FISHING INDUSTRY RESEARCH TRUST ACCOUNT

REPORT

TITLE OF PROPOSAL

Identification of stocks, and migration routes of Spanish Mackerel.

NAME OF APPLICANT

Queensland Fisheries Service.

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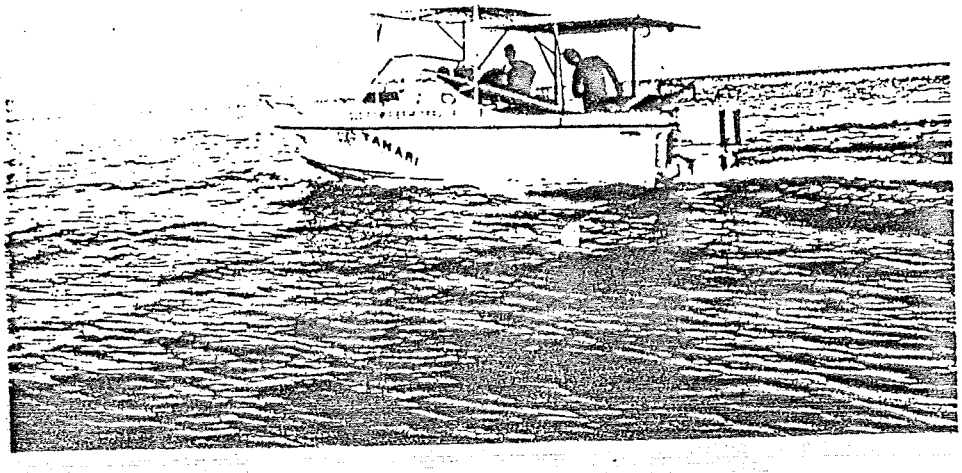
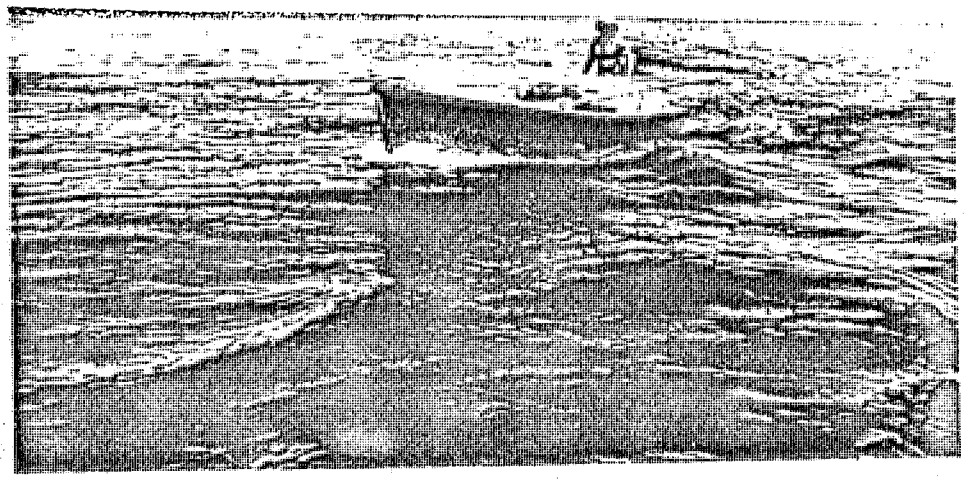
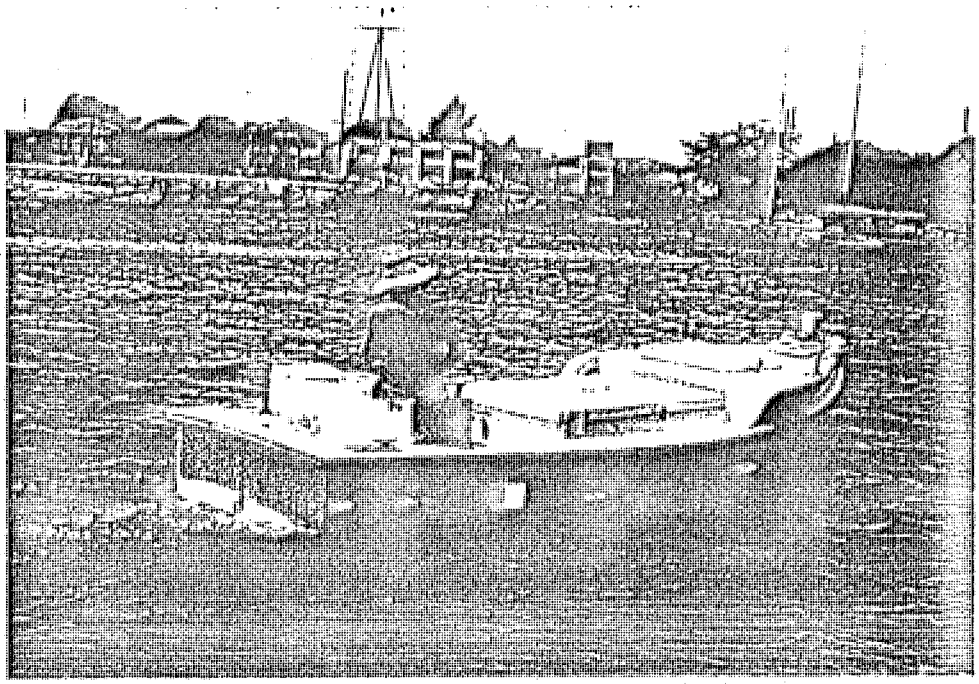
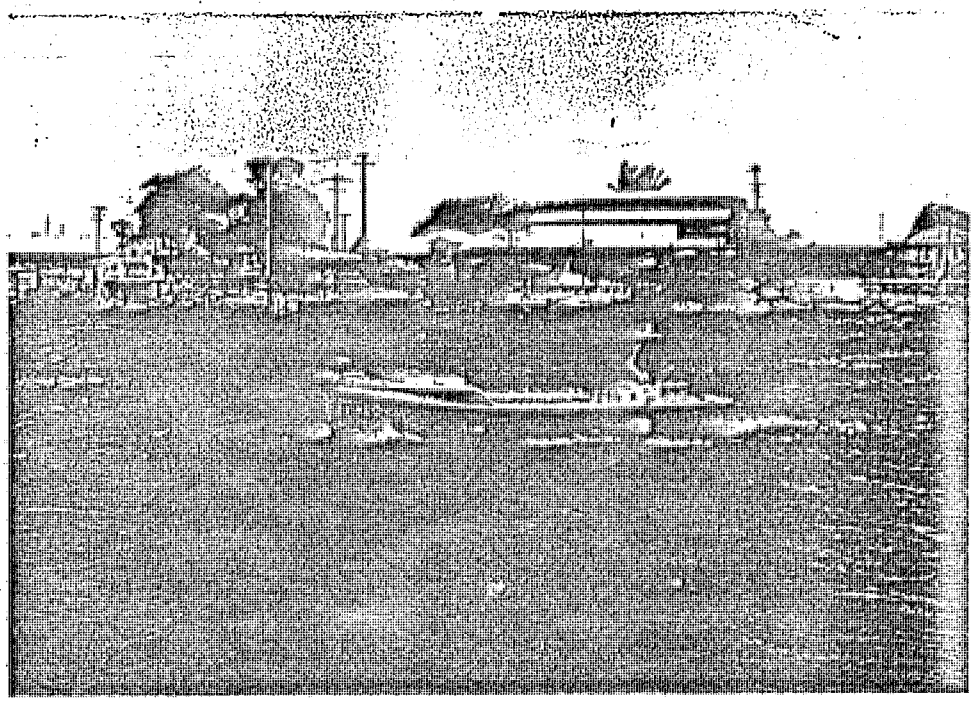


The 7.0m Q.F.S vessel "Tanari" used for tagging in the Green Island area.



The 4.5m chartered mackerel dory used in the Cairns area.





A 5.5m GRP mackerel dory char' ered for mackerel tagging off Townsville in November 1979. The 5.5m "Sagair" is of similar design.

SUMMARY

Electrophoretic studies of blood and liver samples of S. commerson around the northern coastline of Australia did not detect any significant differences between the fished stocks. Tagging in the north east sector of these waters did not provide additional information as returns were restricted to south of Lizard Island ($14^{o}30'S$) on the Queensland east coast.

Data from limited tagging by Q.F.S 1976-1978 were combined with the results from the FIRTA funded 1979-1981 programme. In total, 1959 S. commerson were released by Q.F.S and commercial fishermen in north Queensland waters. An additional 24 fish were released by Q.F.S and amateur fishermen in scuthern Queensland.

At the end of April 1981, 58 fish returns had been reported, giving a return rate of 2.9%. Approximately 16 more returns are anticipated up to the end of April 1982.

It appears that movement within the region of the north east Queensland fishery, up to and during the October - November spawning season are small, with movements of resident and newly immigrant fish generally limited to the same or adjacent reefs. At the conclusion of the spawning season, movements may either remain localised with perhaps a reduced tendancy toward concentrations on specific reef areas, or long range to southern waters.

Participation in a post spawning migration may occur after the first active spawning season when individual fish are entering their third year. Data is limited, yet it is suggested that the proportion of each age class which migrate may become larger as the fish become older.

Models to represent the behaviour of various age classes of S. commerson throughout the year are presented. Each model is composed of two "mobile" components, referred to as either resident or migratory groups (or individuals) of fish.

INTRODUCTION

A number of approaches have traditionally been employed in the subdivision of fishery resources for management purposes. They have included taxonomic approaches, life history characteristics, tagging and genetic examination of tissue proteins by electrophoretic techniques. In some instances the results of one technique have been used to reinforce the conclusions of at least one other approach to the problem.

Tagging and electrophoretic analysis of blood samples have been used to define stocks of skipjack tuna in the Pacific, while of more specific interest, these techniques have indicated the presence of two stocks of Scomberomorus cavalla in Florida (U.S.A) waters (Chittenden, 1978; Williams and Sutherland, 1978).

A number of regional fisheries for S. commerson presently exist around the northern Australian coastline from northern NSW to southern Western Australia. The lack of information available for management decisions in these various areas, outlined the necessity to investigate the stock integrity of this migratory species.

Preliminary blood samples examined by the Inter American Tropical Tuna Commission indicated the species displayed sufficient genetic variation between Australian and Papua New Guinea stocks to continue with electrophoretic investigations throughout Australian waters.

The tagging activities of this study were restricted to the Queensland east coast in order to examine the timing and extent of migrations with regard to age class and season, within the major Queensland S. commerson fishery. Tagging was also considered for examination of residence times in specific areas, such as where ciguatera poisoning is often reported.

Prior to the commencement of the FIRTA tagging programme, the Q.F.S conducted a biological sampling programme of the species in Queensland waters (McPherson, 1981). The most relevant aspect of this study to the current programme is that the species' spawning season was identified in The Torres Strait as between August and December, less protracted (October to early December) in areas between Lizard Island and Townsville and even briefer (October - November) further south between Gladstone and Bundaberg.

