

The Tagging and Marking of Marine Animals in Australia

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THE TAGGING AND MARKING OF MARINE ANIMALS IN AUSTRALIA

By J. M. THOMSON*

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Summary

Twelve different tags or marks have been applied to 183,113 aquatic animals (whales, fish, Crustacea, and shellfish) in Australian waters. Recoveries total 9918 (or 5.5%). The internal tag has given most satisfaction in those species which are cleaned before marketing. For medium or small fish sold in the round, the opercular tag is preferred, except in fish with soft opercles. Hydrostatic tags have been returned at a rate greater than normal fishing mortality; also they and Petersen disks are not favoured because of the wounds produced on a large proportion of fish. Petersen disks are known to work out of shark fins. The modified streamer tag with a plastic head is the most promising tag used on tuna. In crayfish, telson punches last over several moults but become more obscure with each ecdysis; the dart tag now being tested seems most promising. The most suitable tag may vary with age because of the different nature of the fishery operating on young and old age groups (e.g. Australian salmon).

Publicity has been provided by newspapers, periodicals, radio, printed notices, and personal contact. Incentive is provided by monetary reward.

I. INTRODUCTION

This text was prepared for a Symposium on Fish Marketing convened by the International Commission for the Northwest Atlantic Fisheries, and held on May 24-27, 1961, at the Biological Laboratory of the Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, Woods Hole, Mass. It was prepared from the publications listed in Section VIII, from catalogued data, and from information supplied by Dr. A. G. Nicholls (trout), Dr. W. B. Malcolm (Australian salmon and tommy-ruff), Dr. D. E. Kurth (flathead and flounder), Dr. K. Sheard (western crayfish), Mr. A. M. Olsen (southern crayfish, scallop, and school shark), Mr. J. S. Hynd (pearlshell), and Mr. T. R. Cowper (barracouta and gummy shark). Particular thanks are due to Mr. A. Dunbavin Butcher, Director of Fisheries and Wildlife in the State of Victoria, Mr. N. V. Harris, Superintendent of Fisheries in the State of New South Wales, and to Mr. A. J. Fraser, Director of Fisheries in the State of Western Australia, who made available information on tagging carried out by officers of their respective departments.

Because of editorial requirements the version which will appear in the printed record of the Symposium will be shortened. The full text of the paper is presented here because it contains a complete record of Australian activity in this field, and should prove a most useful reference.

II. TYPES OF TAG

Twelve different tags or marks have been applied to fish and other marine animals in Australian waters (Table 1) and some have been attached by more than

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TABLE I
 TYPES OF TAGS USED ON EACH SPECIES

Common Name	Scientific Name	Petersen Disk	Strap	Internal	Hydrostatic	Silver Tape	Fin Clip	Telson Punch	Miscellaneous	Total
<i>Teleostean Freshwater Species:</i>										
1. Brown trout	<i>Salmo trutta</i>		2,845	35		74	18,742			21,696
2. Rainbow trout	<i>Salmo gairdneri</i>		2,258			122	17,455			19,835
3. Australian buss	<i>Percalates colonorum</i>		70							70
4. Gallop	<i>Plectrophites ambignus</i>			502						502
5. Murray cod	<i>Maccullochella macquariensis</i>			2						2
<i>Teleostean Flatfishes:</i>										
6. Smalltooth flounder	<i>Pseudorhombus jenynsi</i>	7		169						116
7. Greenback flounder	<i>Rhombosolen tapirina</i>	626								626
<i>Tunas:</i>										
8. Southern bluefin tuna	<i>Thunnus thynnus maccoyii</i>								600*	600
9. Yellowfin tuna	<i>Neothunnus macroptera</i>								82*	82
10. Albacore	<i>Thunnus germa</i>								1*	1
11. Striped tuna	<i>Katsuwonus pelamis</i>								1*	1
<i>Mullets:</i>										
12. Sea mullet	<i>Mugil cephalus</i>	18	21,581	69					872†	22,598
13. Flat-tail mullet	<i>Liza argentea</i>		3,915		58					3,934
14. Yellow-eye mullet	<i>Aldrichetta forsteri</i>		1,550		19					1,550
15. Telegalene	<i>Mycus elongatus</i>	5	164							172
16. Freshwater mullet	<i>Trachystoma petarii</i>		1		3					1
17. Diamond-scale mullet	<i>Liza virgata</i>		98							98
<i>Thraupins:</i>										
18. Cooktown salmon	<i>Eleutheronema tetradactylum</i>		14							14
19. Burnett salmon	<i>Polydactylus sherridani</i>		6							6
<i>Trevallies, etc.</i>										
20. Trevally	<i>Usacaranx nobilis</i>		206							206
21. Tailor	<i>Pomatomus saltator</i>		199							200

TABLE 1 (Continued)

Common Name	Scientific Name	Petersen Disk	Strip	Internal	Hydrostatic	Silver Tape	Fin Clip	Telson Punch	Miscellaneous	Total
<i>Elaeobranchs:</i>										
52. School shark	<i>Galeorhinus australis</i>	6,167		2,922						6,502*
53. Gummy shark	<i>Mustelus antarcticus</i>	368		567						567*
54. Whiskery shark	<i>Furgaleus ventralis</i>			2						2*
55. Whaler	<i>Carcharhinus greyi</i>			1						1
56. Blacktip shark	<i>Carcharhinus spallanzani</i>			2						2
57. Tiger shark	<i>Galeocerda cuvieri</i>			1						1
58. Spurdog	<i>Squalus megalops</i>			24						24
59. White-spotted dogfish	<i>Squalus karka</i>			59						59
60. Port Jackson shark	<i>Heterodontus portus-jacksoni</i>			7						7
61. Cobbler shark	<i>Sutorectus tentaculatus</i>			1						1
62. Spotted catshark	<i>Halaelurus analis</i>			1						1
63. Stingaree	<i>Urolophus testaceus</i>	92	6							28
64. Melbourne skate	<i>Raja whitleyi</i>			8						8
65. Common skate	<i>Raja lemprierei</i>			1						1
<i>Crustaceans:</i>										
66. Western crayfish	<i>Pandirus longipes</i>							12,976		12,976
67. Southern crayfish	<i>Josus latandii</i>							7,847		9,400
<i>Molluscs:</i>										
68. Scallops	<i>Pecten meridionalis</i>	5,000				4,200				9,200
69. Goldlip pearlshell	<i>Pinctada mazima</i>	6,842								6,842
70. Blacklip pearlshell	<i>Pinctada margaritifera</i>	1,000								1,000
<i>Whales</i>										
71. Humpback whale	<i>Megaptera nodosa</i>								1,323	1,323†
Totals		25,417	66,157	27,824	248	4,727	36,197	20,823	4,432	183,106*

* 2587 school sharks and 368 dummy sharks tagged with both types.

† Dart.

‡ Whale marks.

one method. One or more individuals of 71 species have been tagged or otherwise marked. Table 1 shows that two species have been marked, in numbers in excess of 20,000, four in excess of 10,000 but fewer than 20,000, and 17 in excess of 1000 but fewer than 10,000. The remainder have been tagged in numbers fewer than 1000. Some of these have been tagged in very few numbers indeed for reasons that are dealt with below in the sections discussing the Lake Macquarie investigation and the northern Queensland investigation.

(a) *Strap Tag*

Made in monel metal or german silver, three sizes of strap tag have been used. The majority were 35 mm long, 3.0 mm wide, and 0.6 mm thick. Besides these,

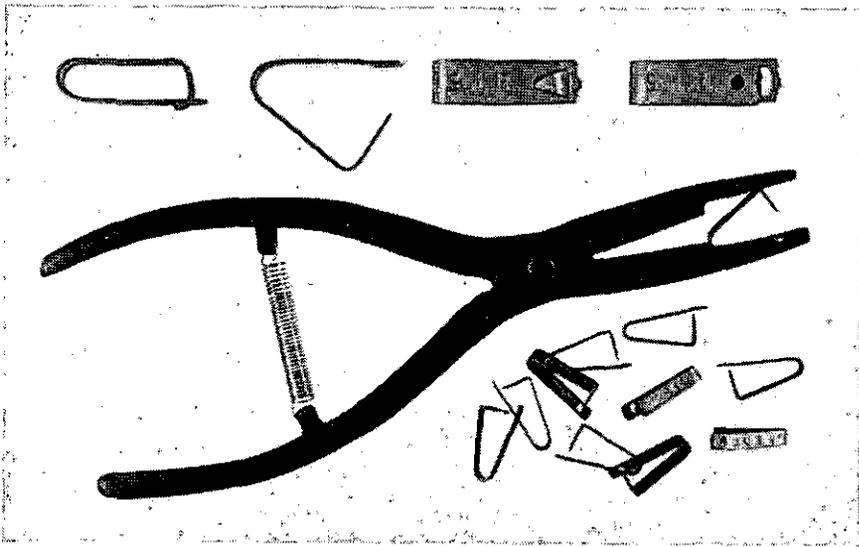


Fig. 1.—Strap tags and clenching pliers.

a smaller number of "fingerling" tags 21 by 2.0 by 0.3 mm and some larger tags 58 by 6.5 by 0.6 mm have been used. All were applied by means of specially made pliers (Fig. 1), the nose pieces of which were incised to hold the tag of appropriate size. On one side, at the point where the opening in the strap tag would lie, the inner face of the nose piece contained a groove into which the tongue of the strap tag would project after passing through the hole. The dimensions of the groove were such that the tongue would be forced over to be clenched immovably.

