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**Preliminary stock size analysis:
Tasman/Golden Bay snapper tagging programme**

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This series documents the scientific basis for stock assessments and fisheries management advice in New Zealand. It addresses the issues of the day in the current legislative context and in the time frames required. The documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Preliminary Stock Size Analysis : Tasman/Golden Bay Snapper Tagging Programme

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1.0 Introduction

The primary goal of this work is to estimate the current biomass of the Tasman/Golden Bay snapper stock, using mark/recapture methods.

Tag release was completed during the summer of 1986/87. In order to meet the assumptions of mixing required by the mark/recapture model, recapture data from the 1987/88 fishing season is considered to be the most appropriate on which to base stock estimates.

This report outlines the methods and results of the tagging programme. Results presented are preliminary and will require further critical

2.0 Methods and analysis

2.1 Tag release

Commercial pair-trawl vessels were chartered to catch fish during the tag release phase of the programme. A total of 4657 fish were tagged during the study (Table 1). The number of tows completed per day by each vessel varied between 3 - 10, dependent upon weather conditions and the number of fish tagged. Tow duration, defined as the period from when the drum brakes were first applied to the start of hauling, varied between 6 and 75 minutes. Most shots were between 20 and 40 minutes. Knotless cod ends were used throughout the programme in order to reduce fish injury resulting from scale loss and bruising whilst held in the cod end. Upon arrival of the gear at the surface, the entire codend was emptied directly into large deck tanks. These tanks were fitted with removable baffles in order to reduce tank slop, and were continuously supplied with fresh seawater when holding fish. When large catches were taken, fish were left swimming in the codend and transferred to the holding tank as space became available. Only fish meeting predetermined acceptance criteria were tagged. Fish were marked using Hallprint loop tags in a position anterior to the dorsal fin. Most fish greater than 45cm in length were double tagged, having a second tag inserted anterior to the primary tag site. During the programme 691 fish (14.8%) were double tagged. Fishing activity was conducted principally in inshore areas. Average depth of shots was 5 metres, but ranged between 3 - 14 metres. Fish having inflated swim bladders were immediately vented by perforation of the bladder laterally through the swimming musculature. Few fish

required venting during the programme (overall 274 = 5.8%). The fork length of all fish was measured and rounded down to the nearest cm below the actual measurement. All fish were injected with a measured dose of the antibiotic tetracycline in order to mark the otolith for ageing studies.

3.0 Estimation model

Biomass has been estimated by length class using the simple Petersen mark/recapture model :

$$N = (M+1) \{(C+1)/(R+1)\}$$

N = the number of fish of the length class in the population.

M = the number of tagged fish in the length class.

C = the number of fish in the length class caught by the commercial fishery over the recapture period.

R = the number of tagged fish in the length class recaptured in C.

Assumptions underlying this model are given in Appendix I.

For the purpose of this analysis, the model is assumed to give a point estimate of biomass within Tasman/Golden Bay (Fishing Statistical Area 038), using catch and recapture data from the period 1st October 1987 - 31st January 1988.

Length classes used in the estimation were : 25-35 cm; 36-44 cm; 45+ cm.

4.0 Estimation procedure

The numbers of fish released in each length class were adjusted to account for initial mortality, tag loss, natural mortality and recaptures, in order to derive the number of tagged fish remaining in the population at the start of the recapture phase (1st October 1987).

The number of untagged fish taken within the recapture period was calculated from catch sampling information. Ratios of tagged/untagged fish were then determined for each length class. These ratios were subsequently multiplied by the estimated number of tagged fish remaining in the population at 1st October 1987. Numbers of fish were

then converted to biomass using the average weight for each size class (calculated from catch sampling data).

Table 2 sets out the steps involved in biomass calculation.

5.0 Estimation parameters

5.1 Initial Mortality

An initial mortality of 10% has been assumed for this analysis. This value is based on results of trials conducted during the Hauraki Gulf/Northland tagging programme for single trawl-unvented fish.

Results of the initial mortality experiments conducted during the Tasman/Golden Bay programme are shown in Table 3. Due to difficulties encountered in carrying out this work, little reliability can be attached to the results of these experiments. Important factors which influenced the results are believed to be, effects of initial shot size/duration/depth, time taken to transport fish to the holding net, stress resulting from net enclosure and repeated handling during net checks, as well as general disruption of feeding and other behaviour patterns.

