

Fisheries Long Term Monitoring Program

Summary of sea mullet (*Mugil cephalus*) survey results: 1999–2006

March 2008



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Contents

Contents	iii
Acronyms	iii
Summary	v
Long Term Monitoring Program background	vi
Introduction	1
Objectives	2
Methods	3
Data summaries and analysis	4
Results and discussion	5
Length–weight	8
Age frequency	8
Growth	13
Future Directions	14
References	15

Acronyms

CFISH	Commercial Fisheries Information System, DPI&F
DPI&F	Department of Primary Industries and Fisheries, Queensland
FL	fork length
LTMP	Long Term Monitoring Program, DPI&F
NSW	New South Wales

Summary

Sea mullet (*Mugil cephalus*) is a schooling species that is distributed in fresh, estuarine and coastal waters throughout the world (Kailola *et al.* 1993). Its main distribution in Queensland is between Townsville and the New South Wales border (Williams 2002).

Queensland commercial fishers target schools of mullet on ocean beaches and in estuaries. The main component of the Queensland commercial mullet fishery has historically been the ocean beach sector, which targets sea mullet during their annual spawning migration between March and July (Virgona *et al.* 1998). The estimated 2005 harvest of mullet for the Queensland commercial fishery was approximately 1637 tonnes (DPI&F 2006). The recreational mullet catch is relatively insignificant compared with the commercial harvest (Bell *et al.* 2005).

The Queensland mullet fishery is managed by the Department of Primary Industries and Fisheries under the Fisheries Regulation 1995. The current management arrangements include spatial and seasonal closures, a minimum legal size limit and limited commercial entry.

The Long Term Monitoring Program (LTMP) monitors the length, weight, sex, and age of the commercial mullet catch. Catches from the ocean beach sector have been monitored since 1999 and from the estuarine sector since 2006. This report presents a summary of the data collected from the ocean beach sector from 1999 to 2006.

The LTMP measured 18,131 mullet from the commercial ocean beach fishery between Fraser Island and the Queensland – New South Wales border. The modal fork length (FL) of mullet was between 320 and 350 mm for all years. When separated by gender, region and year the modal length of females was larger than males, with ranges between 340 and 430 mm, and 310 and 350 mm FL respectively. There was a significant relationship between length and weight of mullet, with females appearing on average slightly heavier at a given length than males. Female mullet appeared to grow larger and quicker than males, although there was a poor relationship between length and age, and a lack of growth rate information for small young mullet. The majority of mullet collected were aged as three year olds, but very few were five years old or older. The length and age frequency data are considered representative of the commercial ocean beach fishery in southern Queensland.

Long Term Monitoring Program background

The Department of Primary Industries and Fisheries (DPI&F), Queensland, manages the state's fish, mollusc and crustacean species and their habitats. As part of this commitment, DPI&F monitors the condition of, and trends in, fish populations and their associated habitats. This information is used to assess the effectiveness of fisheries management strategies and helps ensure that the fisheries remain ecologically sustainable.

DPI&F uses the information to demonstrate that Queensland's fisheries comply with national sustainability guidelines, allowing exemption from export restrictions under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*.

DPI&F initiated a statewide Long Term Monitoring Program (LTMP) in 1999, in response to a need for enhanced data used in assessment of Queensland's fisheries resources. The LTMP is managed centrally by a steering committee, with operational aspects of the program managed regionally from the Southern and Northern Fisheries Centres located at Deception Bay and Cairns respectively. The regional teams are responsible for organising and undertaking the collection of data used for monitoring key commercial and recreational species, and for preparing data summaries and preliminary resource assessments.

A series of stock assessment workshops in 1998 identified the species to include in the LTMP. The workshops used several criteria to evaluate suitability, including:

- the need for stock assessment
- the suitability of existing datasets
- the existence of agreed indicators of resource status
- the practical capacity to collect suitable data.

Resources monitored in the program include saucer scallops, spanner crabs, stout whiting, yellowfin bream, sand whiting, dusky flathead, rocky reef fish, eastern king prawns, blue swimmer crabs, sea mullet and tailor in southern Queensland; tiger and endeavour prawns and coral trout and redthroat emperor in northern Queensland; and mud crabs, barramundi, spotted and Spanish mackerel and freshwater fish in both regions. Various sampling methods are used to study each species.

The LTMP collects data for resource assessment (ranging from analyses of trends in stock abundance indices to more complex, quantitative stock assessments) and management strategy evaluations.

Stock assessment models have already been developed for saucer scallops, spanner crabs, stout whiting, mullet, tailor, barramundi, tiger and endeavour prawns, redthroat emperor, and spotted and Spanish mackerel. In some cases, management strategy evaluations have also been completed and the data collected in the LTMP proved integral to these activities.

The assessments and evaluations have allowed for improvements to the management of Queensland's fisheries resources. Enhancements to ongoing monitoring have also been identified, particularly to address the increasing demand for high-quality data for dynamic fish population models.

Through the ongoing process of collecting and analysing LTMP data, incorporating these data into regular assessments, and refining monitoring protocols as required, DPI&F is enhancing its capacity to ensure that Queensland's fisheries resources are managed on a sustainable basis.

Introduction

Sea mullet (*Mugil cephalus*) are distributed throughout the world, mainly between latitudes of 42° N and 42° S. They inhabit the fresh, estuarine and coastal waters of all Australian states and territories (Kailola *et al.* 1993).

Adult sea mullet inhabit the upper reaches of coastal rivers. During the annual spawning season they migrate north along the coast to the spawning grounds. The exact locations of spawning areas are currently unknown. Sea mullet often occur in schools as juveniles and again as adults during the spawning season. Mullet reach sexual maturity around three years of age and approximately 300 mm total length (Kailola *et al.* 1993).

The annual spawning migration is thought to occur during periods of prevailing offshore winds. The spawning migration on the east coast starts in March and continues until July in southern Queensland (Smith and Deguara 2002a). Sea mullet normally feed on algae and microscopic invertebrates, although they tend not to feed during migration (Williams 2002).