The great majority of strap tags were placed on the operculum, except in the case of leatherjackets (*Monacanthidae*), where they were placed ventrally immediately behind the ventral spine, some barracouta, where they were clenched on the dorsal fin, and some trout and Australian salmon, where they were clenched about the lower jaw. When used as jaw tags the straps were at first applied and rounded off as described by Shetter (1936). Later it was found that rounding was unnecessary

(Nicholls 1957). One arm of the strap tags bore a serial number; the other the letters C.S.I.R. or later C.S.I.R.O., to indicate the tagging organization. This type of tag has been used on 42 species (Table 1).

(b) *Petersen Disk*

These disks were 16 mm in diameter and 1 mm thick. They were attached in pairs, one disk on either side of the tissue pierced. One of the pair was stamped with a serial number and the letters C.S.I.R. (Fig. 2); the other was a blank useful only as a guard to prevent the attachment wire working back through the tissue. The first disks used were of white plastic; later the backing disk was made of clear celluloid. Subsequently, because a number of returned disks showed peculiar scratches and indentations suggesting that the white disks had attracted undesirable attention from other fish, a grey disk was substituted for the white.

When applied to a thin tissue such as the dorsal fin of school and gummy sharks the wire was passed through a hole previously pierced by an awl. Thick tissue such as the fleshy base of the dorsal fin or the caudal peduncle was pierced by a hollow-stemmed needle in the base of which the silver attachment wire was inserted. On passing to the far side the needle was completely removed, leaving the wire projecting and prevented from passing right through by the numbered disk previously threaded upon it. The blank tag was then threaded on the wire; any great excess of wire was cut off and the remainder twisted into a knot by a pair of sharp-nosed pliers. The disk was cemented on mollusc shells (Fig. 3) (Tubb 1946). This type of tag has been used on 21 species.

(c) *Hydrostatic Tag*

The type used was as described in the anonymous (Anon. 1953) Guide to Fish Marks, the dimensions being 45 mm in length and 4 mm in diameter. These were attached by means of silver wire bridles either at the base of the caudal fin or on the caudal peduncle by a hollow-stemmed needle. This type of tag has been used on 13 species, though only in small numbers.

(d) *Silver Tape Tag*

A flat piece of silver tape bearing a number was attached to a few Australian salmon and trout and a few thousand scallops. They were similar to the numbered tags used to identify museum specimens and were attached in the same way by means of a silver wire either to the operculum, the jaw, or the base of the tail, through a hole pierced by an awl. They were attached to scallop shells by passing the wire through a small hole drilled at the shoulder.

(e) *Internal Tag*

The internal tags used were of white plastic with a serial number and instruction for return printed in black (Fig. 2). The tags were inserted into the body cavity through an incision made in the body wall by means of a scalpel (Fig. 4). Three

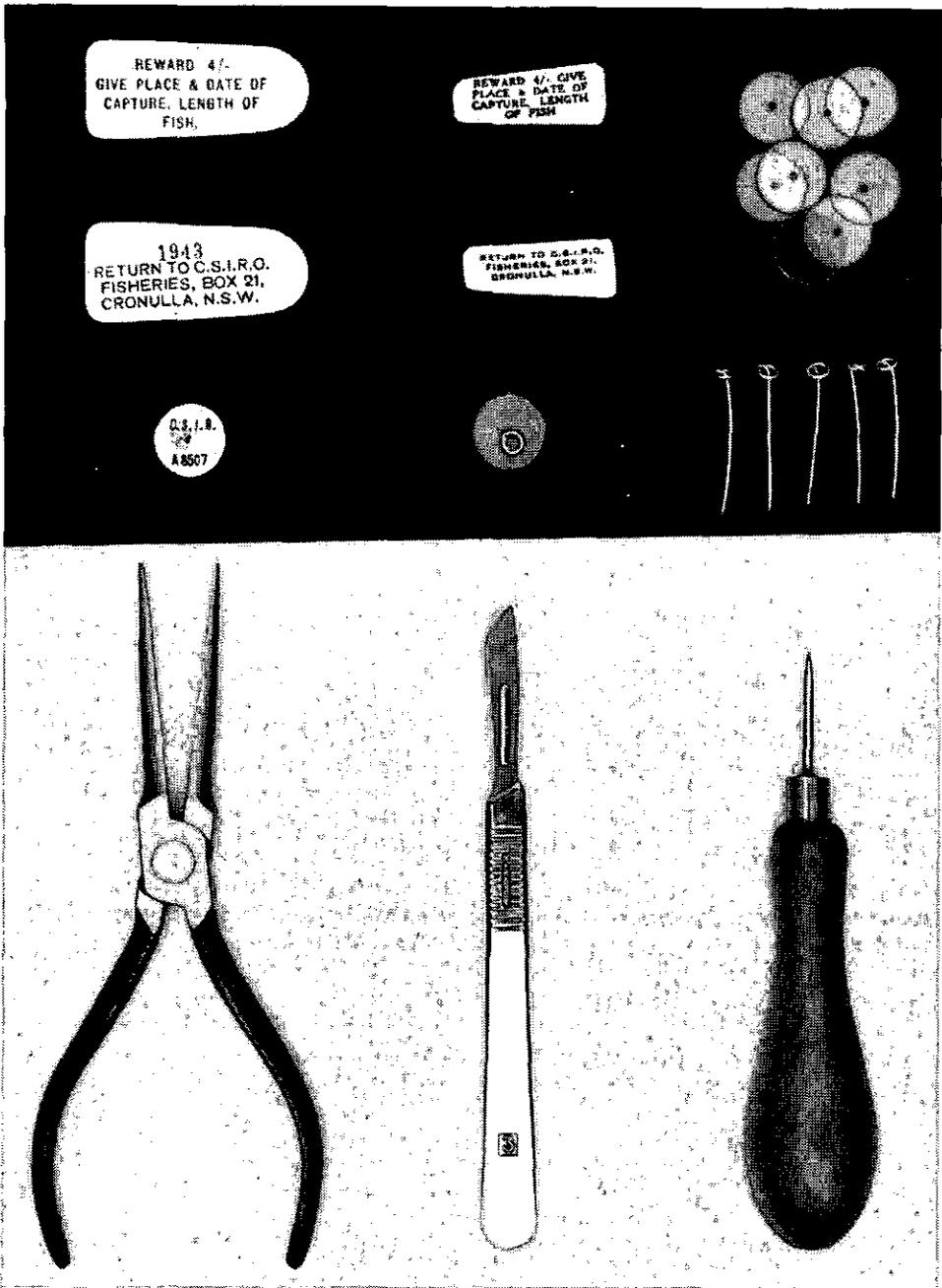


Fig. 2.—Upper: two sizes of internal tags (elongate); Petersen disk (lower left); transparent backing disks (upper right and lower central); silver wire (lower right). Below: tagging equipment—pliers and awl (Petersen disks); scalpel (internals).

sizes have been used appropriate to the size of fish. The largest were 50 mm long and 23 mm wide at the broader end. The medium size were 34 by 13 mm and the

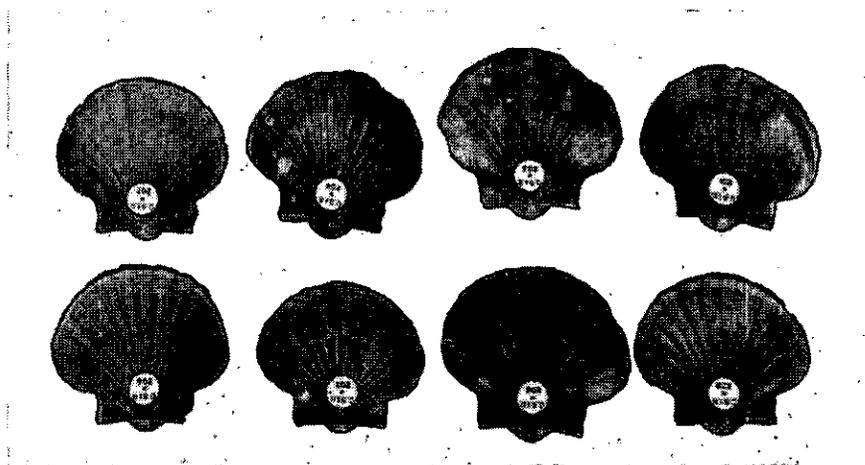


Fig. 3.—Petersen disks cemented to scallop shells.



Fig. 4.—Making incision in school shark to insert internal tag. Note Petersen disk on dorsal fin.

smallest 33 by 10 mm. This tag has been used in several species, particularly sharks, salmon, snapper, and tommy-ruff.

