling of erythrocytes due to hydration has often been described (Soivio and Nikinmaa, 1981; Soivio *et.al.*, 1977; Soivio *et.al.*, 1974b; Holeton and Randall, 1967) and is attributed to stress caused by hypoxia (Soivio and Nikinmaa, 1981). The fish would have encountered acute hypoxia during the onboard handling after capture, even though fish were generally out of water for less than 90 seconds. Acute hypoxic response and recovery is considered to take only an hour or two (Smith, 1982). This appears to be the situation in this study.

The sampling procedure used may also have influenced erythrocyte volume. Nikinmaa and Soivio, (1979) comparing samples obtained by cardiac puncture and dorsal aortic cannulae concluded that cardiac puncture resulted in swollen erythrocytes. It is considered that should this be true of wrasse the error would have been similar across the samples and therefore does not invalidate the findings.

Haematocrit values did not mirror the fluctuations of cortisol and suggests that cortisol titer has no effect in erythrocyte swelling resulting in an increase in haematocrit (Pankhurst *et. al.*, 1992)

Haemoglobin concentration and MCHC showed no significant difference across the samples and this further suggests that the increase in haematocrit is due to erythrocyte swelling and not to additional erythrocytes being liberated into the circulatory system from the spleen.

Implications for live fish transport

The basic requirement for a successful live fish shipment is that the fish arrive alive. This may seem to be an entirely superfluous statement, yet very often all or a number of the fish arrive dead. Many overseas importers severely penalise consignors should either a certain percentage of the fish arrive dead or fish die within a certain number of days after arrival. The penalty is usually financial, i.e., a lesser rate is paid, however if continual problems occur, orders cease. To minimise the chances of dead fish it is logical that the fish must be in prime condition prior to packaging. Yet very little is known about the acclimation regime that must be undertaken before packaging and transport if there is to be 100% success all the time. This study has highlighted that plasma cortisol levels remain elevated for at least six days post capture. Consequently the period of acclimation is more than a week.

Pankhurst and Sharples (1992) describe chronic plasma cortisol elevation in snapper and state that these fish do not feed well and show a tendency towards parasitic infections. In a pilot study to this work I found a very similar situation when wild fish were placed into land based holding systems. Fish developed skin, mouth and gills lesions and refused to feed. Munday (1993) stated that the bacteria most likely to be causing the lesions were *Vibrio spp* and/or *Cytophaga-Flexibacter*-like bacteria. It is that experience that led to the fish in this study being treated with the ectoparasite prophylactic of formaldehyde and malachite green as described by Needham and Cross (1988). In a separate incident Striped Trumpeter (*Latris lineata*), held on board in a flow through system for a week, all died within five days of transfer to the laboratory. Fish exhibited skin lesions, identification of the cause revealed Rhizoid Flexibacter-like bacteria (Clark, 1990). From the above experiences it is highly likely that fish held for only a few days prior to shipment would still suffer from chronic stress and therefore would not be in prime condition. While plasma cortisol titer was not determined in either of the above cases, evidence from many other studies researching the stress response of fish to capture, handling and transport, indicate elevated levels of plasma cortisol (for references see discussion regarding cortisol titer above). No fish in the current study succumbed to a similar disease.

Stress in fish is known to cause immunosuppressince. The effect on the immune system is twofold. There is a decrease in circulating lymphocytes and the effectiveness of the remaining lymphocytes (B and T cells) is compromised. Innoculations of *Aeromonas salmonicida* into rainbow trout (*O. mykiss*) caused an increase in mortality from 40% to 60% when the fish were highly stressed first (Angelidis *et.al.*, 1987). In the case of a heirarchy existing, as it does with Blue-throat wrasse, subordinate Rainbow trout (*O. mykiss*) have been found to be more prone to infection than dominant fish (Peters *et. al.*, 1988). From a live fish transport point of view the time frame in which immunocompetence is first compromised and normality returns is all important. Pickering *et. al.* (1982) conducted a time course study monitoring various parameters (including cortisol and concentrations of erythrocytes, neutrophils and thrombocytes) in brown trout (*S. trutta*) following a two minute handling stress. It took two weeks before prestress levels were regained.

Not only is acclimation time important but holding facility design and stocking density must be given equal consideration. Many tanks are low and it is easy to look at the fish inside. While this may be desirable from a management point of view, all too often the fish will burst into escape speed swimming. This peering into tanks is a form of handling and therefore stocking density will be a function of temperature, physiological condition of the fish and the nitrifying capacity of the biofilter should the system be recirculating. Davis *et. al.*, (1984) report an inverse relationship between population density and incidence of biting by Channel Catfish and Pickering and Pottinger (1983) found that increased stocking levels was directly attributable to higher plasma cortisol levels. Acclimation temperature is also implicated in plasma cortisol titer. Chinook salmon acclimatised to 13°C increased plasma cortisol concentrations from 20 ng mL^{-1} to 70 ng mL^{-1} when the temperature was increased to 23°C (Strange *et. al.*, 1977).

The cumulative effects of multiple stressors cannot be ignored. A single stressor may appear to be within the capability of the fish to cope, however accumulated responses over a short time may prove fatal. Consider the multitude of stressors involved in the capture, subsequent onboard handling, tanking, packaging and final transport to market. Added to this already significant list is the final handling and tanking (destination water quality?).

The current practice of holding fish for a few days prior to shipment is clearly not long enough. Many operators have considered that a 72 hour purge time is ample to ensure that during transport ammonia excretion does not cause a problem. Further studies to identify a suitable recovery period, correct stocking levels , flow rates and system design need to be undertaken. Standard aquaculture routine involves many of the same stressors as the live fish trade (e.g., capture, handling, transport, tanking) and there is substantial literature dealing with these problems. Researchers into the live fish trade have an excellant starting point.

Conclusion

This study has identified basal levels in the Blue-throated Wrasse for plasma cortisol, haematocrit and haemoglobin concentration. The haematocrit and haemoglobin values correlate well with another study (circadian variation) already completed by this author. The major assumption for acceptance of these values to be valid is that the values for cortisol from freshly caught fish had not been affected by capture and that the sample is representative of the population. Wydowski *et. al.,* (1976) concluded that the stress of capture was within the physiological ability of the fish to cope provided fish were immediately retrieved upon hookup. Pankhurst and Sharples (1992) found no difference in cortisol titer between fish sampled underwater and fish caught by rod and line at time zero.

Authors Note

The experimental data given above is partially drawn from a paper presented to ASFB Conference in 1994. For a copy of that paper contact the author.

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Live Transport of the Horseshoe Leatherjacket

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LIVE TRANSPORT OF THE HORSESHOE LEATHERJACKET

Introduction

As fish stocks continue to decline on a global scale there has, and will be, an inevitable swing toward quality rather than quantity in the seafood industry. Live products are the ultimate in a seafood industry which is actively seeking higher quality and value added products. The market for live fish is large and expanding both within Australia and overseas. However, the protocol developed by industry to maintain fish alive during capture, holding and transport is largely the result of haphazard, *in situ* trials. The results of the current methodology are often poor and highly variable, reflecting their base. Their is considerable potential for elucidation of cost effective methods which greatly enhance survival, and thus profit margins, both directly and indirectly. Furthermore, the ability to capture and hold live seafood for an indefinite period has the potential to eliminate supply peaks and droughts which are a common problem in market supply (and price) for many seafood products including live fish.

Species Attributes

The horseshoe leatherjacket, *Meuschenia hippocrepis*, is an attractive monocanthid fish which inhabits the coastal, temperate waters of Tasmania, Victoria, South Australia and southern Western Australia in abundance (Grant 1987). Current market prices for live leatherjackets are approximately six time those of "wet" fish. To take advantage of this price difference, methods which are both successful <u>and</u> cost effective must be determined.

Initial observations suggest that this species is particularly suited to live holding and transport. This conclusion is supported by the following characteristics:-

1. *M. hippocrepis*, like most leatherjackets, is readily trapped eliminating the need to net or line fish. Trapping is the choice of capture methods for fish which are destined for the live seafood market. Furthermore, this species inhabits shallow water reducing the effects of rapid changes in depth during capture.

2. *M. hippocrepis* rapidly resumes feeding once transported to holding facilities. Most specimens have excepted food from hand within three days of arrival. Feeding resumption is socially facilitated further reducing this time period if fish from previous trips are already being held. The relative ease with which these fish become "domesticated" is potentially an indicator of low stress levels in captivity. A decrease in stress induced by human interaction results in a decrease in stress related problems such as increased ventilation and defaecation.

3. To date, mortality both immediately post-capture and during long term holding, is low (<5%). Most of this total is attributable to deaths immediately post-capture during line fishing as a direct result of damage caused by the hook. The use of traps is expected to reduce this figure considerably.

4. There is a reduced risk of skin abrasion and damage due to the leather-like nature of the dermis (hence the name). This characteristic is of great benefit both in survival (due to a reduction in opportunistic pathogen threat and osmoregulatory stress) and final presentation.

Several minor problems with live handling and holding of *M. hippocrepis* have become apparent. The first is the risk to handlers from biting and caudal spines. Much of the head area of *M. hippocrepis* is comprised of large jaw musculature and the single fused teeth of the upper and lower jaws possess considerable shearing power capable of causing considerable damage.

The second problem is substrate biting. Leatherjackets are renowned in the aquarium trade as substrate biters. Specimens of *M. hippocrepis* held at the National Key Centre for Aquaculture for the past nine months have displayed low levels of substrate biting however submerged power cords and temperature probes have been shielded to reduce potential damage. Finally, territorial aggression has been observed particularly after introduction of new specimens. The placement of several one metre lengths of 300mm diameter PVC pipe within the holding tank has considerably reduced observed aggression and subsequent damage to fish.

Specific Areas of Investigation

A) The use of temperature reduction is a powerful tool in reducing respiratory oxygen demand in aquatic poikilotherms for several reasons:-

- Decreases in temperature (which is simply a measure of kinetic energy) reduce the rate of reactions thereby decreasing oxygen demand and waste production.
- Like all gases the solubility of oxygen in water is increased as temperature decreases.
- The oxygen affinity of haemoglobin is labile and decreasing temperature increases the oxygen affinity of haemoglobin (Eckert *et al.* 1988).

Therefore, lowered body temperature (within lethal limits) decreases metabolic oxygen demand in teleosts (eg. Beamish & Mookherjii 1964, Spitzer *et al.* 1969, Cech & Wohlschlag 1973, Ott *et al.* 1980, Hughes *et al.* 1983, Fernandes & Rantin 1989), increases oxygen availability (in an open system), increases efficiency of oxygen supply and decreases production of harmful metabolic waste products. However, optimisation of the protocol of temperature modification (dT/dt) has received little attention. Various protocols will be trialed in an effort to determine an effective method for use in live transport of *M. hippocrepis* which is cost-effective and includes risk analysis considerations.