The sea mullet is a major commercial fish species in Australia and many other parts of the world. In Australia, the main commercial fisheries for sea mullet are in New South Wales (NSW), Queensland and Western Australia harvesting 2552, 1607 and 200 tonnes per annum respectively during 2005-2006 (ABARE 2007). The mullet catch for Queensland waters is composed predominantly of sea mullet with the majority of the catch coming from ocean beaches in the southern half of the state (NSW border to Sandy Cape) (Williams 2002). Further north, the mullet fishery is mainly estuarine based, hence the total catch is relatively small compared to southern Queensland and also includes diamond scale mullet (*Liza vaigiensis*), flat-tail mullet (*Liza argentea*) and other smaller Mugil species (Williams 2002). The estuarine fishery uses gill and tunnel nets to target fish for the local fresh fillet market throughout the year. The ocean beach fishery uses seine or haul nets to target pre-spawning female fish to supply an international export market for mullet roe.

The sea mullet fishery is managed under the Fisheries Regulation 1995 which imposes:

- a minimum size limit of 300 mm
- restrictions on gear
- restriction on the number of commercial licences
- permanent closure areas
- seasonal closures (1st September to 31st March).

The ocean beach component of the fishery is limited to 62 license-holders (K endorsement) in Queensland and to a season extending from 1 April to 31 August (Fisheries Regulation 1995). The K endorsement allows fishing activities on licence-specific ocean beaches (eight zones) during these months using seine nets with a maximum mesh size of 70 mm. Commercial ocean beach fishers target mullet on their seasonal, winter, pre-spawning migration north along the coast from estuaries in NSW and southern Queensland, to Sandy Cape on Fraser Island. Monofilament seine (or haul) nets are used to capture migrating fish, which are usually spotted either schooling in estuaries or swimming in near shore ocean beach gutters. The fish are tracked until they reach a suitable area where the boat deployed net is set around the school and hauled onto the beach.

The estuarine net fishery (various N endorsements) encompasses a wider area and involves significantly more licence holders. In the estuarine fishery, sea mullet are taken as both target and incidental catch. Catches from this fishery are generally smaller in size (CFISH database, December 2006) but contain higher numbers of smaller individuals (Bell *et al.* 2005). The majority of the estuarine catch (61%) is taken during the ocean beach season (CFISH database, December 2006) however operations under an N licence are not permitted on ocean beaches during the ocean beach season.

No significant amounts of sea mullet are caught on ocean beaches between September and December. However, depending on market and environmental conditions, schools of non-reproductive fish, known as hardgut mullet, are sometimes targeted as they migrate from estuarine waters to ocean beaches. Comparatively small in total catch size, the hardgut run was historically economically significant, due to the scarcity of other fish species and the relatively higher prices. However in recent times this run of fish has been inconsistent or non-existent and is generally not targeted (D.Roy, DPI&F, pers. obs. August 2007).

Worldwide few formal stock assessments have been undertaken on this species. Dichmont *et al.* (1999) conducted a preliminary stock assessment that indicated that the mullet stock were possibly being subjected to unsustainable levels of fishing mortality. In response, the DPI&F instigated monitoring of sea mullet in 1999 by annually collecting fishery-dependent samples to monitor the characteristics of the commercial sea mullet catch. This monitoring was designed to complement the compulsory Commercial Fisheries Information System (CFISH) logbook program already in place to collect data on catch and effort. A recent comprehensive stock assessment of the Queensland and NSW mullet fishery was conducted by Bell *et al.* (2005). Recommendations arising from this report included retaining current management strategies and proposed changes to the LTMP for sea mullet.

Objectives

The objective of the LTMP mullet monitoring project between 1999 and 2006 was to collect representative data on the following aspects of the Queensland sea mullet catch:

- length structure
- age structure
- sex structure.

Data on these parameters are required for regular stock assessment to guide the management of the mullet resource, on which the various commercial fisheries depend.

This report presents a summary of the data collected by the LTMP from 1999 to 2006.

Methods

Samples were collected directly from commercial ocean beach mullet fishers or through processors. Representative age sampling procedures are described in the commercial catch sampling protocol (DPI&F In Prep.).

The LTMP sampling protocols for sea mullet are described in detail in DPI&F (2005). In short, the criteria for the collection of samples were ocean beach catch (haul net) between Breaksea Spit and the Queensland – NSW border (Figure 1) between May and August where:

- the total catch was greater than 400 sea mullet, and
- they were not sorted by sex or size.

From 1999–2005, two samples were collected annually from each sampling zone (Fraser, Sunshine Coast and Stradbroke). In 2006 the target number of catches to be sampled was increased to 20 and some basic spatial stratification was applied. The fishery area was divided into five zones (Fraser, Sunshine Coast, Moreton Island, North Stradbroke Island and Gold Coast) each receiving an allocation of target catch numbers based on the reported commercial catch of the area (Table 1).

Table 1. Stratification of sea mullet sampling effort applied during the Long Term Monitoring Program in 2006.

Sampling Zone	No. of catches to be sampled
Fraser	2
Sunshine Coast	6
Moreton Island	4
North Stradbroke Island (Flinders Beach to Southport Seaway)	4
Gold Coast (Southport Seaway to NSW/Queensland border)	4
Total	20

From 1999 to 2003 each fish was aged three times by two readers. One reader aged each fish twice, allowing at least one week between readings. The second reader aged each fish once. From 2004 onwards, one reader read each otolith once and then randomly selected 25% to re-read. All readings were made without prior knowledge of capture date, size and sex. Readers undertook training on identifying the otolith increments, recording otolith readability and marginal increment interpretation before they read collected otoliths.

The increment counts were not adjusted and are considered to represent the age of the fish. In 1999–2003 age estimates used for analysis were calculated by averaging all readings for each otolith and rounding the resultant number to the nearest integer. From 2004 onwards, when there was only one reader, the estimated ages for the first reading were used.

