PICES 17th Annual Meeting

The biology of skipjack tuna (*Katsuwonus pelamis*) (Perciformes: Scombridae) caught by purse seiner in the Western and Central Pacific Ocean: Comparative analysis between Floating object associated school and unassociated school

Guoping ZHU

Liuxiong XU, Xuefang WANG, Xuchang YE, Chunlei WANG

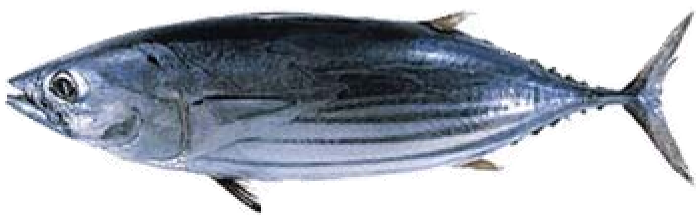
College of Marine Sciences

Shanghai Ocean University

999 Hucheng Ring Road, Lingang New Town,

Shanghai 201306

P.R. China



SHOU

上海海洋大學

SHANGHAI OCEAN UNIVERSITY

Key Laboratory of Oceanic Fisheries Resources Exploitation SHOU

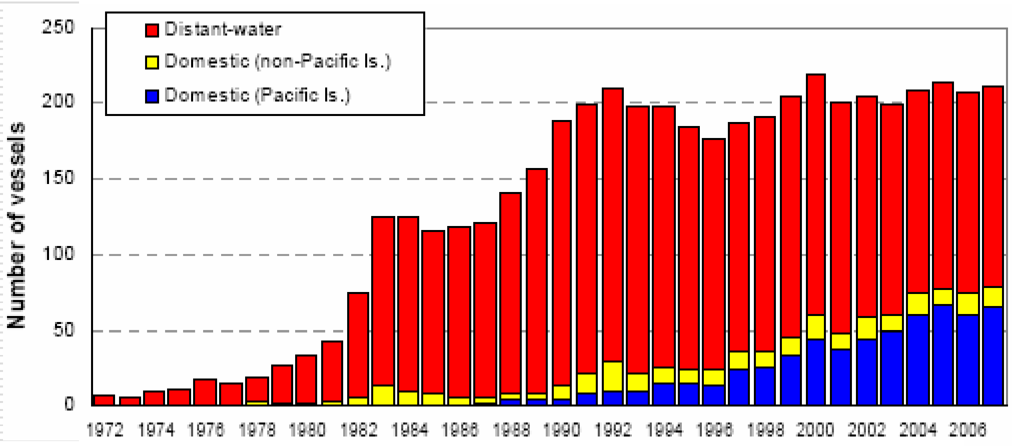
Outline

- Introduction
- Materials and Methods
- Results
- Discussions
- Summary

- Short-lived species
- Growth rapidly
- Rapid population turnover
- High resilience to fishing

Source: http://www.kuuloakai.com/images/aku_large.gif

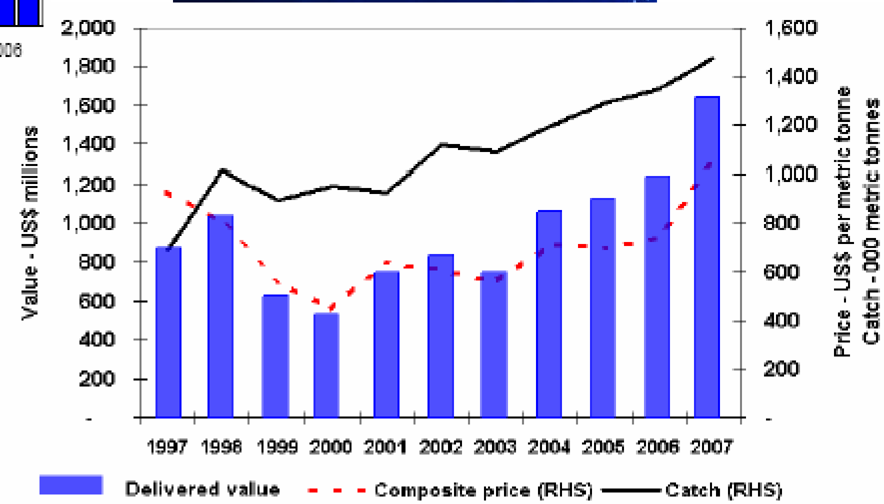
Introduction



Number of purse seine vessels operating in the WCPO in 1972 -2007

Source: Williams and Terawasi (2008)

