FISHERIES RESEARCH SEMINAR

ESPERANCE

APRIL 16, 1980

- SUMMARY OF ADDRESSES -

DEPARTMENT OF FISHERIES AND WILDLIFE
PERTH

FISHERIES MANAGEMENT

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FISHERIES MANAGEMENT D.A. Hancock

Attached is a paper "Biological Considerations in Fisheries Management" which sets out the arrangements for fisheries research in Western Australia by the Department of Fisheries and Wildlife. The research is aimed at producing results, conclusions and recommendations relevant to fishery management.

The paper sets out the general principles of fishery management. These will be referred to in discussing the current status of some of the more important Western Australian fisheries, examples of which are given below.

Methods of control (for categories of information required refer to page 8 on)

Restricted licences

Western rock lobster	)	State fisheries
Prawn	)	
Abalone	)	
Australian salmon	-	State fishery with interstate migrations
200 mile zone	-	Commonwealth/State administration

Restrictions on fishing effort (efficiency)

Western rock lobster - size of boats, number of pots, pot design, closed season.
Prawn - number and size of trawls.

Restrictions on catch (quotas)

Daily	-	amateur fishermen
	-	abalone in metropolitan area
Annual	-	200 mile zone

Closed season

Western rock lobster, marron.

Closed areas

Western rock lobsters	-	zone restrictions
Prawns	-	nursery areas
Abalone	-	zone restrictions

Legal minimum size

Western rock lobsters, marron, scale fish, abalone.

Gear restrictions

Western rock lobster (number of eyes, escape gaps, in pots).
Prawn - headrope length, trawl meshes.
Scallops - trawl mesh.

Biological controls - control of berried females.

Western rock lobster, crabs, marron.

Legal maximum size

Shark - Health Department controls.

State of exploitation

Fully or over-exploited

Western rock lobster, Australian salmon, Abalone.

Moderately to fully exploited

Prawn, Australian herring, Southern bluefin tuna, most scale fish, crabs (locally).

Under to moderately exploited

Offshore trawl stocks, Squid, Tuna species, some scale fish.

ANNUAL LANDINGS OF SHELLFISH AND FISH IN WESTERN AUSTRALIA DURING TEN YEARS *

TONNES

	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
Shellfish	10,100	10,834	12,881	11,275	11,051	10,306	12,714	14,013	13,518	16,260
Rock lobster	8,195	6,970	8,119	8,334	7,261	6,767	8,306	8,757	9,297	10,773
Prawns	1,738	2,496	2,809	2,574	3,059	3,101	3,898	4,432	3,047	3,940
Scallops	121	1,301	1,771	49	283	64	152	248	510	876
Abalone	-	17	121	245	326	245	256	355	300	248
Crabs	28	31	49	53	100	110	70	124	161	127
Fish	5,648	5,724	5,609	6,067	6,925	6,983	7,222	7,778	7,559	10,897
Tuna - Southern bluefin	325	510	558	604	518	429	696	518	656	1,924
Pilchard	111	140	200	140	504	377	667	986	632	1,105
Shark	347	375	470	506	639	762	554	446	554	903
Herring - Aust.	620	615	734	910	1,208	952	794	639	503	811
Salmon - Aust.	2,535	2,142	1,649	1,759	1,491	1,488	1,619	1,128	1,173	750
Mullet - Sea	313	355	314	456	488	599	600	684	468	565
Mackerel - Scaly	47	27	26	30	-	-	-	107	419	524
Mackerel - Spanish	75	60	44	30	93	85	69	110	66	99
Snapper	142	207	192	187	312	389	424	464	556	511
Mullet - yelloweye	262	347	306	255	275	253	401	692	638	449
Herring - Perth	224	83	167	236	187	248	151	193	146	311
Whiting	174	253	226	240	239	259	261	248	309	263

Source: Fisheries - Western Australia (A.B.S.) 21.3.1980.

* Based on the most important fish species taken in 1977/78.

VALUE ($'000)

	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
Shellfish	19,644.5	15,043.5	21,363.5	25,344.5	22,403.2	22,600.7	24,934.6	40,957.2	57,466.8	69,176.7
Rock lobster	17,801.2	12,114.9	18,040.0	22,183.9	17,923.4	17,855.0	19,929.3	29,492.7	44,141.3	50,880.3
Prawns	1,802.1	2,696.6	2,986.3	2,969.5	4,105.7	4,277.0	4,563.7	10,960.3	12,333.5	17,055.9
Scallops	21.3	200.4	214.1	6.6	48.7	7.2	16.7	41.5	75.4	235.4
Abalone	-	7.5	69.7	141.7	254.1	390.9	327.1	257.0	662.3	626.1
Crabs	9.9	17.8	48.1	35.2	61.5	59.4	64.6	160.1	149.7	134.3
Fish	922.3	1,018.8	1,199.7	1,436.5	1,778.3	2,093.0	2,549.0	3,632.8	4,291.1	6,725.0
Tuna-Southern bluefin	35.9	78.5	86.0	119.6	114.1	107.2	195.0	149.9	269.1	866.6
Pilchard	22.6	27.8	57.0	49.4	144.4	120.7	240.1	216.8	195.9	597.0
Shark	92.0	104.0	150.0	168.1	230.5	234.9	279.1	242.8	380.7	511.7
Herring-Aust.	47.3	47.4	64.6	100.1	159.8	123.7	111.1	89.4	105.7	275.7
Salmon - Aust.	204.7	188.5	174.2	216.7	151.4	156.6	223.7	353.0	308.6	269.1
Mullet-Sea	80.9	78.2	89.9	140.4	139.9	185.7	216.0	328.0	299.7	316.3
Mackerel-Scaly	5.9	3.6	8.2	5.2	-	-	-	32.2	129.9	188.8
Mackerel - Spanish	28.6	21.0	18.2	12.0	44.2	44.0	46.6	111.2	71.3	72.7
Snapper	53.2	61.9	67.7	59.3	121.0	171.3	223.9	320.8	436.2	477.8
Mullet - yelloweye	51.0	61.2	60.6	61.6	60.5	58.1	120.3	242.1	306.0	255.5
Herring - Perth	37.0	12.8	36.7	51.9	41.3	62.1	51.3	65.7	67.0	142.9
Whiting	79.5	100.1	103.6	160.7	112.5	161.4	158.8	204.5	338.1	387.6

Source: Fisheries - Western Australia (A.B.S.) 21.3.1980.

BIOLOGICAL CONSIDERATIONS IN FISHERIES MANAGEMENT

D.A. Hancock

I INTRODUCTION TO W.A. BIOLOGICAL PROGRAMMES

(i) ORGANISATION OF RESEARCH IN W.A.

The Western Fisheries Research Committee was appointed in 1961 by the W.A. Minister for Fisheries and Fauna.

The terms of reference of the Committee are:

"In respect of the fish resources of the waters off Western Australia,

(a) to consider

   (i) the research programme and other measures which should be implemented in order to achieve optimum exploitation of the resources; and

   (ii) practical arrangements for the co-operation of such research programmes and other measures; and

(b) to formulate advice on these matters and, in its discretion and according to the nature of the matter considered, to communicate its advice to persons and/or institutions associated with the committee."

Committee membership includes the W.A. Director of Fisheries and Wildlife (Chairman), the Chief of C.S.I.R.O., Division of Fisheries and Oceanography, Professor A.R. Main (University of Western Australia), 1st Assistant Secretary, Department of Primary Industry, Director of Fisheries, South Australia, and the Research Co-ordinator of Western Fisheries Research Committee.

The Committee meets annually to discuss and co-ordinate programmes by personnel concerned with fisheries and associated research in Western Australia. This ensures a high degree of co-operation and integration of studies between the State Department, C.S.I.R.O., W.A. Museum, the Universities and Technical Colleges, and other State and Commonwealth Departments. Traditionally programmes undertaken in W.A. have related to the early life history of the western rock lobster with supporting oceanography, and the biology of the Australian salmon and herring.