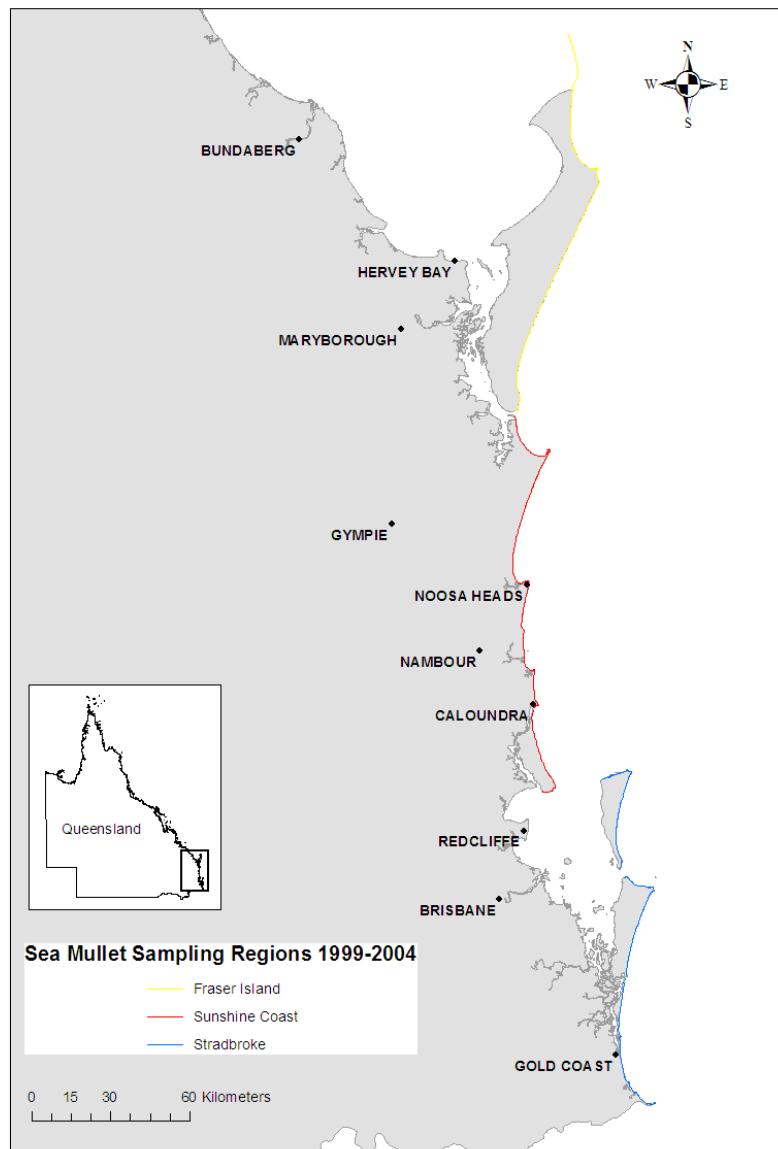


Figure 1. Sea mullet ocean beach sampling regions, 1999-2006

Data summaries and analysis

The length frequency and length–weight data have been summarised by gender, sampling region and year (1999 to 2006). The length frequency data for each region were plotted separately by year and gender. In 2006 length frequencies were scaled by the percentage of each catch measured e.g. if 50% of a total catch was measured the length frequency counts were doubled to represent the entire catch. This scaling was done to ensure larger catches were adequately represented in length frequency summaries.

Otolith increment counts are usually converted to age estimates, considering period of opaque zone formation, category of edge interpretation and date of capture of the fish. In this study, samples were not available throughout the entire year. Therefore edge analysis proved inconclusive and period of opaque zone formation could not be determined. For this reason, increment counts were not adjusted. Quality control measures applied to mullet otolith readings are discussed in the Dodt *et al.* (2007).

Age frequencies were grouped by gender, sampling region and year (1999 to 2006). Linear growth curves were used to describe the growth rates of mullet by gender. Linear curves were used because of the lack of small and younger mullet collected and were constructed using the trend-line option in Microsoft Excel[®].

Data limitations

In interpreting the results in this report, the following factors need to be considered:

- The sampling concentrated on the commercial ocean beach sector. Therefore the results characterise the fish retained by these fishers and may not truly represent the population, because of a combination of fish and fisher behaviour. This may impact on the results due to targeting, fishing location, gear selectivity and size limits. Sample donation to the program is voluntary and factors affecting participation could also correlate with other aspects of fisher behaviour.
- Sample collection was during a specified time period and factors such as moon/tide phase, weather conditions or other environmental influences may have varied. Data have not been standardised to account for any effect these factors may have had on the catch.

Results and discussion

There was little difference between years or regions in the length and age frequency samples collected by the LTMP. The length and age frequencies indicate that mullet recruitment in the Queensland ocean beach fishery is at approximately 320–350 mm fork length (Figure 2 and Figure 3) and three years of age (Figure 7 and Figure 8), and this is supported by previous research by Kesteven (1942), Virgona *et al.* (1998) and Smith and Deguara (2002a, 2002b). This length range is larger than the current minimum legal size limit of 30 cm (total length) (Fisheries Regulation 1995).

The majority of female fish collected in this program were of greater length (Figure 5) and weight (Figure 6) than male fish. This finding supports the results found for NSW mullet by Smith and Deguara (2002b).

The linear relationships for the growth of mullet collected by the LTMP surveys showed that female fish also tend to be larger at a given age than male fish (Figure 12). This finding indicates that female mullet have a higher growth rate than male mullet, which supports previous research (Smith and Deguara 2002a). However, the linear relationships between length and age for both sexes and all regions were weak, because of to the large amount of variation in length at age, and also the absence of small, young mullet in LTMP samples from this fishery.

Table 2. Summary of the number of sea mullet sampled by Long Term Monitoring Program from ocean beach fishery, 1999–2006.

Region	Collection Type	Numbers collected								Grand Total
		1999	2000	2001	2002	2003	2004	2005	2006	
Stradbroke	Length Only	900	600	601	600	300	604	600	2717	6922
	Ageing	300	200	200	198	200	199	198	297	1792
Sunshine	Length Only	600	600	1000	595	599	1000	900	2112	7406
	Ageing	199	200	200	199	200	200	300	235	1733
Fraser	Length Only	705	600	490	600	145	657	0	606	3803
	Ageing	200	200	199	200	100	100	0	68	1067
	Total	2904	2400	2690	2392	1544	2760	1998	6035	22723

