DEPARTMENT OF CONSERVATION, FORESTS AND LANDS
FISHERIES DIVISION

JACKASS MORWONG NEMADACTYLUS MACROPTERUS: REPRODUCTION AND FECUNDITY IN EASTERN BASS STRAIT, AUSTRALIA

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Jackass Morwong *Nemadactylus macropterus*, Reproduction and Fecundity in Eastern Bass Strait, Australia.

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Abstract

The reproductive cycle of female jackass morwong, *Nemadactylus macropterus* was investigated using (i) a time series of gono-somatic index (GSI: ovary weight/gutted weight), (ii) regressions of ovary weight on gutted weight, and (iii) egg diameter frequency distributions. Gonad weight data were collected during the 3 years commencing March 1982. Egg diameter data and fecundity estimates were obtained from ovaries collected between January and August 1984. These were treated with Gilson's fluid, sub-sampled volumetrically, photographed and the negatives projected onto a digitiser linked to a microcomputer where eggs were counted and diameters measured.

Jackass morwong were found to be serial spawners. Most (80%) of the eggs were released during autumn (April - June), but some were released during early summer. Females were sexually mature at 3 years of age.

Fecundity ranged from 100400 eggs for 3-year-old fish to 1419000 eggs for a 14-year-old fish. The relationship between fecundity and length was a geometric function (Fecundity = 0.84 x Length$^{3.72}$), whilst the relationships between fecundity and age and between fecundity and gutted

weight were linear (Fecundity = 117210 x Age - 194518, and Fecundity = 851 x Gutted weight - 104211). A 14-year-old fish was therefore 9.2 times as fecund as a 3-year-old fish.

INTRODUCTION

The jackass morwong Nemadactylus macropterus (Bloch and Schneider 1801) is found in the waters from Western Australia to the central New South Wales coast and is also common in New Zealand waters where it is known as tarakihi. Off south-east Australia this species appears to comprise one genetically similar population (Richardson 1982). The species is very common in south-east Australian waters (Wankowski and Moulton 1986) and is an important species to the trawl fishery in this area which lands around 2000 tonnes annually (Moulton and Wankowski 1985).

In eastern Bass Strait, jackass morwong grows to a fork length of 60 cm over sand, reef, and sponge and bryozoan-covered substrates at depths from the shore to about 400 m.

Most of the publications concerning this species in Australian waters deal mainly with growth and mortality (Smith 1982,1983; Wankowski and Jolly 1986). The results of one study (Han 1964) show that the spawning season of jackass morwong in Australian waters lasts from late summer to mid-autumn (February to late April); that each female lays more than one batch of eggs; that 3-year-old females are sexually mature; and that its fecundity is 190 thousand to 1.3 million eggs. In New Zealand waters jackass morwong spawns serially during late summer to early autumn (Tong and Vooren 1972, Robertson 1978). Age at sexual maturity varied from three years (Han 1964) to four to six years (Tong and Vooren 1972) with the difference explained by the slower growth rate found in New Zealand waters.

In this paper we describe the reproductive cycle of female jackass morwong and estimate fecundity by age class. The work was part of a program designed to develop simulation models of the population dynamics of this species in eastern Bass Strait (Moulton and Wankowski 1985).

Materials and Methods

Commercial landings of jackass morwong were sampled monthly at Lakes Entrance and bi-monthly at Eden between March 1982 and February 1985. A random sample of females stratified by body length was taken (maximum of five fish per 1.0 cm length class). Each female was measured (fork length to the nearest millimeter), weighed whole and weighed gutted. The ovaries of each female were weighed. The age of each fish was determined from otoliths by the Tong and Vooren (1972) and Smith (1982) method (Wankowski and Jolly 1986). During January - June 1984, ovaries from two fish from each 1.0 cm length class were collected each month when samples were available from January to August 1984. These were treated with Gilson's fluid as modified by Simpson (1951) and set aside for a minimum of three months to allow connective tissue to break down. The Gilson's fluid was then decanted from the samples and the remaining solids were shaken vigorously to break down clumps of eggs. The sample was then poured onto a 0.9 mm seive and washed with 10% ethanol to separate the eggs from any remaining ovarian tissue. The eggs were then diluted with 10% ethanol to a known volume. Histological studies of jackass morwong in New Zealand (Tong and Vooren 1972) found that eggs undergoing vacuolation and vitellogenesis ranged from 0.1 mm to 0.5 mm in diameter. In this study all eggs larger than 0.1 mm diameter were considered to be capable of being spawned, and were counted for fecundity estimation. The eggs were then diluted with 10% ethanol to a known volume, subsampled volumetrically, photographed, and counted and measured using a microcomputer and digitizing pad (Hobday and Wankowski 1987).