(ii) CURRENT PROGRAMMES OF W.A. DEPARTMENT OF FISHERIES AND WILDLIFE

Western rock lobster -	
Biology and management of the exploited phase and fishery monitoring	Mr. R. Brown
Study of fishery induced mortality of rock lobsters	Mr. R. Brown
The amateur rock lobster fishery (now completed)	
Prawn biology and management	Mr. J. Penn
Scale fish research -	
Australian salmon and herring	Dr. M. Walker
Shark	Mr. D. Heald
Geographe Bay resources	Dr. M. Walker
Trawl fisheries in the 200 mile zone	Dr. M. Walker
Estuarine research and management studies	Mr. R. Lenanton
Scallop biology	Mr. D. Heald
Abalone biology and management	Mr. J. Penn
Freshwater studies -	Dr. N. Morrissy
Pemberton fish hatchery	
Amateur marron and trout fishery	
Culture of marron	
Pollution and heavy metal research	Mr. J. Edmonds Mr. K. Francesconi
Fisheries orientated environmental problems	Dr. H. Jones
Data collection and analysis	Mr. N. Hall Mr. N. Caputi
Fisheries exploration and development	Mr. J. Robins
Squid and tuna in the 200 mile zone	
Feasibility of an octopus fishery	
Fisheries economics	Mr. P. Rogers
Chief Research Officer and Research Co-ordinator	Dr. D. Hancock

Special interdisciplinary studies

Blackwood Estuary study (completed)
Cockburn Sound study (completed)
Peel-Harvey Inlet study
Mullaloo marina study (completed)
Moore River port feasibility study
Laporte effluent study
Swan River fish and benthos studies

II THE ROLE OF THE FISHERY BIOLOGIST

The fishery biologist by his researches endeavours to find ways of improving the yield and quality of man's harvest from the sea by:

(1) Making an assessment of the distribution and abundance of stocks of commercial and potentially commercial species and conducting a scientific programme which will lead to the introduction of methods or legislation for their rational exploitation.

(2) Introducing, developing and improving techniques of harvesting and cultivation and, where appropriate, artificial rearing and culture.

(3) Understanding and developing methods for dealing with potentially harmful influences in the environment, for example those resulting from domestic and chemical effluents, oil pollution, mineral extraction, poisonous organisms etc., which may affect the species, or render their consumption harmful to man.

III FISHERIES MANAGEMENT STUDIES

The main focus of research programmes in W.A. has been directed towards management of the fisheries resource. The fact that the major fisheries are managed by licence limitation places a special responsibility on the collection and analysis of information from the fishery.

Limited entry fisheries have been established for the western rock lobster (1963), prawn (1963), Australian salmon (1971) and abalone (1973). For these the state of exploitation of the fishery is kept under constant review in order to maintain the optimum number of licences.

Licences in the prawn fishery, which is still in an expanding phase, are subject to triennial review. The number of licences in the rock lobster fishery has not been increased over many years.

Management of the developing fisheries of the Australian 200 mile fishing zone will also involve limitation of licences and restrictions on quotas.

Both the concept of licence limitation and management by regulation require the collection of routine fisheries and biological data on which to base effective regulations.

Sources of such data include:

- Commonwealth monthly returns
- Processors' returns
- Research log books
- Monitoring commercial vessels
- Research vessel investigations
- Aquarium studies
- Exchange of information with the fishing industry
- Economic studies by Department of Primary Industry

IV THE THEORY OF FISHERIES EXPLOITATION

Although interest in marine science and oceanography dates back to the seventeenth century, fisheries biology as we know it today had its origins in Europe in the 1890's (Graham, 1956). It is perhaps surprising to record that Petersen's "button" tag, which is still used today, was first developed in 1894, when Petersen (1894) first propounded a theory of overfishing in terms of growth, mortality and rate of fishing. (By chance, management measures for rock lobster were first introduced into Western Australia in the same year). The years have seen a gradual development of Petersen's theme, and since World War II, various national and international centres for fisheries science have become established.

FISHERIES MANAGEMENT

Today, sophisticated theories of fisheries management can be used to considerable advantage where there is adequate biological and statistical information to formulate regulations in a precise mathematical manner using some form of model (see below) from which a reasoned attempt can be made to forecast the outcome. However, all to often, only limited information is available and management may still be based on single biological observations; for example, a legal minimum size equivalent to the average size at first maturity, on the somewhat emotional concept that an organism should not be caught until it has had a chance to spawn, or a prohibition on the landing of females because they produce the young. Such decisions, made in isolation, without the additional knowledge required for a proper evaluation may be quite erroneous, and possibly dangerous.

Either way, practical and economic factors, as well as biological considerations, will almost certainly influence the choice of management regulations. For example, the 3 inch minimum carapace length of the Western Australian rock lobster historically reflects both an acceptable market size for the industry, as well as the length at first maturity. The Rock Lobster Industry Advisory Committee of Western Australia continues to demonstrate the way in which responsible members of the fishing industry can exert a practical influence on the deliberations of administrators and biologists.

Even when a regulation has its origin primarily in some socio/economic factor, and regulations of this type have been reviewed by Kesteven and Williams (1965), biological information will still be essential to the understanding of its effect on the fishery . For example, where a closed season is requested by industry to prohibit catches of poor quality or flavour which could endanger markets, the effect of such a measure on total catch will need to be understood.

The requirements for information needed to formulate and predict the consequences of regulations will be presented in Section VI (below).

FISHING AND OVERFISHING

First consider a previously unfished stock which has just been located by fishermen or as a result of exploratory fishing by a research organisation. The initial decision on whether this stock will produce economic yields will need to be based on the available numbers, i.e. density and distribution, on the catch rates and on the size and quality of the individuals caught. For mobile fish species or pot-caught animals it is usually very difficult to make a direct assessment of the size of the stock without first subjecting it to commercial fishing, although it has been done quite successfully for a number of sedentary species including scallops. Fortunately, new accoustic methods such as frequency modulated sonar are now capable of detecting individual fish and are becoming increasingly used for the direct estimation of numbers and size of fish in a stock.

As soon as fishing commences a number of consequences will occur:-

(1) As the intensity of fishing increases, although the total catch from the fishery may continue to rise, reduction of the stock will lead to a lowered catch rate (Fig. la); the catch rate is referred to as the catch per unit of effort, where the unit of effort is defined as, for example, one hour's trawling, one pot-day etc.

(2) As the amount of fishing effort increases still further the total catch will reach a maximum, referred to as the "maximum sustainable yield" (Gulland, 1968) and then flatten out or tend to fall (Fig. lb). Here it must be recognised that there may be more than one way of interpreting fishing data (Fig. 1), with uncertainty about which is correct because information at the higher levels of fishing effort has seldom been available. Hence the magnitude of decline of total catch is difficult to forecast without a great deal of additional information, but, even where the total catch remains virtually level, as the effort increases, the catch per boat will become less and will probably have already become uneconomic (Fig. lc).

"Conservation", has been defined by the International Conference on the Law of the Sea, as the maintenance of maximum sustainable yield,; this involves decisions on whether to use a resource now or to put it aside for later use, remembering that, as a renewable resource, fish which are not properly utilised will be wasted.

The term "overfishing" generally implies that there has been too severe a pressure on the stock, resulting in seriously diminished returns for an equal amount of fishing effort. Wise management seeks to arrest this decline at a level which is economic for the individual fishing unit and maximal in terms of yield from the whole fishery. The ability of stocks to recover after they have been reduced below a certain level varies greatly from species to species. Even within the whale group, for example, different species have reacted differently to over exploitation.

A good illustration was given by the north Pacific Halibut fishery (Fig. 2, from Royce, 1965) which shows how by successful management, both the total catch as well as the catch per unit of effort were increased, as a result of reducing the total fishing effort.

From the graphs presented it should be quite clear why it is so important for fishery biologists to have reliable information from industry on both catch and fishing effort. A knowledge of catch is only part of the story; catch per unit of effort tells what the stock is doing.

THE SIMPLE MODEL

The relatively straightforward approach in the previous section can only be used in a fishery where the fishing effort has changed naturally over a number of years or where the level of fishing effort can be manipulated sufficiently to show trends in catch. Often, however, fishing effort remains relatively steady. In this case, and where the effects on the maximum sustainable yield of introducing or changing regulations need to be calculated, a more detailed study has to be undertaken. The name given to the combination of the various factors which affect a stock, its numbers and its weight, is referred to as a fishery model. The model which incorporates sound quantitative biological information has emerged as one of the most powerful tools for fisheries management - but the model based on too many unprovable assumptions could have disastrous consequences.

The model in its simplest form shows the unfished stock in a state of balance with the physical and biological factors, food, predators etc. which compose the environment.

```
Recruits -----→ | Unfished |
                |          | -----→ Death from natural causes
  Growth -----→ |  Stock   |
```

The unfished stock is added to in numbers by entries of young (recruits) and in weight by growth and these are balanced only by losses due to natural causes.

The whole system may be intensely variable from causes which stem from the biology of the species itself or from the factors influencing its environment. This variability of some stocks can lead to great difficulties in management, and for determining the level of maximum sustainable yield.

In simple terms, at any level of stock there is a unique natural rate of increase. If the catch taken can be made to equal this rate of increase the stock will be maintained at that level. The model for a fished population now becomes

```
Recruitment ---→ | Fished | -----→ Death from natural cause
     Growth -----→ | Stock  | -----→ Yield (weight)
```

Here the added mortality due to fishing results in a decrease in the abundance of the fished part of the stock and a shift in its age composition towards the younger fish - eventually, a new equilibrium is established in which the catch is balanced by the compensatory changes which have occurred in one or more of the vital rates of natural mortality, growth and recruitment.