(f) Spiral Tag

These were plastic spirals, sold commercially as leg rings for poultry. No printed message was attached and no serial number, the plan being to use differently coloured rings in different areas. The tag was attached by ringing the caudal peduncle. Only barracouta were tagged in this way.

(g) Safety-pin Tag

These consisted of sterling-silver safety-pins, each bearing an aluminium plate; the dimensions of the pins were length $\frac{3}{4}$ in., width $\frac{1}{8}$ in. The pins were attached to the flesh between the two dorsal fins. A few were used on barracouta.

(h) Streamer Tag

The streamer tag consists of a length of plastic tube which is attached to the fish below the second dorsal fin by means of an aluminium dart which is inserted

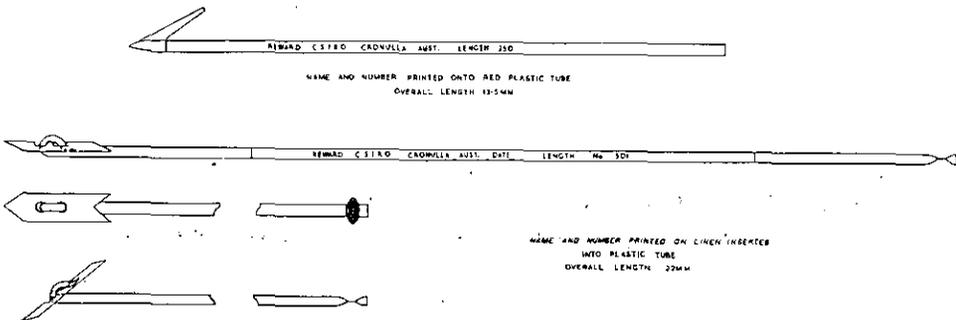


Fig. 5.—Sketch of streamer tags used on tuna.

into the flesh of the back. The first version of this tag had a separate message tape inside the clear tube. The later version had a stouter plastic head and the opaque red nylex tube had a black inscription stamped along its length. The first version was attached by inserting the head under the skin. It was feared that many of these worked out. Subsequently the second type was provided with a barbed arrow head which hooked under a vertebral spine (Fig. 5). This tag has been used on tuna.

(i) Dart Tag

This tag is similar to the streamer tag, but with a flat piece of plastic tape attached to a plastic arrow-head. It has been used on southern crayfish.

(j) Clip and Disk Tag

This was of the type used by Godsil (1938) on tuna and essentially was a strap tag with a disk attached. It was tried only on sea mullet.

(k) Fin Clips

The well-known method of marking by fin clipping has been used in Australia only in studies on the imported salmonids, the brown and rainbow trouts.

(l) Telson Punch

Marking of crayfish by means of cattle-ear punches of different shapes was used prior to the use of the dart tag. The punch mark remained discernible over several moults but with each moult the outline became more indefinite, so that the original shape became unrecognizable. In later work, combinations of punches in telson and uropods were used (Sheard 1949).

TABLE 2
TYPES OF TAG TESTED IN SHORT-TERM STUDIES ON SEA MULLET

Type of Tag	Observation
Medium strap on operculum	No interference with gill movement; no effect on balance of fishes over 15 cm. Fishes under 10 cm definitely unbalanced and unable to swim normally
Small strap on operculum	Fishes less than 7 cm unbalanced

(m) Whale Marks

The majority of marks used were standard Discovery marks (Rayner 1940; Chittleborough 1959a, 1959b). A modified mark (Chittleborough and Godfrey 1957) was also developed, but there are indications that its penetrative power was too good.

TABLE 3
SPECIES OF FISH AND TYPES OF TAG TESTED IN LONG-TERM STUDIES

Species	Type of Tag	Observation
Sea mullet Luderick Black bream	Strap, hydrostatic, and Petersen disk	All appeared satisfactory except straps when left projecting from edge of operculum; in such cases tags worked out
Trout	Strap	Marked proportion worked out over several weeks; but no observation given of projection beyond opercula
School shark	Petersen disk	Appeared satisfactory in pond-held sharks
	Barbed disk	All lost in pond; not used in field
Southern cray	Punch marks	Shape of punch lost after several moults but combination of positions on telson and uropod discernible

III. TESTS OF SUITABILITY

These were confined mostly to species which were tagged in large numbers. The difficulty in holding large scombrid fishes prevented any test experiments with

the tunas. The tests carried out were of two types; either a test of short duration, the purpose of which was to determine whether the fish showed obvious signs of distress or discomfort as a result of the fixing of the tag, or longer tests to observe whether tags were shed or whether ill-effects became apparent with time.

Short-duration experiments were carried out with the species shown in Table 2.

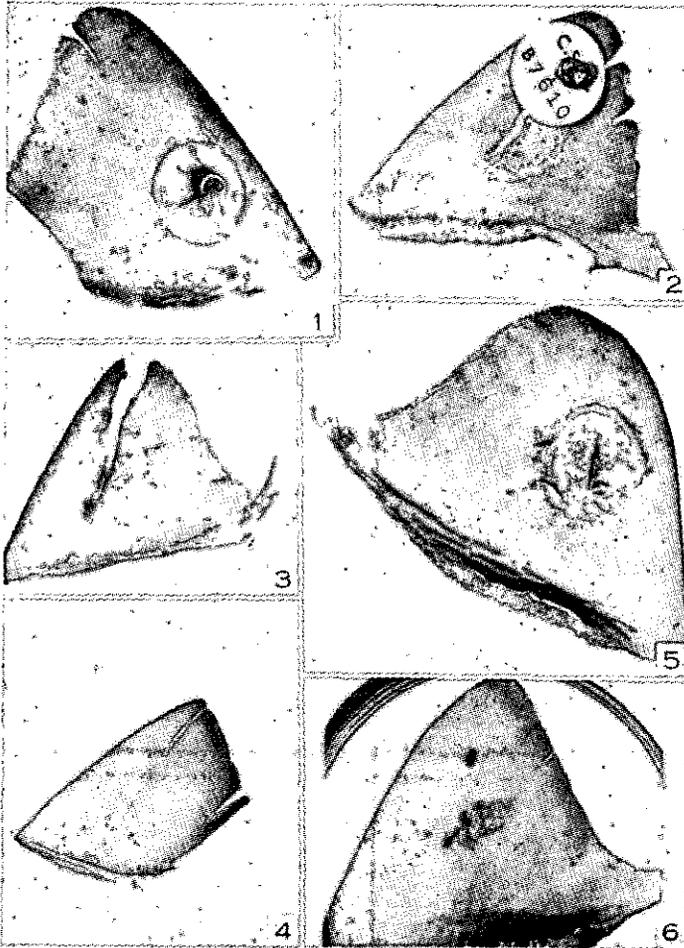


Fig. 6.—Dorsal fins of school shark showing that Petersen disks work out.

Tests of longer duration are reported in Table 3. The early success with the strap tag on mullet led to its use on other species. However, some fish, particularly black bream, were returned with the tag almost lost from the operculum and others with split opercula, suggesting that the tag may have worked or been torn out. The aquarium test showed that this resulted from the procedure of leaving an eighth to a quarter of the loop of the tag projecting beyond the operculum edge to allow for growth. Tags that were clipped with the minimum of projection beyond the edge of

TABLE 4
OBSERVATIONS AT RELEASE

Species	No. Tagged	No. of Release Operations	Average No. Tagged per Release	Range of Numbers per Operation	Length Data for	Weight Data for	Scale Samples for	Sex Determined
1. Brown trout (tags)	2,880	46	62.6	1-470	2,880	2880	548	34
1. Brown trout (fin clips)	18,742	19	997	2-5000				
2. Rainbow trout (tags)	2,258	26	86	6-403	2,242	2216	324	
2. Rainbow trout (fin clips)	17,455	17	1026	1-5700				
3. Australian bass	70	25	2.4	1-12	70			
4. Callop	502	?	?	?	502	?	?	?
5. Murray cod	2	?	?	?	2	?	?	?
6. Smalltooth flounder	116	30	3.8	1-29	116			
7. Greenback flounder	626	11	57	15-118	626			
8. Southern bluefin tuna	600	120	5	1-37	600			
9. Yellowfin tuna	82	46	1.8	1-4	82			
10. Albacore	11	8	1.4	1-4	11			
11. Striped tuna	1	1	1.0	1	1			
12. Sea mullet	21,523	302*	51.7*	1-1006	20,797	693	2649	
13. Flat-tail mullet	3,934	251	15.6	1-295	3,934		16	
14. Yellow-eye mullet	1,550				1,550			
15. Telegalene	172	53	3.4	1-39	172		1	
16. Freshwater mullet	1	1	1.0	1	1			
17. Diamond-scale mullet	98	2	49	33-65	98			
18. Cooktown salmon	14	3	4.7	2-6	14			
19. Burnett salmon	6	1	6	6	6			
20. Trevally	206	36	5.7	1-56	206			
21. Tailor	200	43	4.7	1-31	200			
22. Black bream	6,999	162	43	1-322	6,999		4720	
23. Southern bream	3,530	23†	106†	7-340†	2,450			
24. Tarwhine	2,515	134	19	1-350	2,515		6	
25. Luderick	1,331	178	7.9	1-148	1,331		7	
26. Australian salmon	11,783	138	85.4	1-762	6,427		4618	
27. Tommy-ruff	11,468	41	280	1-1616	5,477		1950	
28. Snapper	9,993	238	42	1-473	9,993	26	6207	
29. Morwong	3	2	1.5	1-2	3			
30. Mulloway	12	7	1.7	1-4	12			
31. Northern jewfish	28	1	28	28	28			
32. King George whiting	29	1	29	29	29		29	
33. Sand whiting	83	29	2.9	1-11	83			
34. Trumpeter whiting	149	37	4	1-32	149			

* Refers to 5603 only.