IDENTIFICATION OF STOCKS AND MIGRATION ROUTES OF SPANISH MACKEREL.

1. STOCK DEFINITION STUDIES OF S. commerson UTILISING ELECTROPHORETIC TECHNIQUES.

As part of a wide study of the ecological genetics of Australian scombrid fishes by A D Lewis of the Australian National University, and following the initial optimism generated from the IATTC analysis of 288 blood samples in 1977, a preliminary population study was carried out on S. commerson. Agencies providing samples for this study included the Queensland Fisheries Service, PNG Fisheries Division and the Northern Territory Fisheries Division.

The QFS and PNG Fisheries Division had collected 472 blood samples between 1977 and 1979 from north east Queensland, Torres Strait and from various localities around Papua New Guinea. During 1980, a total of 98 blood samples were collected between the Gulf of Carpentaria and the Monte Bello Islands (WA) by QFS and NT Fisheries Division.

The results of this preliminary population study were delivered by Lewis at the Northern Pelagic Fish Seminar held at Darwin in January 1981 (Lewis, 1981). A summary of this report appears below.

All blood samples were shipped to Canberra and typed for enzymes that were known to be variable ie 6-PGD, GPI Esterase, PGM Transferrin. Two of the enzymes examined (6-PGD and GPI) displayed significant heterogeneity of alleles from the total samples, suggesting statistically significant genetic variation between New Ireland (north of Papua New Guinea) and the Australian north west coast.

However when the New Ireland samples were removed the allele heterogeneity disappeared, leaving the northern Australian data homogeneous. Lewis believed the data implied that "northern Australian S. commerson may comprise an interbreeding unit isolated from New Ireland populations". He recognised that sample sizes were in many cases small and did not allow sub-division with respect to size, age, season etc and that "the result should be regarded as preliminary".

The results of this study indicate that there is a sufficient level of interbreeding over the northern Australian coastline to distribute the genetic material so that no differences between stocks have been detected. Future research using other techniques such as tagging or life history characteristics will be required in order to confirm or reject this finding.

IDENTIFICATION OF STOCKS AND MIGRATION ROUTES OF SPANISH MACKEREL.

II. STOCK DEFINITION STUDIES OF S. commerson USING TAGGING TECHNIQUES

METHODS

A. QUEENSLAND FISHERIES SERVICE OPERATIONS

The major tagging effort in north Queensland was directed towards the Cairns region where the Q.F.S Green Island Field Station was used as an operational base. A detailed breakdown of Queensland Fish Board landing figures show that Cairns is the second largest production area on the Queensland east coast. Reefs to the north east of Townsville have always been recognised as the major spawning grounds of S. commerson on the east coast and landing figures would seem to confirm this. A tagging effort was planned for this area in 1979 and 1980.

Lizard Island was selected as the third tagging area in north Queensland, partly for its northerly location in the east coast fishery and partly as the spawning stocks resident in the area during October and November are subject to relatively low fishing pressure.

At the commencement of FIRTA tagging operations in mid 1979 three improved tagging cradles were developed for the vessels participating in the programme. The cradle was quite different to the earlier "vee" shaped models. It was more compact, yet restrained all size ranges of S. commerson effectively and improved the unhooking, tagging and measuring process. A schematic diagram of the improved cradle is shown in Figure 1.

The majority of fish were landed by standard commercial gear comprising heavy bowden cable or monofilament handlines of 10 - 40 metres with piano wire trances of 2 - 12 metres. Terminal rigs generally included 10/0 hooks and garfish, although purchased and prefabricated lures were used. Light game fishing rods were also used for trolling or drifting dead baits.

The LCF (length to caudal fork), condition on release (an arbitrary four point scale based on appearance and behaviour) and rig were recorded for each release.

VESSELS AND FACILITIES USED

A 5.5m fibreglass mackerel dory was designed specifically for the tagging programme however construction was not completed until after the 1979 fishing season. The "Sagair" was used extensively for the 1980 season spending most of this period at sea and proving to be an extremely cost efficient and fish effective vessel.

The QFS provided 7.0m launches and aluminium dinghys of approximately 5.0m for various tagging efforts in north and south Queensland, as well as the trawler "Bar-ea-mul" based at Bundaberg.

Tagging in the Townsville area during 1979 was conducted by chartering the 13m commercial fishing vessel "Freelancer", its dory and full time services of its master. An additional mackerel dory (4.5m) was chartered at a nominal rate during the 1979 and 1980 Cairns seasons.

The facilities of the QFS Green Island Field Station were utilised to maintain up to four officers and three vessels during the tagging periods.

B. JUVENILE TAGGING OPERATIONS BY COMMERCIAL FISHERMEN

Involvement of commercial fishermen was a continuation of an existing Q.F.S programme that had already resulted in the release of 97 juvenile S. commerson. In total, fourteen commercial fishermen operating from ports north of Innisfail were issued with tagging kits. Co-operating fishermen would only tag small fish whenever time permitted, it was not expected that tagging would be feasible during periods of peak fishing activity.

The methods used by each fishermen to tag the small fish between 1.5 - 2.2kg varied considerably, although most fishermen believed that the fish could be easily handled if held firmly against the deck at least for the first few seconds. A number of fishermen estimated LCF by marking a scale onto a flat portion of the deck.

C. AMATEUR TAGGING

The vast size of the states' coastline and the related high costs of transportion reinforced the need for greater amateur involvement in pelagic fish tagging for the following reasons :-

- better local knowledge
- year round tagging effort to cope with seasonal movements and weather variabilities.

In 1980 the Queensland Fisheries Service commenced a Sportfish Tagging Programme with the intention of encouraging the tag and release of fish species having both commercial and recreational value. The results to date indicate that fishermen are releasing fish in good condition.

Methods used by amateur fishermen to tag S. commerson varied from tagging and unhooking the fish while still in the water to removing the fish from the water and wrapping them in wet towels for the tagging operation.

RESULTS

A. RELEASES

Although Q.F.S tagging operations have ceased, it is anticipated that commercial and amateur fishermen will continue tagging small S. commerson throughout 1981. Figure 2 shows the release areas for Q.F.S, commercial and amateur fishermen.

I CAIRNS AREA — August - December 1979

Tagging activities began in August with a 7.0m vessel however adverse weather conditions kept the effort of a low level and prevented any tagging during September.

Two vessels were used during October and November, when 299 fish were tagged.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged
2	37	52	356

II LIZARD ISLAND — October 1979

Conditions were not favourable for mackerel fishing, particularly in a small dinghy, as for 50% of the time the SE tradewind was in excess of 15 knots.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged
1	9	9	104

III TOWNSVILLE AREA November 1979

Nine fishing days were completed with the chartered commercial vessel before an accident involving the master necessitated his immediate return to Townsville and subsequent hospitalisation.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged	Rejected
1	9	9	202	15

While fishing conditions were ideal, the number of sharks on the grounds also competing for the mackerel not only reduced the number of mackerel landed, but undoubtedly contributed to injuries incurred to the fish as they struggled against the line while attempting to avoid the sharks. It was impossible to estimate the number of fish taken from the lines by sharks, however six fish were unsuitable for release as a direct result of shark attack and thirteen were rejected for a combination of reasons.

IV MOOLOOLABA - CALOUNDRA March 1980

The decision to choose this period of March was made as a balance between a reduced likelihood of cyclones, favourable tides and a recognised suitable fishing period based on previous years results.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged	Rejected
2	11	20	3	3

Unfortunately six of the available 15 fishing days spent in this area had winds in excess of 20 kts, five of these days having strong wind warnings forecast.

The local professional mackerel fishermen did not land many mackerel when it was possible to go to the wider reefs such as the Barwon Banks, Flinders and Hutchinson Schools. They did comment that the fish were only showing up on small isolated patch reefs and were taking baits presented by very light line (e.g. 6 and 10 kg) and often without trace.

V SANDY CAPE - LADY MUSGRAVE ISLAND

Fishing in this area began with a seven day sampling trip on a commercial vessel. The master of the vessel had intended to fish around the Sandy Cape area where ciguateric fish are thought to originate, however bad weather diverted the vessel to fish in the Lady Musgrave and Fairfax Island area at the southern end of the Bunker Group of islands. The wind maintained a velocity of 15-20 knots throughout the voyage, only thirteen S. commerson stomach samples were taken. With the first break in the weather, the vessel returned to Bundaberg.

The tagging component of the exercise began with excellent weather on the weather side of Sandy Cape Shoals at one of the half dozen locations implicated with ciguatera poisoning. After unsuccessfully fishing for S. commerson around a number of recognised locations at the northern end of Sandy Cape Shoals, a SW gale necessitated seeking a safe anchorage at Lady Musgrave Island. The weather remained poor for the remainder of the voyage, five of the seven days having gale or strong wind warnings forecast. Fishing was attempted on all but one day until the decision was made to utilise a forecast short break in the weather to return to Bundaberg.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged
2	8	16	16

VI CAIRNS AREA — September - November 1980

An early start to tagging in this area was not possible until September when all tagging equipment used off Bundaberg in July and early August arrived back in Cairns.

Tagging commenced using the 5.6m mackerel dory "Sagair" constructed with FIRTA funds.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged	Rejected
3	74	89	532	3

VII LIZARD ISLAND October 1980

The "Sagair" was towed to Lizard Island by a charter boat where it stayed for 24 days and utilised the facilities of the Lizard Island Research Station.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged	Rejected
1	23	23	133	1

VIII TOWNSVILLE REGION November 1980

During this period a Q.F.S daily record was set with one man tagging and releasing 52 fish during two brief tagging sessions.

Examination of S. commerson gonads towards the end of November indicated that the majority of ovaries were substantially reduced in size. A number of spent ovaries were observed. It appeared that the spawning season had virtually ceased by the last week in November and later reports from fishermen on the grounds in December confirmed this.

Max. No Vessels	No Days Fished	Boat Days	Fish Tagged	Rejected
1	22	22	275	18

Sharks were again a significant problem on these grounds. A number of the eighteen fish rejected had hook induced injuries almost certainly incurred by evasive action from sharks. In addition, seventeen fish were taken by sharks as they were being pulled in.

C. AMATEUR TAGGING

The Sport fishing project resulted in the release of 60 Scomberomorous of four species, of which five are known to have been S. commerson which were released in southern Queensland waters.

D. SUMMARY OF S. commerson RELEASES

The peak fishery for S. commerson in north Queensland occurs during the months of October and November. In this period most spawning occurs and the bulk of the northern fishing effort is directed along some three hundred miles of coastline from Lizard Island to Townsville wherever spawning aggregations of fish are encountered. Prior to, and after the spawning season, commercial catches suggest reduced concentrations on specific reefs with evidence of emigration or immigration apparent at different times.

The "fishing year" for S. commerson in Queensland has been divided into three categories in relation to the spring spawning season. The categories are as follows :

(1) Pre-Season i.e. May-September.