B) It is well known in teleosts that the optimisation of ventilation to maintain oxygen transfer and satisfy oxygen requirements is controlled via peripheral oxy-chemoreceptors, central catecholamine responses and mechano- and proprioceptor reflexes acting on the respiratory centre of the medulla and modulated in the mid- and forebrain (Burleson *et al.* 1992, Taylor 1992, Randall 1993, Milson 1993). However, it is hoped that these controls may be manipulated using temperature and oxygen tension to enable "loading" of oxygen and preempt mechanism switches such as those observed by Burggren and Randall (1978) and Fernandes *et al.* (1995) in response to oxygen tension and temperature changes respectively. The relevant cues may then be utilised to take advantage of mechanisms developed in response to environmental demands in a live transport context (eg. immediately prior to transport).

C) Use of lowered temperature to induce coma confers advantages beyond those relating to the temperature alone. Comatose animals are by definition extremely lethargic. The effect of small increases in activity resulting in large increases in oxygen consumption and metabolic waste production is well known (eg. Krogh 1914, Spencer 1939, Spoor 1946, Higginbotham 1947, Graham 1949, Prosser *et al.* 1957, Basu 1959, Brett 1965). Even when external stimuli are essentially eliminated some fish still exhibit a considerable amount of spontaneous activity (Beamish & Mookherji 1964). Coma induction, maintenance and recovery protocols may provide significant advances in live transport of fish.

D) The effect of light levels on fish activity has received little energetic or metabolic consideration. It would be expected that light levels would differentially affect fish species which were nocturnal and diurnal in behaviour. In deer it has been shown that night transport is far more effective and results in dramatically decreased stress levels. Thus, it should be considered that light levels may be modified in order to reduce both activity and stress thereby increasing survival.

E) Krogh (1914) defined standard metabolism as "nearest attainable approximation to the basal metabolism which would obtain when all organs were absolutely at rest." Obviously, in live transport the closer the metabolic rate of the fish to standard metabolism the greater the chance of survival. The difficulty in attaining and measuring standard metabolism in fish is eliminating spontaneous activity. However, investigators who encourage quiescence have recorded lowered rates of oxygen consumption such that these rates were considered to be close approximations of true standard metabolism (eg. Graham 1949, Job 1955, Mann 1956, Pritchard *et al.*1958, Hickman 1959, Moss & Scott 1961). Similar to coma induction, anaesthetics have the potential to reduce activity to very low levels and thus increase survival. However, some anaesthetics such as MS 222 reduce the oxygen tension of blood and therefore should be avoided if other anaesthetics can be substituted (Forteath 1993). It is hoped that a relatively new product known as Aquiesce will be trialed for use in live transport of *M. hippocrepis*.

F) Not all of the oxygen consumed by the body is used in the catabolic reaction of glucose. Reactions which are independent of respiration consume significant quantities of oxygen. Some of these utilisation pathways can be temporarily blocked without long term deleterious effects thus making more oxygen available for respiration during live transport. Trials which use substances that block these biochemical pathways will be conducted in the hope that a significant quantity of oxygen can be made available for respiration. Similarly, not all of the oxygen removed from the water is consumed by fish. Steffensen (1989) observed that consumption of oxygen by bacteria within experimental apparatus can be considerable and must be considered when calculating respiratory demands of fish. An antibacterial chemical, neomycin sulphate, is used by the aquarium trade in Hong Kong to reduce bacterial infection. A dual purpose of antibacterial additives may be to reduce oxygen consumption by bacteria within the system.

The possibility of deleterious synergistic reactions between hitherto independent applications (such as those detailed A-F above) must be considered. Teo *et al.*(1989) observed such effects when clinoptilolite (a zeolite ammonia remover), tris buffer and 2-phenoxyethanol (an anaesthetic) were used in conjunction in several combinations while each of the additives proved beneficial when used independently. To avoid such complications combined protocols should be rigorously tested to ensure deleterious synergism is not occurring.

System Design

The basic design of the flow-through respirometer in use (Figure I) closely follows the design detailed by Cech *et al.*(1979). This design is easily modified for use as a closed ("Brett") type respirometer, intermittent system or static system. Steffensen (1989) recommends that intermittent flows be used in preference to static or flow-through systems. While the criticism of static systems is valid, the author fails to provide sufficient support for rejection of flow-through systems in favour of intermittent flow. By applying the authors own calculations intermittent flow does nothing more than sum repeated errors which are equally applicable to both systems. Intermittent flow greatly increases the complexity of correction based on the Fick Principle and has the potential to increase the error variability due to activity being generated during flushing. Therefore, flow-through systems should not be rejected in favour of intermittent flow.

Steffensen (1989) suggests that the reason for the lag in recorded oxygen consumption behind a change in activity is solely due to the reservoir or wash out effect. However, this lag also incorporates hysteresis between sensory and ventilatory systems. Hysteresis in human respiration is considerable (Eckert *et al.*1988) and it's effect upon the lag in oxygen consumption behind activity in fish can not be discounted at present.

Conclusion

Using a flow-through respirometer to test the effects of various protocols on *M. hippocrepis* respiration it is hoped that efficient, cost-effective methods will be defined. Furthermore, it is anticipated that methods derived for *M. hippocrepis* will provide a solid base for defining effective methods for other species particularly temperate water species.

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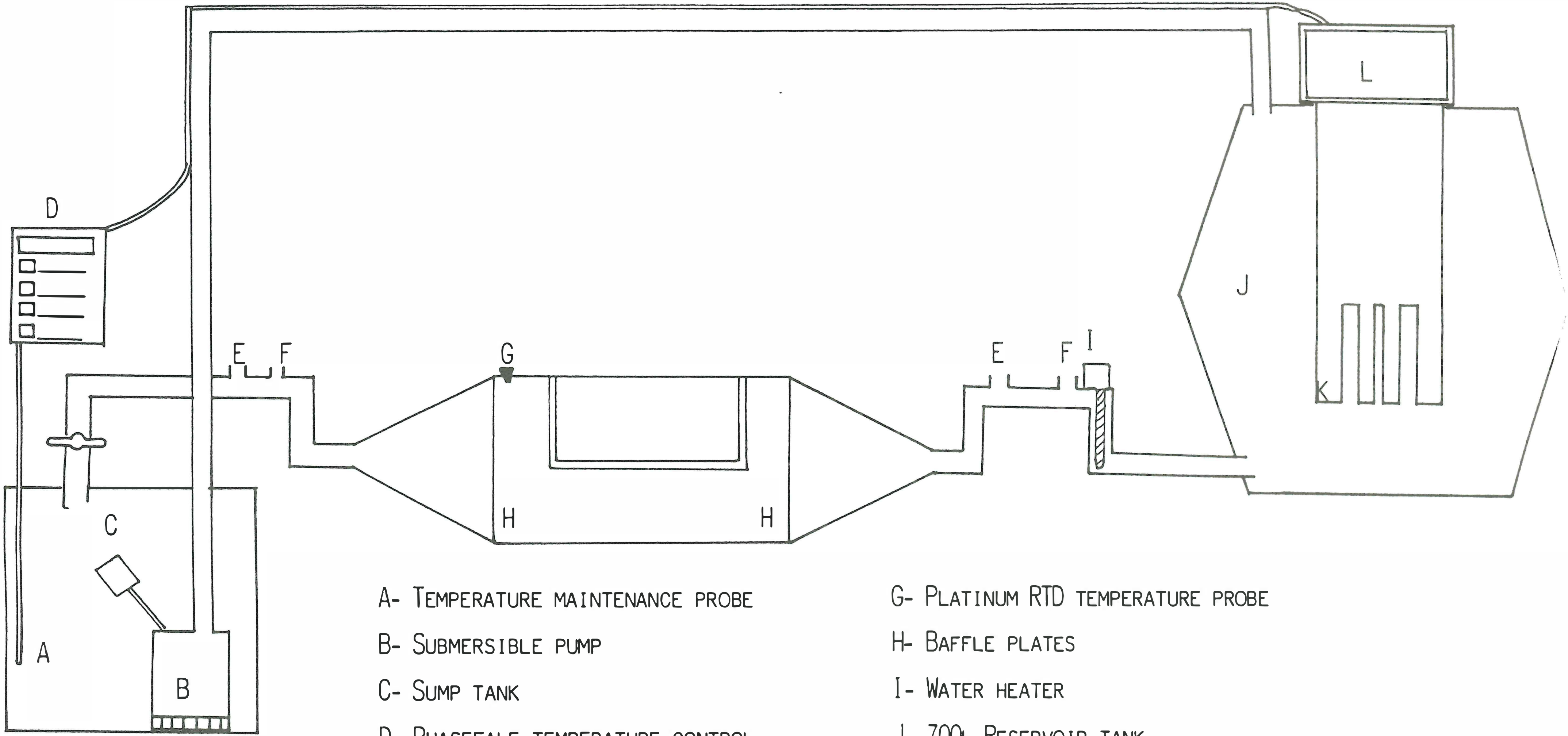
FIGURE ONE



A- Temperature maintenance probe

B- Submersible pump

C- Sump tank

D- Phasefale temperature control

E- pH probe- WTW pH 323

F- Oxygen probe- WTW oxi 323

G- Platinum RTD temperature probe

H- Baffle plates

I- Water heater

J- 700L Reservoir tank

K- Platinum cooling coil

L- Heat exchanger

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Oxygen Consumption by the Southern Rock Lobster *Jasus edwardsii*

Live Fish Transport Workshop
October, 1995

OXYGEN CONSUMPTION BY THE SOUTHERN ROCK LOBSTER *JASUS EDWARDSII*

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INTRODUCTION

The quantity of live spiny lobsters (*Jasus edwardsii* and *Panulirus cygnus*) being exported has increased dramatically in the last few years. There has been a concomitant rise in the number of live holding facilities throughout Australia. Live holding has many benefits, including increasing flexibility of marketing and despatch, and selling when prices are at a peak. In order be able to successfully hold large numbers of rock lobsters it is imperative that information is obtained about their metabolism. Such information is valuable to aid in the design and operation of live holding facilities, if lobsters are to be kept in prime condition.

Oxygen is the major water parameter limiting the carrying capacity of holding facilities. Therefore it is important to know how factors such as low environmental oxygen tensions, activity, weight, water temperature, diurnal rhythm and feeding affect the oxygen consumption rates of rock lobsters. This paper details part of an investigation into factors affecting the oxygen consumption rates of the southern rock lobster, *Jasus edwardsii*.