Given the variability associated with other experiment parameters listed above, it was decided not to attach differing rates of mortality to vented/unvented and single/double tagged fish. This is because firstly, only 6% of tagged fish required venting, and secondly the use of an initial mortality correction of 10% is in itself an approximation. It also assumes that there is no difference in initial mortality between single and double tagged fish.

5.2 Tag loss

Annual loss rates for the primary and secondary tags are calculated as 18.7% (95% C.I. 9.8% - 26.7%) and 22.7% (95% C.I. 13.29% - 31.1%) respectively.

Up until 10th March 1988, 143 double tagged fish had been returned. This represents 21% of the initial number released (691). The presence/absence of the primary and secondary tag on recovery is shown in Table 4.

A constant instantaneous loss rate has been used to adjust for tag loss according to the model below :

$$N_t = N_0 \text{Exp}\{-\mu t\}$$

Where :

N_0 = the initial number of double tagged fish released at time $t=0$.

N_t = the number of fish still tagged after an elapsed time t .

$\exp\{-\lambda_1 t\}$ = the annual instantaneous retention rate $(1 - 0.1867)$ for single tagged fish.

$\exp\{-\lambda_2 t\}$ = the annual instantaneous retention rate $(1 - (0.1867 * 0.2273))$ for double tagged fish.

λt = the time interval between tag release and recovery.

This equation applies to the primary and secondary tags independently. The expression $\exp\{-\lambda t\}$ represents the probability that a particular tag is retained at time t . The instantaneous loss rate parameters λ_1 and λ_2 are estimated by the technique of maximum likelihood.

The rate of tag loss at the primary site is applied only to single tagged fish. In most cases double tagged fish that lost their primary tag were still identified by their secondary tag, therefore a second tag loss rates is required to correct for double tagged fish having lost both tags.

Tag loss is assumed to be independent of tagging site and fish length.

5.3 Natural Mortality

The annual rate of natural mortality is assumed to be 5%.

6.0 Determination of the number of tagged fish remaining in the population at the start of the recapture period (1st October 1988)

The number of tagged fish remaining in the population is estimated over time for each tag release date using the procedure described below where :

N_0 = the number of tagged fish released on a particular date.

t = the time elapsed since date of release.

y_t = the number of fish alive and still tagged at time t .

x_t = the number of tags recovered by time t .

Assuming initial mortality of 10%, annual natural mortality of 5%, and annual tag loss of 18.7% (primary tag) and 22.7% (secondary tag) then y_t is defined by the following equations :

$$y_0 = 0.90 N_0 \text{ _____(1) (Adjustment for initial mortality)}$$

Subsequent adjustment for natural mortality, tag loss and tag recovery is defined by :

$$y_{(t+1)} = \text{Exp}^{-k^*t} y(t) - x_{(t+1)} \text{ _____(2)}$$

Where :

$$\text{Exp}^{-k^*} = (1 - 0.1867)(1 - 0.05) \text{ for single tagged fish.}$$

$$\text{Exp}^{-k^*} = (1 - (0.1867 * 0.2273))(1 - 0.05) \text{ for double tagged fish.}$$

$*t$ = the time interval between tag release and recovery.

After applying equation (1) to each shot, equation (2) is applied on a daily basis until 1st October 1987.

Overall, 2076 fish are removed by this adjustment. This represents a 45% reduction in the initial number of fish tagged. Thus at 1st October, 2582 fish were assumed to be available for recapture.

The estimated number of tagged fish remaining in each length class at 1st October 1987 after applying this procedure is shown in Table 2.

7.0 Tag Returns Made During Recapture Phase

A total of 427 tags were returned during the defined 17 week recapture period. Table 5 shows the number of tags returned by each commercial and recreational fishing method over this time. During the recapture phase, recreational fishers accounted for 6.8% of tags returned. This proportion increased as the season reached the peak of recreational activity during January-March.

8.0 Commercial Landings

Landings from Statistical Area 038 made during the recapture period (as determined from factory landings data) are shown in Table 6. Total landings amount to 189 tonnes. Pair trawl accounts for 71.6% of the catch, single trawl 17.4% and longline 11% by weight.

9.0 Catch Sampling

Catch sampling was conducted throughout the recapture phase. Table 7 provides a summary of catch sampling coverage. Of the 189 tonnes landed by commercial methods during the recapture phase, samples were taken from 68% of the catch. Overall 31.7 tonnes of snapper were measured during the recapture phase. This accounts for 25% of the sampled catch, or 17% of the total commercial landings.