The five months leading up to the spawning season. This period includes the north Queensland winter fishery and the apparent immigration of fish from southern waters.

(2) During Season October-November.

The spawning season observed from the Queensland east coast fishery. The far northern fishery in Torres Strait however has a more protracted spawning season from August to at least December.

(3) Post Season December-April

The five months following the spawning season. Little fishing effort occurs in the north at this time, especially during the cyclone season of December to late March. The fishery in southern Queensland occurs within this period.

On this basis of the above three subdivisions, the tag releases by Q.F.S, commercial and amateur fishermen between 1976 and 1981 have been summarized below.

B. COMMERCIAL TAGGING

As an integral part of the Q.F.S t·gging trials (1976-1978), commercial fishermen began releasing juvenile S. commerson during 1977. A total of 254 releases with yellow dart tags have been recorded up to April 1981. Of this number, 101 (40%) were released between the Gulf of Carpentaria and 14°30'S.

YEAR	GENERAL AREA	NUMBER RELEASED
1977	Cairns	30
1978	Torres Strait - Lizard Island	19
	Cairns	19
1979	Torres Strait - Lizard Island	52
	Lizard Island - Townsville	86
1980	Eastern Gulf of Carpentaria	9
	Torres Strait - Lizard Island	21
	Lizard Island - Townsville	12
1981	Lizard Island - Townsville	6
		254

While fishing pressure is probably not high in the far northern areas which could in turn affect the potential number of returns, the concept of commercial assistance with tagging is seen as an efficient and inexpensive method of tagging reasonable numbers of fish in remote areas.

A. Gulf of Carpentaria, Torres Strait, north of Lizard Island (14°30'S).

FISH TAGGED

Fishing Year	Pre Season	During Season	Post Season	Total
1977	0	0	0	0
1978	22	19	0	41
1979	33	19	0	52
1980	20	9	0	29
	75	47	0	122

B. South of Lizard Island (14°30'S) to Townsville

1976	6	7	4	17
1977	33	11	7	51
1978	20	4	4	28
1979	89	645	17	751
1980	90	866	10	966
	238	1533	42	1813

C. Southern Queensland

1979	0	0	3	3
1980	20	0	1	21
	20	0	4	24

Size of Tagged Fish

Figures 3 and 4 show the combined length frequencies for 1979 and 1980 Q.F.S releases. The most significant variation occurred in the Lizard Island area where I^+ class fish were poorly represented in both years. Perhaps also of interest was the dominance of I^+ class fish in the Cairns region and almost equal representation of I^+ and II^+ class fish off Townsville.

The differing length - frequency patterns were repeated for consecutive years and are unlikely to be caused by differential recruitment. A more plausible explanation would be to hypothesise size/age specific schooling patterns for particular reefs within the three northern Queensland areas studied. Commercial fishermen have long regarded certain reefs off Townsville to consistently produce fish of various classes, and the same may hold true for Cairns and Lizard Island. While no conscious attempt was made to direct fishing effort towards particular age classes, this may have been done unwillingly by aiming primarily at maximising the number of releases.

The LCF's of S. commerson tagged by Q.F.S varied between 50 and 133cms. Estimated LCF's of releases by commercial fishermen ranged from 50-68 cm. The smaller fish in this range reflect the size of first recruitment into the fishery and the larger fish, the size just below commercial acceptance. Measurement or estimated LCF's of amateur released fish in southern Queensland varied from 80 to 109 cm.

Condition of Released Fish

It has already been suggested that the presence of sharks on the Townsville grounds were a contributing factor to the higher rate of rejection for this area. The rate for 1979 and 1980 combined was 7.3% of landed fish off Townsville compared to 0.5% for Cairns - Lizard Island combined.

Neglecting the rejected fish, and comparing the numbers of fish released in the four condition categories, there was no significant difference ($x^2 = 7.18$, df = 3 NS at $\alpha < .01$) between Townsville and Cairns - Lizard Island. The implication is that the instantaneous release conditions were similar throughout the north Queensland tagging region.

E. SUMMARY OF OTHER SPECIES RELEASED

The spanish mackerel fishery in north Queensland is relatively monospecific, particularly if certain types of lures and baits are only used. While no effort was made to search for other species, 130 fish representing 8 families were tagged and released (TABLE - 1).

		North Qld 1979	North Qld 1980	South Qld 1980	TOTAL
- QUEENSLAND FISHERIES SERVICE					
Scombridae	Scomberomorus semifaciat s	3	0	0	3
	Scomberomorus munroi	1	0	1	2
	Scomberomorus queenslandicus	0	1	0	1
	Grammatocynus bicarinatus	8	15	0	23
	Acanthocybium solandri	0	1	3	4
	Euthynnus affinis	3	11	3	17
	Thunnus albacares	0	0	2	2
Carangidae	Seriola grandis	0	0	23	23
	other carangids	4	19	2	25
Corphaenidae	Corphaena hippurus	0	2	0	2
Rachycentridae	Rachycentron canadus	0	2	0	2
Sphyaenidae	Sphyraena species	5	11	1	17
Serranidae	Plectropoma leopardus	0	2	0	2
Echeneidae		0	0	1	1
- COMMERCIAL FISHERMEN					
Scombridae	Scomberomorus munroi	0	1	0	1
	Grammatocynus bicarinatus	0	1	0	1
	Thunnus albacares	1	0	0	1
Istiophoridae	Istiophorus platypterus	1	0	0	1
Carangidae		2	0	0	2
		28	66	36	130

Table 1 - Tag releases of species other than Scomberomorus commerson between 1979 and 1980.

B. RETURNS

Of the 1959 S. commerson tagged in Queensland waters with yellow dart tags since 1976, returns have been restricted to fish released between Lizard Island and Townsville in the north and around Brisbane in the south. By the end of April 1981 (i.e. at the end of the 1980 post season fishing period) 58 returns had been reported. Two returns originated from amateur releases in southern Queensland. Three tags could not be identified. For summary of tag release and recapture data see Appendix I.

A. Returns from North Queensland Releases (i.e. Lizard Island - Townsville)

PERIOD RELEASED

Returns (Releases)

Fishing Year	Pre Season		During Season		Post Season	
1976	1	(6)	0	(7)	1	(4)
1977	3	(33)	0	(11)	2	(7)
1978	0	(20)	0	(4)	0	(4)
1979	6	(89)	19	(645)	0	(17)
1980	8	(90)	13	(866)	0	(10)
	18	(238)	32	(1533)	3	(42)

B. Returns from South Queensland Releases

Fishing Year	Pre Season		During Season		Post Season	
1979	0	(0)	0	(0)	0	(3)
1980	1	(20)	0	(0)	1	(1)
	1	(20)	0	(0)	1	(4)

Partitioning the returns from 1979 and 1980 north Queensland releases into both year of release and period of recapture, it appears that additional returns are to be expected during the 1981 fishing year (i.e. May 1981 to April 1982).

I RETURNS BY FISHING PERIOD

(a) During release year

	Pre Season		During Season			Post Season	
Release Year	1979	1980	1979	1980		1979	1980
Returns	1	1	7	11	NQ	3	6
					SQ	2	3

(b) During following fishing year

	Pre Season		During Season			Post Season	
Release Year	1979	1980	1979	1980		1979	1980
Returns	3	*	6	*	NQ	1	*
					SQ	2	*

* Refers to fishing periods yet to occur.

Assuming that fishing effort during the 1980 and 1981 fishing years will remain relatively constant, it is likely that the tag return rates for a) fish tagged during 1979 - recaptured in 1980 and b) fish tagged during 1980 - recaptured in 1981, will be similar. Given that 30% more fish were tagged in 1980 than in 1979, it follows that actual tag returns from 1980 releases should be proportionally higher (30%) within the initial and subsequent years.

With 12 returns reported for releases made in 1979 and recaptured in 1980, then the best estimate of fish released in 1980 and likely to be recaptured in the 1981 fishing year is approximately 16. It would be premature at this stage to draw final conclusions from the available data until at least after the 1981 spawning season when most of the expected returns will be reported.

II SOURCES OF RETURNS

Release Organisations

The vast size of the Queensland coastline prompted Q.F.S to encourage fishermen to assist in releasing fish, particularly in the south, far north, and north west of the state. The involvement of these groups in "generating" recaptures is shown.

		Identified Recaptures - Releasing Group	
Fishing Years	Q.F.S	Commercial Fishermen	Q.F.S Sportfishing Project
1976-1978	6	1	0
1979-1980	42	4	2

As an incentive to improve the release quality of amateur tagged fish, the Q.F.S, as part of its Sportfish Tagging Project, has instituted a "Tag and Release Award" whereby the tagger receives a cloth emblem following the recovery of a tagged fish.

Reporting of Tags

The majority of returns in northern Queensland have been reported by commercial fishermen, while most of the returns from southern Queensland and northern N.S.W have been reported by amateurs. Although effort data is not available for the commercial and amateur fishery for S. commerson in Queensland, assigning returns to month of capture (Figure 5) gives some indication of both the change in abundance of the species and the effort expended throughout the year.

Non-Reporting of Tags

The number of unreported recaptures was known to be at least 10% in April 1980 (based on reports of misplaced tags), yet assessed to be as high as 20%. An active publicity programme conducted through amateur and commercial fishing magazines reduced the number of previously un-reported recaptures. The rate of non-reporting is presently known to be at least 5% over the entire period of tagging i.e. three tags lost or misplaced.

Three unidentified tags have been recaptured to date. The lettering on one tag had been removed by abrasion while the other tags had been shortened (presumably by an attack by a predatory fish) and almost totally enclosed in the dorsal musculature. As these tags could not be identified by number or Q.F.S label, it is likely that other tags in a similar condition may have been encountered and not reported. Therefore it is possible that the rate of non-reporting of tags is at least 5 - 10% i.e. the actual number of returns should be 5 - 10% higher than at present.

III RETURNS IN RELATION TO RELEASE CONDITION

All fish released by Q.F.S during 1979 and 1980 were assigned an arbitrary release condition taking into consideration factors such as bleeding, torn jaw structures, position of hook penetration, and rate of recovery when immediately released.

Release Rating

	1	2	3	4	TOTAL
No. of Releases	901	492	173	41	1607
No. of Returns	24	16	2	0	42
% Returns	2.7%	3.3%	1.2%	0	2.6%

Differences in the numbers (and percentages) of returns within the release categories were not significant (chi-square at .05 level) although there does appear to be a tendancy toward lower returns or survival rates from conditions 3 and 4.

On the arbitrary scale developed for categorising releases, conditions 1 and 2 differed only by small degrees of hook damage to the jaws and light bleeding. Condition 3 included fish out of the water for longer periods generally due to more complicated hook extractions. Condition 4 fish usually have hooks set deep into the upper jaw close to an eye, or were quite sluggish to recover immediately after release.