MATERIALS AND METHODS

Lobsters were either collected by the Tasmanian Department of Sea Fisheries or purchased from commercial live holding facilities. They were maintained in a recirculating system (35 ppt, 13°C) and fed twice weekly on chopped squid (and occasionally mussels). They were not fed 3 days prior to the start of experiments.

A respirometer system was built. The system was fully automated to allow the measurement of respiration over extended time periods; rock lobsters have been kept in the respirometers for up to 10 days. The respirometers were operated mostly as intermittent flow respirometers but could be operated as closed or flow-through respirometers depending on requirements. The chambers were used as closed respirometers for evaluation of the oxygen independence of lobsters.

The respirometers (each respiration chamber contained 18.2 l of water) were emersed in a water bath. The temperature of the system was controlled by the temperature of the experimental room. The temperature was maintained at 13°C for these experiments. Water was pumped from a reservoir through the respirometers via two way, solenoid controlled valves. When the valves were open (flushing period) reservoir water flowed through each respirometer thus re-oxygenating the chamber. When the valves were closed (measuring period) the decrease in the oxygen tension of the respirometer water was used to determine oxygen consumption. For most experiments a 10 minute flushing period was followed by a 20 minute measuring period. This cycle ensured that the level of oxygen in the chambers did not fall below 70% saturation. Tests without an animal in the chamber showed that a blank correction for bacterial oxygen consumption was not necessary.

Dissolved oxygen concentrations were measured with a WTW OXI 96 oxygen meter. The output from each meter was connected to a datalogger (DataTaker 50, Data Electronics). A small powerhead pump circulated water past the oxygen electrode membrane. This had the secondary purpose of maintaining good water circulation within each chamber during the measuring periods.

Initial experiments showed that lobsters needed to be adapted to the respirometers for 36 h prior to the commencement of any experimental work. The standard and routine metabolic rates were established after the initial acclimatisation period. Experiments were then conducted to examine various aspects of the metabolism of lobsters.

Oxygen independence

The relationship between oxygen consumption and environmental oxygen tension was established. Ten lobsters (360 g - 2180 g) were allowed to exhaust the available oxygen in the respirometers during experiments. This method simulated conditions which might be encountered in holding tanks.

Scope for activity

The scope for activity is the difference in oxygen consumption rate between the standard level and the maximum active level. Thus it represents the capacity of the animal to aerobically carry on activities such as locomotion, digestion and growth, which are above the normal short-term maintenance requirements (Rutledge & Pritchard, 1981). Lobsters were activity stressed by taking them out and placing them in air for a period of 15 minutes. During this time they were stimulated into activity (ie. tail flicks) by continually handling them. They were then placed back into the respirometers to examine their metabolic response to enforced activity and scope for activity.

Oxygen supersaturation

Three animals were subjected to supersaturated water to determine if it has any effect on metabolic rate. The same animals were then subjected to emersion and activity (as above) and placed into oxygen supersaturated (150%) and oxygen depleted (50%) water to determine their ability to extract oxygen from such water after exercise.

RESULTS

Standard metabolism

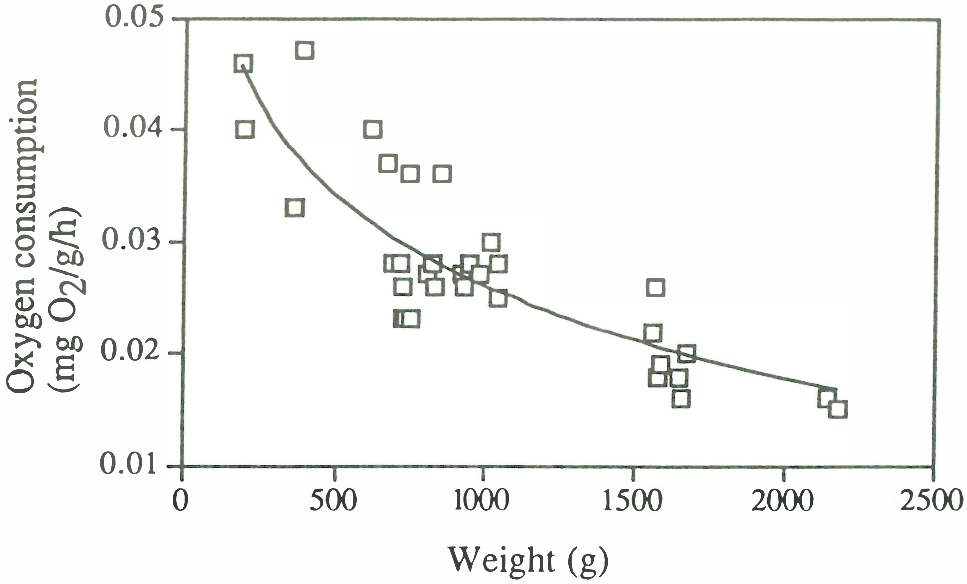
The relationship between wet weight (w) and standard oxygen consumption (VO_2) of lobsters is shown in Fig. 1. A regression line was fitted to the data (after log/log transformation) using the general equation:

$$VO_2 = a\, w^{b-1}$$

where a = intercept on the Y-axis and b = the slope of the regression. The following equation was derived:

$$VO_2\ (mgO_2/g/h) = 0.477w^{-0.426}\ (r^2 = 0.801).$$

Fig. 1: Weight-specific oxygen consumption (mg O_2/g/h) against the wet weight of lobsters



From the standard oxygen consumption rates an estimate of the flowrate of water required to maintain a 1000 kg of lobsters of different sizes was calculated (Table 1). Many crayfish holding facilities are limited by water pumping capacity. Therefore the carrying capacity of a holding facility able to pump 10000 l/h is also shown. These assume that the oxygen saturation level of the output water are maintained above 75%.

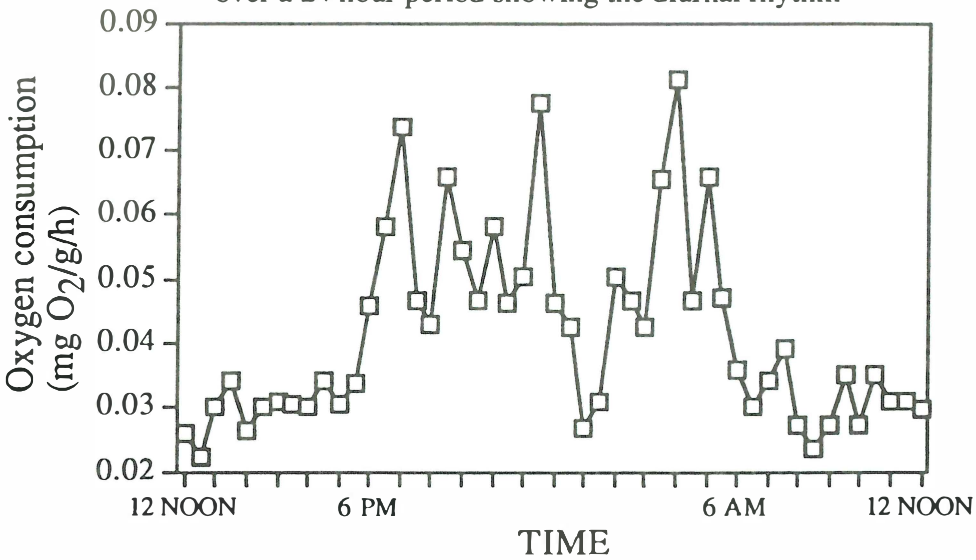
Weight (g)	Metabolic rate (mg O_2/h)	Oxygen requirement per 1000 kg (mg O_2/h)	O_2 required to maintain outlet water >75% saturated (mg O_2/h)	Water flow rate required (l/h)	Carrying capacity if flow rate restricted (kg)
400	14.9	37157	148628	17547	570
600	18.8	31263	125052	14764	677
800	22.1	27657	110628	13061	766
1000	25.1	25149	100596	11877	842
1500	31.7	21159	84636	9992	1001
2000	37.4	18719	74876	8840	1131

Table 1: Shows the water flow rate required in a flow through lobster holding tank if 1000 kg of lobsters are to be held at 13°C. The calculations assume that the lobsters are in a relaxed state, that there is no additional aeration, and that the water entering the system is fully saturated. The outlet water is being maintained at 75% saturation The final column shows the amount of lobsters able to be held in the same system if the pumping rate is restricted to 10000 l/h.

However, there are many situations which result in increased oxygen consumption above a standard rate. Diurnal rhythm provides one of the clearest examples of changes in the oxygen consumption of lobsters (Fig. 2). Video taping showed that during the day the lobsters were mostly inactive.

However nighttime activity increased significantly, even within the confines of a respirometer. The activity was not constant; periods of inactivity were broken by periods of activity which lasted several measuring periods. Recorded oxygen consumption levels reflect the observed nighttime activity, with a nighttime oxygen consumption rate 36.2% higher (n=8) than what it is during the daytime. Routine metabolic rate equals total nocturnal metabolic rate + total diurnal metabolic rate. Therefore the routine metabolic rate at 13°C is 18.1% above the standard metabolic rate.

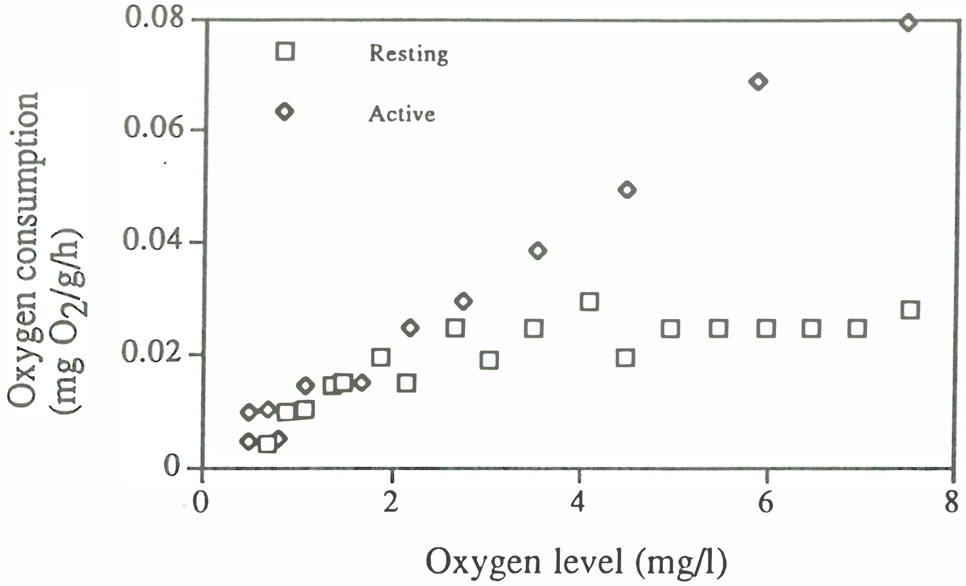
Fig. 2: Oxygen consumption (mg O_2/g/h) of lobsters over a 24 hour period showing the diurnal rhythm



Oxygen independence

Oxygen consumption was maintained independent of environmental oxygen tension down to 2.75 ± 0.08 (mean ± SE, n=10) mg/l or 32.5% saturation (Fig. 3). This level is called the critical oxygen tension. The inflection in the oxygen depletion curve was used to calculate the critical oxygen tension. (Lobster weight did not have a significant effect on the critical oxygen tension, therefore the data for all lobsters was combined). Below this level oxygen consumption was dependent on environmental oxygen tension therefore the lobsters could be termed oxygen dependent.