Length frequency

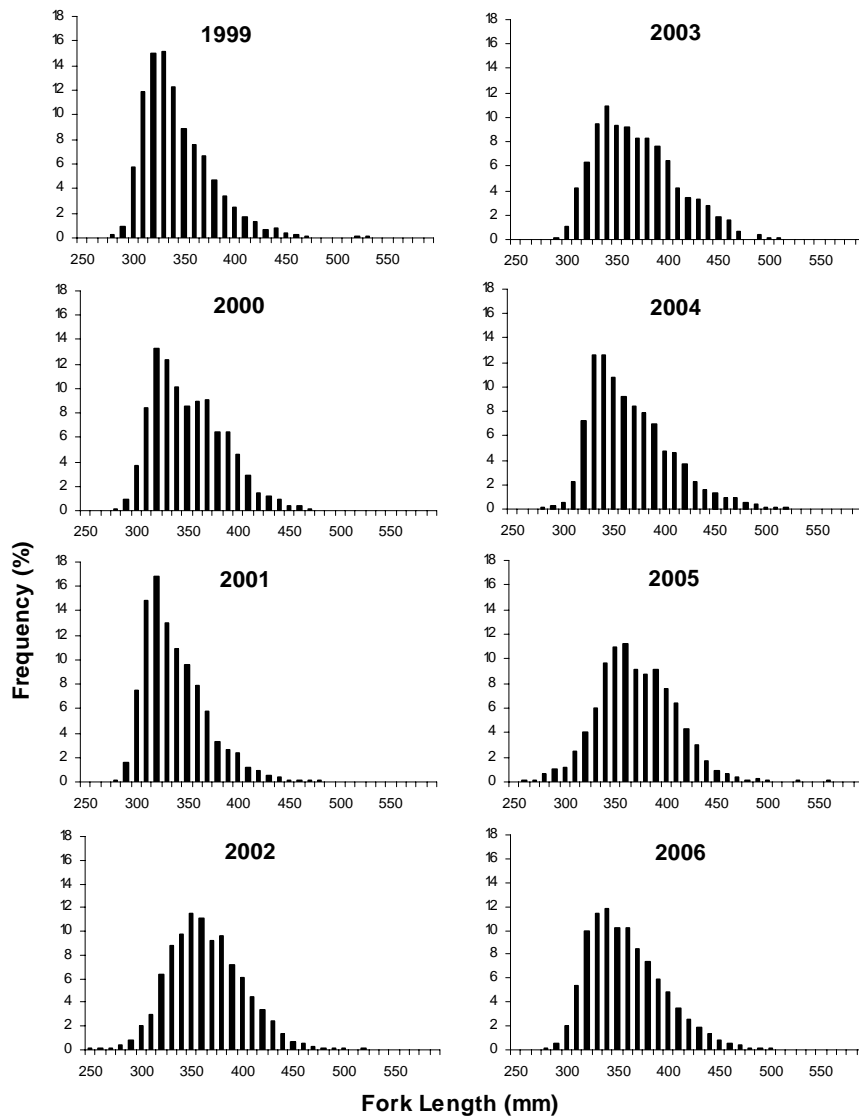


Figure 2. Length frequency of all mullet sampled by Long Term Monitoring Program by year 1999–2006.

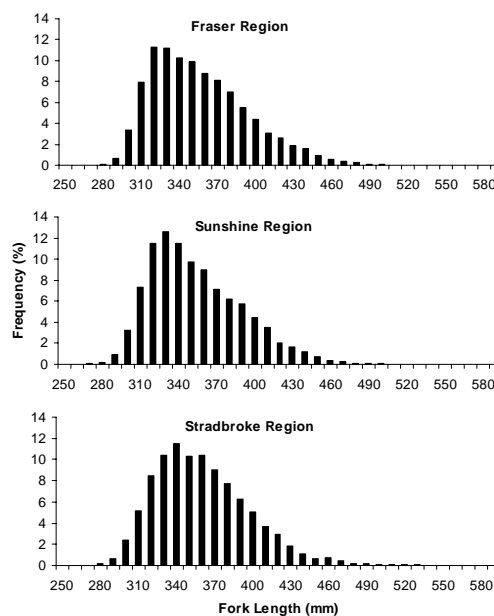


Figure 3. Length frequency of all mullet sampled by Long Term Monitoring Program by region, 1999–2006.