† Refers to 2450 releases in Victoria.

TABLE 4 (Continued)

Species	No. Tagged	No. of Release Operations	Average No. Tagged per Release	Range of Numbers per Operation	Length Data for	Weight Data for	Scale Samples for	Sex Determined
35. Giant perch	1,908	58	33	1-197	1,908	106		
36. Red mullet	2	2	1	1	2			
37. Red gurnard	6	3	2	1-4	6			
38. King flathead	4	1	4	4	4			
39. Tiger flathead	6,232	37	168	3-428	5,240			
40. Dusky flathead	97	51	1.9	1-8	97			
41. Sand flathead	80	3	27.0	10-49	80		80	
42. Barracouta	4,598	113	41	1-235	4,148			
43. Yellowfin leather-jacket	1,256	190	6.6	1-70	1,256			
44. Centreboard	512	114	4.5	1-64	512			
45. Jack mackerel	82	21	3.9	1-17	82			
46. Trumpeter	75	21	3.6	1-12	75			
47. Oldwife	22	14	1.6	1-3	22			
48. Nannygai	12	5	2.4	1-5	12			
49. Butterfish	20	5	4	1-11	20			
50. Stout long-tom	3	2	1.5	1-2	3			
51. Pennant fish	1	1	1	1	1			
52. School shark	6,502	342	19.0	1-239	2			
53. Gummy shark	593	59	10.1	1-110	593	23		593
54. Whiskery shark	2	1	2	2	2	2		2
55. Whaler	1	1	1	1	1	1		1
56. Blacktip shark	2	1	2	2	2	2		2
57. Tiger shark	1	1	1	1	1			1
58. Spurdog	24	10	2.4	1-5	24	14		24
59. White-spotted dogfish	59	10	5.9	1-15	59	49		59
60. Port Jackson shark	7	2	3.5	1-6	7	6		7
61. Cobbler shark	1	1	1	1	1			1
62. Spotted catshark	1	1	1	1	1			
63. Stingaree	28	6	4.8	1-14	27			
64. Melbourne skate	8	5	1.6	1-3	8			8
65. Common skate	1	1	1	1	1			1
66. Western crayfish	15,731	154	102	3-270	7,691			10,381
67. Southern crayfish	7,847	131	60.2	5-252	7,847	1481		7,487
68. Scallops	4,200	15	280	100-700	4,200			
69. Goldlip pearlshell	6,842	18	380	17-1000	6,842	6842		
70. Blacklip pearlshell	1,000	3	333	200-500	1,000	1000		
71. Humpback whale	1,323							

the operculum did not work out in aquarium tests, and from such firmly attached tags long-term recoveries have been made even with black bream. Such tags produced an invagination in the edge of the operculum. However, aquarium tests may be misleading; three species of fishes were tagged with hydrostatic and Petersen tags and held in the aquarium for over 3 months without deleterious effect. But estuarine fishes recovered in the field, and particularly those bearing hydrostatic tags, had nasty wounds about the wire. Because of this, and also because both hydrostatic tags and Petersen tags without the fish attached were recovered from nets in which they were entangled, use of these two types of tag was discontinued in the Lake Macquarie investigation mentioned below, after about 200 Petersen disks and 120 hydrostatic tags had been released.

TABLE 5
CHARACTERISTICS INVESTIGATED BY TAGGING TECHNIQUES

Species	Movements	Growth	Population Limits	Population Numbers
Trout	+	+	+	
Greenback flounder	+	+	+	
Sea mullet	+	+	+	+
Flat-tail mullet	+	+	+	+
Other mullets	+	+		
Black bream	+	+	+	+
Tarwhine	+	+		+
Luderick	+	+		+
Australian salmon	+	+	+	
Tommy-ruff	+	+	+	
Snapper	+	+	+	+
Tiger flathead	+	+	+	
Barracouta	+	+	+	
Yellowfin leatherjacket	+	+	+	+
School shark	+	+	+	
Gummy shark	+	+	+	
Other fishes	+	+		

Results in the field also led to the substitution of internal tags for Petersen disks in the case of sharks because the disks were found to work out of the fin, as described by Olsen (1953) (Fig. 6).

IV. RELEASE OPERATIONS

The numbers of each species marked or tagged are given in Table 1. Table 4 gives information on the number of tagging operations involved and the number of fishes tagged for which information on various biometrical and other data was collected. As more than one series of investigation were made on some of the species, this record of results is further subdivided in the following brief descriptions of individual investigations.

The teleost fishes involved in these studies do not show any obvious external differences between the sexes. However, such differences exist in the elasmobranchs

and the crustaceans, and the sex was usually recorded when these animals were released. Size, usually in terms of length, was recorded in the majority of cases, exceptions being in the fin-clipped releases of trout which were hatchery reared fish of one age group whose probable size range was determined by subsampling, and in the mass telson punching of "white" crayfish where the size range is limited and was determined by subsampling.

In almost all cases the purpose of tagging was primarily to obtain data on the movements of the fish (Table 5). Advantage was taken in most cases of obtaining direct measures of growth simultaneously with the major objective of the investigation. An important problem for resolution in several investigations was to determine whether one or more populations were involved. Tagging was used to indicate the degree of mingling of specimens of the one species obtained from various areas. In one instance (Section IV (o)) an attempt was made to assess the population numbers of several species.

TABLE 6
RELEASE DATA FOR TROUT

Area	No. Tagged	No. of Operations	Av. No./ Operation	Range/ Operation	Length Data	Scale Samples	Weight Data	Sexed
Tasmania	2845	36	79	3-470	2845	548	2845	
Victoria	35	10	3.5	1-8	35	—	35	34

(a) Trout (*Species 1 and 2, Tables 1 and 4; Species 1-4, Table 11;*
Nicholls 1957, 1958a, 1958b, 1958c)

Data are summarized in Table 6.

(i) *Tagged Fish*

Thirty-five brown trout were tagged in Victoria by the Victorian Department of Fisheries and Wildlife; the rest were tagged in Tasmania by C.S.I.R.O.

(1) *Plan of Release.*—Fish were tagged and released in selected streams where fishing intensity was such that reasonable returns were anticipated.

(2) *Purpose.*—To determine growth rate, migration, or contribution to the population, or more than one of these combined.

(3) *Circumstances of Release.*—Some fish have been hatchery stock; most were released with larger numbers of fin-clipped fish; others were obtained in estuaries by beach seining; others have been taken by net or trap in the fresh water zone, particularly while on their spawning run.

(ii) *Fin-Clipped Fish*

(1) *Plan of Release.*—Release of fish in waters where fishing intensity gave hope of satisfactory returns.

(2) *Purpose.*—Assessment of contribution of hatchery reared fish to fishery.

(3) *Circumstance of Release*.—Hatchery reared and held fish were fin clipped and placed in a live-car in which they were transported to the release site and freed. A subsample was measured.

(b) *Tuna Investigations (Species 8–11, Tables 1 and 4)*

(1) *Plan of Release*.—Tuna are tagged and liberated in the main commercial fishing area.

(2) *Purpose*.—To obtain data on movements and on growth.

(3) *Circumstances of Release*.—Tuna caught by trolling in the known fishing areas and reaching the deck of the research vessel uninjured and in good condition are tagged, measured, and released immediately, with a tagging team of two men.

TABLE 7
DETAILS OF RELEASE IN THE MULLET STUDIES

Area	No. Tagged	No. of Operations	Av. No./ Operation	Range/ Operation	Length Data	Scale Samples
Eastern Australia	4307	79	54.5	6–214	4307	2622
Western Australia	7110	74	96	1–346	7110	—
Queensland	4032	—	—	—	4032	—
South Australia	1023	2	511	17–1006	140	—
Lake Macquarie	3163	147	21.5	1–404	3163	27

(c) *Sea Mullet (Species 12, Tables 1 and 4)*

This species has been tagged in five separate series of investigations (Table 7):

(i) *Eastern Australian Study (Kesteven 1942, 1953)*

(1) *Plan of Release*.—To tag at selected places along the extent of the eastern Australian coastline.

(2) *Purpose*.—To determine the direction and extent of movements from various parts of the natural range; direct information on growth rate.