Purse seine fishery

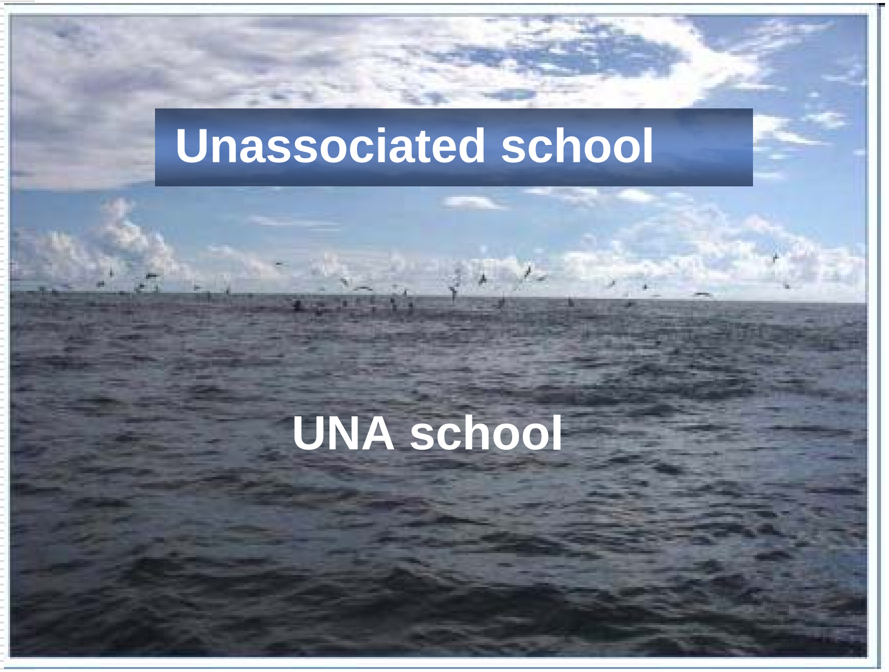


Skipjack in the WCPFC purse seine fishery –Catch, delivered value of catch and composite price