Small numbers prevented detailed examination of the relationship between return rates of 0^+ age class (approx. < 70cm) fish released by commercial fishermen and Q.F.S. Returns from commercial tagging in 1977, 1979, and 1980 ranged between 3.3 and 4.5% with Q.F.S returns from 1977 and 1980 fishing years showing little difference (4.8% and 3.2% respectively).

S. commerson 0^+ Releases South of $14^{\circ}30'S$

Fishing	Commercial Releases			Q.F.S Releases		
Year	Released	Returned	Return %	Released	Returned	Return %
1977	30	1	3.3%	21	1	4.8%
1979	86	3	3.5%	46	4	8.7%
1980	22	1	4.5%	31	1	3.2%
	138	5	3.6%	77	6	7.8%

A total of 4 recaptures from 46 Q.F.S releases in 1979 (8.7%) do not fit the above general return rate. However, in general I believe that the release conditions achieved by commercial fishermen are comparable to those of Q.F.S, thereby justifying confidence in the continuation of tagging activities by commercial fishermen in Torres Strait and Gulf of Carpentaria waters.

IV BIOLOGICAL INFORMATION

Relevant biological data pertinent to returns were recorded in a variety of ways. Of the 44 returns not examined by Q.F.S - 32% were recorded as weight only (generally headed and gutted by commercial fishermen and whole by amateurs) while the majority were measured in some way that permitted an estimated conversion to LCF. There is a growth differential between the sexes and thus it was disappointing to obtain only 21 recaptures accompanied by both length and sex data. Publicity for this requirement is to be maintained throughout the 1981 fishing year.

Only 12 heads were returned from tagged fish. Despite the low numbers, some 47 returns were assigned to one of three estimated year class groups i.e. 0^+, I^+, and $\geqslant II^+$ (for explanation see Appendix II).

During the tagging programme it b came quite apparent that errors incurred from release and recapture LCF measurement could be greater than the actual growth increment over short time periods. Of 12 recaptures at liberty for less than one month, 4 displayed negative growth increments. This result was not unexpected and it is likely that fish at large for up to two months at least should be neglected for growth rate determination. Growth rates will not be examined in this report, but will be the subject of a later publication.

V MOVEMENTS OF RETURNS

To simplify the expression of resultant movements or recapture vectors, two general conventions were adopted. First, distances between reefs were taken from the mid point along the reef face. Second, recaptures over distances greater than 95 nautical miles (nm) were regarded as due north or south, perhaps not strictly correct for long range movements yet sufficient to express movement as parallel to a generally north-south oriented coastline.

Figures 6 and 7 show the short term movements of *S. commerson* in the Cairns - Townsville and Lizard Island (-Cooktown) areas respectively. The longer range movements to southern waters, and movements within the south Queensland region are shown in Figure 8.

A) RECAPTURE VECTORS

The recapture vectors of returns from each tagging period were stratified by subsequent fishing periods.

In summary it appears that movements within the region of the north east Queensland fishery, up to and during the spawning season are small, with movements of resident and newly immigrant fish generally limited to the same or adjacent reefs (range 15nm).

At the conclusion of the spawning season, movements may remain local with perhaps a reduced tendancy toward concentrations on specific reef areas (range 50nm up to six months and range 140nm over periods in excess of a year), or are long range to southern waters (range 700nm).

Apart from very localised returns made within the Lizard Island area, the most northerly recorded movement was from Townsville to Cairns.

B) RECAPTURES IN RELATION TO SPECIFIC AREAS

Examination of the recapture vectors within each tagging year has provided some idea of the short term movement pattern of individuals of the species. These movements, and to a greater extent the relatively longer recapture vectors in subsequent years, may perhaps be better understood if the direction component of recapture vectors is related to bearings from specific localities within the general reef environment. Two possible examples of specific localities would be "spawning reefs" and inshore islands.

Munro (1942) suggested that spawning of S. commerson may occur at suitable localities between Cooktown and Gladstone but identified the main concentration of fish as occuring in the Townsville area. Munro identified the spawning areas by the condition of the fish, and the aggregation of fishermen that assembled each year from major Queensland ports. It has been only in recent decades that the Cairns and Lizard Island areas have become widely regarded as regions of spawning concentrations.

There is no accepted clear cut definition of "spawning reefs". Discussions with fishermen invariably provide endless exceptions to a "list" of spawning reefs, however assuming that spawning (as suggested by fish in at least a running ripe condition) may occur at suitable localities between Lizard Island and Gladstone there are three generally accepted areas of peak spawning aggregations within the northern region. Figure 9 shows the major areas off Townsville, Cairns - Port Douglas and Lizard Island.

Although evidence to relate recaptures to specific reef areas is available, no additional comment is warranted until the anticipated 1981 fishing season recaptures have been analysed.

C) Recaptures in Relation to Age Class

A total of 51 returns were assigned to one of the three age groupings. The terms used in this study are tentative - see Appendix II.

i.e. 0^+ class - second year fish

I^+ class - third year fish

II^+ class - fourth year and older fish.

The distance moved by individuals of the various year groupings within the initial, and subsequent years are presented in Table 2. Over short periods (i.e. within each tagging year) 0^+ class individuals appear more restricted in their movements than other year classes. The lack of observed movement and with few reports of the year class occurring south of Barrier Reef waters suggest that 0^+ class fish do not embark on a post spawning season migration.

With the older I^+ class, local movements tend to be more widespread. Southern migration, apparently at the conclusion of the first spawning season, becomes evident. A similar pattern of behaviour for II^+ class fish is also apparent.

Insufficient data from tagging results and statewide catch sampling precludes a detailed comparison of the relative proportions of each year class that embark on southern migrations. However, summarising all recapture data to show the geographical distribution of tag returns for each year class, does support a contention that a greater proportion of older year classes migrate.

Geographical Distribution of Tag Returns by Year Class

		Year Class		
NQ Releases	Returns	0^+	I^+	II^+
	NQ	6 (100%)	20 (90%)	13 (75%)
	SQ - NSW	0 (0%)	2 (10%)	4 (25%)
	TOTAL	6	22	17

DISCUSSION

Initially, a major objective of the programme was to determine the integrity of the fished stocks between the east coast and Gulf of Carpentaria. The results of the electrophoretic study did not detect any obvious variation between the stocks over northern Australia; however this is not to say that the stocks are identical. Low levels of interbreeding with pelagic species may be sufficient to mask any small difference that could exist with life histories.

Thus, rather than relying solely on the results of the electrophoretic technique, a tagging study should be undertaken in far northern waters. Whether or not there is sufficient Australian fishing effort in the far north and northwest to give adequate tag returns is uncertain.

The more concentrated tagging efforts within the east coast fishery have provided an outline of certain life history aspects of S. commerson. The results of the study should be regarded as tentative at this stage, as additional returns are anticipated during the 1981 fishing year. Despite this, additional returns are not expected to alter the essential elements of a preliminary model proposed here for S. commerson movements on the east coast of Queensland, south of $14^{\circ}30'S$.

The presence of size independant, non moving individuals or groups, of members of species generally regarded as migratory has been reported elsewhere. Tanaka (1979) felt there was evidence to suggest local groups of yellowtail Seriola quinqueradiata on the eastern coast of Japan. Skipjack in northern Papua New Guinea waters were shown to be comprised of resident and nomadic components (Lewis, 1980), the presence of the latter being influenced by variations in the levels of primary productivity.

Models

A. During the Spawning Season

The north Queensland spawning reefs are closely adjacent to the inshore areas where young of year S. commerson are encountered most frequently on Queensland coast (McPherson, 1981). With respect to S. commerson in far southern reef waters which are of extreme distances from the coast, there is an apparent movement of fish toward inshore areas to spawn.

The dependance on inshore areas for juvenile development is in marked contrast to S. cavalla which in many ways is the ecological eqivalent of S. commerson in Florida waters. No estuarine-inshore component has been attributed to the early development of this species.

The fish encountered on spawning reefs are aggregations of both resident and migratory fish. Movement of both groups (or individuals) appear to be limited, a reasonable claim as this would tend to favour optimal spawning conditions. Unpublished data and the observations of Munro (1942) suggest that age at first spawning is at approximately two years (year class I^+). Whether full spawning potential is attained at this time is the subject of further study, yet is suffices to say that this age class makes a significant contribution to the total spawning effort.

B. Post Spawning Period

The segregation of individuals or schools of fish into resident or migratory components commences at the conclusion of the spawning season when catch rates drop dramatically and resident fish have spent or resting gonads. This division first occurs within the I^+ age group, but is observed for subsequent year classes.

Migratory Fish

The location of the southward migration routes is not known. A small number of tag returns within north Queensland have provided some evidence that movement may be within the steamer track inside the Great Barrier Reef. Like the other seventeen species in the genus, S. commerson is found within continental shelf waters and usually in shallow water less than 100 metres deep. Movement south of reef waters could well be within short distances of the coast.

The speed of movement may be quite rapid. Indirect evidence from one return has shown a possible upper limit of 950 nautical miles in about 28 days, a daily average of 34 nautical miles.

Orr (1933) citing the Australia Pilot (1928) identified a south going current within the Barrier Reef during the summer months (November - January). Further to the south, beyond the limits of the Barrier Reef and in near shore waters, the Australia Pilot III (1973) represents a current set of 21 - 24 nautical miles per day at the time of the recorded migrations. Thus currents may greatly assist the southward migration of S. commerson.

A return of an amateur tagged fish within a short distance of its release site in southern Queensland suggests that migratory I^+ class fish at least, may not move appreciable distances when summer destinations have been reached.

Resident Fish

Concomitant with the departure of migratory fish from the spawning reefs, the resident fish generally disperse throughout the overall reef area. Tag returns indicate that S. commerson do not appear to move far within the post spawning period. Small 0^+ class fish probably move the least distances. This group does show more propensity to school in the traditional sense than other classes, yet overall movement is low as the schools tend to remain around specific foci e.g. certain reefs or inshore islands.

In the later months of the post spawning period, young of year fish are first recruited to the resident stocks in reef waters (McPherson, 1981).

C. Pre Spawning Season

Migratory Fish

No direct tag return information is available to substantiate a northward migration of S. commerson. The movement is hypothesised from the disappearance of the species from troll catches in northern N.S.W waters (30°S latitude) during April - May, and a progression of peak Queensland Fish Board landings between Brisbane and Mackay after April. That there are progressive peaks towards the north may be evidence that the pre spawning migration proceeds at a slower rate than the post spawning movement. This rate of movement is not unexpected as it would be initially directed into a south setting current of 21 - 24 nautical miles per day to the southern limits of the Barrier Reef. From the Capricorn Channel and to the north within the steamer track, the energetic efficiency of the migration would be enhanced by a trade wind induced north west current (Woodland, 1970; Cresswell and Greig, 1978; Australia Pilot III, 1973).

Resident Fish

Little variation is likely from the behaviour of this category during the post spawning season. Towards the conclusion of this period there may be a general movement towards the spawning reefs. Recruitment of young of year fish (becoming 0^+ class) from inshore development grounds is maintained.