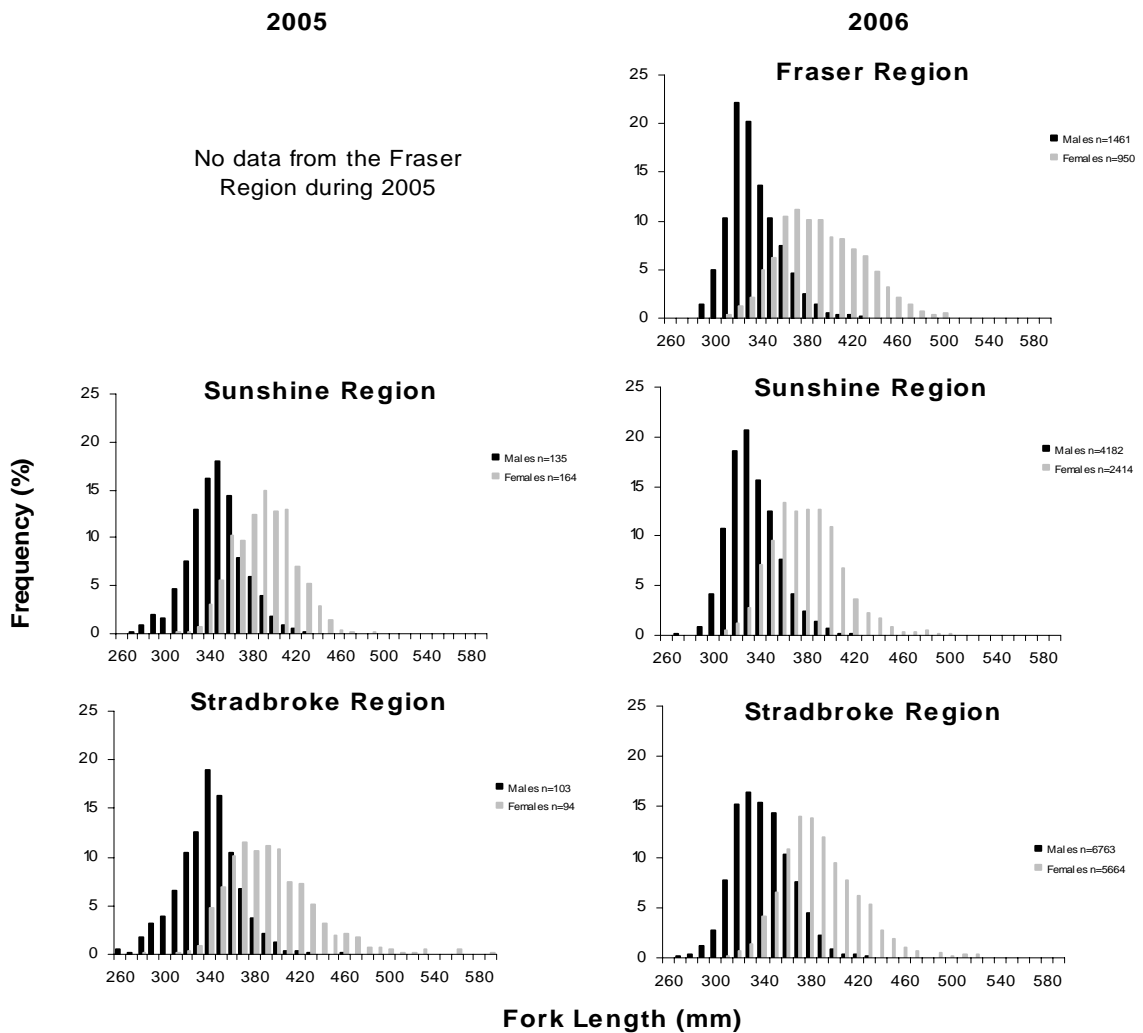


Figure 4. Length frequency of mullet for each region by gender, sampled by Long Term Monitoring Program in 2005 and 2006.

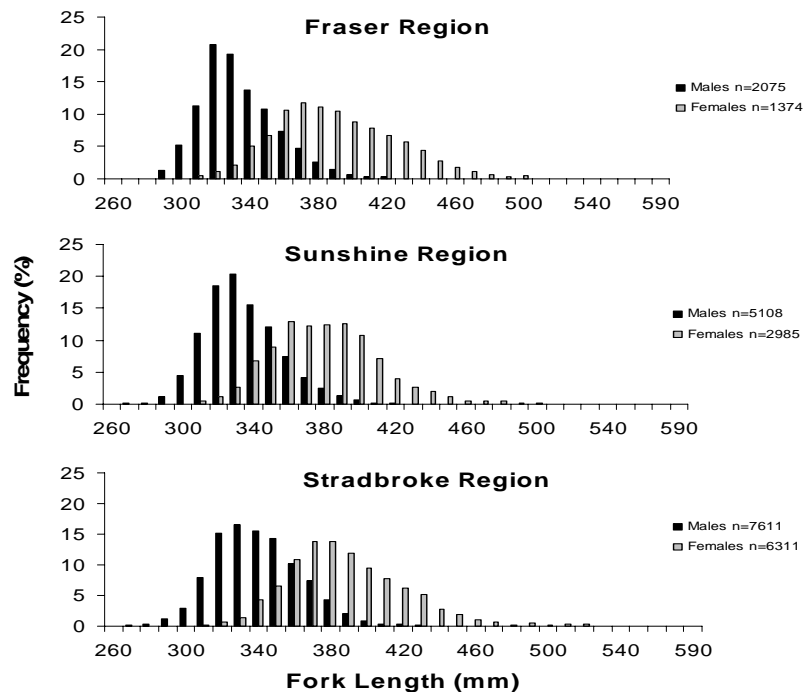


Figure 5. Length frequency of mullet for each region by gender, sampled by Long Term Monitoring Program, 1999–2006.

Length–weight

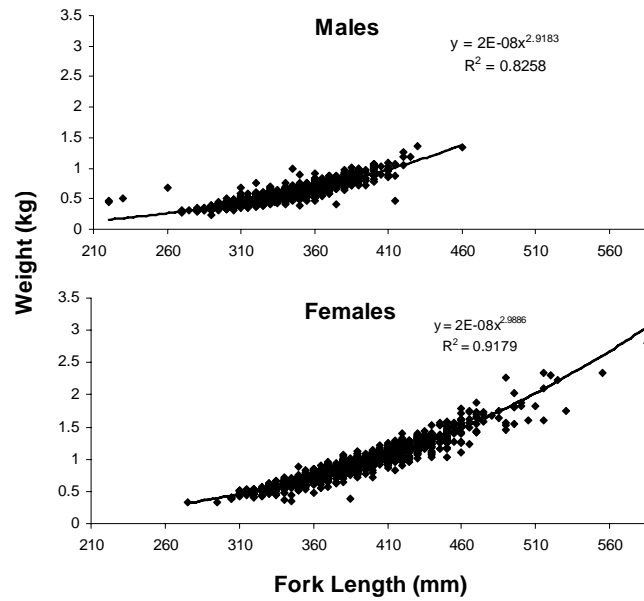


Figure 6. Length–weight of mullet from all regions and years sampled by the Long Term Monitoring Program from years 1999–2006.

Age frequency

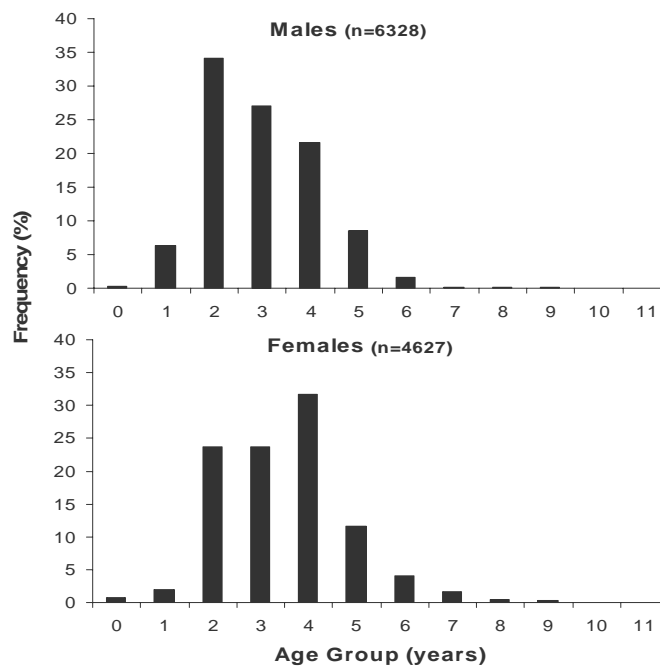


Figure 7. Long Term Monitoring Program mullet age frequency for all sampling regions by gender, 1999–2006.