(3) *Circumstances of Release*.—Fish obtained by commercial fishermen, using beach seines; fish held in bunt in water until tagged. A tagging team of three; a recording clerk, and a measurer who also held the fish for the third man to tag and remove a few scales. The majority of fish were measured and all but a few had scale samples taken.

(ii) *Queensland Study (Thomson 1955)*

This was designed as a follow-up study to the eastern Australian investigation, which had demonstrated a consistent movement to the north. The majority of

the fish tagged in the earlier study had come from the central coast. The later study concentrated on releases on the northern New South Wales coast and along the Queensland coast as far as Rockhampton, to determine whether there was a return south by the mullet at the northern end of the migration path.

The fish were obtained both by commercial fishermen and by an experimental tagging crew, and some from shoreline traps in the neighbourhood of Rockhampton. A two-man tagging team was involved except in Moreton Bay where three men were available. Only a few scales were taken as the growth pattern of mullet had already been established, but all fish were measured.

(iii) *Western Australian Study (Thomson 1951, 1955)*

The plan of release was similar to that of the first study on mullet, but carried out on the west coast of the continent. The purpose was identical with the additional purpose of comparing behaviour (movements) and physiology (growth) of western and eastern representatives of the species. A two-man tagging team was involved and relatively few scales were taken as other studies indicated similarity of annulus pattern with eastern Australian fish. All fish were measured before being released.

(iv) *South Australian Study*

(1) *Plan of Release.*—To tag a large number of mullet at a spot where they concentrate in South Australian waters.

(2) *Purpose.*—To test whether this is a homogeneous stock or part of the eastern or western stocks of mullet.

(3) *Circumstances of Release.*—Fish obtained by commercial fishermen using a beach seine; one man tagging, measuring a subsample for length, but not taking scales.

(v) *Lake Macquarie Study*

This was part of the general Lake Macquarie study listed in Subsection (o).

(d) *Yellow-eye Mullet (Species 14, Tables 1 and 4; Thomson 1957)*

(1) *Plan of Release.*—To tag as many fish as possible in the estuaries of south-western Australia at all seasons of the year.

(2) *Purpose.*—To determine the direction and extent of movement between estuaries; direct information on growth rate.

(3) *Circumstances of Release.*—The tagging program was carried out concurrently with the study on sea mullet in Western Australia and the circumstances of release were identical.

(e) *Black Bream (Species 22, Tables 1 and 4)*

This species was also studied in the Lake Macquarie investigation, but before this time a more extensive investigation of the stock along the entire east coast had been made (2281 strap tags in Lake Macquarie, and 3357 strap and 1355 disk tags elsewhere; lengths only recorded at Lake Macquarie, and lengths recorded and scales taken elsewhere).

(1) *Plan of Release*.—To tag black bream in representative rivers and coastal lakes along the east coast of Australia.

(2) *Purpose*.—To determine the amount of interchange between river systems; to obtain direct evidence of growth rates.

(3) *Circumstances of Release*.—The fish were obtained by commercial fishermen using beach seines, the bunt being held in the water until the fish were measured and tagged and scale samples taken.

(f) *Southern Bream (Species 23, Tables 1 and 4)*

This species has been tagged in Victoria and in Western Australia (2450 opercular strap tags were applied in Victoria, and 1080 internals in Western Australia).

TABLE 8
RELEASE DATA FOR SALMON

Area	No. Tagged	No. of Operations	Av. No./ Operation	Length Data	Scale Samples
Western Australia	2484	74	33.5	421	—
South Australia	4104	15	273	1411	784
Tasmania	935	19	49	935	174
Victoria	3760	27	139	3160	3160
New South Wales	500	3	167	500	500

(g) *Australian Salmon (Species 26, Tables 1 and 4; Malcolm 1960)*

This species has two subspecies with a common nursery area but spawning in widely separated regions (Fairbridge 1950; Malcolm 1959). (See Table 8.)

(1) *Plan and Purpose of Release*.—(A) Tagging on nursery grounds in Tasmania, Victoria, and South Australia to determine subsequent movements within the adult range; (B) tagging in the adult habitat of the subspecies to determine pre- and post-spawning movements within the adult range.

(2) *Circumstances of Release*.—The fish were obtained by commercial fishermen using beach seines. One man or sometimes a two-man team did the tagging. At times the fish had to be held in the bunt of the net in the surf, particularly in the second type of release; under these circumstances measuring and scale taking were sometimes impossible, but whenever possible these two operations were carried out before the fish were released.

(h) *Tommy-ruff (Species 27, Tables 1 and 4)*

Release data are presented in Table 9.

(1) *Plan of Release*.—Tagging wherever ruffs were available in South Australia and Western Australia.

(2) *Purpose*.—(A) To establish whether the ruffs along the Australian south coast were one homogeneous stock; (B) to test the theory that the young ruffs of South Australia migrate to Western Australia to spawn.

(3) *Circumstances of Release*.—Beach hauls by commercial fishermen using a beach seine; one or two men tagging, measuring, and when possible taking scale samples.

TABLE 9
RELEASE DATA FOR TOMMY-RUFFS

Area	No. Tagged	No. of Operations	Av. No./ Operation	Length Data	Scale Samples
Western Australia	7299	23	317	3378	1950
South Australia	6693	18	372	2099	—

(i) *Snapper (Species 28, Tables 1 and 4)*

This species has been tagged in two investigations (Table 10), one carried out by the Victorian Department of Fisheries and Wildlife on the Victorian coast, and the other by C.S.I.R.O. in the Lake Macquarie investigation (Section IV (o)).

(j) *Tiger Flathead (Species 39, Tables 1 and 4)*

Two separate investigations have been made on this species, one off the New South Wales coast and the other off the Victorian coast (2683 tagged in New South Wales, 3549 in Victoria).

TABLE 10
RELEASE DATA FOR SNAPPER

Area	No. Tagged	No. of Operations	Av. No./ Operation	Range/ Operation	Length Data	Scale Samples	Weight Data
Victoria:							
Strap	2099	41	51.2	1-354	2099	2099	—
Internal	4108	104	40	1-460	4108	4108	26
Lake Macquarie:							
Strap	3786	93	41	1-473	3786	—	—

(i) *New South Wales*

(1) *Plan of Release*.—To tag flathead wherever fish in good condition were available.

(2) *Purpose*.—To determine movements on the known trawling grounds and to obtain direct evidence of growth rate.

(3) *Circumstances of Release*.—Fish obtained by a commercial Danish seine; measured, tagged, and released. It was observed on several occasions that the swim bladders were inflated and the fish remained at the surface after release, where albatrosses and molly-mawks consumed a number.

(ii) *Victoria*

(1) *Plan of Release*.—To tag as many flathead as possible on the Lakes Entrance fishing ground.

(2) *Purpose*.—To determine whether there is an interchange with the stock on the New South Wales coast.

(3) *Circumstances of Release*.—Fish obtained by commercial Danish seiner; on landing up the net the most active fish were placed in a tank where they were kept for 15 min; any fish appearing to be distressed at the end of this period was rejected. The others were measured and tagged; the air bladder was deflated by pricking with a short needle. On release these fish swam strongly downwards.

(k) *Barracouta (Species 42, Tables 1 and 4)*

(1) *Plan of Release*.—To tag barracouta on the various fishing grounds throughout its range in south-eastern Australia.

(2) *Purpose*.—To determine whether there were one or more stocks.

(3) *Circumstances of Release*.—Fish were obtained by trolling from an experimental vessel; after being hauled aboard they were measured, tagged, and released.

(l) *School Shark and Gummy Shark (Species 52 and 53, Tables 1 and 4; Olsen 1953, 1954)*

(1) *Plan of Release*.—Release of small sharks in selected inshore nursery areas, and release of larger sharks on the banks supporting the commercial fishery in south-eastern Australia.

(2) *Purpose*.—To test whether there were one or more populations within the range of distribution of the species in south-eastern Australia; to determine the direction and extent of migration; to obtain direct measurement of growth rates.

(3) *Circumstances of Release*.—The offshore sharks from the commercial fishing banks were obtained by longlining from a research vessel. The inshore, mostly juvenile sharks, were obtained by handlining in the bays and estuaries. Only apparently uninjured sharks in good condition were released. All sharks were measured and sexed.

(m) *Elasmobranchs (Species 12, 13, and 54–65, Tables 1 and 4)*

Prior to the detailed work on school and gummy sharks, some of these species (27 and 26 respectively) had been tagged as part of a general investigation of the elasmobranchs of the Australian region by Mr. G. P. Whitley of the Australian Museum, who was seconded for this purpose to the C.S.I.R. Division of Fisheries during the war years.

(1) *Plan of Release.*—To tag elasmobranchs wherever available.

(2) *Purpose.*—To determine the extent of their movements.

(3) *Circumstances of Release.*—The fish were obtained from longlines and by handling from commercial craft.

(n) *North Queensland Investigations (Species 17, 18, 19, 31, 35, and 46, Tables 1 and 4)*

This study was directed principally to the giant perch (marketed under the name "barramundi", a name applicable to a different fish), but other species taken in the same hauls were also included.