The fact that changes in one factor may affect one or more of the others, e.g. if recruitment is high, lowered growth and greater mortality may accompany the larger numbers, indicates that this simple additive model rarely works in practice. The result has been the development of comprehensive mathematical models which fully describe these complicated interactions. The model of Beverton and Holt (1957) is an example of several now employed widely for fish:-

$$Y = FRW\, e^{-M(t_c - t_r)} \sum_{n=0}^{3} \frac{U_n\, e^{-nK(t_c - t_o)}}{F + M + nK}$$

which is presented here only to (a) show how complicated it is, (b) demonstrate how it includes reference to the main processes of recruitment (R), growth (K), natural mortality (M) and fishing mortality (F), (c) show why fishery biologists require the use of mathematics and computers.

In the following sections have been listed the information which is relevant to fisheries management (Section V) and the specific information needed for the choice of effective regulations (Section VI).

V BIOLOGICAL, QUANTITATIVE AND FISHERY INFORMATION RELEVANT TO MANAGEMENT

1. BIOLOGICAL

(i) Correct identification of the species

(ii) Sexual behaviour

(iii) Spawning season and area

(iv) Fecundity

(v) Larval behaviour

(vi) Method of growth - continuous, moulting, etc.

(vii) Longevity

(viii) Mobility

(ix) Diurnal behaviour

(x) Distribution of nursery grounds

2. QUANTITATIVE

(i) Area occupied by unit stock

(ii) Density

(iii) Abundance

(iv) Size/age/sex composition of the stock

(v) Growth rates

(vi) Mortality - due to natural causes
- due to fishing

(vii) Size/age at first maturity

(viii) Pattern of recruitment

(ix) Migrations

(x) Catchability

(xi) Density dependence of growth and survival

(xii) Relationship between stock and recruitment

(xiii) Seasonal changes in quality

3. CHARACTERISTICS OF THE FISHERY

(i) Type and size of boat and its efficiency

(ii) Fishing technique and its efficiency

(iii) Single or mixed species

(iv) Single or mixed gear

(v) Fishing season - biological or controlled

(vi) Method of management - unrestricted
- regulated
- limited entry
- limited catch
- aquaculture

(vii) State of development - new fishery
- established but still developin
- long established, fully exploit
- long established, over exploite

(viii) Economics of the fishery

VI INFORMATION REQUIRED FOR SELECTED REGULATIONS

(i) LIMITATION OF LICENCES - i.e. conservation by limiting effort.

Annual catches over a sequence of years
Annual effective fishing effort
Maximum sustainable yield
Economics of the fishery

(ii) CATCH QUOTAS - i.e. conservation by limiting catches.

Annual and seasonal catches
Number of fishing units
Maximum sustainable yield

(iii) CLOSED SEASON - to protect spawning stock or young, or to maintain market quality, or to reduce overall effective effort.

Spawning season
Growth rates
Longevity
Rate of exploitation
Seasonal changes in quality

(iv) CLOSED AREAS - to protect spawning stock or nursery areas or to reduce overall effort.

Migrations
Spawning season and distribution of spawners
Distribution of nursery areas
Growth and mortality rates of juveniles

(v) LEGAL MINIMUM SIZE

Growth rates
Size/age at first maturity
Mortality rates
Size/age composition of the stock

(vi) GEAR RESTRICTIONS - mesh regulations, escape gaps, to protect juveniles, and/or spawners.

Size composition of the stock
Size composition of the catch with different gears
Required market size
Growth and mortality rates

(vii) BIOLOGICAL CONTROLS - e.g. prohibition on berried females.
Fecundity
Stock/recruitment relationship
Immediate catch loss due to controls

(viii) LEGAL MAXIMUM SIZE - to control the sale of larger fish containing metals.

VII COLLECTION OF BIOLOGICAL INFORMATION

The requirements for biological information are given for a few selected situations as follows:-

(i) MINIMUM SIZE

In selecting a minimum size it is implicit that if a fisherman is required to throw fish back his eventual yield will be if not greater, no less, i.e. if fish are returned or allowed to escape, e.g. through large meshes, escape gaps in pots etc., the loss in numbers due to predation or other natural causes will be more than balanced by the increase in weight from growth to the time of recapture. This biological principle will apply save where there is a compelling administrative or practical reason, e.g. acceptable market size. The eventual yield will depend on the measure and relationship of deaths from natural causes (M) and fishing (F). A factor taken into consideration may be the size at which spawning first occurs in situations where it is important to conserve breeding stock.

Biological information required will include:-

a) Size, age and sex composition of individuals in the catch

b) Duration of spawning season

c) Age/size at first maturity

d) Minimum marketable size

e) Seasonal changes in quality

f) Growth rates

g) A measure of deaths from natural causes

h) A measure of the rate of exploitation

i) A knowledge of the migratory pattern

Items a - f can be measured by direct sampling of the commercial catch throughout the season; f, h and i require tagging experiments; g is difficult to measure directly except with some sedentary species.

Example: European crab fishery.

(ii) CLOSED AREA, E.G. NURSERY AREA

The extent of the nursery area should be delimited by taking samples with gear capable of taking small individuals, and by measuring individuals in representative samples. Repeating this at intervals will give the period of the year during which the area acts as a nursery, and, providing migration has not occurred, the growth rates of the juveniles. Measurements throughout the area will give information on migration routes which can be confirmed by tagging. Individual tags can give more reliable information on growth. The question of if and when a nursery area can be opened to fishing should in biological terms, reflect a size at which mortality is more than compensated by growth. An additional criterion, which sometimes takes precedence over the biological, is the minimum size for market acceptance or the season of acceptable quality.

Biological information required will include:-

Items a, d, e, f, g, h, i.

Example: Shark Bay prawn fishery.

(iii) A FULLY EXPLOITED FISHERY - e.g. western rock lobster.

There has been no increase in total catch from this fishery for many years though the effective fishing effort has continued to increase. Current research is aimed at:-

a) Detailed analysis of the data needed for yield assessment/maximum sustainable yield.

b) Keeping the stock/recruitment relationship under constant review to avoid biological deterioration of the stock.

c) Examination of the basis for all existing regulations and their interrelationships in order to ensure maximum effectiveness.

d) Examining ways for reducing fishing effort to encourage greater economic stability and to ensure biological stability of the stock.

e) To quantify all other sources of exploitation, e.g. the amateur fishery for which precise data have so far not been available.

f) To look for causes of predation and wastage due to fishing practice with a view to conserving the stocks by predator control and improved fishing technology.

Biological information required:- virtually all items listed in Sections V and VI.

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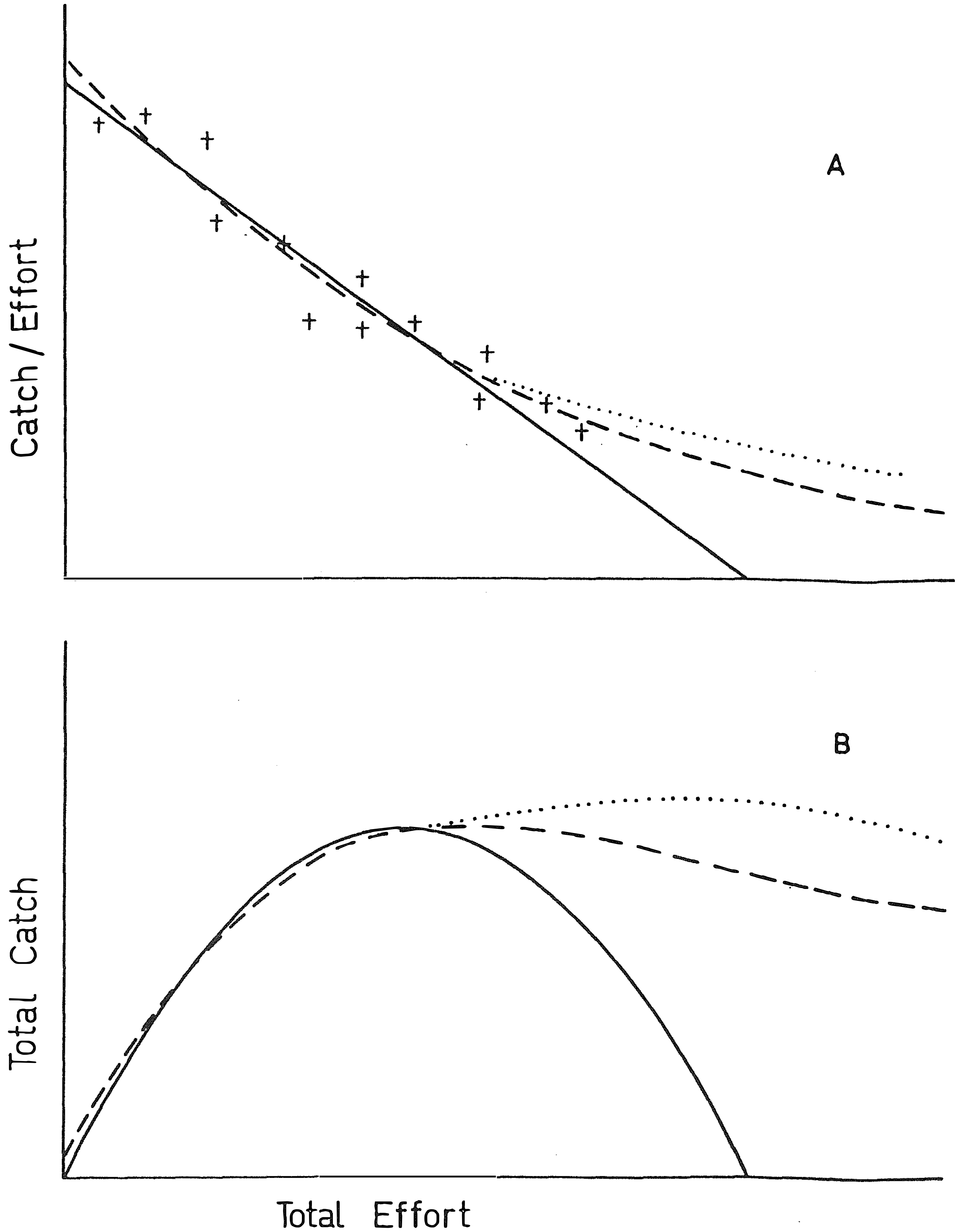

FIG.1.