Fig. 3: Oxygen consumption (mg O_2/g/h) of active and resting lobsters as the oxygen level of water decreases



Scope for activity

The typical response of lobsters subjected to activity is shown in Fig. 3. Oxygen consumption in the active stressed individual is elevated above the values of the resting individual at PO_2 values above P_c. Activity causes the lobsters to act as oxygen dependent animals. The difference between standard and active rates represents the scope for activity. The metabolic rate at 100% saturation represents the maximum sustainable level of respiration for the lobster. The magnitude of the oxygen consumption seen was similar to levels measured during normal (non-stressed) activity in respirometers The maximum sustainable level was approximately 3 times the standard metabolic rate.

Oxygen supersaturation

The oxygen consumption rates of lobsters under various conditions are shown in Table 2. Supersaturated water had no effect on standard oxygen consumption rates. The rates obtained with activity stressed lobsters being placed into supersaturated water were not significantly different ($P>0.05$) to maximal rates obtained during non-stressed daily activity. However, when activity stressed lobsters were placed into 50% saturated water the oxygen consumption rates were significantly lower ($P<0.05$) than maximal rates.

Lobster weight (g)	Standard O_2 consumption (normal and supersaturated water)	Maximum O_2 consumption	150% saturated water	50% saturated water
1040	0.028	0.083	0.080	0.038
805	0.027	0.071	0.077	0.031
980	0.027	0.074	0.075	0.036

Table 2: Oxygen consumption levels (mg O_2/g/h) of three lobsters subjected to various conditions. The maximum consumption level were recorded during

normal diurnal rhythm activity. The final two columns refer to consumption recorded immediately after placing lobsters back into respirometers (with O_2 saturated or depleted water) after 15 minutes of emersion with activity.

DISCUSSION

The standard rates of oxygen consumption measured in this experiment are similar to levels measured in other species of spiny lobsters, for animals of a similar size held at the same temperature (Table 2). However, the rate obtained for *Jasus edwardsii* in Waldrons (1991) study was considerably lower than that obtained in this study.

Species	Wet mass (g)	Temperature (°C)	Metabolic rate (mg O_2/g/h)	Reference
Jasus edwardsii	500	13	0.034	This study
Jasus edwardsii	300-730	15	0.020	Waldron, 1991
Jasus lalandii	500	13	0.037	Zoutendyk, 1989
Panulirus interruptus	200-600	13	0.034	Winget, 1969

Table 2: Mass specific oxygen consumption rates obtained in this study compared to rates obtained in other studies.

The weight specific response of oxygen consumption rates is typical of most animals. This data provides valuable information for holding facility operators and designers. The weight of lobsters that a storage system will safely support is known as its carrying capacity. In order to calculate the carrying capacity, oxygen consumption rates need to be known. Carrying capacity can be calculated in two ways (Beard & McGregor, 1991). Where the maximum weight of lobsters that are to be held is known, the minimum flow rate needed to hold that quantity safely can then be calculated. Alternatively, where flow rate and tank size are fixed (ie. in an existing system) the maximum weight of lobsters that can safely held can be calculated. It must be stressed that the rates shown in Table 1 are absolute minimum rates and do not take into account factors such as activity, feeding, water temperature and diurnal rhythm.

Diurnal rhythm provides a clear example of a factor affecting oxygen consumption rates. In the wild lobsters are nocturnal feeders, hence their activity increases significantly at night. They do not lose this natural cycle during the short period they are normally held in holding systems. Therefore operators need to ensure that the increase in oxygen consumption (36% above standard rates) does not result in low oxygen levels in the tanks at night. The other important thing to note is that the oxygen content of water can decrease at night (assuming a flow through system) as plant biota uses oxygen for its own requirements instead of producing oxygen.

The oxygen consumption rates of non-stressed lobsters are oxygen independent down to 32.5% O_2 saturation. Keeping oxygen saturation levels well above this level (75%) should ensure that lobsters do not suffer from lack of oxygen once they are settled into the holding tanks. However, activity had a dramatic effect on the level of oxygen-independence. Lobsters became oxygen dependent up to 100% saturation after being subjected to activity. Thus activity requires highly saturated water. Such activity (emersion + handling) is part of the processing procedure prior to stocking lobsters into holding tanks. Therefore lobsters will require high levels of oxygen when first placed into holding tanks. The level of oxygen in tanks can drop to 30% saturation when first stocked with large numbers of lobsters (Pers. obs.). It has been shown that the amount of oxygen able to be extracted from water 50% saturated is significantly lower than lobsters require after activity. Therefore the ability of lobsters to repay oxygen debts accumulated during activity would be severely impaired under those conditions.

The oxygen content of the holding tanks needs to be kept high. Pure oxygen has been used in holding tanks as a method of aiding in the recovery of lobsters transported to the holding facilities. Supersaturation in itself does not increase the level of oxygen that lobsters can extract from the water. However, it will help to guarantee that the level of oxygen in the water will remain close to saturation. This ensures that the oxygen level does not limit lobsters ability to recover from activity induced stress.

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Investigations of On-Boat Handling in the Queensland Live Coral Trout Fishery

Live Fish Transport Workshop
October, 1995

INVESTIGATIONS OF ON-BOAT HANDLING IN THE QUEENSLAND LIVE CORAL TROUT FISHERY

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INTRODUCTION

Live export of fish and shellfish has gained increasing prominence over the past five years as a marketing approach for Australian seafoods (Grant, 1993; Rimmer et al., 1994). The growing affluence of Asian and South East Asian countries combined with a cultural preference for high quality, fresh seafoods has stimulated demand. This has resulted in the development of holding and packaging technologies aimed at maximising survival during postharvest storage and transport (Forteath, 1993, 1995; Rimmer et al., 1994). One fishery which has benefited from these developments and in which an increasing proportion of the catch is being exported live is the Queensland East Coast Reef Line Fishery.

The Queensland East Coast Reef Line Fishery operates from Torres Strait to the southern part of the Capricorn-Bunker Group targeting high value reef fish, in particular, coral trout. The fishery had an annual harvest of 2,240 tonnes in 1993 (C. Turnbull, pers. comm.) and employed between 1000 and 2000 fishers. It is a highly mobile fishery, concentrating on regions such as the Swain Reefs off Mackay, the Whitsunday Group and the far northern Great Barrier Reef on a rotational basis depending on the time of year.

Fishers operate in the daytime, fishing out of small (approx. 4-7m) dories which work to a mother ship. Most mother ships operate 3-5 dories, with one fisher per dory. Fish are caught by hand line and their swim bladder is deflated. They are then placed in small tanks on board the dory before being transferred to the mother ship holding tanks. The catch is transferred to the mother ship twice a day, at midday and in the late afternoon. Coral trout, red bass, stripey bass, wrasse and cods (A-grade fish) are placed in the live holding tanks in the dory while B-grade fish (trevally, red emporer, jobfish, spanish mackerel and stripey mackerel) are killed and placed in an ice chest for later processing. The latter part of the catch is chilled whole or filleted and frozen. Most fishers catch between 20-40 kg A-grade fish /day and fishing trips generally last for 3-5 days depending on the weather and the health status of the stored live fish.

Upon arrival at the wharf, the live product is transferred to a tank on board a vehicle and then transported to the processing factory. Fish are held in the processing factory for days to weeks before shipment to markets. Some fish are sold locally and to interstate markets but the majority is transported by airfreight to overseas markets.

The tanks used for holding the live fish in the dories and on board the mother ship are usually fitted with a flow-through water exchange system. However, at least one boat has recently installed a recirculating system in the mother ship holding facility.

The design of the water exchange systems and of the tanks themselves varies considerably between boats. Overall there is a lack of knowledge and understanding in the fishery of the principles underlying live fish holding and the technology required for maximising survival of stored product. Mortalities are not uncommon and most boats limit fishing trips to 3-4 days to avoid excessive mortality of the catch. There appears to have been few studies of the cause(s) of death of stored fish and introduction of improved technologies for holding the fish is largely based on intuition rather than investigation.

The current holding tank technology and handling techniqes restricts the time the fish can be held on board fishing vessels. If the storage time could be extended the vessel could remain at sea for longer time periods and fish greater distances from port. Overall the efficiency and economy of the fishery would be enhanced if reliable technology could be developed for extended live storage of reef fish on board mother ships. The aim of this project is to investigate the influence of environmental factors and holding system design features of fish health with the view of extending the safe holding period for on-board live storage of reef fish.

LIKELY CAUSES OF MORTALITY IN LIVE FISH STORAGE

There appear to have been few detailed investigations of the cause of mortality in fish held in live tanks on-board fishing vessels or stored in recirculating or flow-through systems in fish processing factories. Fishers describe the appearance of ulcers or 'ammonia burns' in moribund fish prior to death but the etiology of these lesions is uncertain.

The main reason that a wild capture fish will die in captivity is that it has been exposed to an environmental perturbance to which it cannot adequately adjust. Fish, like all other animals, maintain the composition of their body fluids within narrow concentration ranges. The processes by which this is achieved is referred to as homeostasis. Homeostasis works on the principle of negative feedback - receptors within and on the surface of the body constantly monitor internal and external environmental conditions(**chemical components** such as oxygen levels, carbon dioxide levels, pH, glucose concentrations, Na^{+}, Cl^{-}, Ca^{++} etc. and **physical factors** such as temperature, light and mechanical pressure). When a change in an environmental factor is detected a series of physiological reactions are initiated which counteract that change. The result is that the composition of body fluids constantly oscillates between a narrow range. Similarly the movement and behaviour of fish consists of a constant series of actions and reactions aimed at ensuring the on-going health, survival and well-being of the animal.