(1) *Plan of Release.*—To release tagged fish on selected beaches and in estuaries.

(2) *Purpose.*—To establish the amount of interchange of stocks between river systems; to obtain direct evidence of growth rate.

(3) *Circumstances of Release.*—On the sea beaches and at river mouths fish were obtained from shore-traps; upstream in the rivers and in water-holes on the flood-plains giant perch were obtained by seining. The fish were measured and a sub-sample weighed before release.

(o) *Lake Macquarie Investigation (Species 6, 12, 13, 15, 16, 20, 21, 22, 24, 25, 28, 29, 30, 33, 34, 36, 37, 40, 43-51, and 63, Tables 1 and 4)*

(1) *Plan of Release.*—To tag as many fish of all species as possible at selected spots around the lake.

(2) *Purpose.*—To assess the degree of interchange between the northern and southern portions of the lake; to assess the population numbers.

(3) *Circumstances of Release.*—Three fixed shoreline traps were visited regularly and all fish tagged; these were supplemented by fish obtained from both commercial and experimental seines; a number of squire (young snapper) and young black bream were obtained by an otter prawn-trawl and by a sunken trap.

(p) *Western Crayfish (Species 66, Tables 1 and 4)*

(1) *Plan of Release.*—To mark crays on selected grounds.

(2) *Purpose.*—To estimate rate of fishing in short-term recapture experiments; to assess degree of movement at critical periods such as mating and spawning; to prove "white" crayfish are a growth phase of normal reds.

(3) *Circumstances of Release.*—Crays obtained from pots, marked, and released in the same area.

(q) *Southern Crayfish (Species 67, Tables 1 and 4)*

(1) *Plan of Release.*—To release on a few selected beds.

(2) *Purpose.*—To assess the degree of movement; to check growth rates directly.

(3) *Circumstances of Release.*—Crays obtained by SCUBA diving were released on their home ground after telson or uropods or both were punched.

(r) Scallops (Species 68, Tables 1 and 4)

(1) *Plan of Release*.—To place marked scallops evenly over known beds.

(2) *Purpose*.—To assess the degree of movement on and from the bed; to estimate the intensity of fishing; to obtain direct estimates of growth.

(3) *Circumstances of Release*.—Scallops obtained by dredging; tags attached, and shellfish released by broadcasting evenly into water while the ship worked a grid pattern over the bed.

(s) Pearlshell (Species 69 and 70, Tables 1 and 4)

(1) *Plan of Release*.—To place shell on selected beds.

(2) *Purpose*.—To obtain a direct measure of growth rate.

(3) *Circumstances of Release*.—Shell obtained from natural beds was marked by affixing a Petersen disk by marine glue. One thousand *P. maxima* were hung from nylon ropes suspended from a raft; the remainder were returned to their original environment. *P. margaritifera* shells were divided into three groups set out according to three different cultivation methods.

(t) Whales (Species 71, Tables 1 and 4)

(1) *Plan of Release*.—To mark humpback whales while in Australian waters.

(2) *Purpose*.—To obtain information on migration and dispersal paths; to obtain growth data by marking calves.

(3) *Circumstances of Release*.—Mark is fired from a shot-gun as whale surfaces near vessel.

V. REPORTS OF RECOVERIES

(a) Publicity and Incentives

To ensure the return of discovered tags, the existence of the tagging program and its objects were publicized as widely as possible. Notices such as that shown in Figure 7 have been displayed at all fisheries inspectors' offices, and at all fish markets and storage depots to attract the attention of commercial fishermen, and the angling public has been alerted by the display of notices at boat-hiring premises and at favourite fishing spots such as jetties.

In the study on trout, an appeal for cooperation in the return of tags was included on the licence issued to anglers. In some of the more restricted fisheries, such as that for Australian salmon or the estuarine fishery in Lake Macquarie, each licensed fisherman was interviewed personally to appeal for his cooperation.

Periodic publicity was given to the investigations by press releases and radio news flashes about any interesting returns. The weekly newspaper columns of angling experts provided contact with sports fishermen, and the Australian Fisheries Newsletter reached the commercial fishermen.

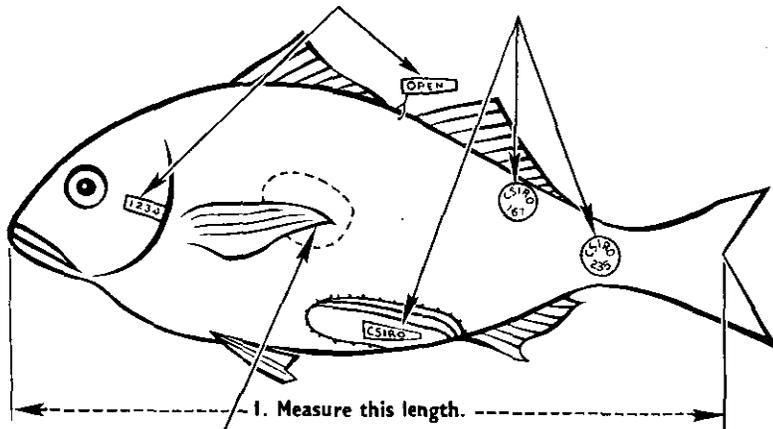
To provide an incentive beyond that of mere interest, a reward has been paid for each tag returned. In the period 1938–48 this was 2s. (about 20 cents) per tag; it was increased to 4s. (about 40 cents) after 1948. In the investigation of goldlip pearlshell, the incentive offered was the exchange of double the tagged shell's weight in good pearlshell. A point featured in the publicity concerning the investigations

was that the fish themselves should be returned wherever possible. In such cases the market price of the fish and the cost of postage or cartage was also reimbursed. In practice, relatively few of the tagged fish found by fishermen were returned, the tag alone being sent with the fisherman's "guesstimate" of length or weight. In about 25% of cases scales were also included. Every tagged fish that was detected in the markets was made available for biometric and other work.

TAGGED FISH

REWARD TO FINDERS

Look **HERE** and **HERE**



2. Take a few scales from here.

3. Send tag with a record of the length of the fish and the place and date of capture, and the scale samples to C.S.I.R.O., DIVISION OF FISHERIES, P.O. BOX 21, CRONULLA, N.S.W., or to the nearest Fisheries Inspector. If finder prefers to return whole fish, market price will be paid besides reward. Please help this Fish Conservation programme. Returning tags helps tell when and where fish move and how fast they grow. 4/- reward will be paid for each tag returned with desired information.

Fig. 7.—Reward notice used in Lake Macquarie investigations.

(b) Source of Returned Tags

The majority of tags are returned by fishermen, but some are not detected until they reach markets, shops, or even private households. The proportions detected and returned from these various sources vary with the fishery concerned. Obviously, where cleaning takes place on the beaches, internal tags have little chance of reaching sources other than the fishermen themselves. Where heads are cut off, opercular strap tags will not get through to the later sources of detection. The only case in which definite figures can be given is the Lake Macquarie study where a number of species was involved. Sources of detection of tags returned from fishes tagged in this study (1953-56) is as follows:

Anglers, 212; net fishermen, 442; spear fishermen, 2; dead on shore, 2; market, 22; retail shop, 6; household, 3.

TABLE 11
REPORTED RECOVERIES OF TAGS BY SPECIES

Species	No. Recovered	Per-centage Recovered	Lengths	Length Increments	Weight	Scales	Scales at Release and Recovery	Age from Shell Markings	Sexed	Average Days Free
1. Brown trout (tags)	247	8.5	233	229	238	200	196		237	615
2. Brown trout (fin clips)	75	0.4								
3. Rainbow trout (tags)	399	18.0	373	373	372	261	229		354	275
4. Rainbow trout (fin clips)	3	0.02								
5. Australian bass	5	7.1	3	3						37
6. Greenback flounder	30	4.8	24	24						166
7. Southern bluefin tuna	10	1.7	5	5	5					312
8. Sea mullet	785	3.6	325*	325*		105	78			210
9. Flat-tail mullet	221	5.6	110	110		16				140
10. Yelloweye mullet	17	1.1								180
11. Talegalene	3	1.7	2	2	1					58
12. Diamond-scale mullet	2	2.1	2	2						68
13. Trevally	23	11.2	20	20						60
14. Tailor	5	2.5	3	3						104
15. Black bream	254	3.6	211	211		20				209†
16. Southern bream	195	5.5†	27†	27†	17†					86
17. Tarwhine	364	14.4	332	332		4				186
18. Luderick	66	5.0	63	63	35	2				122
19. Australian salmon	1212	10.3	349	167						164
20. Tommy-ruff	145	1.3	32	3						59
21. Snapper	760	20.1	685	685		20				

TABLE 12
RECOVERY DATA FOR BROWN TROUT

Area and Tag	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
Tasmania:				
Silver tape	8	11.0	8	336
Jaw strap small	35	2.5	33	925
Jaw strap medium	136	16.4	126	400
Jaw strap large	66	12.5	64	935
Victoria:				
Internal	2	5.7	2	237

TABLE 13
RECOVERY DATA FOR RAINBOW TROUT

Type of Tag	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
Silver tape	68	55.7	68	281
Jaw strap small	56	3.9	47	143
Jaw strap medium	118	43.9	113	529
Jaw strap large	137	32.7	125	506

TABLE 14
RECOVERIES OF SEA MULLET

Area	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
Eastern Australia	228	5.3	185	190
Western Australia	240	2.4	180	—
Queensland	142	3.5	—	—
Lake Macquarie	161	5.0	138	239
South Australia	Nil	Nil	—	—

(c) *Recovery Data*

Table 11 sets out the data on the 37 species of which recoveries have been made. The percentage recovery of all species is small, exceeding 20% only in two instances (ignoring both the morwong, whose one return from three tagged fish provides a rate of return not readily comparable with those from fish tagged in greater numbers, and the blacklip pearlshell which was held under cultivation).