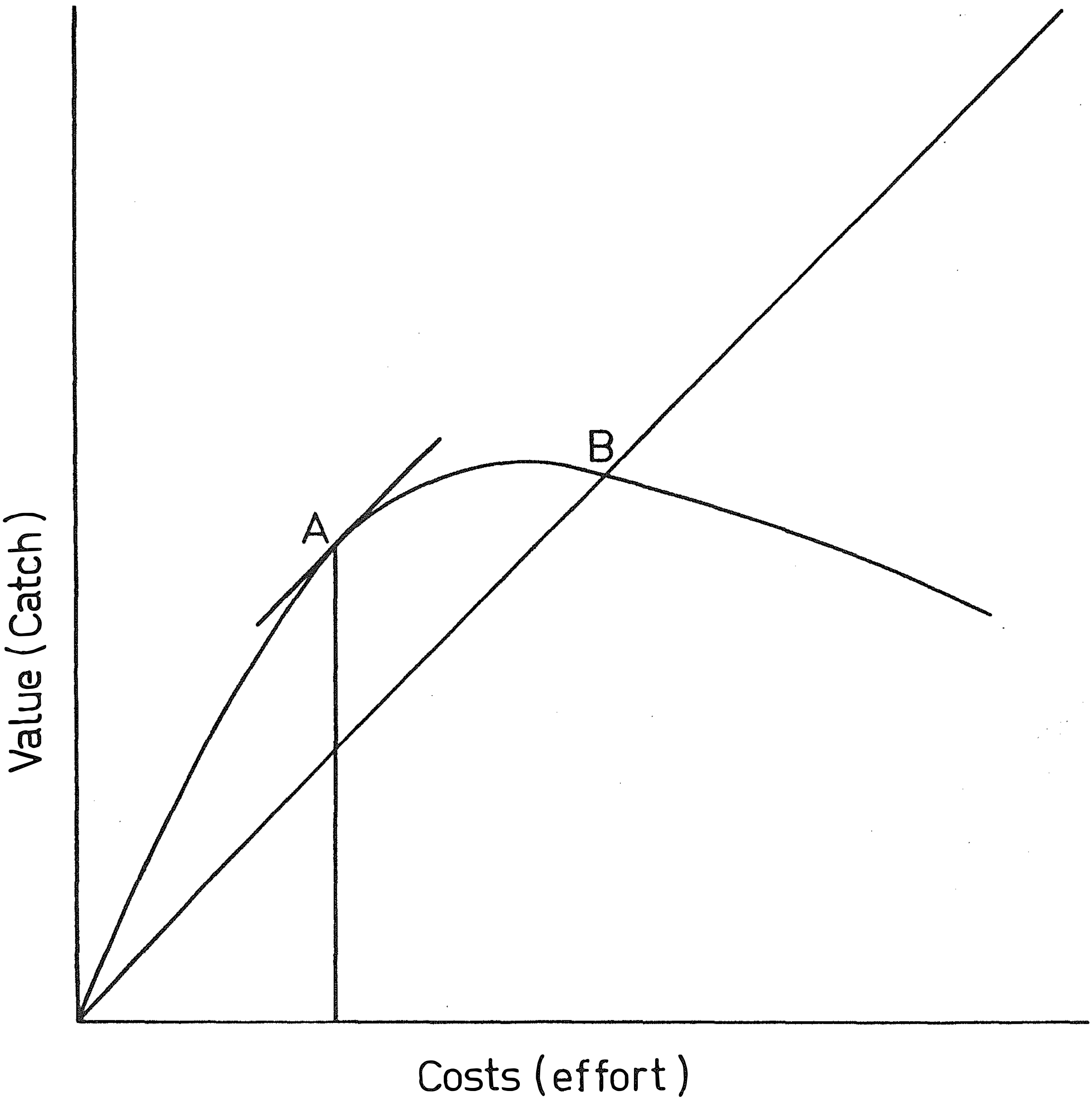

FIG. 1c.

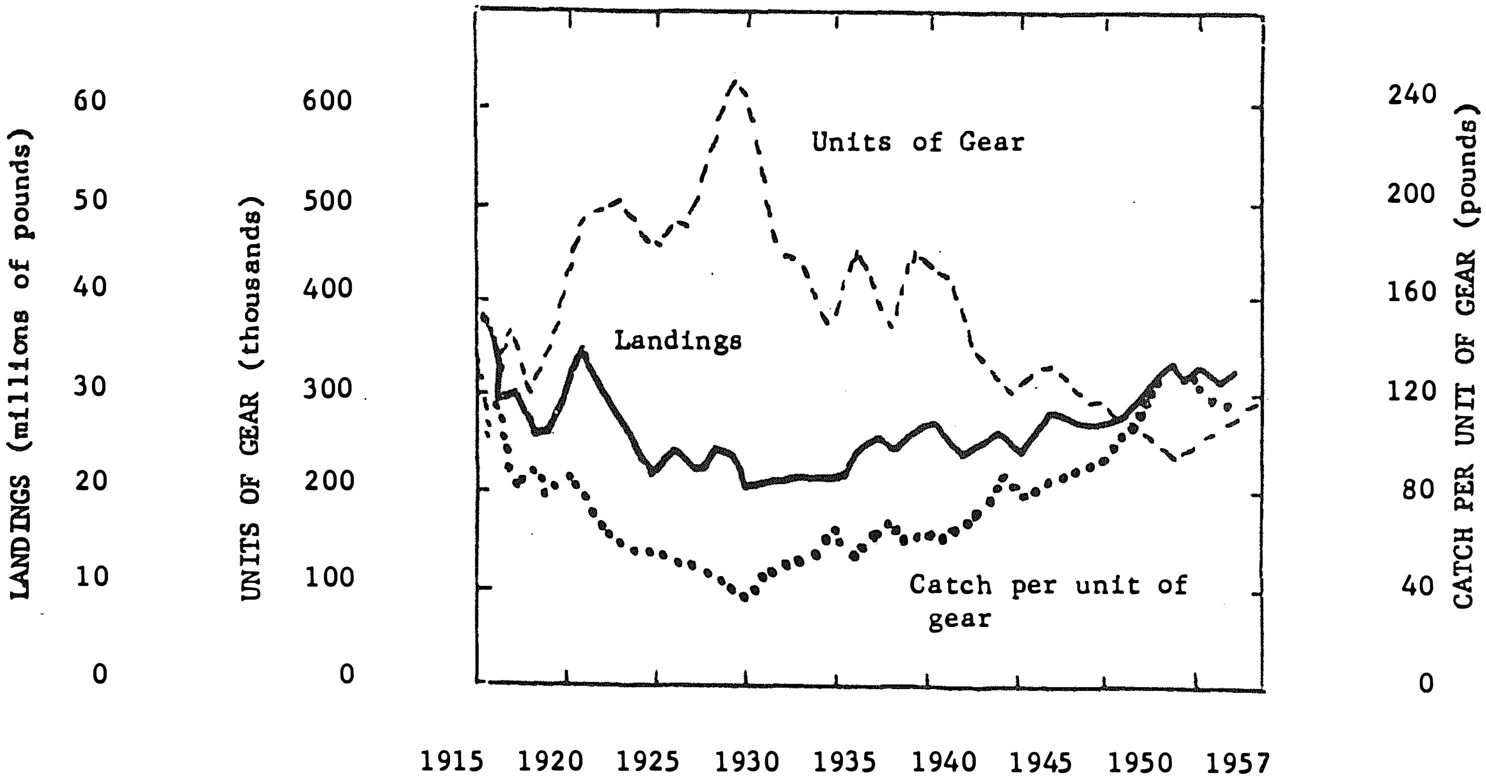

Figure 2. Basic statistical data on the north Pacific halibut fishery (from figure 8 of Royce, 1965).