A gono-somatic index (GSI = ovary weight / gutted weight) was calculated for each female fish from the length stratified sample. The seasonality of spawning was determined (i) from the frequency distribution of GSI for each month, (ii) from the slope of the regression of ovary weight on gutted weight for each monthly sample, and (iii) from egg diameter frequency distributions.

Monthly egg diameter frequency distributions were calculated by the method described by Hobday and Wankowski (1987).

The potential fecundity (F) of each fish was calculated:

$$F = N_s * (V_t / V_s)$$

where N_s = number of eggs in the subsample

V_t = volume of diluted sample

V_s = volume of subsample

Potential fecundity was regressed on age, on length and on gutted weight, and predicted potential fecundity at age, length and gutted weight determined. Regression functions (linear, geometric, logarithmic and exponential) which resulted in the lowest standard error of the regression and, the highest correlation coefficient (r) were chosen as the preferred models.

RESULTS AND DISCUSSION

Interpretation of GSI data was complicated because we were unable to collect samples during about one third of the commercial samples. GSI

(Fig. 1) were lowest from June to November or December, the resting phase of the reproductive cycle, and increased rapidly to a maximum between January and March or April, the period of ovary development and spawning. GSI then declined to a minimum again in June. From these data, we conclude that spawning could have occurred between January and June. This is consistent with the observations of Han (1964) who reported that jackass morwong spawn from late February to April, and of Tong and Vooren (1972), who reported that spawning started in March and ended in late April or early May.

Monthly variation of the slope of regression coefficient of ovary weight on gutted weight (Fig. 2) shows the same seasonality cycle as do the GSI distributions but highlights the very rapid increase in gonad development between, for example, March and April 1984. The similar rapid increase in ovary weight at this time (Tong and Vooren 1972) also shows that maturation was a rapid process. This rapid increase started earlier in 1982 than in 1984 and may indicate an earlier spawning in 1982.

The frequency distribution of egg diameters for the months sampled fell into two groups: (i) a unimodal distribution with a mode at 0.2 - 0.3 mm diameter but a maximum egg diameter less than 0.5 mm, and (ii) a bimodal distribution with a second mode between 0.4 and 0.6 mm diameter but maximum egg diameter greater than 0.5 mm. Since the ovaries in which egg diameter distribution was unimodal did not contain large eggs, we can conclude that the ovaries were either in early stages of development or spent, most likely the latter, given the time of sampling. The proportion of ovaries which gave a unimodal distribution of egg diameters increased from 0.25 in January, to 0.50 in April and to 1.00 in March, corresponding to the proportion of spent ovaries. The maximum egg diameter was 0.65 mm, which, when compared with Tong and Vooren's (1972) measured mean diameter of 0.93 mm for mature eggs, indicates that the ovaries we collected were all in the developing stages (Fig. 3) and no mature or primary eggs present.

During the 3 months January to March the maximum egg diameter decreased and the second mode, in which eggs had a diameter of 0.4 - 0.6 mm, was absent; this result indicates that spawning activity took place between these two samples. Both the maximum egg diameter and the GSI of the April sample was higher, indicating development of eggs before further spawning. The main spawning appears to have occurred during the 3 months April - June as the mean relative fecundity (F/G) declined by 324 (eggs / g gutted weight) during this time, whereas it decreased by only 73 (eggs / g gutted weight) between January and April (Table 1). Larger eggs were still present in June but the number of eggs were very low (Table 1). By August, the diameters of all eggs were less than 0.1 mm, indicating that ovaries were in a resting phase.