(i) *Trout (Species 1 and 2, Tables 1 and 4; Species 1-4, Table 11)*

Table 11 reports the data for all the types of tag used on trout. In Tables 12 and 13 are reported the data according to the type of tag for brown trout and rainbow trout respectively.

(ii) *Bluefin Tuna (Species 8, Tables 1 and 4; Species 7, Table 11)*

Only 1 out of 219 of the earlier type of streamer tag (see Section II(h)) was retaken, but 9 of 381 of the later type have been recaptured (2.3%).

(iii) *Sea Mullet (Species 12, Tables 1 and 4; Species 8, Table 11)*

The data in Table 11 refer to all five investigations on mullet mentioned in Section III(c). Table 14 shows the returns for each investigation.

Differences were also apparent in the rate of recovery of different types of tag (Table 15).

The high rate of return of the few hydrostatic tags is noteworthy; they were returned up to 12 months after liberation and their use was discontinued only because of the marked wounds caused by the tag. In most instances the wound may have been caused at the time of recapture owing to entanglement of the tag and the fish's struggles, but some wounds were obviously old and all received adverse comment from the finders.

(iv) *Black Bream (Species 22, Tables 1 and 4; Species 15, Table 11)*

The recovery data for each investigation and type of tag are shown in Table 16.

(v) *Southern Bream (Species 23, Tables 1 and 4; Species 16, Table 11)*

The proportion of tags returned is higher in Western Australia (165 tags or 15.3%) than in Victoria (30 tags or 1.2%).

(vi) *Australian Salmon (Species 26, Tables 1 and 4; Species 19, Table 11)*

The rate of return of the various types of tag used on this species is shown in Table 17.

The rate of return varied from one area to another (Table 18). The higher rate of return from those tagged in Western Australia was to be expected as these were adult fish which would be accessible to fishing immediately. The young fish from Tasmania would not be subject to fishing for several years.

The evident superiority of returns of internal tags in the Western Australian and Victorian fisheries is related to the practice of cleaning the fish immediately on capture. The white internal tag shows up against the viscera when the cleaning is being done and is thus easily detected, whereas the strap tag on the operculum may well be overlooked in the speed with which the fish are headed and gutted.

The preponderance of Petersen tags in Tasmania results from the recapture of small fish mainly by handline fishermen, the Petersen disk being readily detected, whereas

TABLE 15
RECOVERIES OF SEA MULLET CARRYING SPECIFIED TYPES OF TAG

	Eastern Australia 1938-42		Lake Macquarie 1954-56		
	Godsil Tag	Strap Tag	Strap Tag	Hydrostatic Tag	Petersen Disk
No.	4	224	151	10	1
Percentage	0.4	6.4	5.2	17.0	5.5

TABLE 16
RECOVERY DATA FOR BLACK BREAM

Area and Tag	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
New South Wales:				
Petersen disk	71	5.2	43	98
Strap (opercle)	22	0.6	12	79
Lake Macquarie:				
Strap	161	7.0	156	110

TABLE 17
THE RATE OF RECOVERY OF VARIOUS TYPES OF TAG USED ON AUSTRALIAN
SALMON

Tag Type	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
Internal	740	11.9	260	193
Strap	363	9.1	35	29
Tape (operculum)	0	—	—	—
Tape (jaw)	17	5.6	8	152
Petersen disk	92	7.3	37	42

the internal tag would not be observed and in most cases the undersize salmon would be returned to the water.

(vii) *Tommy-ruff* (Species 27, Tables 1 and 4; Species 20, Table 11)

In this species the rate of return of internal tag was slightly less than that of the operculum strap tags. Assuming that no loss of tags from the operculum occurred, approximately equal returns might be expected as this species is sold in the round.

TABLE 18
RATE OF RETURN OF TAGS USED WITH SALMON

Area and Type of Tag	No. Recovered	Percentage Recovered	Length Data
Western Australia (total):	499	20.1	23
Strap	268	17.6	3
Petersen disk	15	6.9	—
Internal	216	27.6	20
South Australia (internal)	409	9.9	165
Tasmania (total):	34	3.6	17
Petersen disk	8	8.0	4
Tape (jaw)	1	1.3	1
Internal	25	3.3	12
Victoria (total):	220	5.8	115
Strap	95	3.9	28
Petersen disk	19	3.7	8
Tape (operculum)	0	—	—
Tape (jaw)	16	6.9	7
Internal	90	15.0	72
New South Wales (Petersen disk)	50	10.0	25

TABLE 19
RECOVERY DATA FOR TOMMY-RUFF

Area	No. Recovered	Percentage Recovered	Length Data
Western Australia:			
Internal (tag)	100	2.4	25
Strap (operculum)	20	3.3	—
South Australia:			
Internal	25	0.4	7

A better return from tagging in Western Australia (Table 19) is to be expected, as the smaller South Australian specimens migrate to Western Australia for spawning and would not be susceptible to fishing for a longer period after tagging.

A small rate of return is to be expected in this species as the intensity of exploitation of the stocks is low.

(viii) *Snapper* (*Species 28, Tables 1 and 4; Species 21, Table 11*)

The recovery data on snapper for different areas and different types of tag are shown in Table 20.

TABLE 20
RECOVERY DATA FOR SNAPPER

Area	No. Recovered	Percentage Recovered	Length Data	Scale Samples	Av. Days Freedom
Victoria:					
Internal	7	0.3	7	—	215
Strap (operculum)	114	2.8	103	—	464
Lake Macquarie	760	20.1	685	20	59

(ix) *Tiger Flathead* (*Species 39, Tables 1 and 4; Species 25, Table 11*)

A slightly better rate of return came from the tagging in Victorian waters than that off the coast of New South Wales (Table 21). The average days of freedom were also somewhat greater in the Victorian group.

(x) *Barracouta* (*Species 42, Tables 1 and 4; Species 27, Table 11*)

All seven recovered tags were Petersen disks; two white, the others grey.

TABLE 21
RECOVERY OF TAGGED SCHOOL SHARK RELEASED AT VARIOUS PLACES

Area	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
New South Wales	11	0.41	4	35
Victoria	37	1.03	13	49

(xi) *School Shark and Gummy Shark* (*Species 52 and 53, Tables 1 and 4; Species 33 and 34, Table 11*)

Of the 41 gummy sharks recaptured, 39 had been tagged with internal tags, and the other two were double tagged; no gummies tagged with the Petersen disk alone were returned. Olsen (1953) has reported that the rate of return of tags was doubled by double tagging, though it is noteworthy that approximately half of the double tagged sharks had lost their Petersen disks when recaptured. Olsen (1953) also reported a better return from grey Petersen disks than from white.

The rate of return of tags differed according to the site of release (Table 22).

(xii) *Lake Macquarie Investigation*

Table 11 gives adequate data for the majority of species covered in this investigation, and Tables 14 and 20 show data for sea mullet and snapper respectively.

TABLE 22
RECOVERY OF TAGGED SCHOOL SHARK RELEASED AT
VARIOUS PLACES

Area	No. Recovered	Percentage Recovered
St. Helens, Tas.	82	20.8
Pittwater, Tas.	44	3.6
Port Sorell, Tas.	16	1.6
Portarlington, Vic.	127	6.1
Offshore tagging	178	9.0

TABLE 23
RECOVERY DATA FOR LAKE MACQUARIE FISHES WITH MORE THAN ONE TYPE OF TAG RECOVERED

Species	Tag	No. Recovered	Percentage Recovered	Length Data	Av. Days Freedom
Flat-tail mullet	Hydrostatic	3	17.3	2	117
	Strap	218	5.5	108	140
Luderick	Hydrostatic	10	53.0	9	549
	Petersen disk	1	3.0	—	243
	Strap (operculum)	55	4.3	41	119
Tarwhine	Petersen disk	2	1.9	2	5
	Strap (operculum)	362	14.9	294	87
Yellowfin	Petersen disk	4	14.8	2	301
Leatherjacket	Strap (ventral flap)	218	17.7	163	114
Centreboard	Hydrostatic	1	50	—	739
	Strap (ventral flap)	112	22.0	94	46

Table 23 shows the relative returns of different types of tag used on a few of the species.