THE ABALONE FISHERY

Mr.J. Penn.

THE WESTERN AUSTRALIAN ABALONE FISHERY

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INTRODUCTION

Abalone are herbivorous marine gastropods which inhabit coastal reefs in temperate and tropical seas. The life cycle of a typical abalone starts when the female spawns large numbers of eggs, which after fertilization drift freely with the water currents dispersing the developing larvae over considerable distances. Once the shell begins to form the larvae settle on the shallow coastal reefs where they grow to maturity, usually a period of 3 to 5 years depending on the particular species. The food of abalone is predominantly marine algae which is obtained by either grazing the algae on the reef (juveniles especially) or by actually catching drifting algae which has broken free of the reef. Because of this method of feeding, food supply can vary from location to location, leading to considerable variations in growth rate and hence recovery times for exploited stocks.

HISTORY

In Western Australian waters three species of abalone (Greenlip - *Haliotis laevigata*, Brownlip *H. conicopora* and Roe's abalone *H. roei*) are sufficiently abundant to be harvested commercially. The W.A. fishery for abalone began in 1964 and continued at a low level, with part-time divers until 1969. An influx of divers from the Eastern States in 1970, in response to rumours of a bonanza in W.A., resulted in the accessible parts of the coastline being rapidly explored. This exploration resulted in the discovery of limited stocks which were then in immediate danger of over-exploitation. For this reason, the number of divers was limited to 36 in 1971. This number has been subsequently reduced to 26, i.e. 6 divers in Zone 1 (SA/WA border to Shoal Cape), 8 divers in Zone 2 (Shoal Cape to Cape Naturaliste) and 12 divers in Zone 3 (Cape Leeuwin to Carnarvon). The catch from the fishery since 1964 is given in Table 1 and the catch/diver for each zone from 1976 to 1978 is given in Table 2.

MANAGEMENT

The management regime for the W.A. abalone stock has basically involved the use of licence limitation to control total effort and size limits to protect the breeding stock and recruitment. In addition, closed seasons in the form of rolling closures, to maximise the catch rates and reduce operating costs have also been instituted in some areas.

Because of the special problems involved in operating a fishery in a highly populated area, additional regulations in the form of limits on daily catch and fishing time have had to be introduced for the Zone 3 metropolitan reefs. Almost all of these management measures have resulted from the combined inititives of the abalone divers and the Department of Fisheries and Wildlife.

As the Western Australian stocks have become better known, the abalone divers have generally become more efficient, with the result that the catch from known areas is now taken in less time than in the early years of the fishery. This has resulted in more time for exploratory fishing, which has now covered virtually all parts of the W.A. coastline. A recent survey of the head of the Great Australian Bight and the fishing of the Kalbarri Cliffs are direct results of this increase in efficiency. Now that the available stocks are being fully exploited, long term improvements in income from abalone fishing will only come from rationalising effort to reduce the costs of production. Some of the methods which may assist this process will be discussed during the seminar.

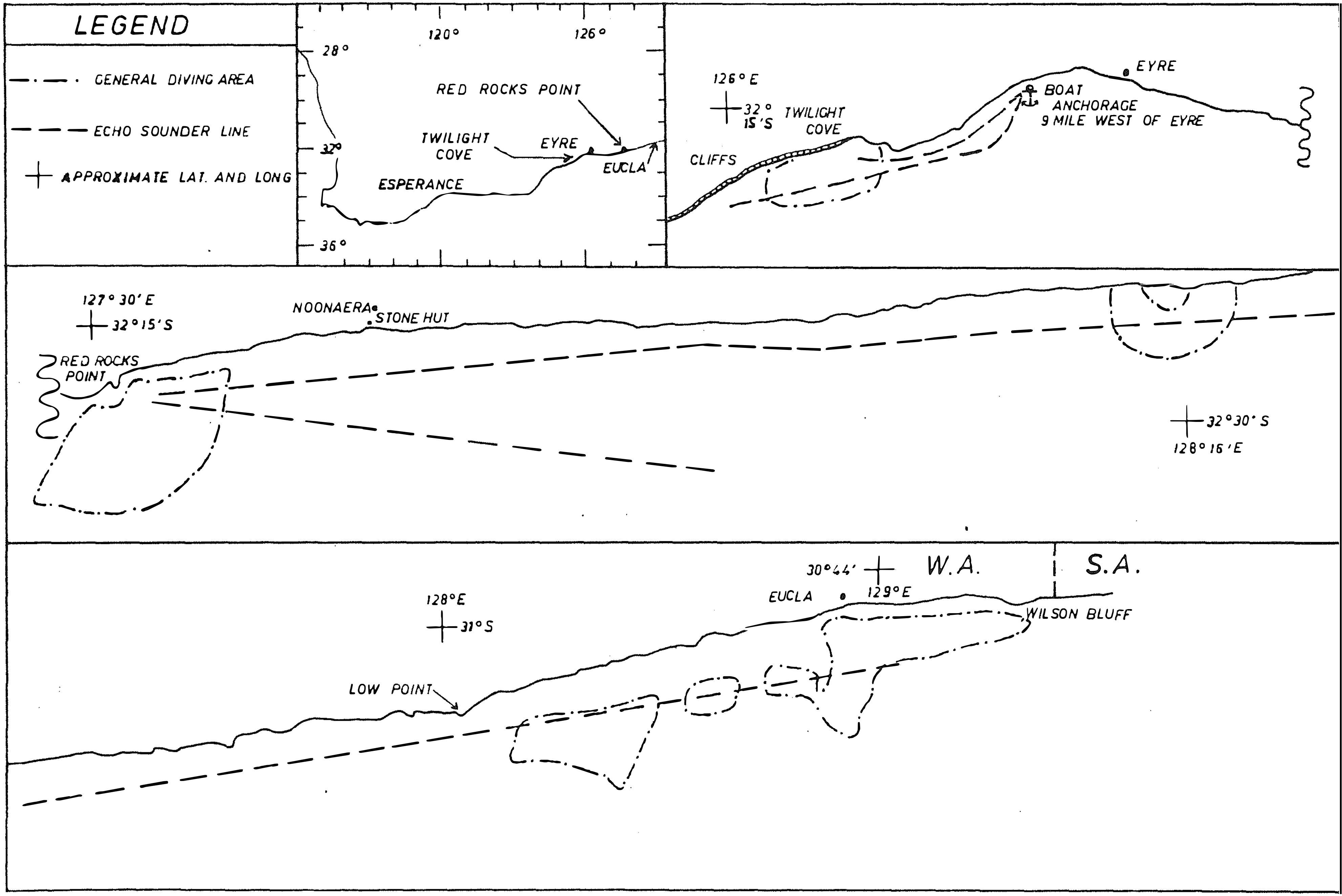
TABLE 1: Western Australian abalone catches (tonnes live weight) from 1964 to 1978.

Year	Roe's Abalone	Greenlip and Brownlip Abalone
64/65	Est. 4	-
65/66	6	-
66/67	15	-
67/68	12	-
68/69	No market	-
69/70	14	14
70/71	59	118
71/72	170	181
72/73	123	176
73/74	102	162
74/75	85	120
75/76	127	160
1976*	132	142
1977	147	99
1978	125	167

* Change from records in financial years to calendar year.

TABLE 2: The catch per diver from each zone for the period 1976-1978.

Year	Zone 1	Zone 2	Zone 3
1976	12.8 tonnes	8.3 tonnes	11.0 tonnes
1977	9.0 tonnes	5.6 tonnes	12.3 tonnes
1978	11.3 tonnes	12.4 tonnes	10.4 tonnes
Average	11.1 tonnes	8.8 tonnes	11.2 tonnes


LEGEND
GENERAL DIVING AREA
ECHO SOUNDER LINE
APPROXIMATE LAT. AND LONG
120°
126°
28°
32°
36°
RED ROCKS POINT
TWILIGHT
COVE
EYRE
EUCLA
ESPERANCE
126° E
32°
15'S
TWILIGHT
COVE
CLIFFS
EYRE
BOAT
ANCHORAGE
9 MILE WEST OF EYRE
127° 30' E
32° 15'S
NOONAERA
STONE HUT
RED ROCKS
POINT
32° 30' S
128° 16' E
30°44'
W.A.
S.A.
EUCLA
129°E
128°E
31°S
WILSON BLUFF
LOW POINT

THE GREAT AUSTRALIAN BIGHT TRAWL FISHERY

Dr. Mike Walker

(Dr. Walker's paper will be distributed at the seminar)

FOREIGN FISHING WITHIN THE 200-MILE AUSTRALIAN FISHING ZONE

B.K. Bowen

FOREIGN FISHING WITHIN THE 200-MILE AUSTRALIAN FISHING ZONE

B.K. Bowen

The Commonwealth Government, in co-operation with the State Governments, has adopted the following mechanisms for the entry of foreign fishing vessels into the Australian Fishing Zone (AFZ). These are:-

(a) Fishing under bi-lateral agreements. An example is the operation of the Japanese tuna long-liners which operate under license following an Australia/ Japan agreement on access to the AFZ.