Implications for Management

The tagging results have shown that *S. commerson* is most vulnerable to fishing presure during the spawning season when individual fish movements appear to rarely extend beyond adjacent reefs.

The numbers of fish tagged in this programme are not considered sufficient to estimate the size of the Queensland east coast stocks of *S. commerson* by way of the recapture rate. However the 2.9% return rate on the 1st May 1981 and the projected rate of 3.7% by 1st May 1982 is likely to stabilise at an annual return rate of 3.3%. A significant figure when compared to the 4 to 4.5% annual return rate from the US fishery for *S. cavalla* which is considered to be a far more intensive fishery and under consideration for management measures (Williams, personal communication).

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APPENDIX I

ecapture No	Area Release	Date Years/Months	LCF (cm)	Area Recapture	Time Out Years/Months	Distance (nautical miles)	Direction (°)	Growth (cm)
1	C	12-76	88	SQ	3.5	822	180°	4*
2	C	6-77	62	C	1.6	0	-	4*
3	C	6-77	86	C	1.6	0	-	0*
4	C	6-77	88	C	4.4	9	130°	4
5	C-T	12-77	91	C-T	2.2	0	-	1
	C	9-76	100	C	1/11.4	26	-	10
7	C	12-77	64*	C-T	10.3	98	180°	23*
8	C	8-79	82	C	0.2	7	240°	1
9				UNIDENTIFIED				
10	C	8-79	84	C	1.6	8	280°	2
11	C	8-79	66	C	2.1	0	-	2
12	C	10-79	86	C	0.5	15	140°	1
13	C	11-79	79	C	0.3	0	-	0
14	C	10-79	88	C	1.5	22	140°	0
15	C	11-79	91	C	0.3	29	165°	0
16	C	10-79	66	C	1.3	0	-	-
17	L	10-79	80	L	1.1	42	180°	-
18	C	8-79	99	C	2.6	0	-	3*
	L	10-79	67	C	1.1	0	-	0
20	T	11-79	100	NSW	5.2	880	180°	2
21	C	11-79	82	C	9.3	10	160°	9
22	T	11-79	106	NSW	3.8	809	180°	-
23	L	11-79	67*	L	9.9	58	180°	13*
24	C	10-79	86	C-T	11.3	85	170°	6
25	C	8-79	56	C	1/1.6	11	290°	17
26	C	9-80	57	C	0.7	12	290°	-1*
27	C	9-80	87	C	0.8	9	315°	0
28	C	9-80	79	C	1.0	0	-	1
29	T	11-79	99	C	11.2	140	0°	4
30	C	9-80	65	C	2.3	0	0°	2

Recapture No	Area Release	Date Years/Months	LCF (cm)	Area Recapture	Time Out Years/Months	Distance (nautical miles)	Direction (°)	Growth (cm)
31	C	10-80	83	C	0.3	0	-	0
32	C	9-80	103	C	2.3	0	-	0
33	T	11-80	95	T	0.1	16	160°	0*
34	T	11-80	94	T	0.1	0	-	0*
35	C	10-79	85	T	1/0.3	116	180°	14*
36	C	9-80	93	T	1.4	98	180°	-
37	C	11-79	91	T	11.9	96	180°	11
38	C	9-80	92	T	1.8	115	180°	2
39	C	9-80	89	T	1.8	105	180°	-
40	T	11-79	86	T	11.2	7	120°	7*
41	T	11-80	94	T	0.5	28	320°	0*
42	T	11-80	100	T	0.4	0	-	0*
43	T	11-79	92	T	11.3	7	300°	7
44	C	11-80	89	T	0.7	115	180°	0
45	L	10-79	67	NSW	1/1.1	950	180°	27
46	C	10-80	80	C	2.0	10	90°	4*
47				UNIDENTIFIED				
48	NSW	5-80	105	NSW	7.3	102	180°	2
49	C	11-80	85	C	1.8	7	45°	3
50	T	11-80	95	NSW	3.0	725	180°	-
51				UNIDENTIFIED				
52	SQ	1-81(?)	-	SQ	UNCERTAIN	TO	DATE	
53	C	11-80	103	C-T	4.0	45	150°	4*
54	C	11-79	87	SQ	1/3.4	800	180°	7*
55	C	7-79	55*	C	1/7.5	2	315°	34*
56	C	10-80	78	C	5.2	10	200°	9
57	T	11-80	101	NSW	5.4	880	180°	-
58	C	11-80	94	NSW	5.8	850°	180°	-

APPENDIX I Summary table of approximate tag release and recapture data.

Key to Appendix I

Area Release/Recapture - C (Cairns), T (Townsville), L (Lizard Island), SQ (Brisbane, Southern Queensland), NSW (Northern NSW).

Growth - * represents an estimate growth increment.

APPENDIX II

AGE CLASSES

Tentative age class terminology for S. commerson at this stage is similar to that of Malcolm (1960) and Stanley (1978) for Arripis trutta. This system was adopted for the period of otolith reading and analysis as it suited many aspects of the observed growth patterns.

Adoption of a modified scheme may be considered at a later stage.

Present Age Class Term	Approximate LCF Range	Fishermens Term For Size Class	Age
"0" (Young of Year)	< 50cm	rare, usually "doggie"	first year
0^+	50-80cm	"doggie"	second year
I^+	80-92cm	"winter" or "school"	third year
$\geqslant II^+$	> 92cm	"school" 100cm	fourth year

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$\geqslant II^+$	> 92cm	"school" 100cm	fourth year

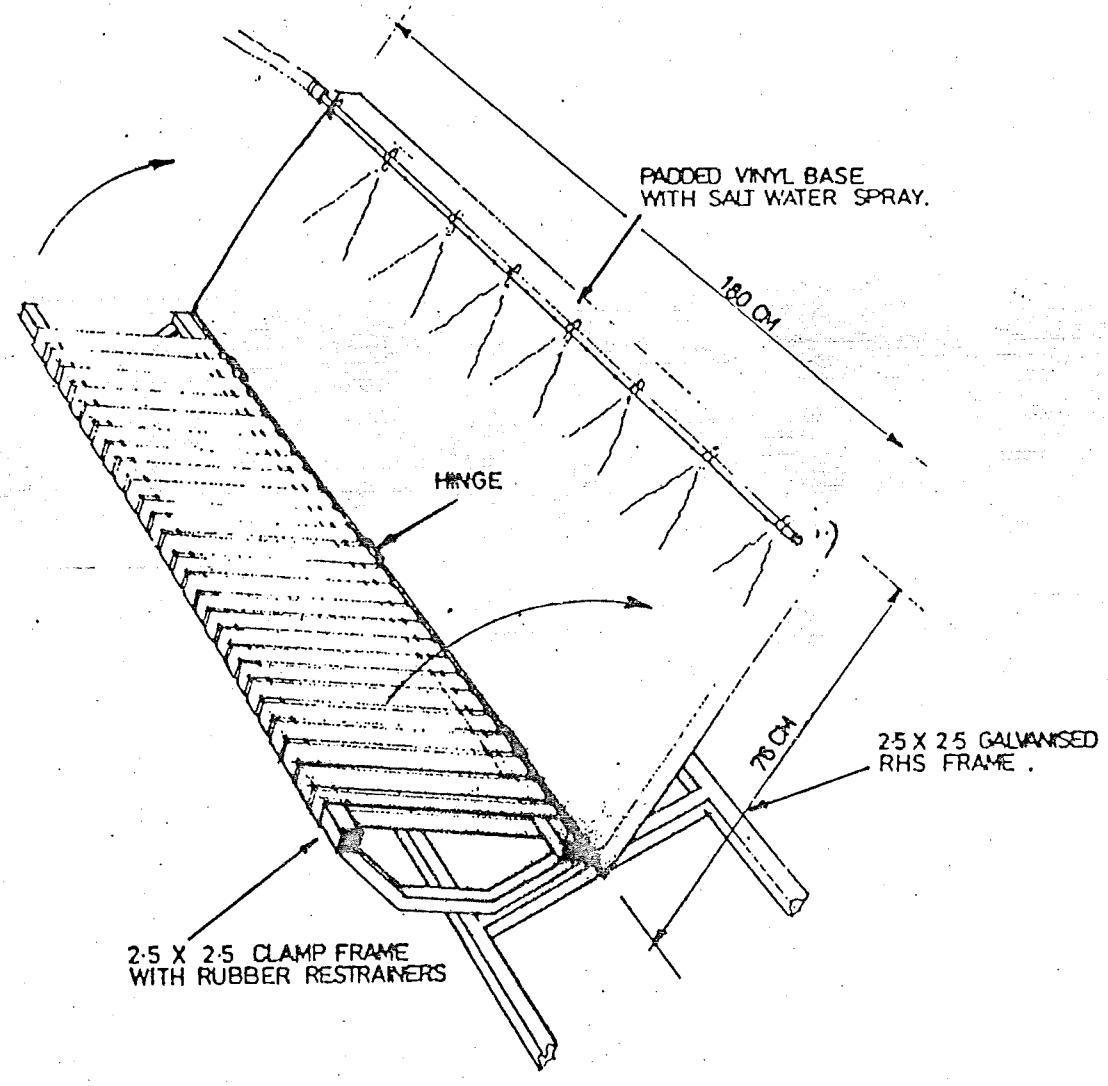

Figure 1. Schematic diagram of the tagging cradle design for the FIRTA programme.