Our results are therefore consistent with those of Han (1964) and Tong and Vooren (1972) that jackass morwong are serial spawners, but are different in showing that most of the eggs are released in autumn.

Fecundity estimated from each of the monthly samples available during 1984 was low during January and March but increased in April before declining by June (Fig.4).

Developing and spent ovaries were differentiated by examining estimates of fecundity and the distribution of egg diameters from which they were derived. Unimodal distributions of egg diameters could be present because ovaries were developing and fecundity would be relatively high but large eggs had not yet developed, or because ovaries were spent, fecundity would be low and large eggs had been shed. Bimodal distributions of egg diameters represent ovaries in the later development stages before spawning. If fecundity estimates from unimodal and from bimodal distributions in a sample were the same, then the ovaries for which the distribution is unimodal were probably developing. If fecundity estimates from unimodal distributions were lower than those from bimodal distributions, the ovaries were probably spent.

As there was no difference between fecundity estimates from unimodal and from bimodal frequency distributions of egg diameters in the January sample (Fig. 4), we considered the ovaries to be developing. Evidence for a partial spawning between January and March is provided by the decrease in fecundity during this time (Fig. 4) and the fact that in March all ovaries showed unimodal egg diameter distributions (Fig. 3). By April fecundity had increased and we considered ovaries in this sample to be developing before the main spawning because there was no separation of fecundity by egg diameter frequency distributions (Fig. 4).

Since the main spawning occurred between April and June, we consider that the April sample provides the best estimate of fecundity. We did not attempt to determine the number of batches of eggs released in a reproductive season or the extent of resorbtion of eggs. Further refinement of the estimates allowing for some fish spawning earlier than the main spawning would add little to the age related estimates in this study.

The ovaries of 20 females sampled during April were used to estimate potential fecundity at specific ages. All were developing or mature according to Tong and Vooren's (1972) maturity scale. Potential fecundity (F) ranged from 72000 for a 2-year-old fish (19.6 cm fork length), to 1419000 for a 14-year-old fish (48.5 cm fork length). A geometric function relating F to length gave the best fit to the data:

$$F = 0.84 \times Length^{3.72} \qquad (r^2 = 0.91)\ (Fig.\ 4)$$

Linear functions gave the best fit to the data relating F to both age and length:

$$F = 117210 \times Age - 194518 \qquad (r^2 = 0.80)\ (Fig.\ 4)$$

$$F = 851 \times Gutted\ weight - 104211 \ (r^2 = 0.83)\ (Fig.\ 4)$$

Fecundity estimates derived from these linear functions (Table 2) were expressed relative to age three as Han (1964) reported this to be the age at first maturity. Tong and Vooren (1972) reported that no 3-year-old fish were mature and by the age of 6 years all were mature. They also found limited egg development in some immature fish but thought it unlikely that this would result in spawning. For this reason the one 2-year-old fish with developing eggs in April (Fig. 4) was classed immature and was not included in the age related fecundity estimates. The results show that a 14-year-old fish was 9 times as fecund as a 3-year-old fish (Table 2).

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Table 1. Mean monthly relative fecundity (F/G, eggs/g gutted weight), standard deviation (S.D.) and number of fish sampled (N), for the months available between January and June 1984.

Month	January	March	April	June
F/G	429	385	356	32
S.D.	202	59	136	46
N	12	7	20	10

Table 2. Potential fecundity (F) of jackass morwong and potential fecundity relative to age three (F_r).

Age (years)	F (millions)	F_r
3	0.1565	1.0
4	0.2735	1.8
5	0.3905	2.5
6	0.5075	3.2
7	0.6245	4.0
8	0.7415	4.7
9	0.8585	5.5
10	0.9755	6.2
11	1.0925	7.0
12	1.2095	7.7
13	1.3265	8.5
14	1.4435	9.2

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FIGURE CAPTIONS

Figure 1. Relative frequency distribution of gono-somatic index. N: number of gonads sampled.

Figure 2. Time series of monthly values of the slope of the regression of ovary weight on gutted weight.

Figure 3. Egg diameter frequency distributions for the months between January and June 1984 for which samples were available.
N: number of ovaries sampled.