10.0 Calculated Biomass

Results of this tagging programme produce an estimate of stock size of 1576 tonnes for the Tasman/Golden Bay snapper fishery.

Most of this biomass (86%) is found in the 45+ cm length class. Only 2% of the biomass is found in the 25-35 cm length class.

11.0 Recreational Catch

The total number of fish taken by the recreational fishery over the recapture phase has been estimated by length class. As a first approximation, the number of recreational tags returned in each length class has been scaled up by the appropriate mark/unmarked ratio, based on commercial catch. The resulting numbers of fish are then converted to biomass using length class weights determined from catch sampling.

Using this procedure a catch estimate of 7.61 tonnes is calculated for the recreational catch during the 17 week recapture period.

TABLE 1. Number of snapper tagged and released in Tasman and Golden Bay, Nov 1986- Feb 1987.

Release Date	Tasman Bay	Golden Bay
PHASE 1		
15.11.86	143	-
16.11.86		497
17.11.86		112
18.11.86		867
19.11.86		375
20.11.86	35	-
22.11.86	432	-
23.11.86	60	-
25.11.86	57	-
TOTAL	727	1851
PHASE 2		
08.12.86	256	-
09.12.86	35	-
10.12.86	777	-
11.12.86	188	-
13.12.86	93	-
14.12.86	218	-
16.12.86	29	-
17.12.86	38	-
TOTAL	1634	-
PHASE 3		
09.02.87	-	369
10.02.87	6	-
11.02.87	70	-
TOTAL	76	-
PHASE 1-3	2437	2220
TOTAL	4657	

TABLE 2. Calculations for estimation of snapper biomass.				
Length Class	25 - 35 cm	36 - 44 cm	> 45 cm	Total
Initial Number of Fish Tagged	1992	1623	1043	4658
Estimated Number of Tags Remaining at 1st Oct 1987 (M)	930	892	760	2582
After Correction for Initial Mortality 10% Tag Loss, Primary 18.6%, Secondary 22.7%				
Natural Mortality 5%				
Recaptures to 30 Sep 1987				
Commercial Tags Recaptured (Rc) During Recapture Phase	196	113	89	398
Recreational Tags Recaptured (Rr) During Recapture Phase	18	8	3	29
Total Tags Recaptured (Rt)	214	121	92	427
Number of Fish Caught (C) by Commercial Fishing During Recapture Phase (including (Rc))	8665	16145	41899	66709
Ratio $(C+1)/(Rc+1)$	44	142	466	
Ratio $\{(M+1)*(C+1/Rc+1)\}$	40955	126477	354288	521719
Average Weight of Fish in each Length Class (kilograms)	0.7034	1.4781	3.8405	
Calculated Biomass (tonnes) in each Length Class	28.81	186.95	1360.64	1576.40
Estimated Number of Fish Caught by Recreational Fishing (RC) During Recapture Phase (including (Rr))	792	1136	1398	
Ratio $\{(C+1)/(Rc+1)*(Rr)\}$				
Calculated Recreational Catch (tonnes) taken in each Length Class during Recapture Phase	0.56	1.68	5.37	7.61

TABLE 3. Results of Initial Mortality Experiments.

First Experiment

TREATMENT	Dead	Alive	Total	% Mortality
Single tag non-vented	2	24	26	7.69
Single tag vented	6	11	17	35.29
Double tag non-vented	1	7	8	12.5
Double tag vented	1	8	9	11.11
TOTAL	10	50	60	16.67

Second Experiment

TREATMENT	Dead	Alive	Total	% Mortality
Single tag non-vented	28	51	79	35.44
Single tag vented	1	0	1	100
Double tag non-vented	14	4	18	77.78
Double tag vented	3	2	5	60
TOTAL	46	57	103	44.66

TABLE 4. Recoveries of double tagged fish.