Introduction

Be classified by set type categories

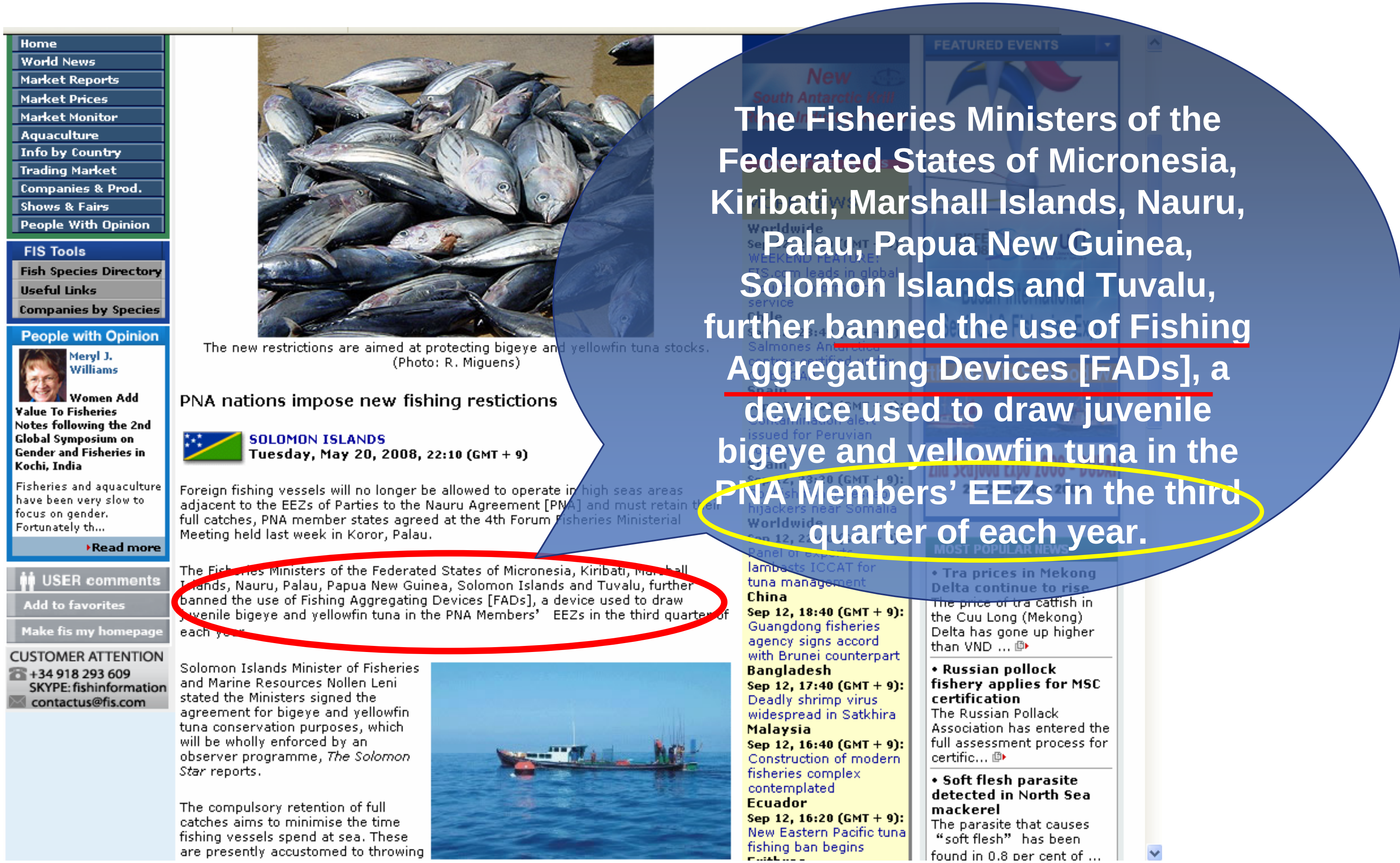
Source: http://tunaseiners.com/



A fish aggregating device (FAD) deployed in the Bismark Sea, Papua New Guinea

Source: www.collapse.com.au/source/pacific12.html

Introduction



Source: www.fis.com

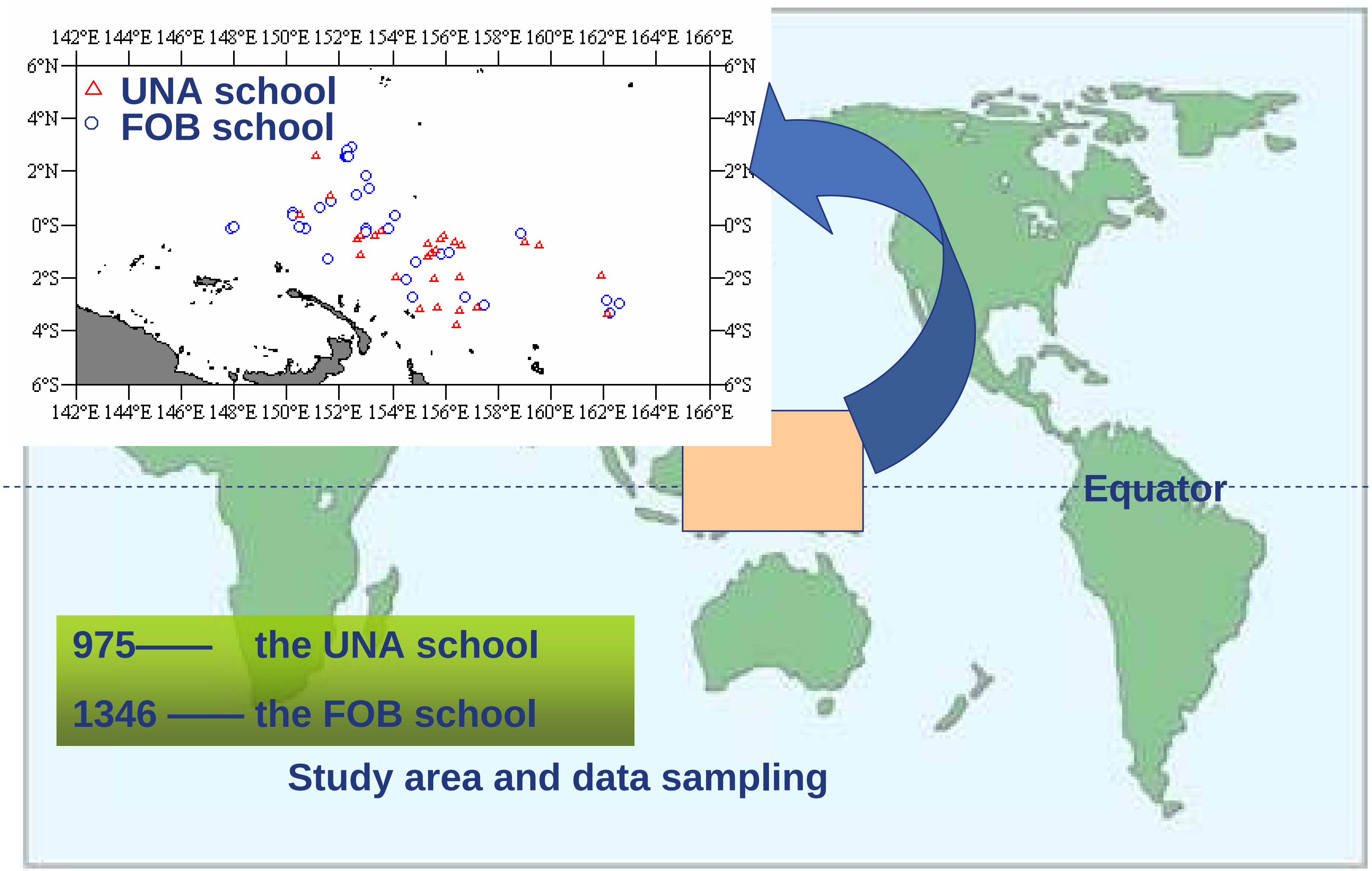
Introduction

- Many literatures are report the biology of skipjack (such as Batts 1972a, Batts 1972b, Wild and Foreman 1980, Chur and Zharov 1983, Richardson and Georgeha 1987, Sosa-Nishizaki et al. 1989, Nootmorn and Panjarat 2001, Andrade and Campos 2002). **However, few studies are focus on comparing the biology of skipjack between the FOB school and the UNA school.**

Introduction

- **The aim of the present study**:
- To compare the biological traits of skipjack inhabiting the WCPO waters between the FOB school and the UNA school from the fork length distribution, the length-weight relationship, sex ratio, size at sexual maturity and stomach fullness stage
- To further provide the information to fishery management.

Materials and Methods



975—— the UNA school

1346 —— the FOB school

Study area and data sampling

Materials and Methods

- **Fork length (FL) distribution**
-
- The difference of FL distribution between sexes was tested by two-sample Kolmogorov-Smirnov test (K-S test). The 95% confidence intervals of mean FL were estimated from running 1000 bootstrap runs.

Materials and Methods

❖ Length-Weight relationship

$$W = aL^{b}e^{\varepsilon}$$

$\varepsilon \sim N(0, \sigma^2)$

The parameters (*a* and *b*), the coefficient of determination (r^2) and the standard errors (S.E.) were estimated over the entire period by least squares regression using the log transformed weights and sizes.

Materials and Methods