(b) Feasibility fishing with an Australian partner. An example is the trawl fishing project between Lombardo Marine Group Fremantle and Dong Bang Ocean Fisheries of Korea. Under these arrangements the Australian partner arranges the entry of a foreign vessel for up to two years for the purpose of gathering data on the potential for exploitation as well as gaining experience in processing and marketing.

(c) Feasibility fishing without an Australian partner. There are no examples to date.

(d) Joint venture fishing.
This was planned to follow feasibility fishing. There are no examples to date.

Each of these approaches to foreign fishing will be discussed.

RECHERCHE ARCHIPELAGO

Dr. A.A. Burbidge.

RECHERCHE ARCHIPELAGO

by

DR. ANDREW A. BURBIDGE

The Recherche Archipelago is one of Australia's outstanding Nature Reserves. It comprises about 100 granite-gneiss islands ranging in size from less than 0.5 ha to 1090 ha spread over more than 3500 km^2 of ocean. Most islands are dome shaped and rise steeply from the water to 100 m or more. Larger islands usually appear as a continuation of two or three domes. Soil is sparse on most islands and there are few sandy beaches.

The islands of the Recherche Archipelago are an important conservation area for many reasons, e.g.

1. They have a vegetation different from that of the adjacent mainland.

2. They harbour terrestrial mammals either not known elsewhere (e.g. Hacketts Rock-wallaby) or are now rare on the mainland (e.g. the Tammar and the Black flanked Rock-wallaby).

3. They provide breeding places for a wide variety of seabirds including penguins, petrels, sheerwaters, cormorants, storm-petrels, gulls and terns.

4. They provide breeding places for Fur Seals and Sea Lions.

5. They are the only place in Western Australia where the Cape Barren Goose breeds.

6. They provide places where plant and animal communities remain unaffected by man's actions. Islands are the only places in Australia where the animals introduced by Europeans do not now occur.

7. They provide places where scientific research can be conducted.

Recent work by the Wildlife Research Centre has concentrated on Middle Island where a study is in progress on regeneration following the 1973 and 1977 fires.

THE TUNA FISHERY

Mr. J.P. Robins.

THE TUNA FISHERY

1. Introduction

Of the 13 species of tuna which occur around the coast of Australia and of which, on a world basis, there are six species of significant commercial value, namely southern bluefin, yellowfin, albacore, skipjack or striped tuna, bigeye and northern bluefin, only two are exploited significantly by Australian fishermen.

These two species are southern bluefin tuna predominantly and skipjack to a much lesser degree.

The contribution to the total landed catch of tuna in Australia by yellowfin and northern bluefin tuna is very small indeed.

Along the southern coast of Western Australia there is only one species, southern bluefin, which is being exploited, but from time to time occasional small or individual catches of skipjack, yellowfin tuna and bigeye tuna and very occasionally individual albacore catches are made.

Again there is a seasonal occurrence of bonito, one of the tuna-like species, along this part of the Western Australian coast.

The opportunity for development of a fishery on yellowfin tuna, a sometime seasonal visitor to southern waters, will not occur for its main distribution lies in tropical seas; very little is known about the juvenile stages of the bigeye tuna which appears, at times, in near coastal surface waters in both tropical and temperate seas.

However, the skipjack tuna, a tropical-subtropical waters inhabitant and probably the most cosmopolitan of all commercial species, is a regular seasonal migrant into south coast waters in reasonable abundance, but as yet no real effort has been made to commercially exploit it. The main reasons for non-exploitation to date, are that the price offered has not been conducive to fishermen to catch it and the livebait and pole technique required for its capture is somewhat more refined than that presently used for the capture of southern bluefin tuna.

2. Southern Bluefin Tuna

2.1 Distribution:

This species' distribution is confined to the waters of the southern hemisphere in the waters of the Pacific, Indian and Atlantic Oceans and except for the breeding population between Indonesia and north west Australia, its main area of distribution lies roughly between 30°S and 50°S.

The more juvenile part of the population, i.e. fish ranging in age between two and five years, is that part of the population exploited by Australian fishermen (Figure 1).

These juveniles occur much more frequently in the surface waters than do the older age classes as well as occurring closer to the coast.

Small quantities of fish, five years and older, are taken in the Australian pole and line fishery but at these ages the fish are more oceanic in habit and it is in the oceanic regions, mainly in the West Wind Drift (below 40^0S) where the Japanese tuna long line fleet operates for the capture of southern bluefin tuna as well as for bigeye, albacore and species of billfish (Figure 1).

The small tuna purse seine fleet in Eastern Australia appears to operate on that part of the population which falls between the major size groups operated on by the Australian livebait and pole fleet on the one end of the size scale, and the Japanese longline fleet on the other.

2.2 Migrations (Figure 2)

Although many thousands of bluefin tuna have been tagged since tagging operations commenced in New South Wales waters in 1957 and subsequently in waters off Western Australia, South Australia and Tasmania, and much information on movements and growth has been gained from recaptures of tagged fish, important details relating to proportional and directional separation of the population before and after tagging as well as fishing mortality cannot yet be fully resolved.

It is obvious from a study of the size composition of the catches of bluefin by the Japanese longliners operating off South Africa, that all the juveniles which leave the spawning ground south of Java do not migrate south about Western Australia, thence to South Australia and Eastern Australia.

That portion of the juvenile population which does frequent the waters of Southern Australia carry out both intra- and inter-fisheries migrations, i.e. some short term (one to several months) recoveries of fish tagged in Western Australia indicate movements eastward and then westward between the Albany and Esperance fisheries; some migrate to South Australian and some to New South Wales waters in the same season.

Again, some fish tagged in South Australia migrate to Western Australia and some to New South Wales; similarly fish tagged off New South Wales migrate to South Australia.

Long term recoveries of fish tagged in Western Australia have been made by Japanese longliners in waters off New Zealand, south of Australia across the Indian Ocean, and in the South Atlantic.

One expected key recovery which has not been recorded is one, or more, from adult bluefin in the spawning area. There are several probable and interrelated explanations for this lack of migratory evidence, the chief of which is that fishing effort by the Japanese in the bluefin breeding area was greatly reduced (and has remained so) at the critical time when the first juvenile fish (two years old) tagged off Albany, Western Australia, in 1962, were expected to arrive as sexually mature fish in the breeding area in 1967. A second reason is that the adult population numbers may be severely reduced, as indicated by the reduced catch per unit of effort in subsequent years in this particular area.

2.3 Age, Growth and Sexual Maturity

Growth and weight curves have been constructed from analysis of data relating to length frequency measurements from samples of fish taken from the commercial catches throughout the fishing seasons and from analyses of lengths of fish at tagging and subsequent recapture.

These curves show that the fish may grow to a maximum size of about 220 cm in length, 200 kg in weight and maybe to at least 20 years in age.

The fish attain sexual maturity between 125 and 130 cm in length at about 41 kg in weight at an age of about 7 years.

2.4 The Catch and Fleet

Since commercial fishing for bluefin commenced in 1969 off Albany and subsequently in 1975 off Esperance the total catches (on a calendar year basis) in each area have fluctuated (Table I). Vessel numbers, subsequent to the 1969 season in Albany, remained relatively steady but in 1979 there was a very marked increase. In the Esperance area vessel numbers have also risen. The average catch per vessel operating out of Albany has fluctuated markedly in some years, and similar fluctuations off Esperance are also expected in future.

Table II shows the history of the southern bluefin catch by both Australians and Japanese since 1955/56.

2.5 Prospect for Further Development

The prospect for further development in the bluefin fishery has constraints attached to it, both biologically and economically.

Murphy (1979) states - "All evidence points to the fact that the stock is fully exploited. Any increase in catch by Australian fishermen would reduce the Japanese catch. Any significant increase in the Japanese catches might reduce the Australian catch, especially if they fish in zones in which small fish are available."