If the fish is exposed to a marked change in a chemical, physical or biological factor and its capacity to respond by normal homeostatic mechanisms is exceeded, a stress response will occur. The purpose of the stress response is to bring other body forces into play which will ensure that normality is restored. If these are ineffective then the animal will die. Such factors may be the sudden exposure to a marked temperature change, lack of oxygen, the appearance of a predator, sudden changes in light or even simply being held in a net for a short time period (seconds or minutes). Physical handling invariably evokes a stress response and may also lead to scale loss which predisposes fish to bacterial infections.

The stress response comprises a sequence of physiological reactions which are initiated by the secretion of stress hormones, the corticosteriods(mainly cortisol) and catecholamines(adrenalin and nor-adrenalin). The actions of these hormones lead to changes in metabolism(e.g. rise in blood glucose and lactic acid, increase in oxygen consumption), acid-base balance(fall in pH), osmoregulation(rapid alterations in concentrations of key ions), decreased host defense capacity(as evidenced by a fall in the number of circulating leukocytes) and morphological changes(e.g. increase in size of intrarrenal cells, the cells which secrete corticosteroids).

If the stress response is mild and transient, body function will return to normal. If the initiating factor is severe the reactions may not restore normal function and the animal will die. If, on the other hand, there is a persistence of the stress response, due to prolonged or repetitive, cumulative mild stimuli profound alterations in physiological function will occur. These include alterations in disease resistance, growth performance, reproductive capacity and, ultimately, death.

Key environmental factors which affect postharvest survival in fish are temperature variation, reduced oxygen availability and exposure to high environmental ammonia, nitrite or CO_2 concentrations (Horton et al., 1956; Johnson, 1979; Carmichael et al., 1984; Spotte, 1992; Wedermeyer, 1992; Fries et al., 1993) . Exposure to dissolved toxins such as copper or chlorine and the accumulation of slime and excreta in holding containers can also affect survival (Spotte, 1992; Wedermeyer, 1992) as can the handling procedures used during capture and storage.

Postharvest mortality may to result from exposure to adverse environmental conditions which cause gross physiological dysfuntion leading to death. Alternatively, and more probably, the fish die from secondary bacterial infections which result from the detrimental effects of stress responses on immunocapacity and health status.

MEASUREMENT OF STRESS RESPONSES IN FISH

One approach to minimising postharvest mortality is through the investigation of stress responses resulting from postharvest practices and an evaluation of the effect on those responses of modifications in postharvest procedures and technology.

Quantitative measurement of physiological responses to stressors are used by many researchers to evaluate the intensity of a given stressor and, hence, the likely effect of that stressor on subsequent health and survival. A number of different approaches have been used to study and measure stress responses in fish. These include measurement of plasma cortisol (see review, Barton & Iwama, 1991), plasma lactate (Pickering et al., 1982; Wells et al., 1984; Smith, 1992), plasma glucose (Pickering et al.,1982; Carmichael et al., 1983; Maule et al., 1988; Thomas & Robertson, 1991; Smith, 1992; Staurnes et al., 1994) haematological parameters (Bourne, 1986; Maule et al., 1988; Pickering & Pottinger, 1988; Goede

& Barton, 1990), osmoregulatory parameters (Carmichael et al., 1983; Mazik et al., 1991; Wagner & Driscoll, 1994; Staurnes et al., 1994), immunological parameters (see review, Anderson, 1990) and quantitative morphological measurements such as determinatiion of mean intrarrenal cell nuclear size (see review, Hinton & Lauren, 1990).

The parameters most often used to measure the stress response are plasma cortisol, plasma glucose and various serum ions. However, assessment of stress responses in harvested fish on board fishing vessels through analyses of these blood components presents significant problems. Some of the measurements(e.g. plasma glucose) should be conducted soon after removal of blood while others(e.g. plasma cortisol, serum electrolytes) require that the blood sample is collected by syringe and stored at -20^{o}C until assayed. These procedures are best performed by staff who are trained in laboratory procedures and who have immediate access to laboratory equipment such as centrifuges and spectrophotometers. It would be advantageous if the approach used to study stress responses in harvested fish does not require sample collection by laboratory trained staff or immediate access to laboratory equipment. Examination of quantitative or morphological changes in fixed blood and tissue specimens collected by fishers during routing fishing trips is one such procedure. This is the approach which is currently being examined in the project described in this report.

EXPERIMENTAL APPROACH

Key environmental parameters - oxygen, temperature, pH, ammonia, nitrite and nitrate - were measured in the 280L 'Southwind' dory holding tank over six fishing excursions and in two x700L holding tanks on the mother ship over a five day fishing trip. Kits were used to measure ammonia, nitrite and nitrate and the remaining measurements were performed by standard procedures. Records were kept of the time and approximate weight (estimated by visual observation) of each fish placed in the holding tanks. A cumulative assessment of fish biomass was determined from these observations.

Water exchange in the dory was achieved by a scoop which circulated water when the dory was underway and by a battery operated pump when it was stationary. Oxygen, temperature and pH measurements in the dory tank were taken at half hour intervals and ammonia, nitrite and nitrate readings were made at the start and the end of every trip. Surface water temperature measurements were also made at half hourly intervals.

Water exchange in the mother ship holding tank was achieved by a flow-through system which had approx. five exchanges per hour.The of pattern water flow through the two tanks is shown in Figs. 1 & 2. Water enters the tanks along two PVC pipes which run the length of the tanks and exits via by skimmer holes on the top of the stern wall of each tank and by a main drain on the bottom port side of the right hand side tank. Water flows from the left tank to the right tank via a drain at the junction of the two tanks(figs.1 & 2). Oxygen and pH were measured three times a day with readings being taken at three postions in the tank(fig. 3) while temperature measurements were made at the surface and at the bottom of the tank three times a day. Ammonia, nitrite and nitrate measurements were performed daily.