Figure 4. Potential fecundity for January, March, April and June 1984.
Squares: unimodal freuency distributions of egg diameter;
Crosses: bimodal freuency distributions of egg diameter.

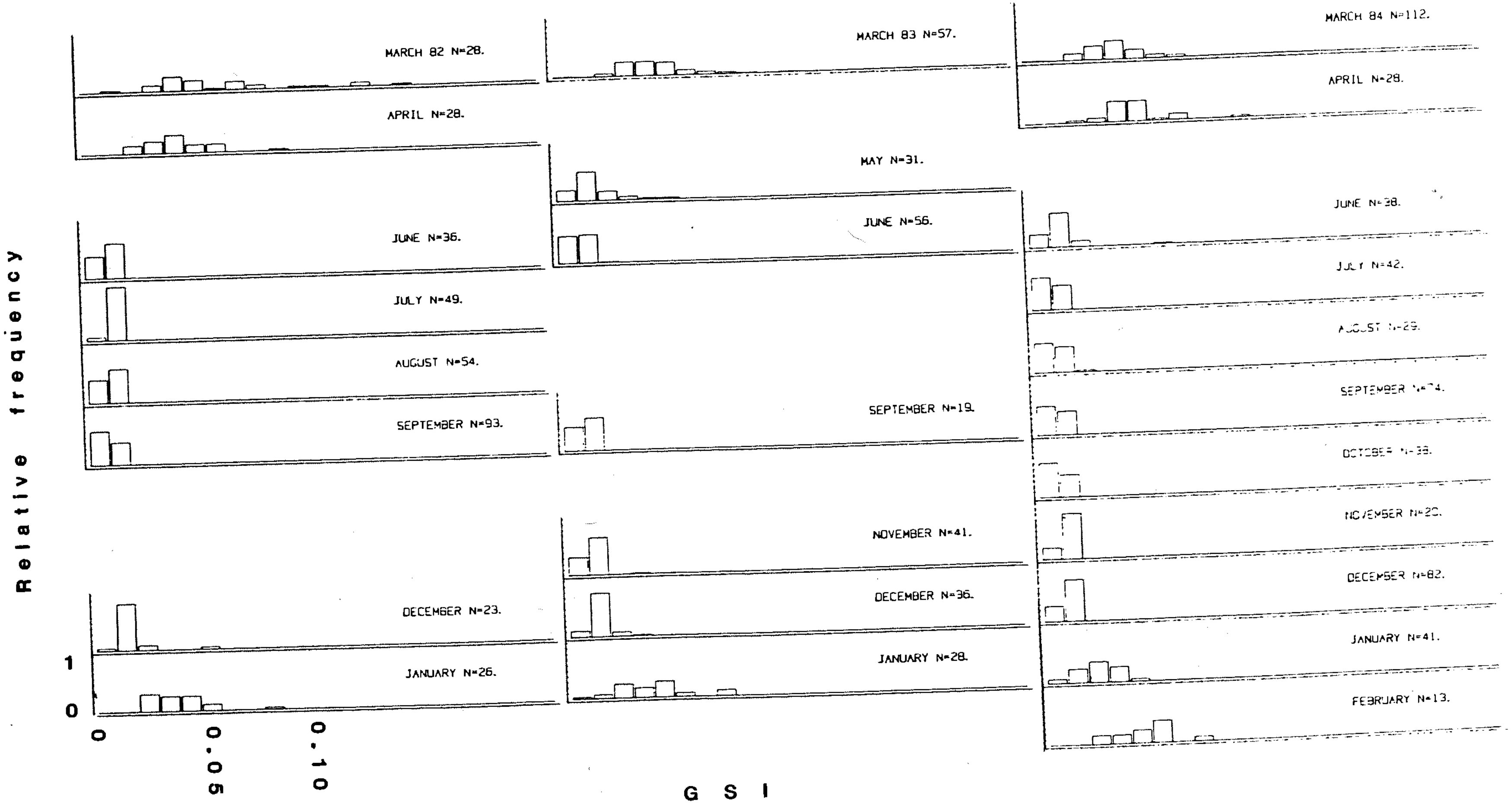
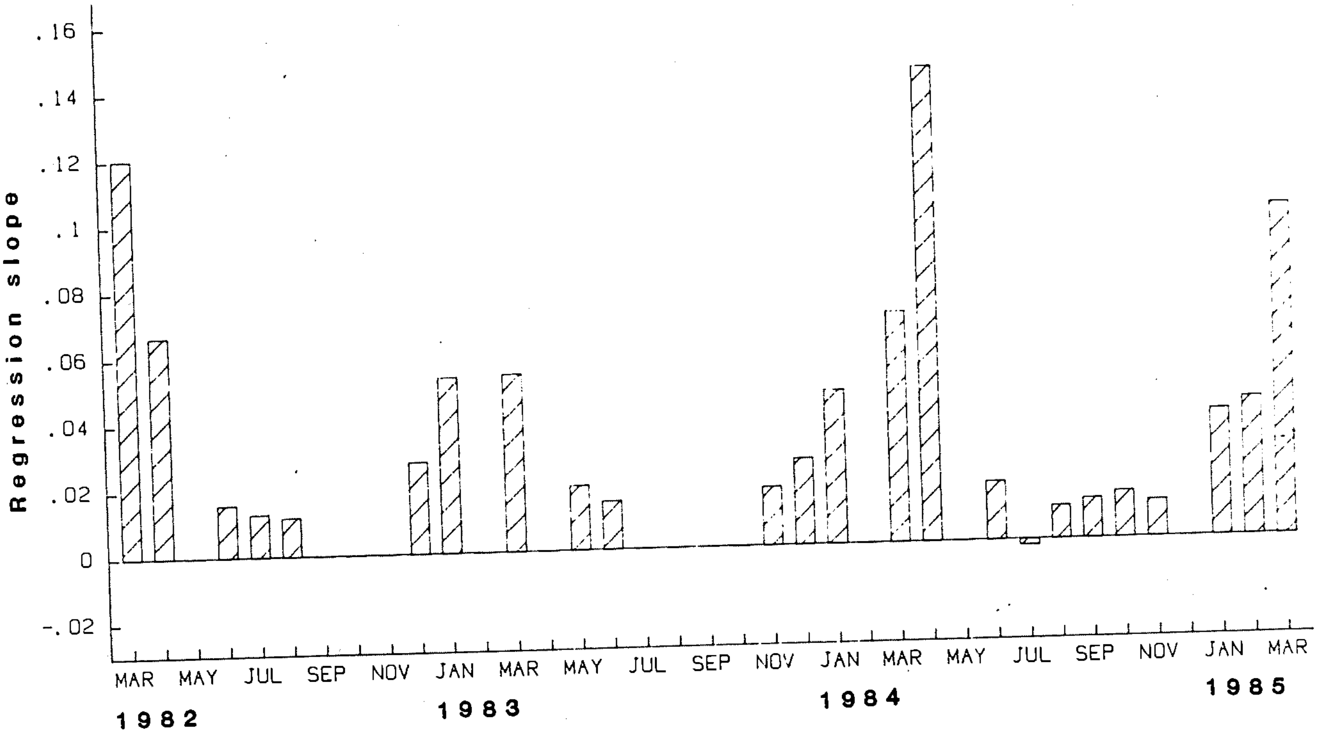