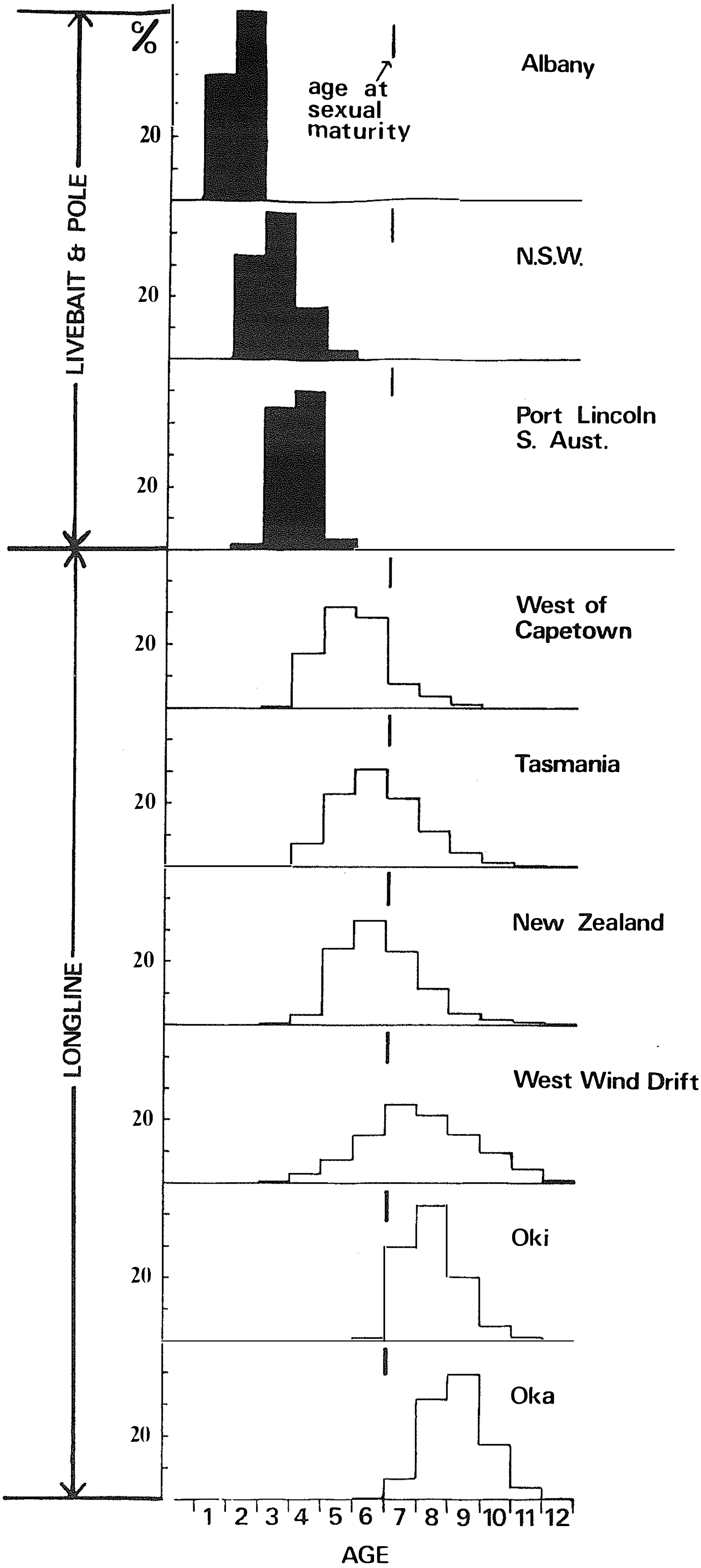
TABLE I. Analysis of Catch off Albany and Esperance

Year	ALBANY			ESPERANCE		
	Catch (Tonnes)	No. of Catching Vessels	Av. Catch/ Vessel	Catch (Tonnes)	No. of Catching Vessels	Av. Catch/ Vessel
1969	299	9	33.2	-	-	-
1970	708	21	33.7	-	-	-
1971	600	29	20.7	-	-	-
1972	757	28	27	-	-	-
1973	308	30	10.3	-	-	-
1974	321	28	11.5	-	-	-
1975	772	23	33.5	*118	4	66
1976	227	20	11.4	61	2	30.5
1977	534	26	20.5	448	12	37
1978	1 048	37	28.3	998	30	33.3
1979	1 247	63	19.8	1 010	49	20.6
	6 821	314	21.7	2 705	97	27.9

* A catch of 276 tonnes by three South Australian vessels excluded

TABLE II. Annual Catches (Tonnes)

Year	Australia (Pole & Line)			Japan (Longline)
	N.S.W.	S.A.	W.A.	All Fishing Grounds
1955/56	425	-	-	6 095
1956/57	810	210	-	12 190
1957/58	750	500	-	19 301
1958/59	1 550	625	-	27 428
1959/60	1 400	1 200	-	69 078
1960/61	1 820	2 200	-	74 158
1961/62	1 400	3 350	-	53 841
1962/63	1 382	3 590	-	47 730
1963/64	2 610	5 508	-	51 809
1964/65	2 274	4 768	-	40 634
1965/66	2 355	5 993	-	31 492
1966/67	2 144	3 426	-	38 603
1967/68	3 728	2 945	-	54 857
1968/69	5 436	3 121	-	36 571
1969/70	6 338	1 892	299	48 761
1970/71	3 612	2 817	708	34 539
1971/72	5 034	4 375	600	33 523
1972/73	6 135	6 836	757	42 666
1973/74	1 811	7 699	308	26 412
1974/75	5 186	4 842	321	22 247 (1974) 29 500
1975/76	2 465	6 938	1 236	21 400 (1975)
1976/77	308	8 649	288	23 771 (1976)
1977/78	4 814	4 934	982	Est. 27 872 (1977)
1978/79	4 332	4 313	2 046	NA (1978)

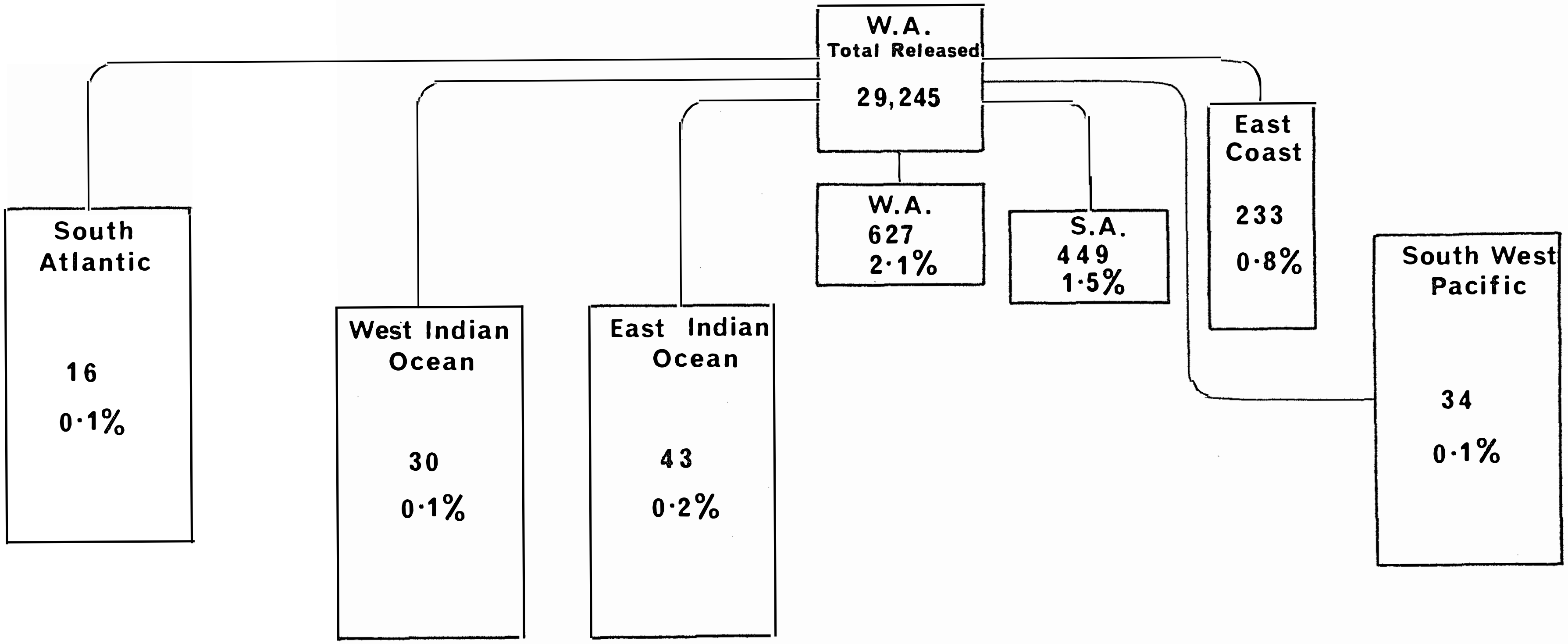


AVERAGE AGE COMPOSITION OF SOUTHERN BLUEFIN TUNA CAUGHT IN THE NINE FISHING GROUNDS.

Fig 1.

Fig 2.

SCHEMATIC DIAGRAM OF TOTAL SOUTHERN BLUEFIN TUNA TAGGED IN W.A. AND SUBSEQUENT RECOVERIES BY AREA AND REGION.



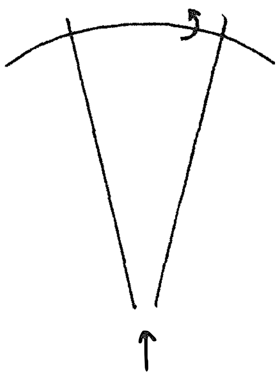
TOTAL RECOVERIES: 1432 – 4·9 %

DEPARTMENT OF
FISHERIES AND WILDLIFE.