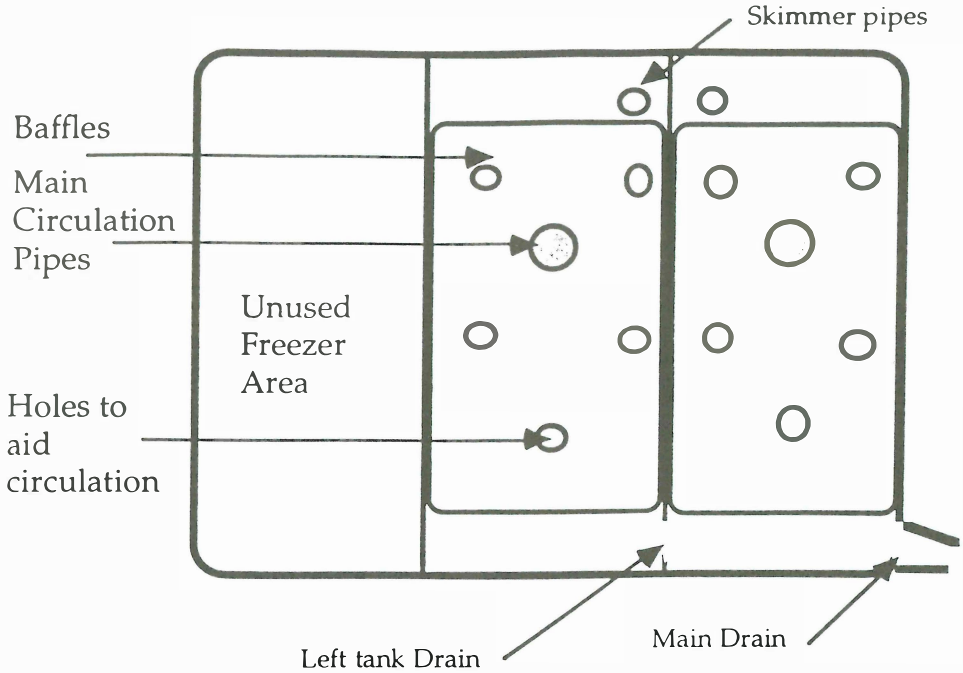

Fig. 1 Cross section view of main holding tanks on mother ship

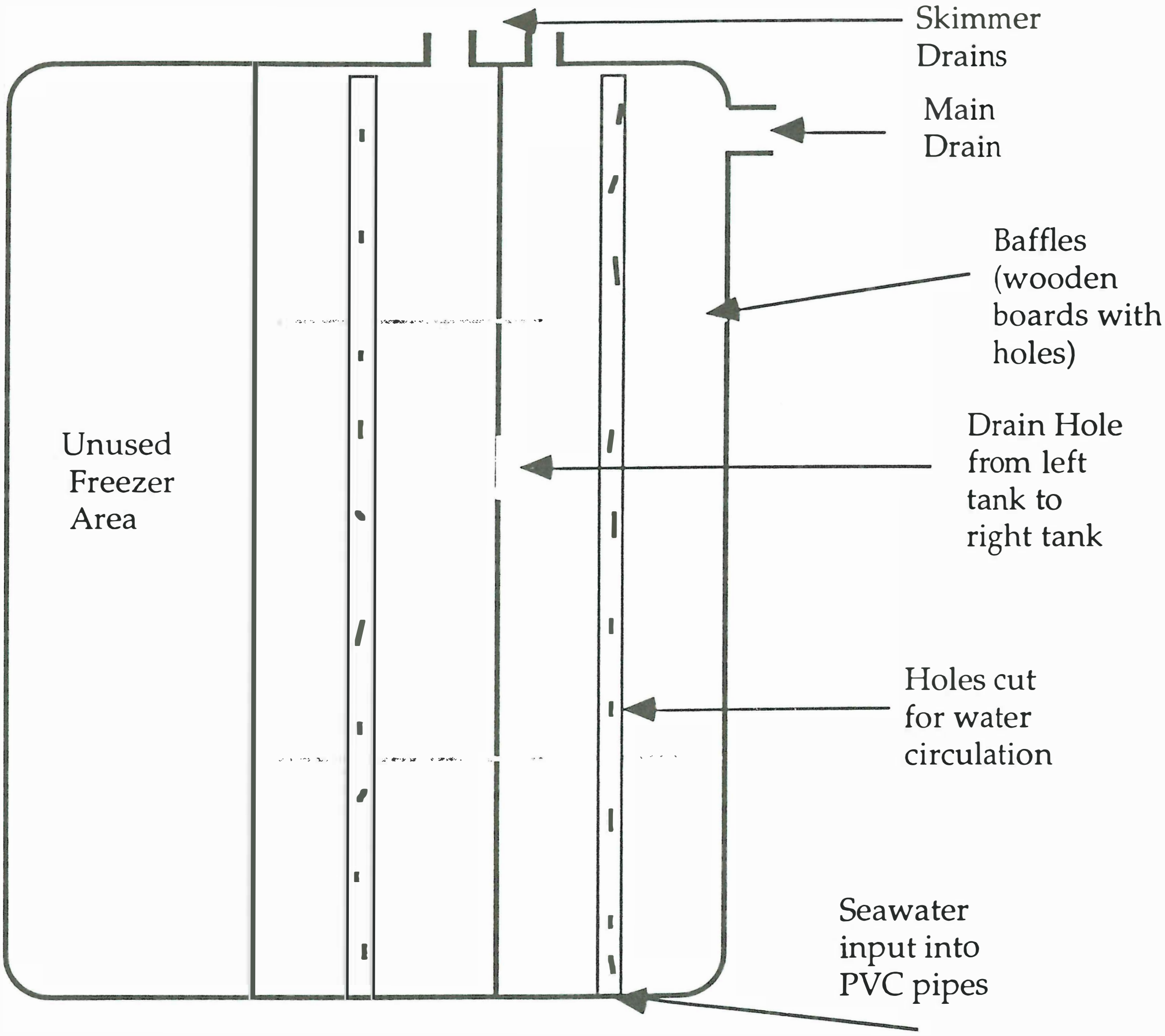

Fig. 2 Top view of main holding tanks on mother ship

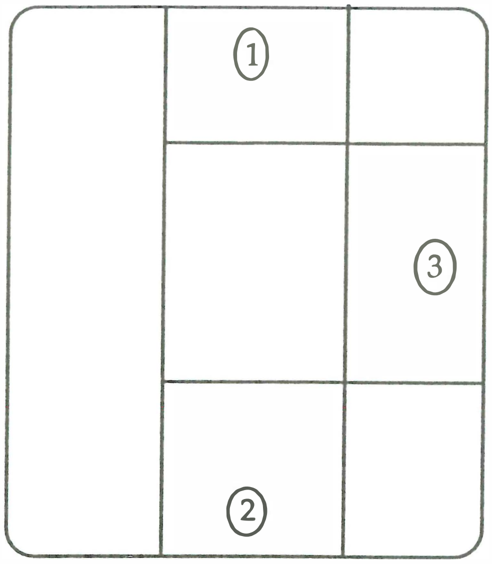

Fig. 3 Postions of oxygen, pH and temperature measurements in main holding tanks of mother ship

In addition to the water quality measurements tissue samples and blood smears were collected from six coral trout immediately after transfer to the mother ship and from a further six coral trout immediately prior to transfer of the catch to the wharf. Samples were collected from gills, head kidney, gut and liver and fixed in Bouins fixative for later processing into histological sections. This report describes the results of the water quality and temperature analyses along with preliminary data on the blood smear examinations. Histological analyses have yet to be completed.

RESULTS AND DISCUSSION

A total of 330kg live fish were caught during the five day fishing trip. Daily observations of fish in the mother ship holding tank revealed that different species of fish tended to occupy different sections of the tank with coral trout occupying the lower section and bass the surface region. Colour change, swimming behaviour and the appearance of the fins were used by fishers to judge fish health. Moribund fish were observed to have abnormal swimming actions and feathered tails and fins. Twelve fish died during the trip, eleven of which were red bass.

Oxygen concentrations at the commencement of fishing operations in the dory ranged from 6.9-7.6ppm. There was a consistent trend of decreasing dissolved oxygen concentration with increasing stocking density. The results obtained on the day on which the highest catch was recorded are shown in Figure 4. Oxygen recordings at the completion of the fishing operation ranged from 4.4-6.0ppm with the lowest recording being obtained with the highest stocking density(45.5kg). The results suggest that the water flow through the dory tank was insufficient to maintain optimum levels of dissolved oxygen and exposure to low oxygen probably contributed to a deterioration in health status of harvested fish.

Oxygen concentration in the mother ship holding tank decreased as the stocking density in the tank increased(fig. 5). The lowest observed concentration, 3.7ppm in

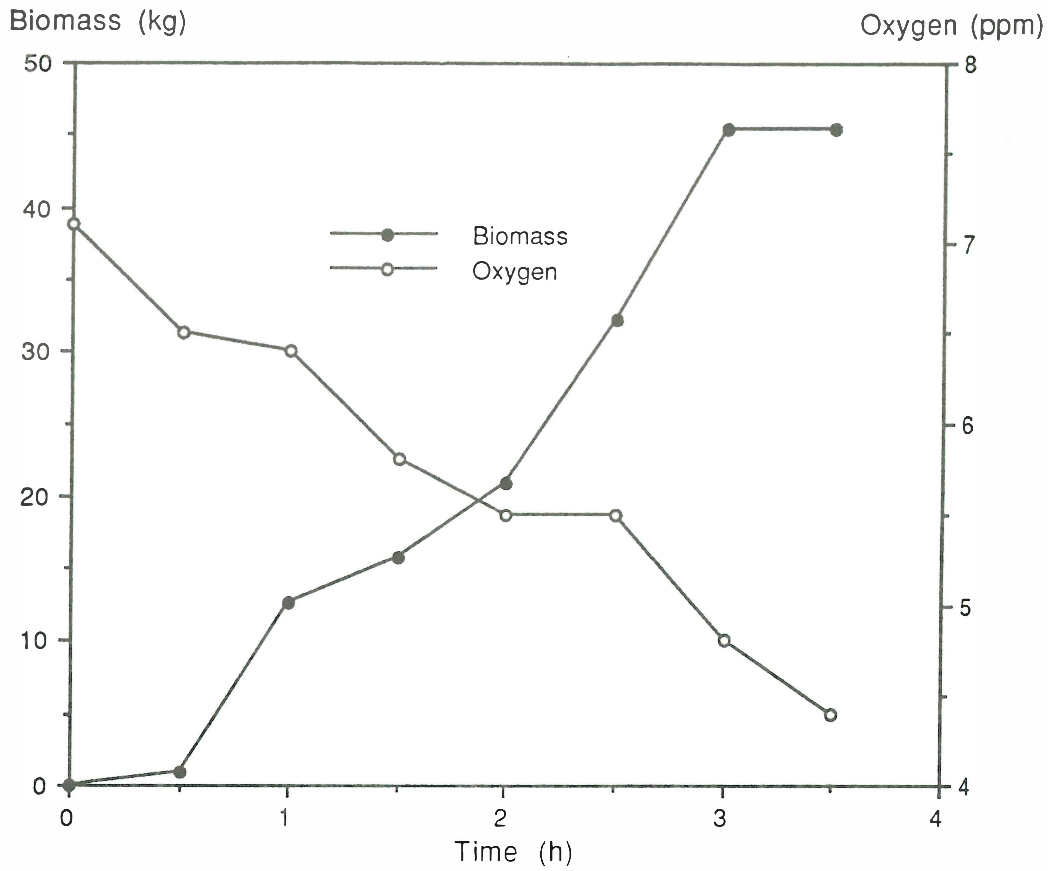

Fig. 4 Fish biomass and dissolved oxygen in dory holding tank during a fishing trip excursion

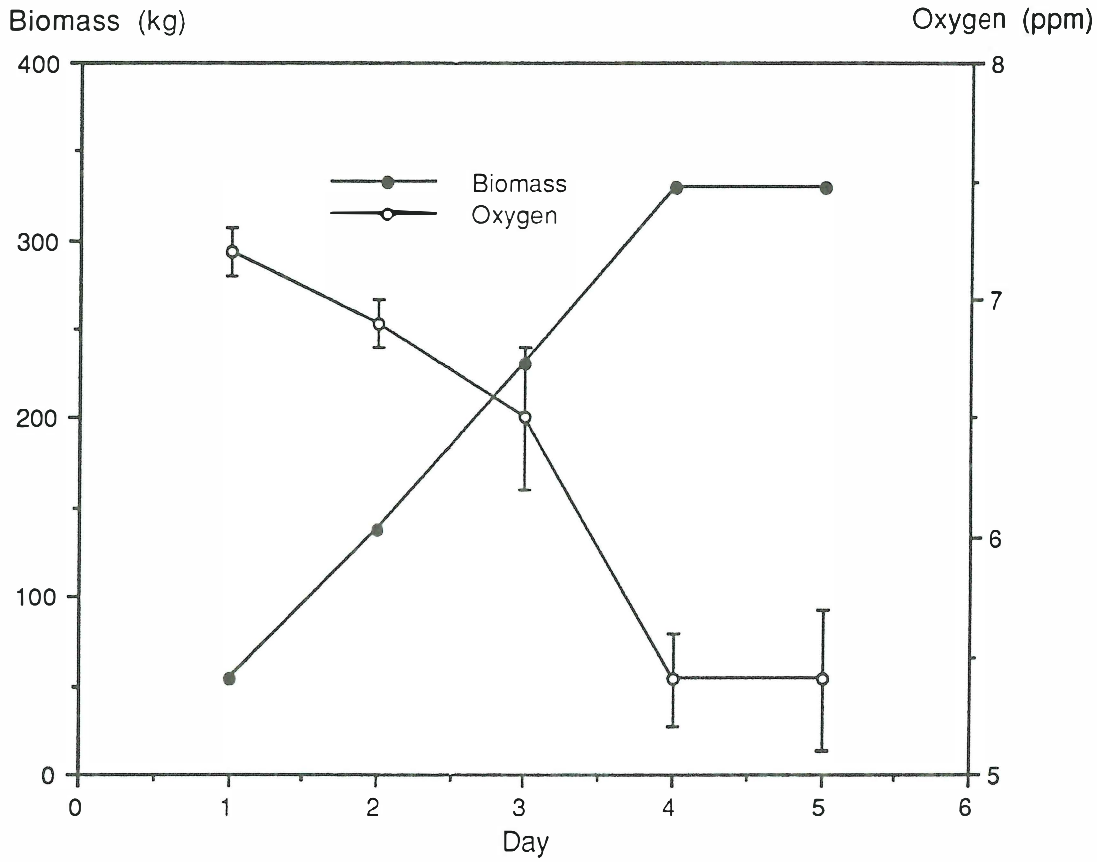

Fig. 5 Fish biomass and dissolved oxygen in mother ship holding tanks over fishing trip

Table 1 Temperature and pH measurements in mother ship holding tanks(location of measurement positions shown in fig. 3)