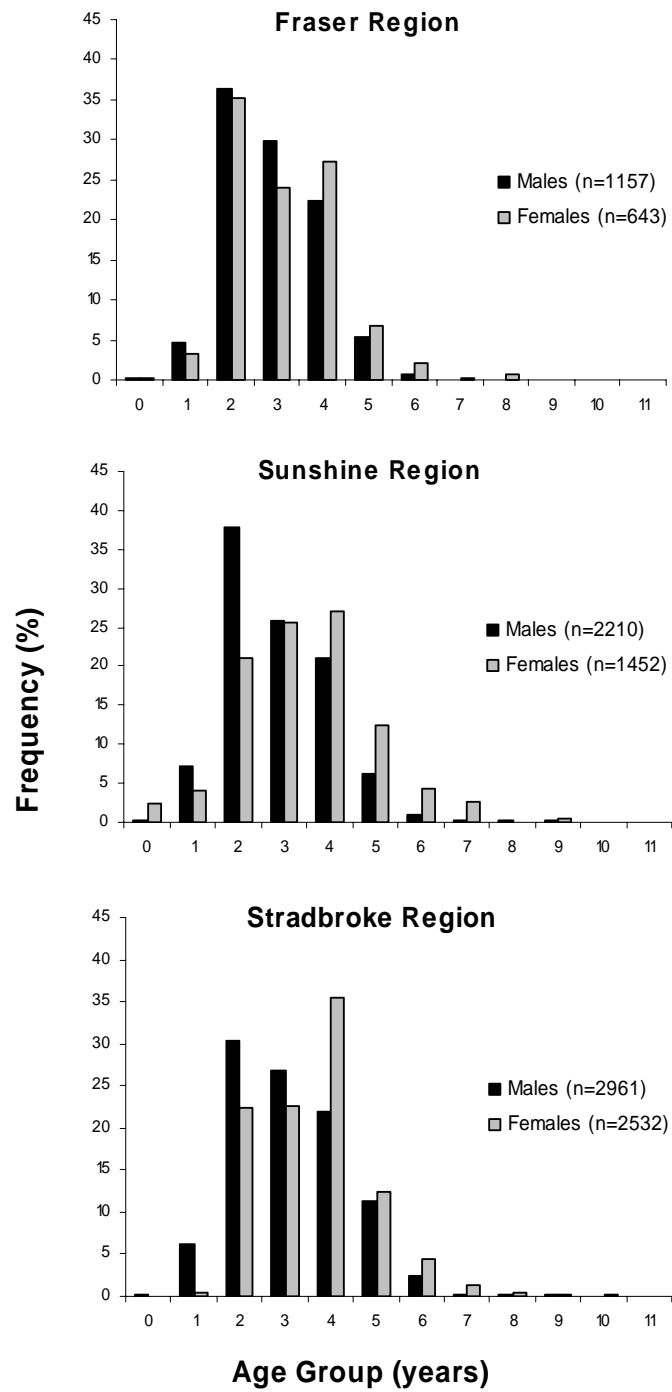


Figure 8. Long Term Monitoring Program mullet age frequency by sampling region and gender, 1999–2006 combined.

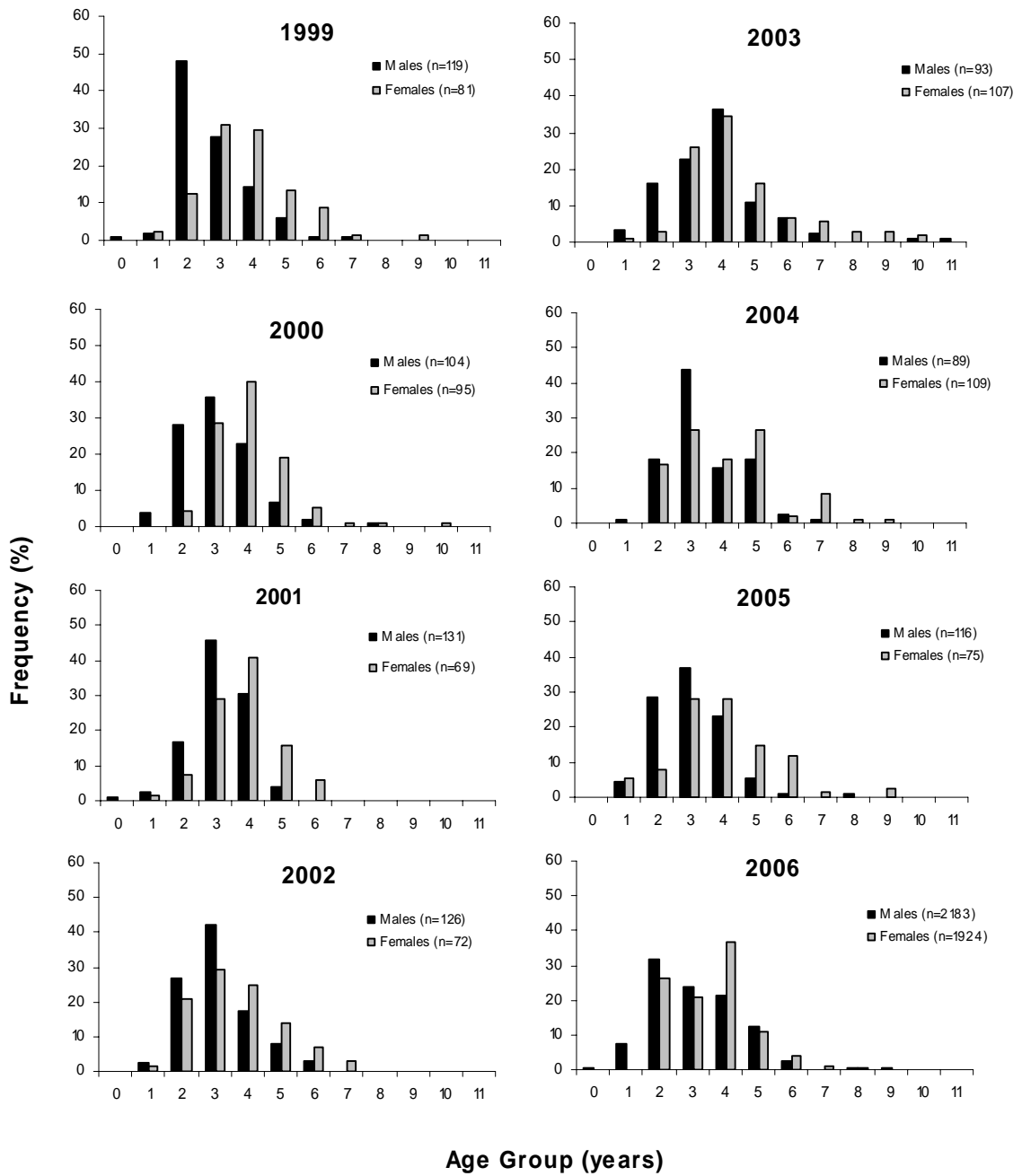


Figure 9. Long Term Monitoring Program mullet age frequency for Stradbroke region by gender and year 1999–2006.