Suitability of various types of Farm Dams for Home Aquaculture

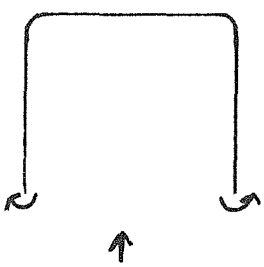
Trout and marron purchased from the Pemberton Fish Hatchery can provide good crops and a welcome change of diet for the farmer. This brief guide seeks to prevent disappointment as a result of stocking unfavourable dams.

GULLY DAMS



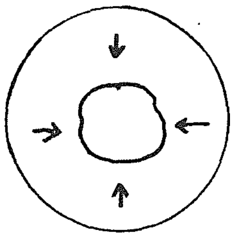
These dams are built in steep gullies in the cooler, wetter coastal hills of the south-west. Water supply varies between a minimum of a winter creek and springs, and a maximum of a perennial creek; the latter requiring a well-constructed spillway with a grid to prevent fish escapement. Dams are usually overstored giving good flushing by overflow. The dam bed and banks should be cleared of scrub and grassed to prevent excessive initial organic enrichment which leads to oxygen deficiencies. The normally clear water allows bird predation but weed beds usually provide refuge. These dams are suitable for trout or marron. Marron will breed but trout will not and should be fished out and restocked every three years.

EXCAVATED TANK DAMS



These dams are characteristic of the drier, flatter inland wheatbelt areas from Geraldton around to Esperance. They should be built on the higher valley slopes to avoid salting. They are filled and flushed by overflow during winter run-off from crop, pasture, scrub or roaded catchments(in ascending order of favourability). They are commonly organically polluted by heavy summer downpours which can be diverted by a diversion bank and gate across the front of the dam. Direct cattle access to the dam leads to unfavourable pollution for marron. White clay turbidity prevents bird predation. Suitable for marron but not trout. Suitable only for yabbies or koonacs if the water is polluted (a green colour).

SPREAD-BANK CATCHMENT AREAS



These dams are characteristic of the flat station areas of ill-defined river drainage toward, and particularly east of, Esperance. Water supply comes from runoff from the large, man-made catchment. Some dams also have a water supply input from paddock and roaded catchments.

The dams are understored. Lack of provision for overflow flushing of salt and nutrients and rapid silting by clay from the catchment greatly limit their useful life for marron. If drainage is possible, provision of an overflow pipe just below high water mark would be beneficial. Fencing off of stock from the dam and catchment is also highly desirable to prevent pollution.

Some dams have a circular silt trap to prolong storage life.

Marron can be successful briefly in new dams but older dams are usually suitable only for yabbies or koonacs.

GENERAL

Trout are successful only in clearer gully dams. Marron are successful in both gully and turbid excavated tank dams and perhaps some spread-bank dams protected from pollution. Very large dams are not necessarily more productive than smaller ones for crayfish since water deeper than 1-2m during summer is deficient in oxygen.

Prepared by: Dr Noel Morrissy
W.A. Marine Research Laboratories
Waterman

THE GREAT AUSTRALIAN BIGHT TRAWL FISHERY

INTRODUCTION

The continental shelf in the Great Australian Bight is the largest shelf area of southern Australia. The total shelf area between 123°30' E to 134°30'E latitude, bounded on the seaward side by the 200 fathom/366 metres contour, is approximately 54,000 square nautical miles (see Figure 1). An approximate division of this area according to depths is given (Table 1).

TABLE 1: Area of the Continental Shelf of the Great Australian Bight at various depths, between 123°30'E and 134°30'E. (After Kesteven and Stark, 1967.)

Depth Fathoms	Depth Metres	Area (Sq. nautical miles)	Percentage
0 - 25	0 - 46	7 560	14
26 - 50	47 - 91	32 508	60
51 - 75	92 - 137	10 206	19
76 - 100	138 - 183	1 984	4
101 - 200	184 - 366	1 795	3

HISTORY OF THE FISHERY

The area of the Bight has historically attracted considerable attention from the fishing industry as it seemed that such an area could support substantial fishing, especially trawling.

The Bight trawling grounds were discovered by the Fisheries Investigation Ship *Endeavour* during 1912/13. She showed that the Bight was inhabited by a wide range of demersal fish species. The catch rates *Endeavour* obtained for the Bight were slightly lower than she obtained on the Shelf off the southern N.S.W. coast.

Further exploration work occurred in the Bight in 1914 with a S.A. Government vessel *Simplon* and a W.A. Government vessel *Penguin*. The first commercial venture began in 1929/30 with a vessel *Bonthorpe*. This was followed by commercial ventures with *Trussan* in 1948, *Ben Dearg* and *Commiles* during 1949-1952, and *Southern Endeavour* during 1959-1960. In 1975/76 a W.A. company, Southern Ocean Fish Processors, operated three Scottish side trawlers *Saxon Onward*, *Saxon Progress* and *Saxon Ranger*. The results obtained with these vessels led this company to form a joint venture with British United Trawlers (B.U.T.) and operate three large *Othello* class stern trawlers during 1977-79, i.e. *Othello*, *Orsino* and *Cassio*. Another vessel, a converted Japanese tuna longliner, *Miss Boomerang* operated successfully in the Bight during 1977 to 1978. All commercial ventures to date have been unsuccessful, for a variety of reasons, such as: unsuitability of vessels used for the grounds fished; mechanical problems with vessels and difficulties in obtaining spare parts; problems in obtaining fishing gear; inexperience of the crew and other crew problems; and marketing and processing problems associated with the catch.

THE GREAT AUSTRALIAN BIGHT TRAWL FISHERY

The trawl fishery of the Great Australian Bight is based upon both demersal (bottom) and pelagic resources. Catches made, in terms of species composition, by the three B.U.T. vessels in the period 19.11.1977 - 30.6.1978 are shown (Table 2).

TABLE 2: Catches Southern Trawl Fishery 19.11.77-30.6.78.

Red snapper	312,722	Boarfish	16,069
Sea Bream	202,932	Angel Shark	13,517
Leather Jacket	114,422	Mixed Fish	10,580
Shark	92,395	Pilchard	3,341
Ruby Fish	88,790	Australian Tusk	3,188
Trevally	78,743	Hapuku	2,738
Jack Mackerel	74,925	Silver Dory	2,475
Deep Sea Flathead	67,488	Dory	2,020
Knife Jaw	60,680	John Dory	2,011
Latchet	60,083	Frost Fish	1,912
Barracouta	41,895	Nannygai	1,532
Blue Mackerel	41,744	Moonlighter	657
Spotted Boarfish	39,567	Mirror Dory	534
Gemfish	38,952	Warehou	445
Black Spot Boarfish	29,223	Pink Snapper	171
Swallow Tail	22,601	Giant Boarfish	140
Queen Snapper	22,291	Westralian Jewfish	70
Squid	18,954	Total 1,469,807 kg.	

The most commercially important fish species are:- Red snapper/Bight redfish, Jackass morwong/Sea bream, Chinaman leather-jacket, Ruby fish, Deep-sea flathead, and Knife jaw (all demersal species), and Blue mackerel, Jack mackerel, and Trevally (pelagic species).

In general terms productivity of the fishery increases with depth to the edge of the continental shelf, where the best catches occur. Trawling conditions improve likewise as less sponge is encountered with depth. The edge of the shelf, or drop off area (150-180m), is small in terms of the total Great Australian Bight area, it amounts to about 5% of the area.

The composition of the fish fauna generally corresponds to the nature of their food supply. The fish fauna can be split into the faunas of the continental shelf and the continental slope. Juveniles of many species are found in the shallower waters of the shelf with the adults being encountered on the continental slope. The shelf area is low in terms of benthos (bottom living animals), thus fish species occurring there tend to be plankton feeders. The bottom of the slope area is more silted and supports more benthos, thus the proportion of benthos feeding fishes increases. However, plankton feeding fishes still predominate on the slope.

Seasonal changes in the fish fauna occur due to seasonal variation in water circulation, temperature, and enrichment of the shelf edge in Summer. Many of the commercial species breed in late Summer and Autumn. Some fish species move up and down in the water column at dusk and dawn.

IN CONCLUSION

There would appear to be reasonable demersal resources in the Great Australian Bight. However, they appear to be only available at the shelf edge in worthwhile concentrations for part of the year, during late Summer and Autumn. Pelagic resources, especially Blue mackerel have been shown to be available during late Autumn and Winter, and a good potential appears to exist to exploit them. Both demersal and pelagic resources utilized together, with the right vessel and processing facilities, perhaps add up to an ongoing fishery, or if utilized one at a time suggests pulse fishing operations only.

THE GREAT AUSTRALIAN BIGHT showing half degree grid squares (30 mile x 30 mile)