- Regression analysis was done separately for males and females. The analysis of t-test was used to examine the difference of slope between sexes in the two fish schools. If no significant difference between sexes can be found, the difference of slope between the two fish schools is then tested by t-test after combined the samples.

Materials and Methods

- The differences of length-weight relationship between sexes were tested by ANCOVA (ANalysis of COVAriance). If no significant difference between sexes can be found, the difference of length-weight relationship between the two fish schools is then tested by ANCOVA after pooled the samples. The hypothesis of isometric growth was tested using the t-test ($P < 0.05$).

Materials and Methods

- **Sex ratio**
- Sex ratio was calculated as the proportion of males by size class (5cm). For each fork length class, Chi-square (χ^2) tests were used to test for any significant difference to the theoretical ratio of 1:1.

Materials and Methods

- **Size at 50% sexual maturity (*L_{50}*)**
- For each ovary, the oocytes in the most-developed mode were classified as:
- Ⅰ - Undeveloped stage;
- Ⅱ - Early developing stage;
- Ⅲ - Later developing stage;
- Ⅳ - Mature stage;
- Ⅴ - Spawned stage;
- Ⅵ - Spent stage

Materials and Methods

- The size at which 50% of fish were sexually mature was estimated for reproductively active fish (Stages Ⅳ–Ⅵ) per 5 cm size-class by fitting a model

$$P_L = \frac{G}{1 + e^{-\delta(L_{50} - L)}}$$

P_L is the proportion of the mature fish at length L,

G is maximum attainable proportion of the mature fish in the analysis;

L_{50} and δ (the rate at which maturity is attained) are the parameters to be estimated.

Materials and Methods

- The above parameters (L_{50} and δ) were estimated by non-linear minimization of a negative binomial log-likelihood