Date	Time	Position	pH	Temperature	
				Surface	Bottom
20/7	8.30am	1	8.4	24.5	24.5
		2	8.4	24.5	24.5
		3	8.4	24.5	24.5
20/7	3.00pm	1	8.4	24.2	24.2
		2	8.4	24.2	24.2
		3	8.4	24.2	24.2
20/7	8.15pm	1	8.4	24.2	24.2
		2	8.4	24.2	24.2
		3	8.4	24.2	24.2
21/7	7.15am	1	8.4	24.1	24.1
		2	8.4	24.1	24.1
		3	8.4	24	24
21/7	12.30pm	1	8.4	23.8	23.8
		2	8.4	23.8	23.8
		3	8.4	23.8	23.8
21/7	8.45pm	1	8.3	23.6	23.6
		2	8.3	23.6	23.6
		3	8.3	23.7	23.7
22/7	7.00am	1	8.4	23.5	23.5
		2	8.3	23.5	23.5
		3	8.3	23.5	23.5
22/7	Noon	1	8.4	23.4	23.4
		2	8.4	23.4	23.4
		3	8.3	23.4	23.4
22/7	8.00pm	1	8.4	24.5	24.5
		2	8.3	24.5	24.5
		3	8.4	24.5	24.5
23/7	7.30am	1	8.4	24.4	24.4
		2	8.4	24.4	24.4
		3	8.4	24.4	24.4
23/7	Noon	1	8.4	24.5	24.5
		2	8.4	24.5	24.5
		3	8.4	24.5	24.5
23/7	7.00pm	1	8.4	24.5	24.5
		2	8.4	24.5	24.5
		3	8.4	24.5	24.5
24/7	3.00am	1	8.3		
		2	8.3		
		3	8.3		
24/7	7.00am	1	8.3	24.3	24.3
		2	8.3	24.3	24.3
		3	8.3	24.3	24.3
24/7	11.30am	1	8.3	23.7	23.7
		2	8.3	23.7	23.7
		3	8.3	23.7	23.7
24/7	Noon	1	8.3	24	24
		2	8.3	24	24
		3	8.3	24	24

the right tank on the morning of the last fishing day, was well below what is commonly accepted as adequate aeration in flow-though tanks.The oxygen concentration in the right tank, the'downstream tank'(figs. 1&2), was consistently lower than that in the left tank. The results suggest that the flow rate in the mother ship holding tanks was insufficient to maintain optimum levels of dissolved oxygen.

Temperature recordings in the dory tanks ranged from 23.0 to 24.3^{O}C. The half hourly recordings showed no marked changes during any of the fishing excursions. Temperature and pH recordings in the mother ship holding tanks are shown in Table 1. Both parameters were quite stable and showed no marked fluctuations.

Ionized and unionized ammonia concentrations obtained in the dory tank are shown in Table 2. There was a tendency for ammonia levels to rise over the period of holding in the dory tank. The levels observed at the end of four of the five fishing trips , 0.023 - 0.046ppm, were higher than levels generally considered to be associated with deterioration of fish health status (0.02ppm) but information on the tolerance of coral trout and red bass to unionised ammonia is lacking and no conclusion can be reached concerning possible effects of exposure to unionized ammonia of harvested fish in the dory tank. No nitrite or nitrate was detected in the water samples tested from the dory tank. Ammonia, nitrite and nitrate measurements performed on water samples taken from the mother ship holding tanks were unreliable and are not reported.

Date	**Time**		**Ionized ammonia (ppm)**		**Unionized ammonia (ppm)**		**Kilos of fish caught**
	Start	Finish	Start	Finish	Start	Finish	
21/7	8.15am	Noon	0.1		0.008	0	33.3
21/7	1.20pm	4.30pm	0.2	0.3	0.015	0.023	16.6
22/7	7.30am	Noon	0.1	0.5	0.008	0.038	21
22/7	1.30pm	5.00pm	0	0.4	0	0.031	45.5
23/7	8.00am	11.00am	0.3	0.6	0.023	0.046	16.4

Table 2 Ionized and unionized ammonia levels in dory tank on five fishing excursions

Preliminary examination of blood smears taken from fish soon after capture and after storage for one to four days in the mother ship holding tanks showed that the thrombocyte numbers significantly increased during holding in the main tanks ($p<0.01$). Further studies on blood smears and on histological preparations are in progress and will be reported separately.

CONCLUSION

The results obtained in this study suggest that the circulation of seawater in the dory and mother ship holding tanks was insufficient to maintain optimal levels of oxygen in holding tank water. Decreases in available oxygen may have contributed to the mortalities observed during the fishing trip. Modifications to water circulation systems should be performed and their effect on water quality conditions evaluated. It is of significance to note that prior to this study the tanks used for live holding in the fishing boat on which the study was performed were considered to have adequate circulation to maintain optimum water quality. This study highlights the need for water quality studies on commercial fishing boats involved in the live fish industry.

Ammonia measurements in the dory tank suggested that the fish may have been exposed to transitory levels of high unionised ammonia. However, the kit method used for the analyses tended to be unreliable and these results should be viewed with caution. Further studies of nitrogenous waste accumulation in the dory and mother ship holding tanks and of the tolerance of reef fish to ammonia and nitrite appear warrented. Investigations are also required on the possible influence of other biological factors such as light exposure and water motion on fish health and survival in harvested fish.

Most of the fish which died during the fishing trip were red bass. It would appear that red bass have a reduced tolerance to live fish handling procedures compared to coral trout. When a suitable long term holding technology is developed red bass could be used as a sentinal species to allow for early detection of water quality deterioration.

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Barramundi or *Moribundi*

Live Fish Transport Workshop

October, 1995

Barramundi or *Moribundi*? Interactions between water quality changes and fish physiology during live transport

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Summary

Water is a major expense when air-freighting live fish. However, if you reduce the volume of water relative to the amount of product then you foul the water faster with carbon dioxide (CO_2) and ammonia (NH_3). Studying how the fish respond to high levels of these wastes may show what factors are most important and indicate ways to circumvent this problem. The physiological responses of seawater-adapted barramundi, Lates calcarifer, *were studied during simulated live transport and transport under circumstances of elevated CO_2 or NH_3. Blood samples were removed from fish exposed to these treatments and compared to samples from control fish, (free in the tank) and fish confined in a box but with free-flowing seawater. Analysing the blood samples showed that simulated transport caused the plasma pH of the fish to fall, threatening the blood's ability to transport oxygen, but the red blood cells apparently defended their internal pH and oxygen transport capacity, and swelled measurably as a result. Exposing fish to unusually high carbon dioxide or ammonia levels caused plasma pH to fall to near lethal levels The effects of both of these wastes need to be considered when studying the responses of barramundi to live transport. Water quality parameters do not act in isolation. Attempts to reduce carbon dioxide accumulation, for example by using a buffer to control the water pH, may influence the fish's ability to excrete ammonia.*

Introduction

Water is a major expense when air-freighting live fish. If you reduce the volume of water relative to the amount of fish then you foul the water faster with the wastes that the fish excrete, carbon dioxide (CO_2) and ammonia (NH_3). Much of our knowledge of the physiological responses of fish to adverse water quality has been gained in studies of freshwater species, particularly the rainbow trout *Oncorhynchus mykiss* (Perry 1982, Thomas et al 1988).

The barramundi or Asian sea bass *Lates calcarifer* is cultured widely throughout S.E. Asia. Virtually nothing is known about its physiological responses to handling and poor water quality. Understanding how a fish such as a barramundi responds to stagnating water allows us to understand why the fish die and leaves us better placed to make decisions about modifying the transport methods applied to this and other species.

Fish blood and respiration

Fish blood serves two functions that impinge greatly on a fishes response to transport stress. The blood transports oxygen that the fish absorbs from the water and at the same time carries toxic wastes such as carbon dioxide and ammonia which must be excreted from the fish.

Fish blood, like that of humans, is made of cells circulating within a fluid (the plasma). The blood has a characteristic colour because most of the cells present are red (the red blood cells). These red cells contain a red-coloured molecule called haemoglobin. Haemoglobin collects oxygen diffusing into the blood plasma in the gills and then loses it when the blood passes through tissues that are consuming oxygen. The oxygen stored on haemoglobin substantially augments the limited amount of oxygen that can be carried in solution in the blood plasma.

Carbon dioxide and ammonia in blood plasma

From what we know about the fate of carbon dioxide and ammonia in fish blood we can predict that a number of processes may be important. Firstly, high levels of carbon dioxide are probably lethal to fish because it impairs the oxygen transport capacity of fish blood (Berka 1986). Secondly, carbon dioxide gas behaves as an acid when dissolved in water. It readily enters the blood plasma as non-toxic bicarbonate ions and makes the plasma more acidic. Accumulation of acid in the plasma can have detrimental effects on the fish.

Low pH also impairs the oxygen carrying function of haemoglobin. The red blood cells of trout defend their internal pH against a fall in blood plasma pH using ionic 'pumps' built into their cell envelopes. The acid (H^+) is removed from the cells, and one of the consequences of this is that 'salt' (especially sodium ion, Na^+) is loaded into the cell. The osmotic pressure rises within and water follows the salt, causing the red blood cells to swell. This response can be shown clinically by a rise in the volume of red cells in the blood (measured as the haematocrit) without at a rise in haemoglobin concentration in the blood.

The experiment

The physiological responses of seawater-adapted barramundi were studied during simulated live transport and transport under circumstances of elevated CO_2 or NH_3 (Table 1). The fish were stored in seawater in a double-lined plastic bag (about 3 litres of seawater per kg of fish) that was inflated with oxygen, tied and then placed in a polystyrene seafood box. Blood samples were removed from fish exposed to these treatments for 20 hours and compared to samples from control fish, (free in the tank) and fish confined in a box but with free-flowing seawater. The blood samples were analysed for haematocrit, haemoglobin concentration, and then the plasma was separated and analysed for pH and NH_3 concentration. Values of dissolved oxygen, pH, carbon dioxide and ammonia in the water of each treatment were measured at the beginning and the end of treatment (Table 1). The water temperature range was 20 to 22°C during the experiment.

Table 1. Mean water quality measurements at the start and final measures after approximately 20 hours simulated transport.

		Treatment[1]			
		Flow	Standard	$+NH_3$	$+CO_2$
DO	Initial	7.2	7.1	7.6	5.9
(mg/l)	Final	6.5	2.2	2.5	7.0
pH	Initial	7.8	7.8	7.7	5.6
	Final	7.6	5.5	5.4	5.5
Total CO_2	Initial	9.3	11.2	10.7	211.1
(mg/l)	Final	13.4	112.5	117.7	141.2
Total	Initial	<0.5	<0.5	12.6	<0.5
Ammonia (mg/l)	Final	<0.5	10.3	21.6	10.7

[1] Flow represents fish in a foam box with seawater flowing through. Standard refers to fish packed in water inside a double plastic bag placed in a foam box, $+NH_3$ is identical to Standard except that ammonia concentration is deliberately high to begin with, $+CO_2$ is identical to Standard except that carbon dioxide is deliberately high to begin with.