		Primary Tag		
		Present	Absent	Total
Secondary Tag	Present	107	16	123
	Absent	20		20
	Total	127	16	143

TABLE 5. Recaptures by commercial and recreational fishers by method of capture and length class

Method	Length Class			Total	
	25 - 35 cm	36 - 44 cm	> 45 cm		
Commercial Longline	1	10	13	24	
Commercial Pair trawl *	170	86	61	317	
Commercial Set net	1	2	0	3	
Commercial Single trawl	24	15	14	53	
Commercial Unknown	0	0	1	1	
Total Commercial	196	113	89	398	17 #
Recreational Boat rod	12	5	2	19	
Recreational Longline	2	1	1	4	
Recreational Shore rod	3	0	0	3	
Recreational Set net	1	2	0	3	
Total Recreational	18	8	3	29	5 #
Grand Total	214	121	92	427	22 #
Returned tags as a % of those estimated remaining in the population at start of the recapture phase	20	12	11.4	14.8	

* Includes 31 tags to compensate for cases of known commercial non-reporting (Appendix II)

#Returns since 31st January 1988

Data from 'RCOMM87'

TABLE 6. Commercial landings of snapper recorded by method for the period Oct 1987 - Jan 1988.

Landings by Month (Kilograms)

	October	November	December*	January	Total	% of Total
Longline	0	32	3885	16875	20792	11.00
Pair trawl	1900	40722	58616	34187	135425	71.63
Single trawl*	811	5293	5698	21044	32846	17.37
Total	2711	46047	68199	72106	189063	
% of Total	1.43	24.36	36.07	38.14		
Cum % of Total	1.43	25.79	61.86	100.00		

* Southern Tasman Bay closed to pair trawl 15/12/87

* Includes a minor amount of set net catch

TABLE 7. Summary features of catch sampling programme.

Vessel Category	(C 1) Total Landings (Kilograms)	(C 2) Total Landings From Which Catches Were Sampled (Kilograms)	(C 2) as % of (C 1)	(C 3) Actual Catch Measured (Kilograms)	(C 3) as % of (C 2)
Pair trawl (large)	50620	50398	99.56	7873	15.62
Pair trawl (small)	84805	58633	69.14	17111	29.18
Single trawl (large)	27078	17041	62.93	5425	31.83
Single trawl* (small)	5768	1063	18.43	727	68.39
Longline	20792	588	2.83	588	100.00
Total	189063	127723	67.56	31724	24.84

* Includes a minor amount of set net catch

Appendix I

Assumptions underlying the stock estimation.

The model assumptions listed below are not expected to hold exactly, the issue is how reasonable are they?. These assumptions will be assessed thoroughly before final biomass estimates are produced.

Model assumptions :

- 1- The population is closed i.e. from the period 1/10/87 to 31/1/88 no snapper enter or leave the Tasman/Golden Bay fishery.
- 2- All snapper which were originally tagged and are still alive and have their tag attached, are still in the fishery.
- 3- Tagging does not affect catchability of snapper i.e. tagged and untagged snapper of the same fork length are equally vulnerable to recapture.
- 4- The catch of snapper taken by all fishing methods over the study period consists of a combination of simple random samples of each fork
- 5- The processes of initial mortality due to tagging, natural mortality since tagging and tag loss are adequately described by the procedures
- 6- All tagged snapper caught over the study period are recognised and
- 7- The growth of tagged snapper since release can be ignored i.e. as a first approximation, growth is assumed to have no effect on estimation and is not included.
- 8- The fact that catches and tag recoveries are spread over time can be ignored without undue loss of accuracy i.e. assumption 4 is assumed to apply as if all catches and recoveries occurred on 1/10/87. Adjustments can be made for the time spread of catches and tag recoveries; rough

Parameter assumptions :

- 9- An initial mortality of 10% resulting from tag and release.
- 10- Annual natural mortality of 5%.
- 11- Annual losses of the primary and secondary tags of 18.7% and 22.7% respectively.
- 12- Tag loss at the primary and secondary sites occurs independently.
- 13- Tag loss is independent of fish length.

Appendix II.

Vessels	Catch by Length Class		
	25 - 35 cm	36 - 44 cm	> 45 cm
Anna/Rong	547	2007	8796
DMay/Da	446	1628	1774
Gleam/Nim	523	1856	2002
LadyL/Maj	958	1799	1744
Rong/Rongo	1780	419	374
Sea/Star/JoM	698	894	1643
Total Catch (fish)	4952	8603	16333
Sea/Lou •	956	1300	1937

Vessels	Tags by Length Class		
	25 - 35 cm	36 - 44 cm	> 45 cm
Anna/Rong	8	7	11
DMay/Da	4	7	6
Gleam/Nim	20	4	8
LadyL/Maj	40	16	5
Rong/Rongo	21	11	0
Sea/Star/JoM	33	16	6
Total Tags	126	61	36
Ratio Fish/Tag	39	141	454
Sea/Lou • Actual	2	0	6
Sea/Lou • Estimated	24	9	4