$$-\ln L = \sum_L y_L \ln\left(\frac{P_L}{1-P_L}\right) + n_L \ln(1-P_L)$$

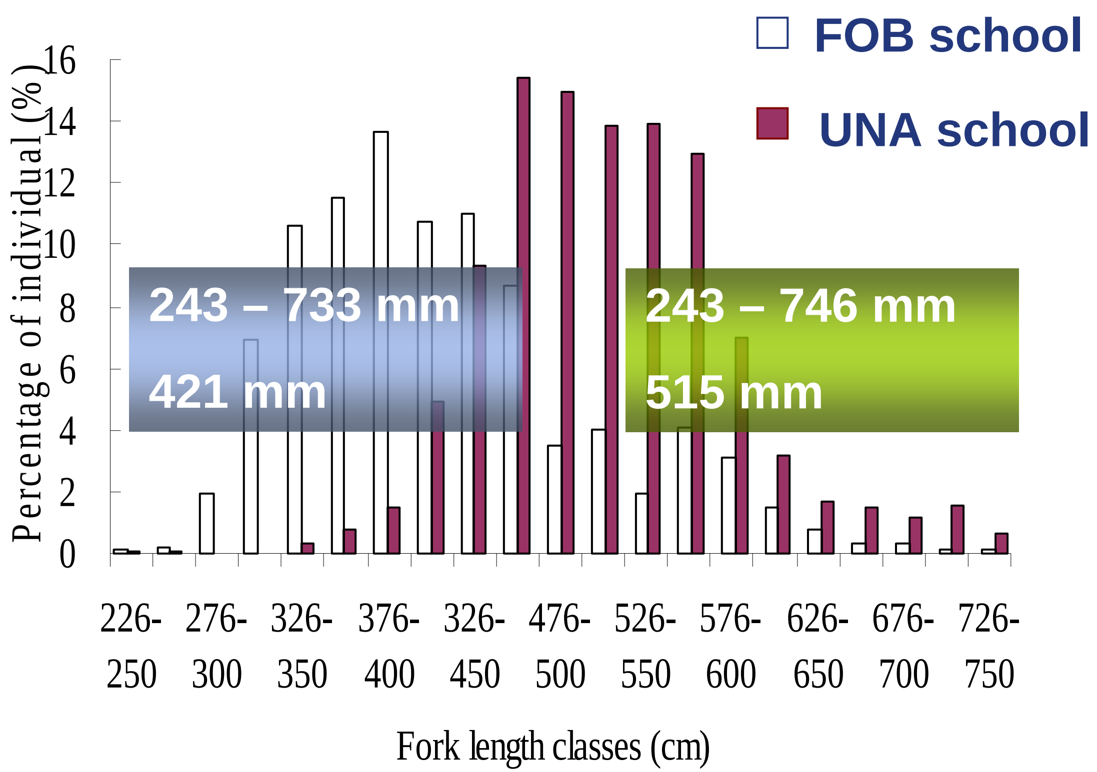
y_L is the observed numbers of fish mature in a total n_L of fish sampled in length class L.

Maximum-likelihood estimates of the parameters were obtained using the routine SOLVER in the Microsoft Excel and calculating the likelihood of immature and mature individuals as 1- P_L and P_L .

Materials and Methods

- **Stomach fullness**
- The analysis of two-factor contingency table was used to analyze the difference of skipjack tuna's stomach fullness between the UNA school and the FOB school ($p<0.05$).