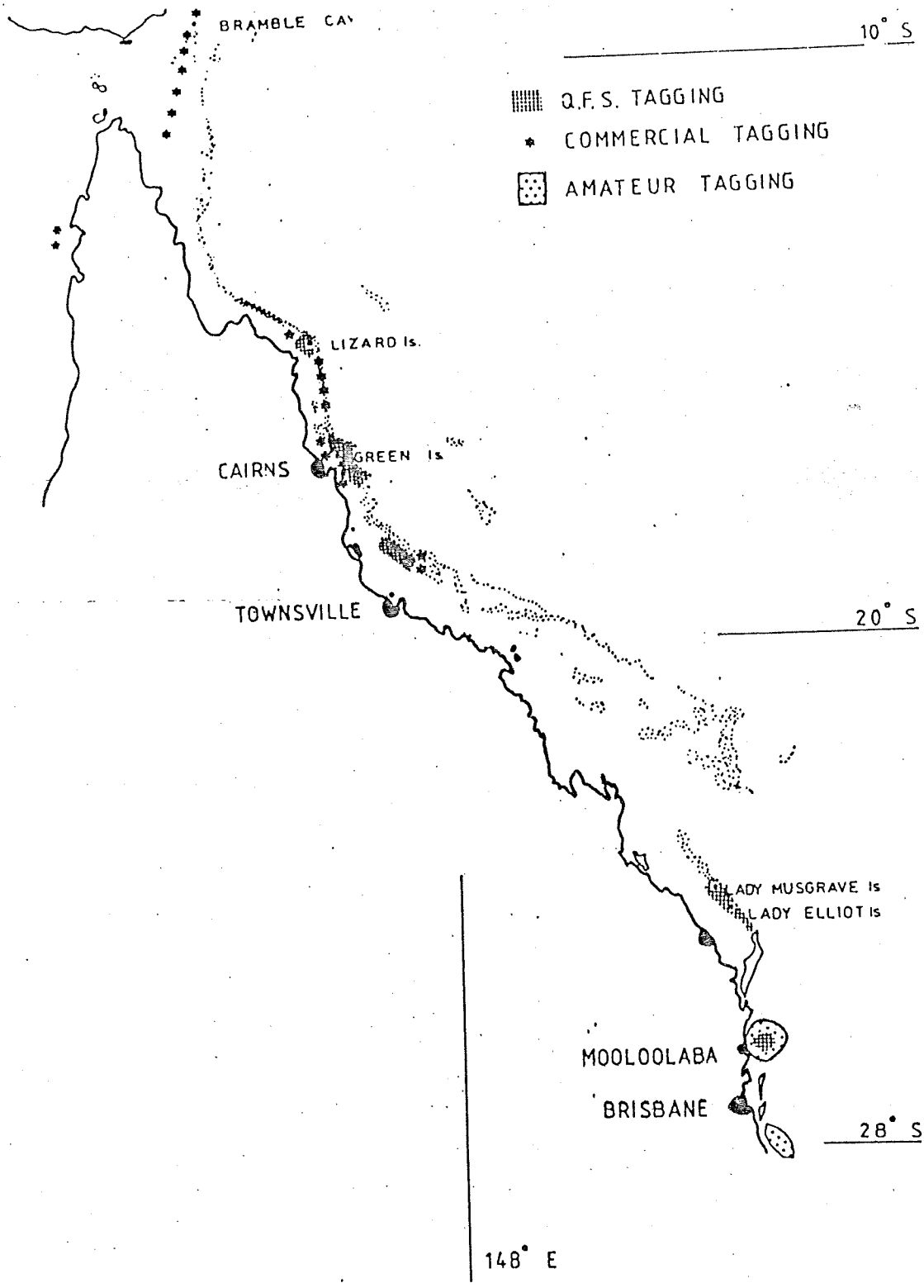

Figure 2. Tag Release areas.

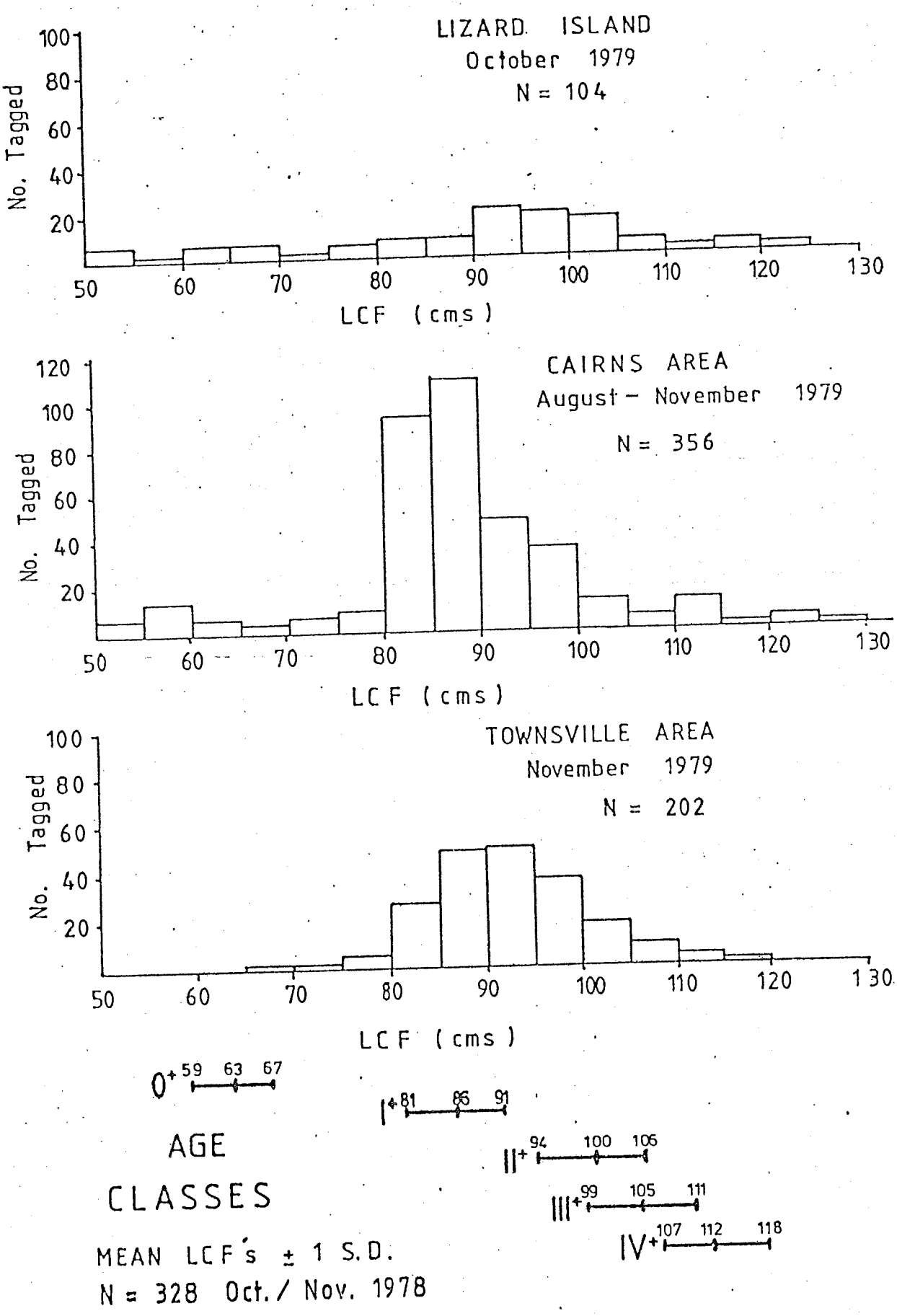

Figure 3. Length frequencies of Q.F.S released S. commerson in north Queensland, August - November 1979.

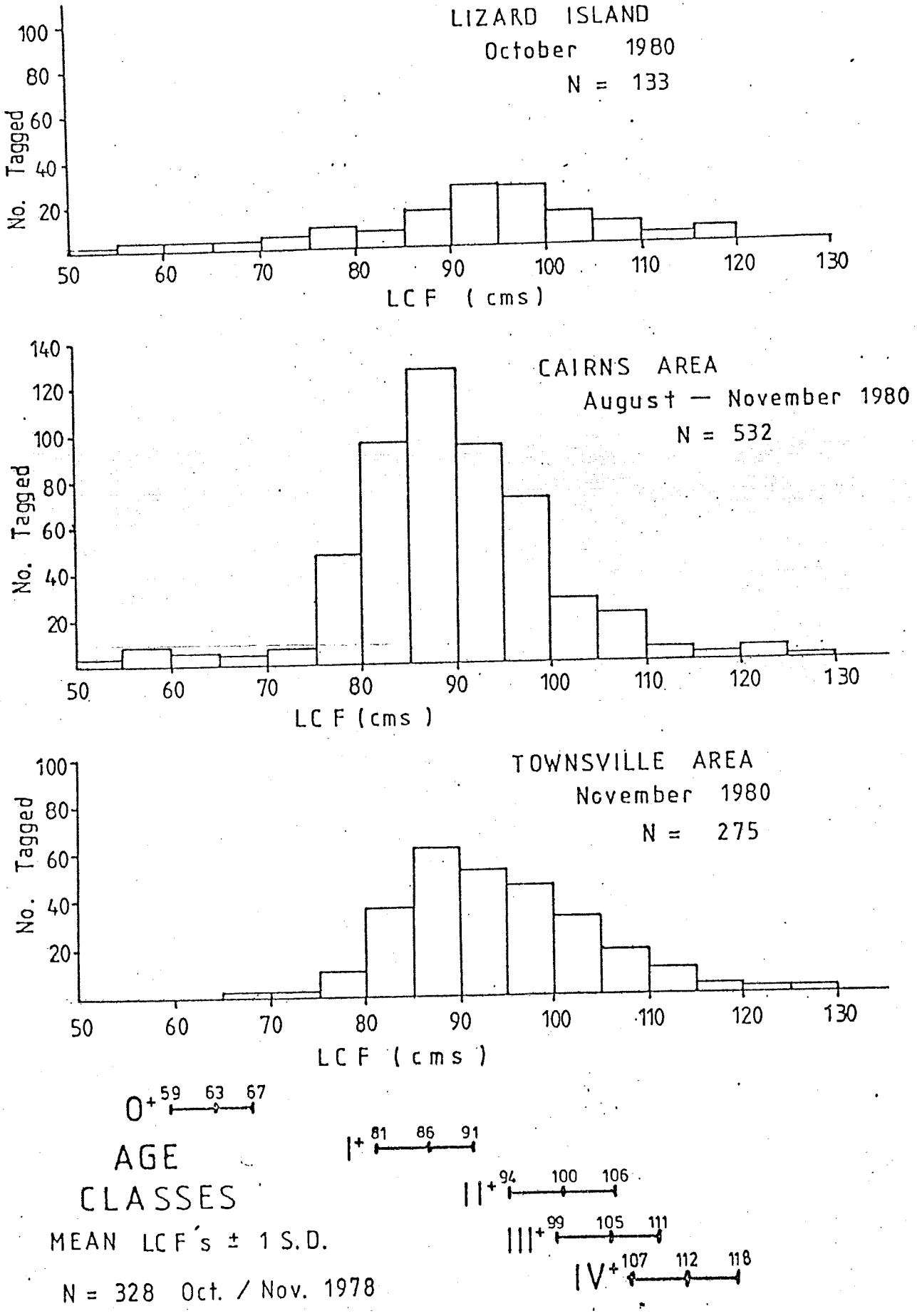

Figure 4. Length frequencies of Q.F.S released S. commerson in north Queensland, August - November 1980.