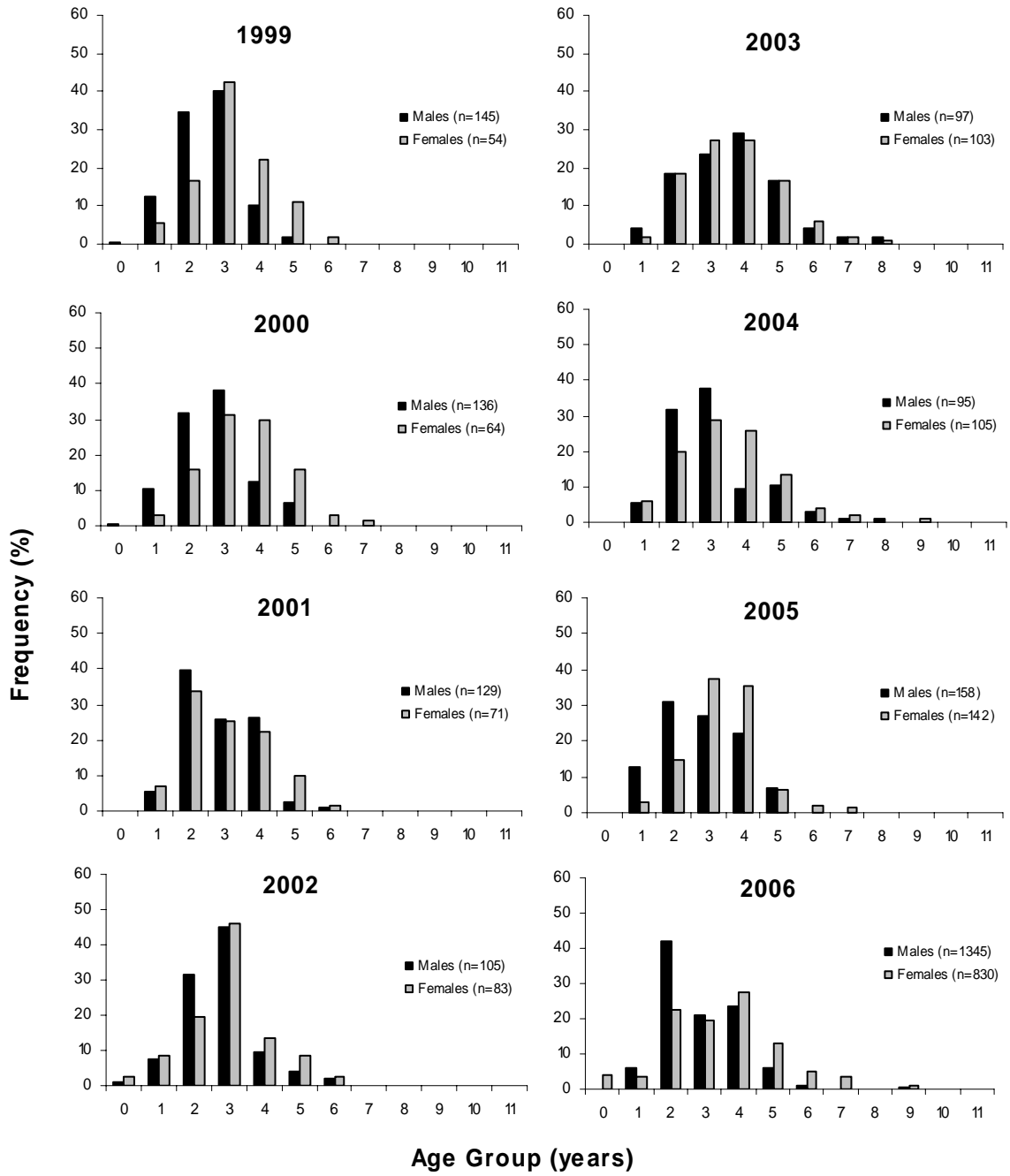


Figure 10. Long Term Monitoring Program mullet age frequency for Sunshine region by gender and year 1999–2006.