Results

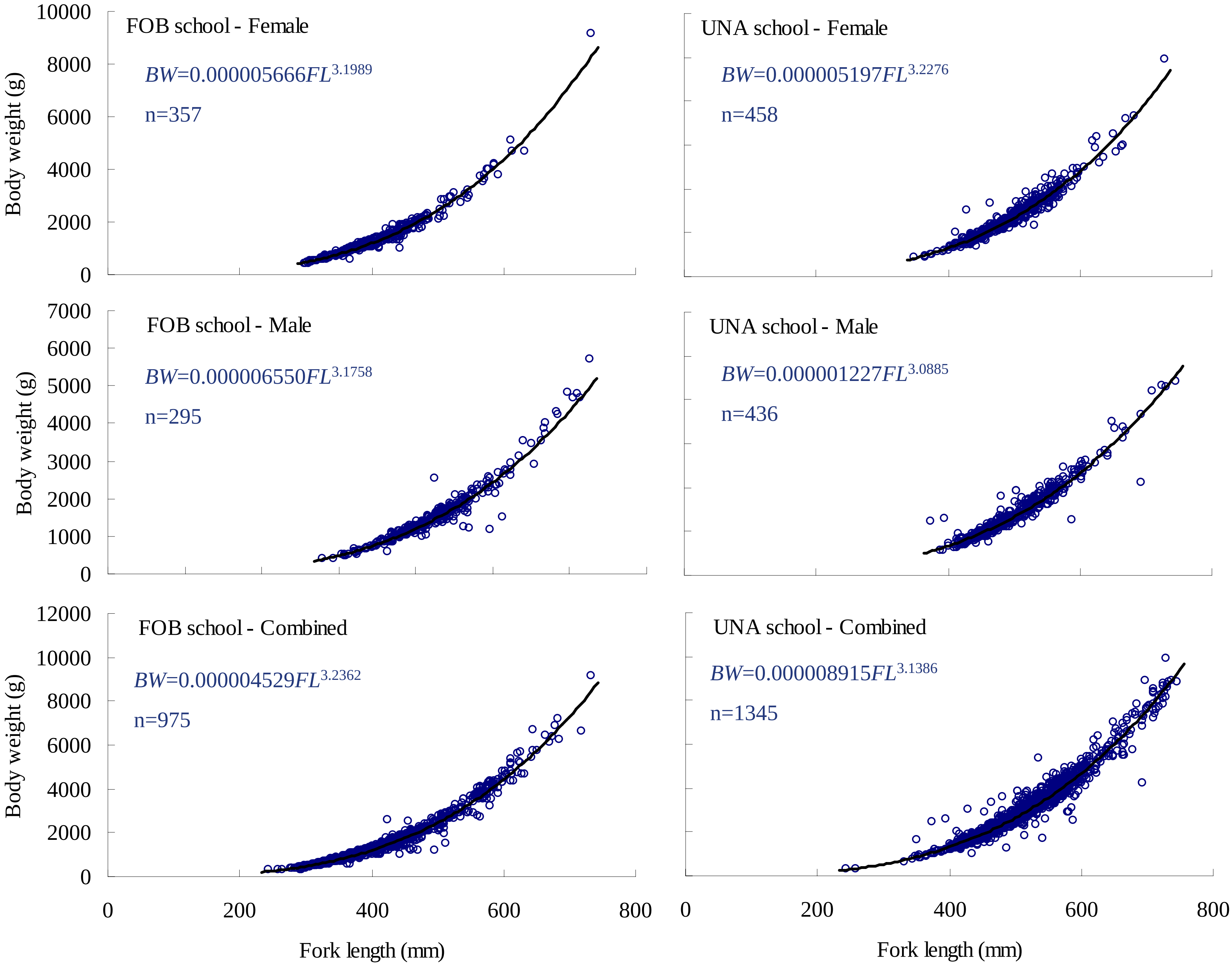


K-S test; Z=0.32, *P*<0.05

Results

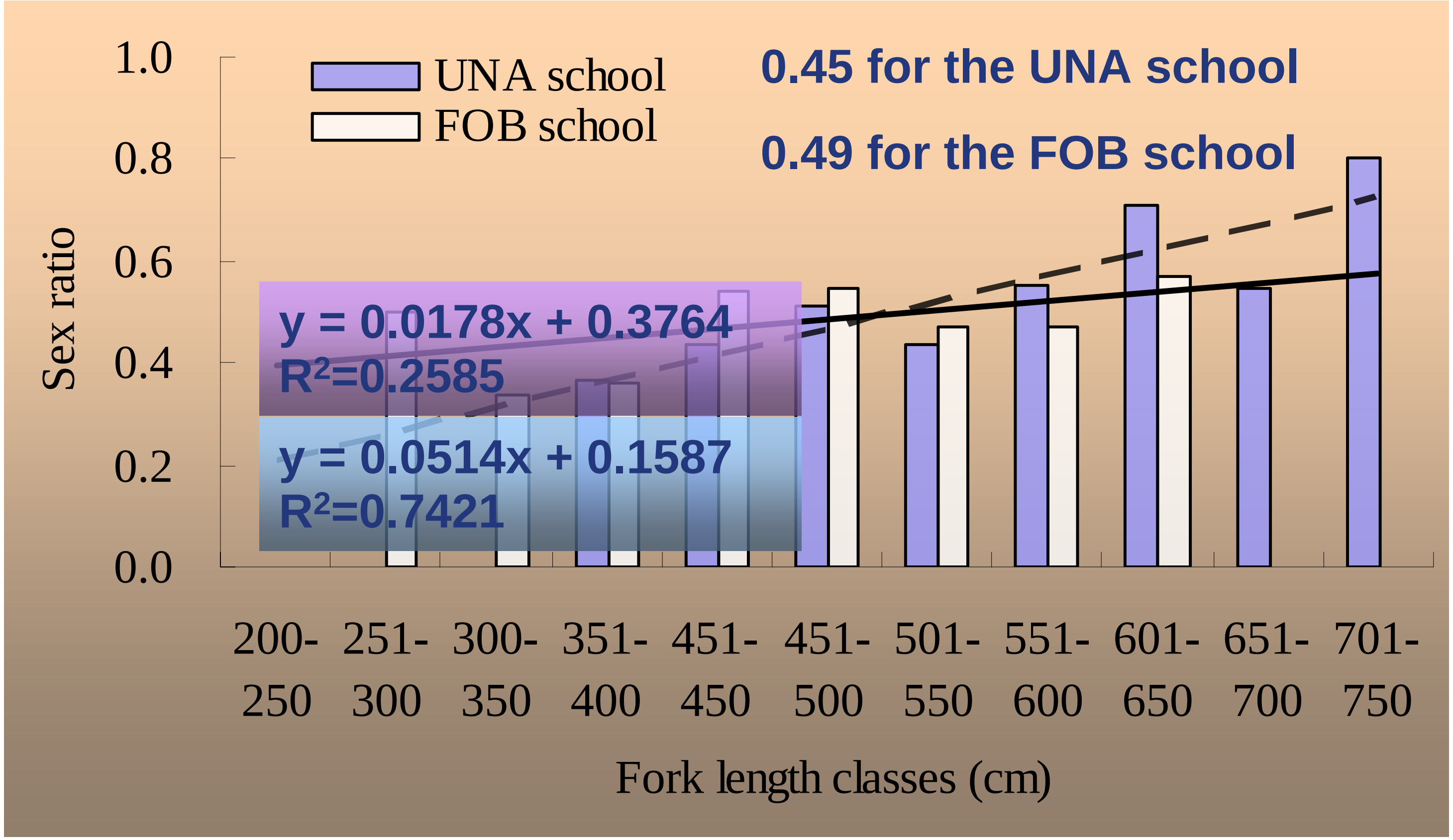
The body weight – fork length relationship of skipjack tuna by sex and school type.