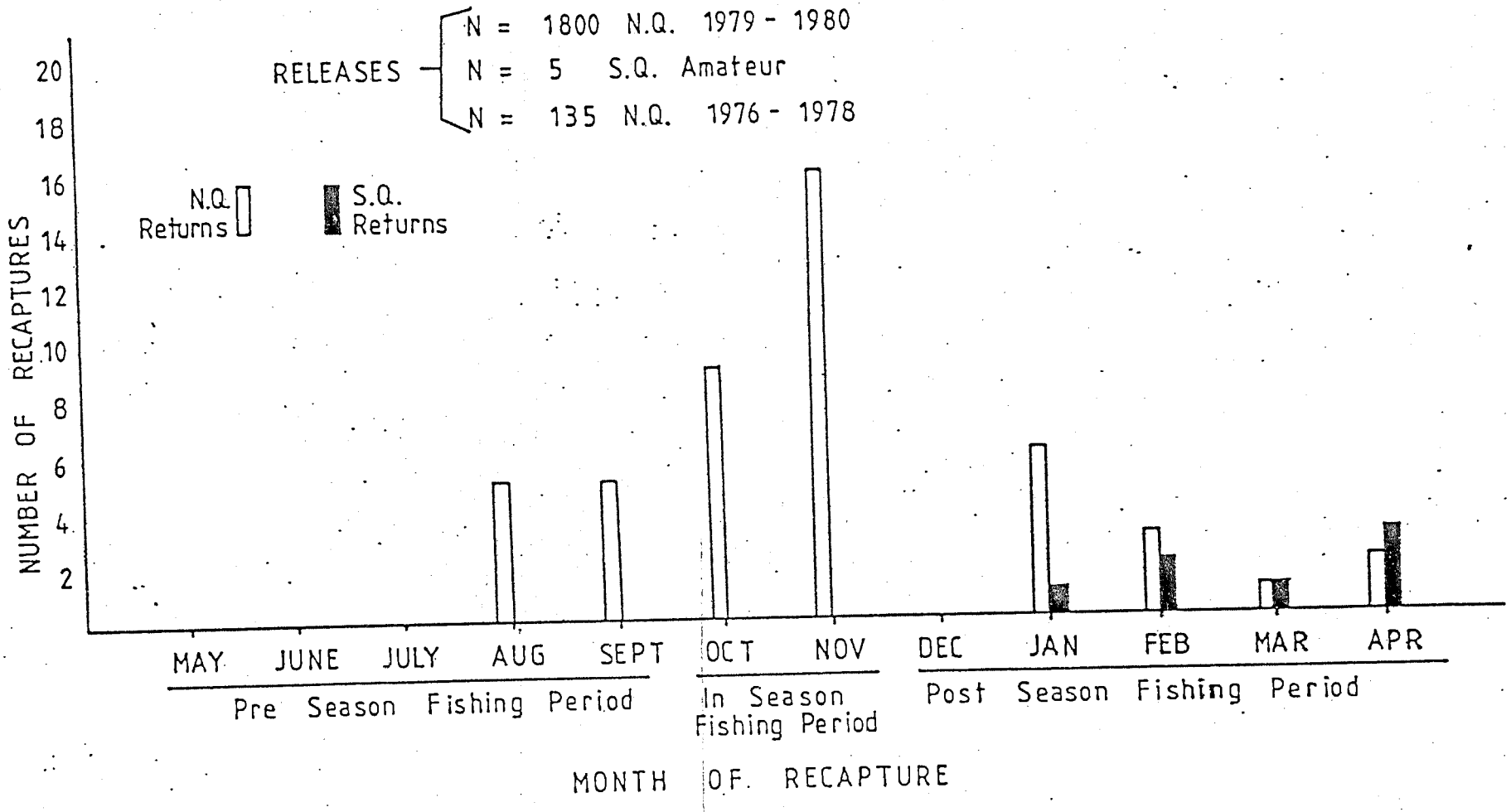

Figure 5. Number of tag recaptures by month of recapture.

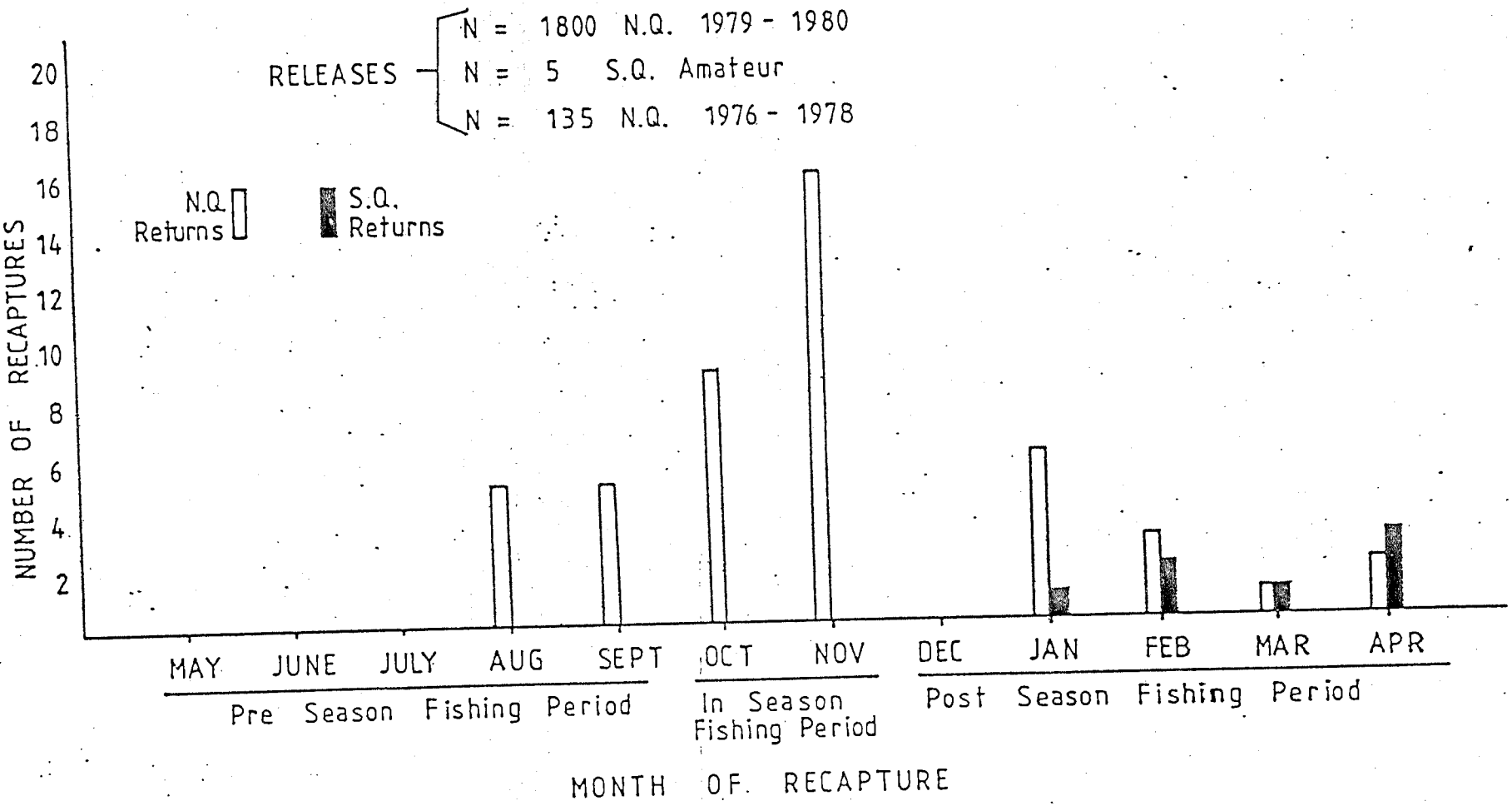

Figure 5. Number of tag recaptures by month of recapture.

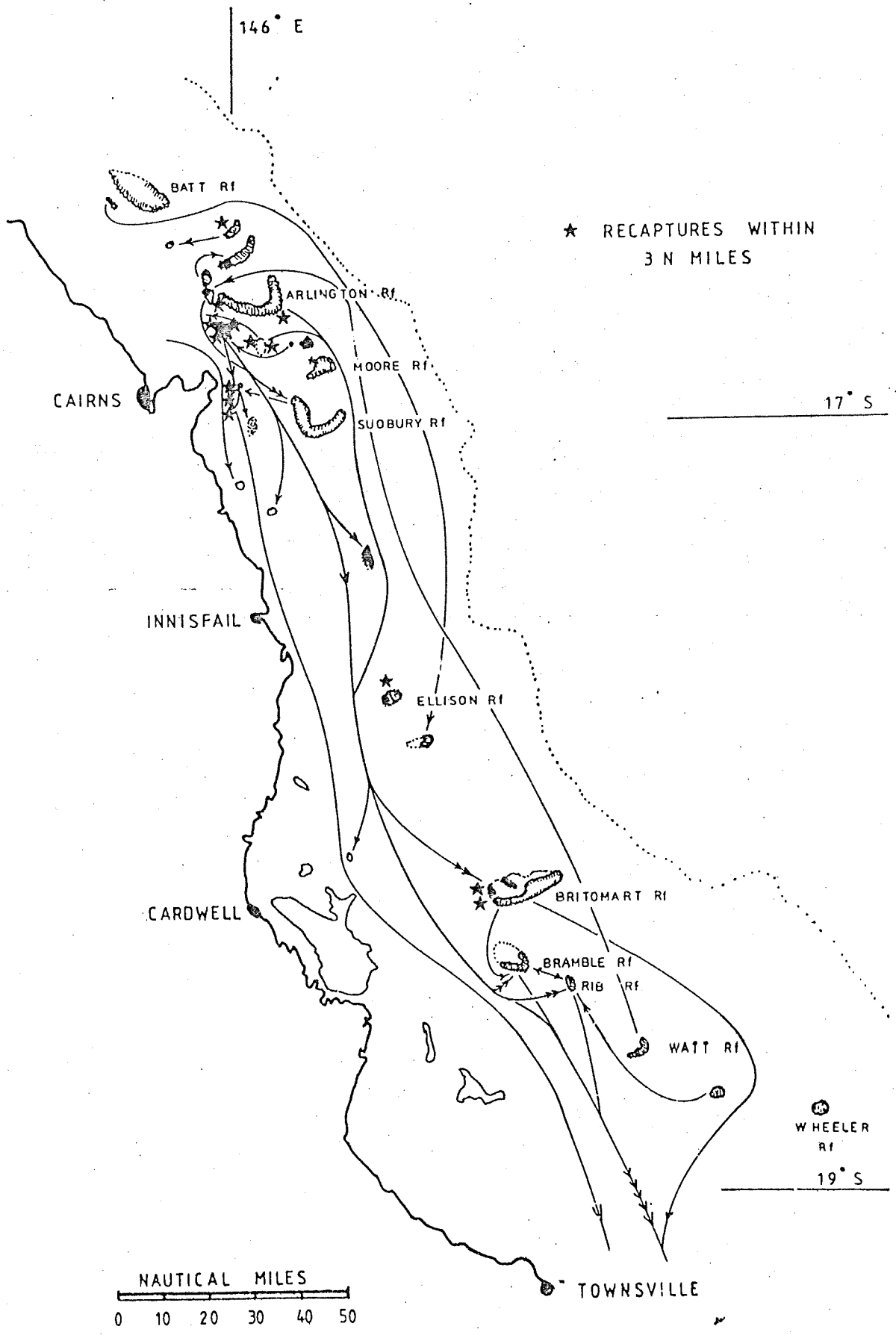

Figure 6. S. commerson movements in the Cairns - Townsville area. Movements beyond Watt Rf are long range to southern Queensland and northern NSW.