Simulated shipment

Blood plasma pH fell when barramundi were stored in closed conditions for 20 hours (Table 2). The acidosis was accompanied by a rise in the haematocrit of the blood. This occurred without a rise in blood haemoglobin concentration, which rules out recruitment of red cells from the spleen as an explanation. Therefore, it seems likely that the red cells have swollen while regulating their internal pH, as has been demonstrated in rainbow trout (Fievet et al 1988). Red-cell swelling in some fish is enhanced by circulating hormones so a study of the mechanisms of this response in barramundi may prove fruitful.

Table 2. Effect of water quality on blood and plasma physiology of the barramundi *Lates calcarifer* packed for 20 hours in a standard fish box, in boxes spiked with excessive ammonia and carbon dioxide, and compared to fish loose in a tank (Control) and held in a box with free flowing water (Flow)

	Treatment				
	Control	Flow	Standard	$+NH_3$	$+CO_2$
No. of fish	16	13	11	9	4
Hct %	31.1*c*	32.4*bc*	36.0*a*	38.1*a*	36.0*ab*
Hb g 100 ml^{-1}	10.06*a*	10.00*a*	10.00*a*	9.72*a*	8.88*a*
MCHC g 100 ml^{-1}	32.35*a*	31.04*a*	27.82*b*	25.57*c*	24.77*c*
pH	7.707*a*	7.742*a*	7.451*b*	7.177*c*	7.055*d*
Tot_{Amm} mg 100ml^{-1}	2.95*a*	3.29*ab*	3.49*bc*	3.85*c*	4.08*c*

Abbreviations: Hct is haematocrit. Hb is blood haemoglobin concentration, MCHC is mean cell haemoglobin concentration and Tot_{Amm} is total ammonia concentration. Parameters are given as means. For each row, means sharing the same letter are not significantly different at 5%.

Elevated carbon dioxide and ammonia

Blood plasma pH fell lower when either the carbon dioxide or ammonia concentrations were at a high level from the very start of the storage period (Table 2). Some fish in these extreme treatments died, though their results are not considered here with the surviving fish. The very low pH associated with the high CO_2 and high NH_3 levels did not lead to further swelling of the red cells. It is quite conceivable that these fish are having trouble delivering oxygen to their tissues.

So why does the plasma pH fall? The explanation differs depending upon the nature of the waste product involved. High external levels of CO_2 will obviously lower the plasma pH by raising the carbon dioxide tension and HCO_3^- level in the plasma (Perry 1982). To offset this, a means might be found to buffer the external water to maintain a higher pH. Incidentally, carbon dioxide also anaesthetises fish, which may explain the higher oxygen levels after this treatment (Table 1).

Something else has happened in the high ammonia treatment. The external pH and CO_2 level in the high ammonia treatment was comparable to that of the standard pack (Table 1), so these parameters cannot explain the lower pH in the blood plasma of the ammonia-treated fish. On the face of it, you expect that storing barramundi in a high total ammonia concentration will cause more ammonia to accumulate in their blood. However, the high ammonia treatment had no effect on the ammonia level in the blood plasma (Table 2). The barramundi were still excreting ammonia.

Two mechanisms may be responsible. Firstly, the difference in pH between the blood plasma and the water favours the diffusion of gaseous NH_3 from the fish by keeping the level of the gas in the water at a minimum. Secondly, the fish may be expending energy by actively exchanging outgoing ammonium ions (NH_4^+) at the gills for incoming sodium (Na^+) or hydrogen (H^+) ions (Walsh and Henry 1991). This last mechanism is a possible explanation why the plasma pH of fish in the high ammonia treatment was lower than that of fish in the standard pack. Further studies of waste excretion of barramundi under simulated transport conditions are required to explain why high ammonia levels by themselves can cause plasma acidosis.

Conclusions and practical implications

Confining barramundi in closed boxes with rising carbon dioxide and ammonia levels causes a fall in plasma pH and a compensatory swelling of the red blood cells that may help sustain respiration under the conditions of transport. Exposing fish to very high levels of carbon dioxide or ammonia decreases the plasma pH even more and killed some fish. Since the major problem for the fish seems to be low blood plasma pH, it seems to make sense to use a non-toxic buffer to keep the pH of the external medium from falling. However, the situation is not that straightforward because raising the pH could have consequences for the way ammonia is excreted from the fish.

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How to Live Longer and Suffer Less

Live Fish Transport Workshop

October, 1995

HOW TO LIVE LONGER AND SUFFER LESS
"If you're a Fish on the move"

B Goodrick & P Exley
International Food Institute of Queensland

A Jerrett & J Holland
New Zealand Crop & Food Research Institute

Live Seafood Transport Forum
Hobart Tasmania
October 1995

Introduction

One of the major barriers to the transport of live seafood over long distances is the stress or exhaustion that results from even the best of techniques used in the preparation, packaging and transportation of the live product to it's respective market. The use of sedatives or anaesthetics is one way of improving the survival, presumably by reducing stress/exhaustion.

The use of anaesthetics is not allowed in Australia and although a number of exporters may commonly add a sachet of a "magic"powder or so many millilitres of "special" liquid to the tank or box before shipment, this practice is most probably not legal.

New Zealand Crop and Food Research Institute have developed a food grade anaesthetic which is currently under trial in the aquaculture salmon industry in Australia and already in use in the salmon industry in New Zealand. This may also provide benefits for the shipment of live seafood.

General Background to Aqui-S

Aqui-S was developed as a tool that would enable researchers to investigate the impact of harvesting on fish muscle quality. It became apparent that a reliable, food-compatible, method of eliminating struggling during capture was required. Commercially available anaesthetics failed to meet the food safety criteria or elicited struggling and/or avoidance reactions.

Gaining specific information on the ingredients and exact mode of action of Aqui-S is not possible at this stage due to patent applications, intellectual property protection and non-disclosure agreements. Patent protection has been sought for the product which is the result of four years research funded by the New Zealand Government, Public Good Science Fund. While this may be very frustrating to the scientists seeking greater knowledge of how this product works the effectiveness of this technology cannot be denied and the application potential is indeed interesting.

In simple terms Aqui-S is a stress and exhaustion prevention tool that allows the flesh to stay fresher longer. This is reported to be made possible by reducing the large amounts of energy usually expended by the fish immediately before harvest.

In terms of post-harvest quality, reducing the stress means that the muscle cells have greater energy reserves after the oxygen supply stops, resulting in seafoods that retain their freshness characteristics longer. The natural colour and lustre of the flesh and skin is reported to be retained and the tensile strength of the flesh remains high.

The correct use of Aqui-S in harvesting processes eliminates struggling elicited by stress, a major source of bruising and other external and internal damage. By preserving intra-cellular energy reserves the process of rigor mortis may be extended by up to 24 hours, with less severe rigor contractions. This results in improved muscle tensile strength and hence improved texture of the flesh. The rigor delay provides seafood operators with greater opportunities for the marketing of pre-rigor fish with firmer flesh.

AQUI-S is a liquid that is added to the water in which the seafood is confined. It is used at concentrations of only 17 parts per million with fish, and is environmentally benign. Tolerable dosages and exposure times vary with species animal condition and application. Exposure times can be varied from 5 minutes to 24 hours.

It contains biodegradable compounds that occur naturally in several plants and are commonly used in foods such as ice cream and chewing gum.

The compounds that make up Aqui-S are approved for use by the United States Food and Drug Administration under GRAS (generally regarded as safe) certification, and the product has been licensed by the New Zealand Animal Remedies Board.

While post-harvest quality benefits have received the greatest focus to date, unreported work has indicated a strong potential for this product in the facilitation of live transport. It is already being used by staff in aquaculture farms so fish can be handled for grading or transport purposes or humanely killed for processing. The benefits are said to be derived from the fact that the animals treated with AQUI-S are not physically damaged or stressed in any way. With correct handling procedures, normal feeding patterns are reported to resume within as little as 1.5 hours after treatment.

One New Zealand salmon producer (Regal Salmon) have reported that grading is a lot more effective as they can return undersized fish. It provides them with a more humane harvesting method. They also stated that the flesh quality of the salmon is much improved and preferred by buyers and that a huge increase in the yield of quality fillets from their smokehouse has been achieved. They said that "the flesh had fewer blemishes and blood spots which meant they benefit through the production of more premium grade fish."

THE POTENTIAL FOR USE IN LIVE TRANSPORT

An application for registration of Aqui-S as an anaesthetic treatment in the production of aquacultured fish has been submitted to the Australian National Registration Authority. This is likely to take some time to process. In the interim, Aqui-S is being trialed to gain more information on the changes that will be required to the harvesting and processing operations where Aqui-S is used as a tool to assist culture and harvesting practices.

Studies on flesh and environmental residues, application techniques and quantification of the benefits of use in aquaculture are near completion. A number of research publications by (Jerrett & Holland) of the Crop & Food Research Institute in New Zealand, are due for release in the near future.

While unreported trials on the use of Aqui-S for live shipment of seafood, including several crustacean and mollusc species, have shown promising results, further species-specific trials are required over the next year or so.

The International Food Institute of Queensland, Seafood Group will be undertaking work in conjunction with the New Zealand Crop & Food Research Institute. This research may consider a number of alternative factors as the mode of application will be somewhat different to its application in the aquiculture industry.

While we are very optimistic about the suitability of Aqui-S in live transport applications, a number of other issues must be considered when Aqui-S is applied in this way. Apart from the application techniques, developmental work will be required to determine how long the treatment may remain effective and at what dosage level. This work will generally be undertaken on an individual species basis.

For further information, please contact Bruce Goodrick or Paul Exley of the International Food Institute of Queensland, 19 Hercules St Hamilton Qld 4007 Ph 07 32688579 Fax 07 32687532 or to Alistair Jerrett or Jan Holland of the Crop & Food Research Institute P O Box 5114, Nelson New Zealand. Ph 64-3-5480362 Fax 64-3-5469666.

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New Report

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LIVE SEAFOOD HANDLING - STRATEGIES FOR DEVELOPMENT

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Australia's live seafood trade is valued at over $250 million, and is a major reason behind the growth in seafood exports in recent years. While the industry enjoys considerable success, there is still the need to solve a variety of highly complex problems associated with the capture, holding, and transport of a range of species.

The National Seafood Centre recently held a live seafood handling forum to discuss many of these issues. The forum was preceded by a survey of commercial live seafood operators and scientists involved in research activities. The report contains the results of the survey (as presented at the forum), papers presented by researchers, and summaries of workshop sessions held at the forum.

The proceedings of the forum are now available in a comprehensive report of 136 pages. The report captures information discussed during the forum, and documents the major concerns facing commercial live seafood operators. The forum concluded with the formation of a Steering Committee which will assist in the establishment of an on-going reference group which will offer broad comment on issues impacting on the live seafood sector.

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Please send me __ copies of the report ***Live Seafood Handling - Strategies for Development***.
The cost is $35 per copy (includes postage within Australia).

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