(xiii) *Western Crayfish (Species 66, Tables 1 and 4; Species 36, Table 11)*

The data from all tests are shown in Table 11. These include tests of various kinds which are reported in Table 24.

The years listed under the heading "white crays" are the years of recapture of marked crays from two release operations in 1954. The grounds were fished subsequently 12 months and 26 months after marking.

TABLE 24
RECOVERY DATA FOR SEPARATE OPERATIONS ON WESTERN CRAYFISH

Type of Test	No. Recovered	Percentage Recovered	Av. Days Freedom
Continuous fishing:			
1948	545	11.8	2
1953	20	0.8	2
Movements:			
(1)	25	0.8	40
(2)	259	12.6	35
(3)	0	0	—
Spawners:			
(1)	6	2.2	2
(2)	9	2.4	3
White crays:			
1954 (short term)	15	3.7	2
1954 (long term)	242	13.7	100
1955	61	2.5	365
1956	3	0.1	770

(xiv) *Southern Crayfish (Species 67, Tables 1 and 4; Species 37, Table 11)*

The data in Table 11 refer to the punch-marked crayfish only. The dart tags have been used in an experimental area only to test their efficacy. Sixty-one were released in 1960 and 14 of these were recovered 12 months later. Another 1492 were tagged in the summer of 1961 and will be fished for in the summer (January) of 1962. The recovery of 14 tags indicates that, if properly applied, the dart tag is retained through ecdysis. The 1492 released in 1961 have also been punch marked for double checking.

VI. RESULTS

No attempt is made in this document to analyse the results in detail. Table 25 indicates for each species, for which any results are forthcoming, what type of information has been obtained. Too few of the remainder of the species listed in Table 11 have been recovered to provide any useful information. Some comments on individual species follow.

(a) *Trout*

Data on growth are available for both species. Information on movements and the assessment of the contribution of hatchery reared fish to the fishery are better for brown trout than for rainbow. In streams where there is any natural spawning, contribution to the fishery from hatchery plantings seems negligible.

TABLE 25
THE TYPES OF INFORMATION OBTAINED BY TAGGING EACH SPECIES
? Indicates data are few and results may possibly be atypical

Species	Movements	Growth	Mortality Rates	Population Size
Southern bluefin tuna	+?	+	-	-
Sea mullet	+	+	+	+
Flat-tail mullet	+	+	+	+
Yellow-eye mullet	+	+	-	-
Australian salmon	+	+	-	-
Tommy-ruff	+	+	-	-
School shark	+?	+?	-	-
Gummy shark	+	+	-	-
Brown trout	+	+	+	+
Rainbow trout	+	+	-	-
Snapper	+	+	+	+
Tiger flathead	+?	+?	-	-
Giant perch	+?	+?	-	-
Barracouta	+?	+?	+	-
Black bream	+	+	-	+
Southern bream	+?	+?	+	-
Luderick	+	+	+	+
Tarwhine	+	+	+	+
Yellowfin leatherjacket	+	+	+	+
Centreboard	+	+	+	+
Trevally	+?	+?	-	-
Tailor	+?	+?	-	-
Greenback flounder	+?	+?	-	-
Goldlip pearlshell	-	+	+	-
Blacklip pearlshell	-	+	-	-
Western crayfish	+	+	-	+
Southern crayfish	+	+	-	-
Scallops	+	+	+?	+?

(b) *Bluefin Tuna*

The information on movements is not clear-cut, except that one fish was recaptured in South Australian waters some hundreds of miles from the tagging place off southern New South Wales, indicating that the southern and eastern stocks may be one.

(c) *Sea Mullet*

The sea mullet programs have been very successful in showing the pattern both of short-term local movements and longer-term migration paths. Valuable

data on growth rates have been obtained (Thomson 1951; Kesteven 1953). The Queensland study shows movements at the northern end of the mullet's range consistent with the pattern further south, indicating that the adult mullet do not return southwards. There were no returns from the South Australian study, so that no proof of either independence or homogeneity with eastern or western stocks has been forthcoming.

(d) *Australian Salmon*

The tagging program has shown conclusively that the two stocks or subspecies mingle in the nursery areas of Bass Strait, but that as maturity nears the western subspecies moves westward along the coast of South Australia to Western Australia where it spawns, whereas the eastern subspecies remains in the vicinity of the eastern end of Bass Strait and spawns off south-eastern Australia (Malcolm 1959, 1960).

(e) *Tommy-ruff*

Tagging has demonstrated that the ruff population along the southern shores of Australia is homogeneous. The young ruffs of the South Australian region migrate to Western Australian waters as they near maturity (Malcolm, unpublished data).

(f) *School Shark*

The pattern of movements of young and adult sharks in the south-eastern Australian waters has been demonstrated. The school sharks of South Australian, Victorian, Tasmanian, and New South Wales waters form one intermingling stock with free interchange across the range of distribution. It is not known to what extent there is continuity with the school sharks of south-western Australia because no fishery for the species exists in that area (Olsen 1954, 1959).

(g) *Lake Macquarie Investigation*

It was hoped in this study to assess the numbers of the important commercial and forage fishes. Apart from the fact that one of the requirements of the mark and recapture method, namely, that the market fish should be randomly distributed throughout the population, was probably not realized (Thomson 1959a, 1959b), the confidence limits to the estimates were very wide. To a considerable degree this was due to the very small proportion of the fish population that received tags. More intensive tagging would have reduced the spread of the confidence limits. This could have been done only by providing more tagging crews, which was an economic impossibility.

(h) *Western Crayfish*

Punch marking of western crayfish proved beyond any doubt the fact believed by scientists on anatomical grounds, but disbelieved by a majority of fishermen, that the white crayfish are a growth phase of the normal reds. Continuous fishing tests to estimate the intensity of fishing have been carried out successfully and data on short- and long-term movements have accumulated (George 1957, 1958).

(i) Humpback Whales

Whale marking has shown that some degree of intermingling takes place between two humpback populations previously considered to be distinct (Chittleborough 1959c). Marking of female whales has given evidence on the rate of ovulation (Chittleborough 1959d).

Table 25 indicates the categories of information obtained for other species.

(j) Tagged Fish Competitions

An unusual use of fish tagging has grown up in Australia during the last 10 years. Originated by one of the oil companies and followed by other organizations, fishing competitions have been organized in natural habitats in which a certain number of tagged fish are liberated just prior to the competition. Quite large sums of money or other valuable prizes are offered as inducements to the large crowds that are attracted. The competition usually lasts 1 day only, but sometimes over 2 or 3 days. It is of interest that both the company which first sponsored this type of competition in Australia and the insurance company with which they insured against having to pay out prizes, consulted the C.S.I.R.O. Division of Fisheries and Oceanography to ascertain the proportion of tagged fish of various angling species that had been caught within 24 hr or so after being tagged. In fact, very few fish are recaptured within 24 hr of tagging. To our knowledge 1204 tagged fish have been released in such competitions since their inception in 1948. Of these 110 have been in fresh water, and the remainder in salt. The majority probably has been bream, but those known to the Division are:

Trout, 100; freshwater jewfish, 7; golden perch, 3; bream, 69; luderick, 50; flathead, 21; squire, 5; tarwhine, 3.

As far as is known, nine tagged fish (four of them trout) have been retaken during the currency of the competition, and five others have been retaken subsequently.

VII. COMMENTARY

Field staff are unanimously agreed that opercular strap tags are the easiest to apply on all but very large fishes whose opercula resist penetration. The rapidity of attachment of this type of tag shortens the time out of water, a point which is important in the warm temperate and subtropical conditions of the Australian inshore.

Where cleaning is done at sea or on the beaches, internal tags have a better rate of return. Internal tags from fish marketed in the round often fail to convey information because it is usually impossible to track down the place of recapture.

Tables 15 and 23 suggest that hydrostatic tags are detected and returned in greater numbers than other types. But the greater return possibly reflects only the greater likelihood of capture of a fish if it bears a hydrostatic tag because of the ease with which the wire entangles in a net. In other words, it is suggested that the fishing mortality rate for fishes bearing hydrostatic tags is greater than for the population as a whole. The principal reason for discontinuing the use of inshore investigations with hydrostatic tags was the adverse criticism of the members of the public recovering the tagged fish because of the obvious wound areas around the wire.

For molluses the Petersen disk cemented onto the shell has proved very useful. Opinion is divided on the use of these tags on fish. The application is slower than the opercular strap tag, but where it is suspected that strap tags work out of the operculum, Petersen disks have been used. These disks themselves are known to work out of the dorsal fins of sharks (Olsen 1953).

The rate of return of tags definitely improved when publicity was given to the various programs. The Australian fishing public, both commercial and sporting, is now so aware of the tagging work that the intensity of publicity is not as necessary as formerly, but it is continuing both as a reminder to established fishermen and to make newcomers aware of the existence and significance of the tagging.

Whether all or a majority of tags are returned when found remains unknown; but the proportion returned is believed to be greater where direct personal contact has been made with the fishermen as in the Lake Macquarie investigation and in the work on the salmon fishery.

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