MARCH 82 N=28.
APRIL N=28.
JUNE N=36.
JULY N=49.
AUGUST N=54.
SEPTEMBER N=93.
DECEMBER N=23.
JANUARY N=26.
MARCH 83 N=57.
MAY N=31.
JUNE N=56.
SEPTEMBER N=19.
NOVEMBER N=41.
DECEMBER N=36.
JANUARY N=28.
MARCH 84 N=112.
APRIL N=28.
JUNE N=38.
JULY N=42.
DECEMBER N=82.
JANUARY N=41.
FEBRUARY N=13.
Relative frequency
1
0
0
0.05
0.10
G S I

Fig 1



.16
.14
.12
.1
.08
.06
.04
.02
0
-.02
Regression slope
MAR MAY JUL SEP NOV JAN MAR MAY JUL SEP NOV JAN MAR MAY JUL SEP NOV JAN MAR
1982
1983
1984
1985

Fig 2

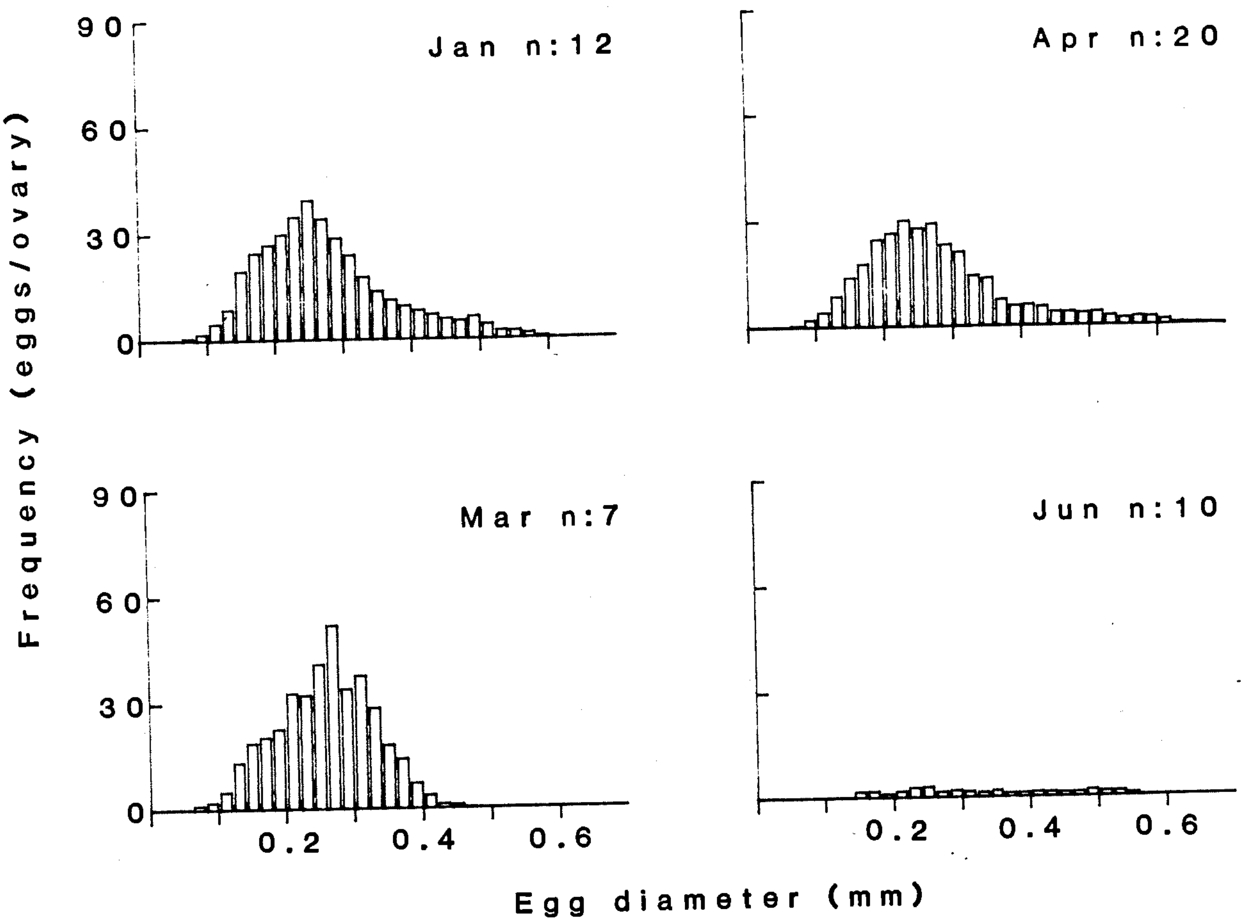
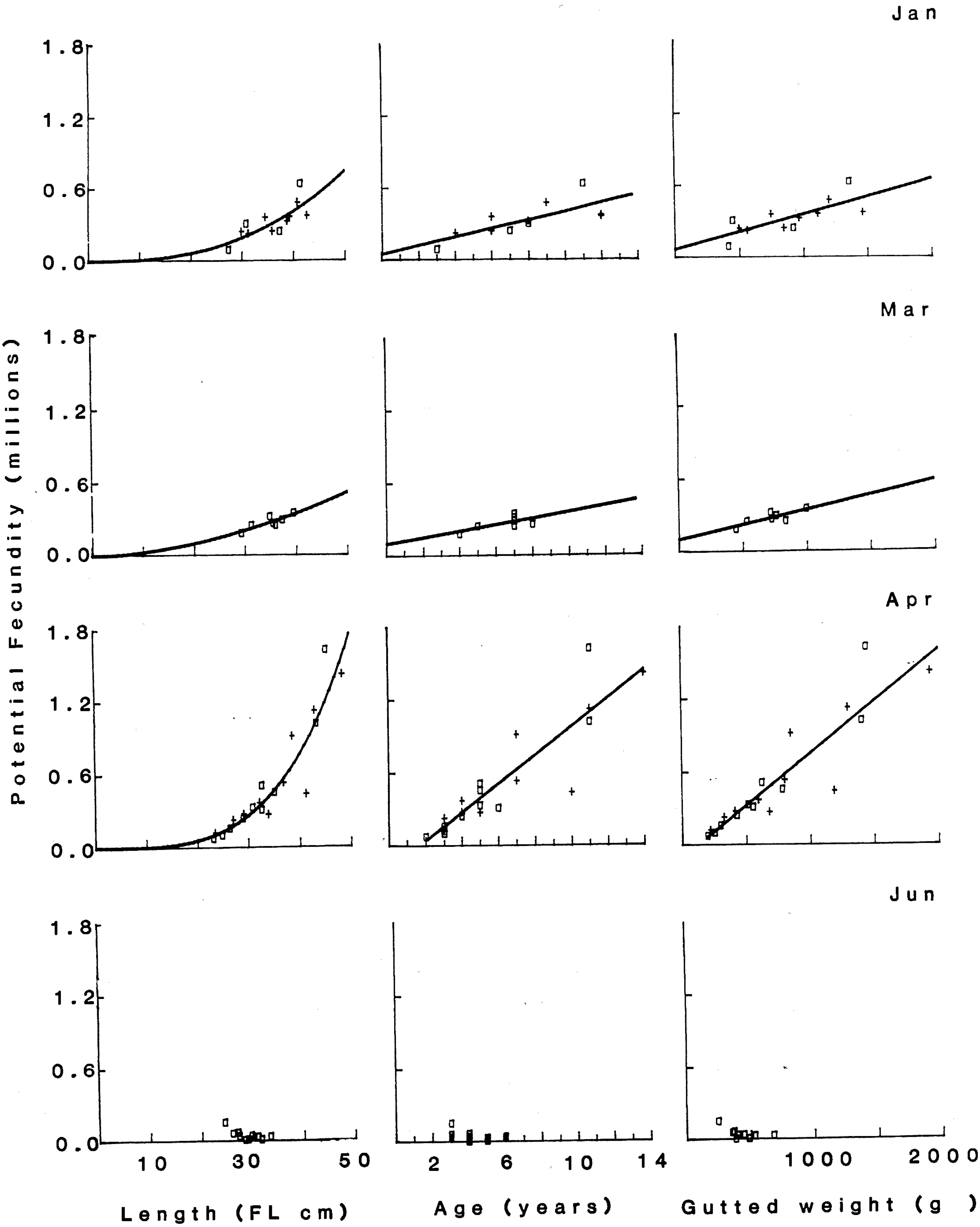

Jan n:12
Apr n:20
Mar n:7
Jun n:10
Frequency (eggs/ovary)
90
60
30
0
0.2
0.4
0.6
Egg diameter (mm)

Fig 3



Jan
Mar
Apr
Jun
1.8
1.2
0.6
0.0
Potential Fecundity (millions)
10
30
50
2
6
10
14
1000
2000
Length (FL cm)
Age (years)
Gutted weight (g)

Fig 4

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