School type	Sex	Intercept	S.E.	Slope	S.E.	Number	t-test t	t-test p	ANCOVA F	ANCOVA p
UNA school	Female	-12.0811	0.1744	**3.1989**	0.0290	357	7.9833	<0.001	0.3585	>0.05
	Male	-11.9561	0.2543	**3.1758**	0.0421	295				
	Combined	-12.3050	0.0910	**3.2362**	0.0151	975	133.8678	<0.001	244.5427	<0.001
FOB school	Combined	-11.6277	0.1248	**3.1386**	0.0200	1345				
	Female	-12.1675	0.2214	**3.2275**	0.0357	458	52.9360	<0.001	0.5641	>0.05
	Male	-11.3087	0.2636	**3.0885**	0.0424	436				



FOB school - Female
BW=0.000005666FL^3.1989
n=357
UNA school - Female
BW=0.000005197FL^3.2276
n=458
FOB school - Male
BW=0.000006550FL^3.1758
n=295
UNA school - Male
BW=0.000001227FL^3.0885
n=436
FOB school - Combined
BW=0.000004529FL^3.2362
n=975
UNA school - Combined
BW=0.000008915FL^3.1386
n=1345
Body weight (g)
Fork length (mm)
0
200
400
600
800
1000
2000
3000
4000
5000
6000
7000
8000
10000
12000