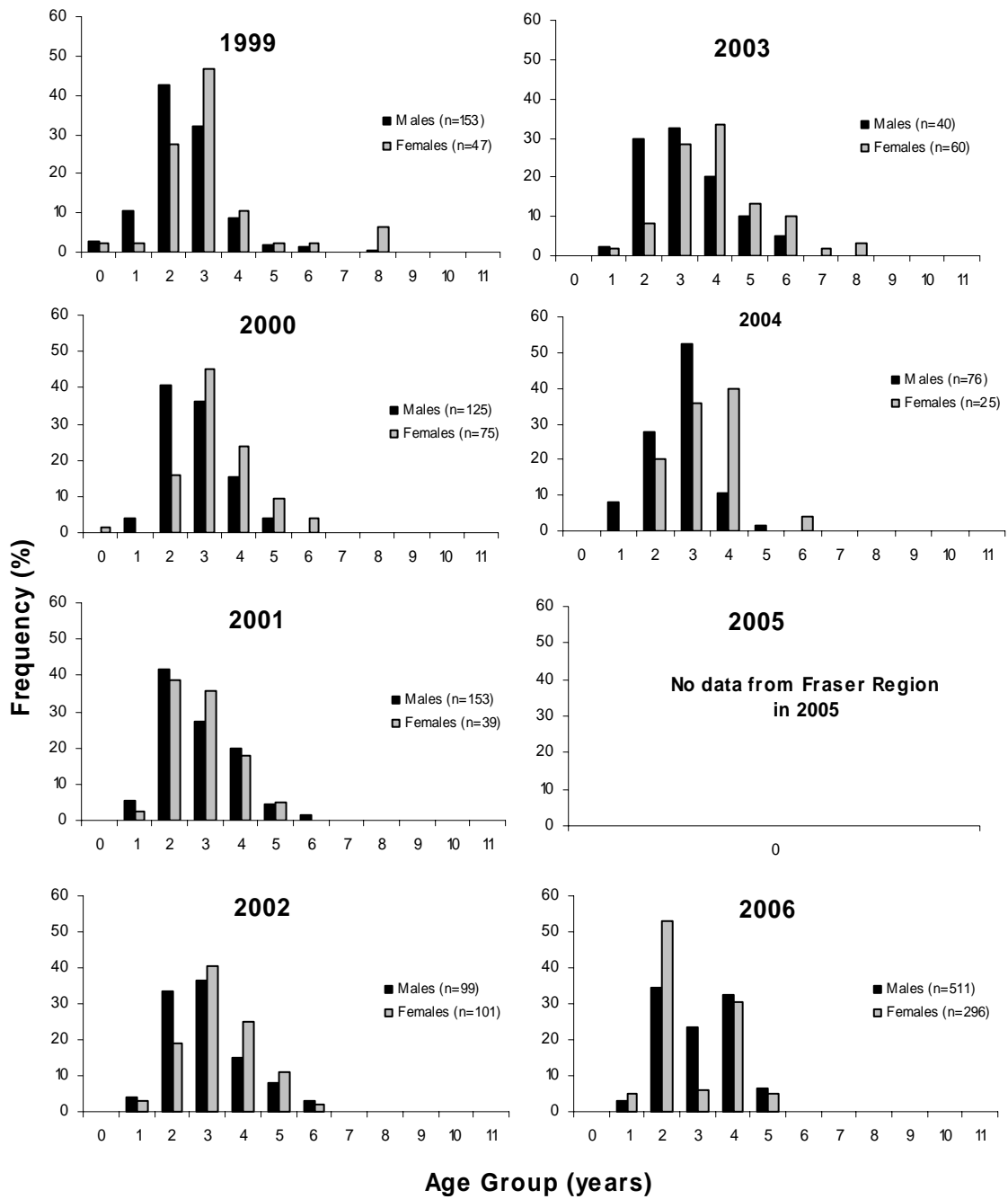


Figure 11. Long Term Monitoring Program mullet age frequency for Fraser region by gender and year 1999–2006.

Growth

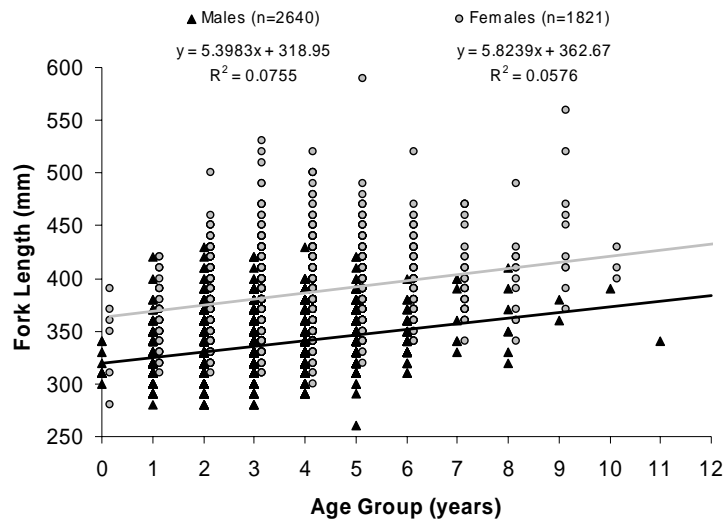


Figure 12. Mullet length at age of fish sampled by Long Term Monitoring Program, 1999–2006.

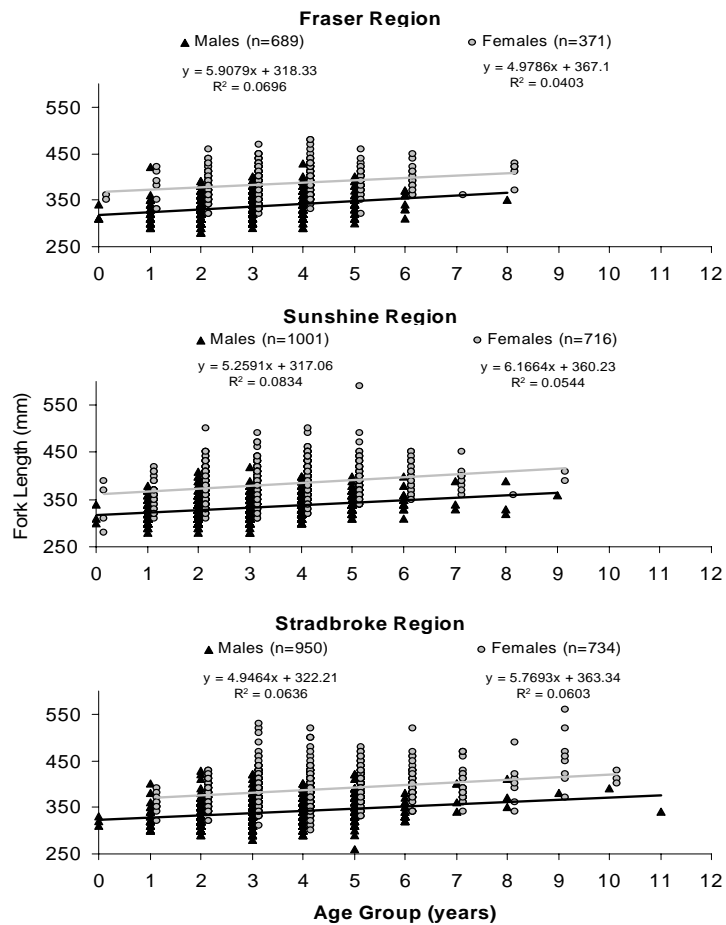


Figure 13. Mullet length at age of fish sampled by Long Term Monitoring Program by gender and region, 1999–2006.

Future directions

Following recommendations made as part of a stock assessment of sea mullet by Bell *et al.* (2005) the objectives and resulting design of this component of the LTMP monitoring program was reviewed. The program has been expanded in 2007 to include the sampling of estuarine catches (gillnet and tunnel net) and an increase in sampling intensity both temporally and spatially which will enable access to a greater proportion of the annual catch (DPI&F 2007). This will allow sex-length keys to be generated using representative catch data from the entire fishery, rather than the current data which are only representative of the ocean beach sector of the fishery. Fishery-independent methods of monitoring this resource are still being evaluated.

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