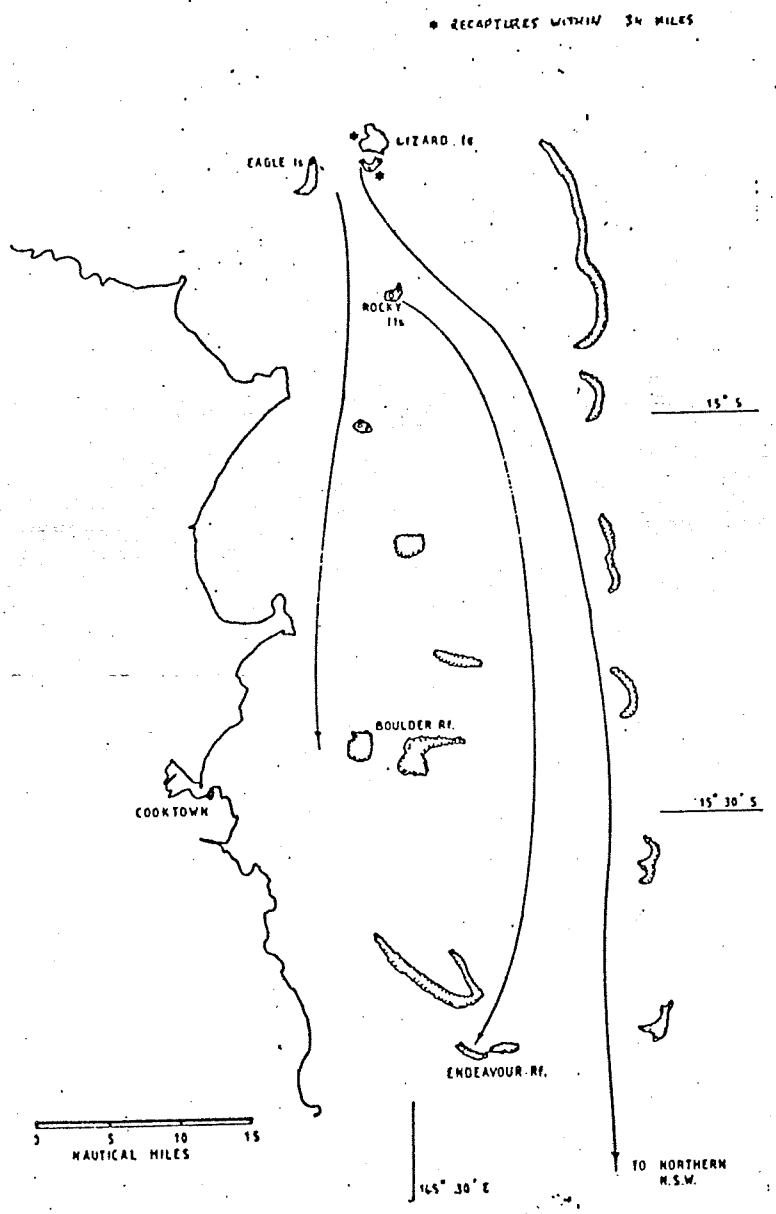

Figure 7. S. commerson movements in the Lizard Island - Cooktown area.

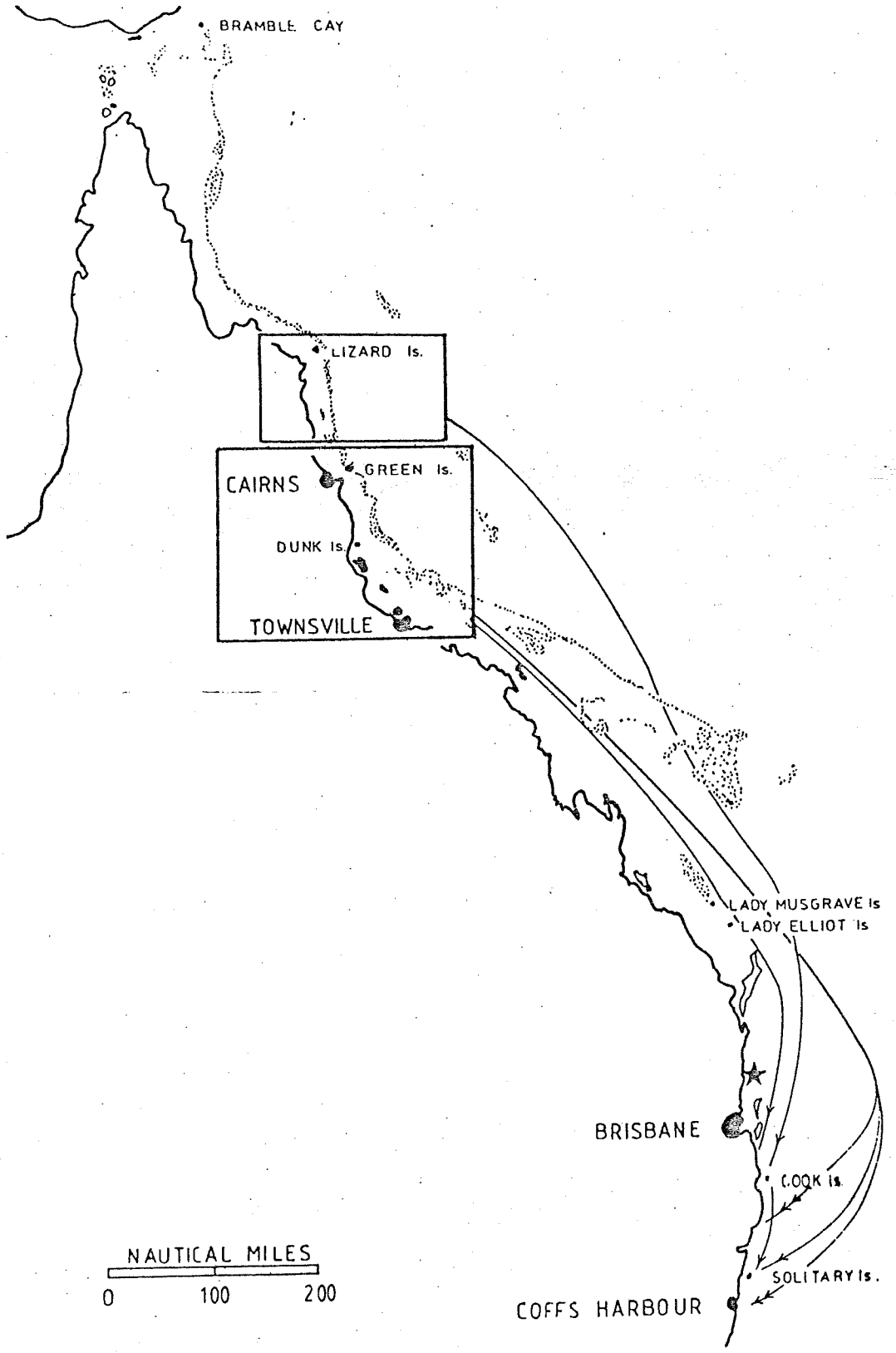

Figure 8. Long range movements from the Lizard Island - Cooktown and Cairns - Townsville areas.

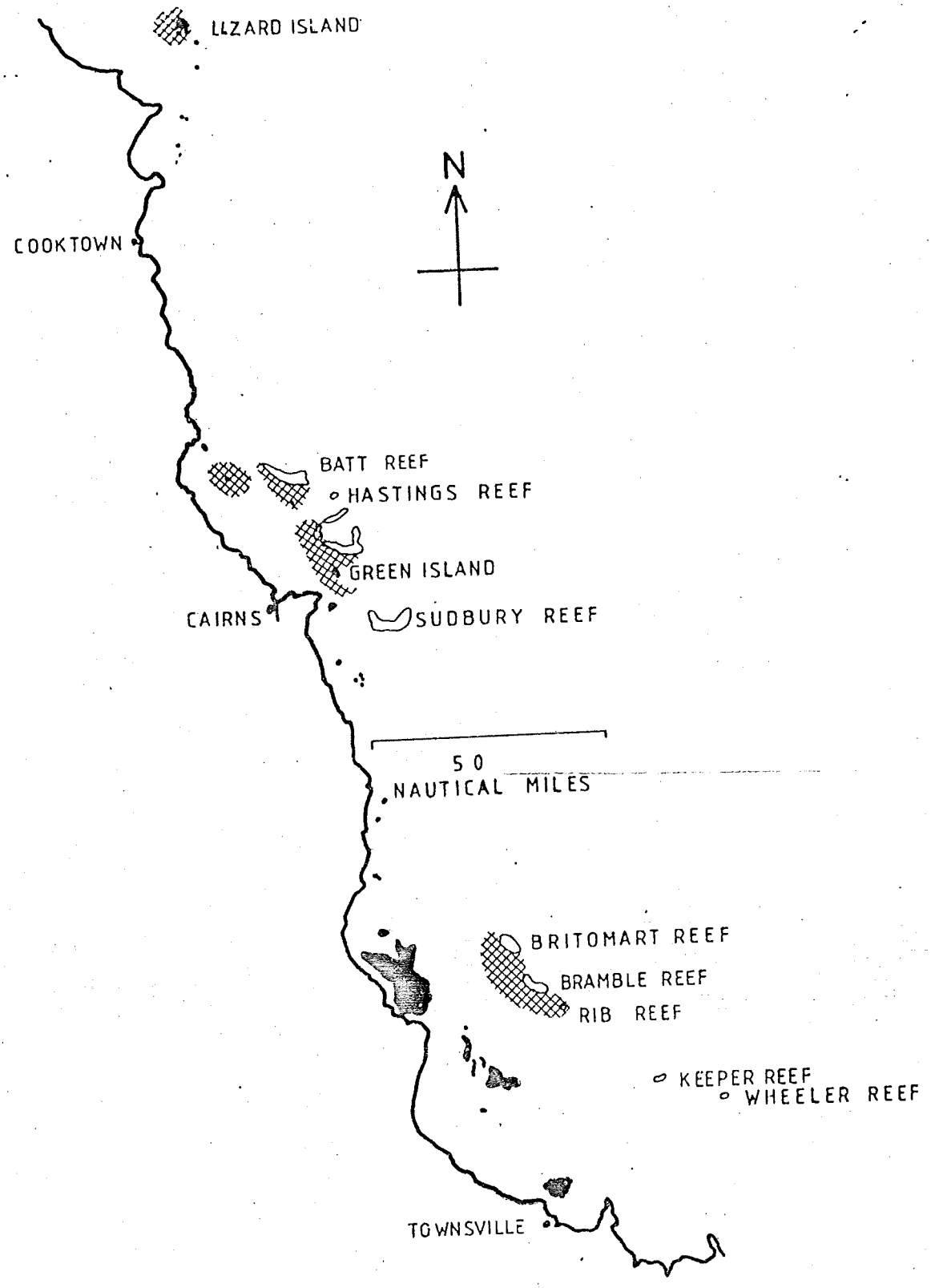

Figure 9. Major "spawning reef" areas in north Queensland.