Results

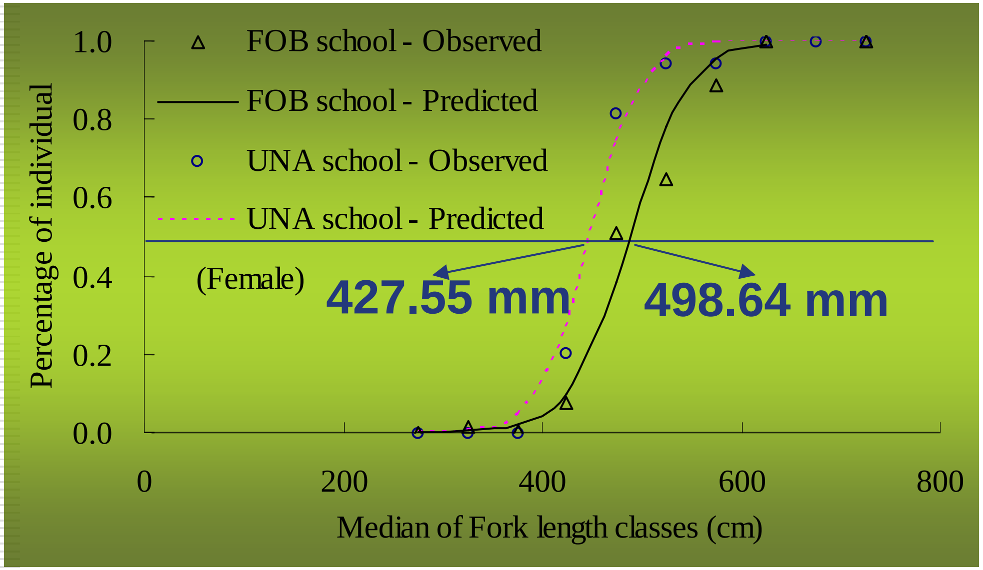


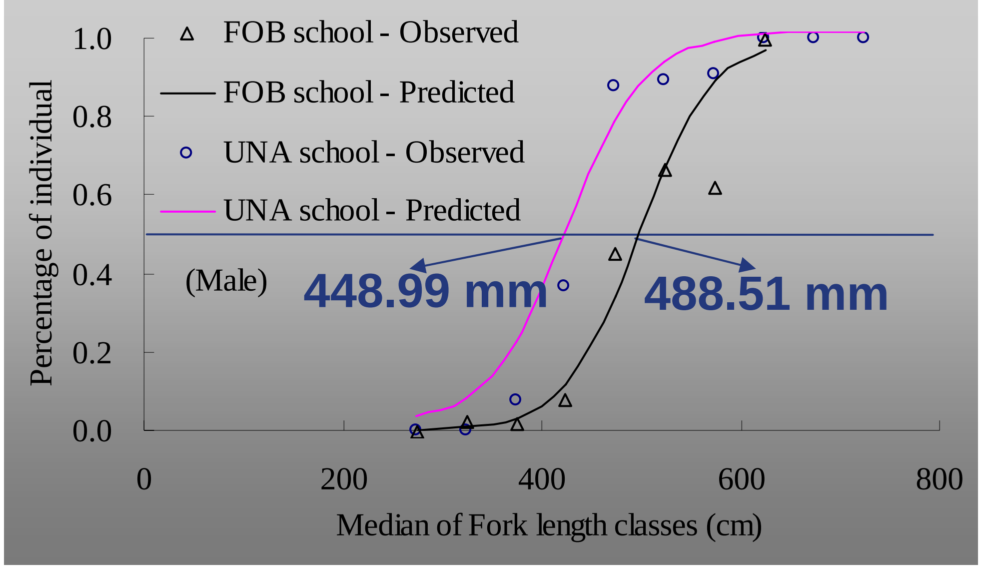
Sex ratio of skipjack tuna with pooled data by school type (in 50 mm interval)

UNA school: 501 - 550mm (χ^2=4.00, P<0.05) and 601 - 650mm (χ^2=4.17, P<0.05)

FOB school: 301 - 350mm (χ^2=7.78, P<0.05) and 351 - 400mm (χ^2=4.00, P<0.001)

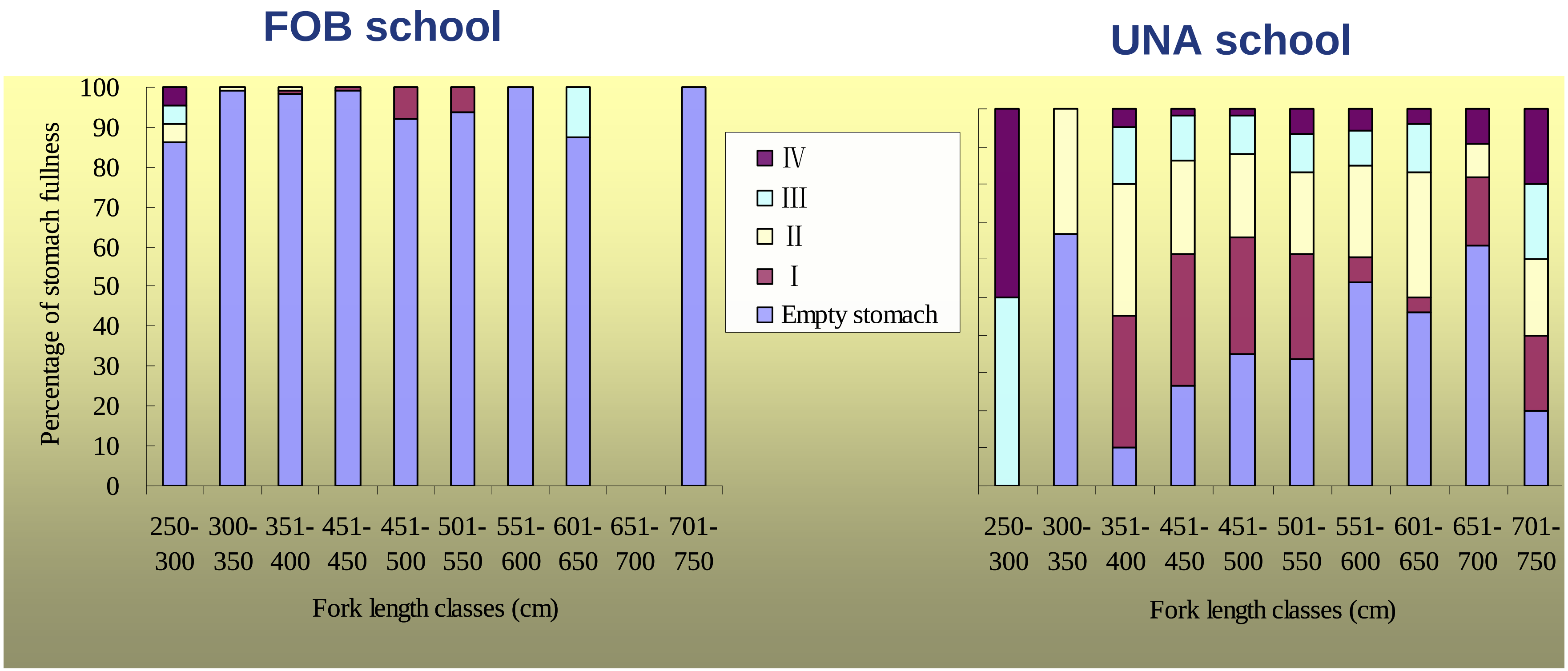
Results





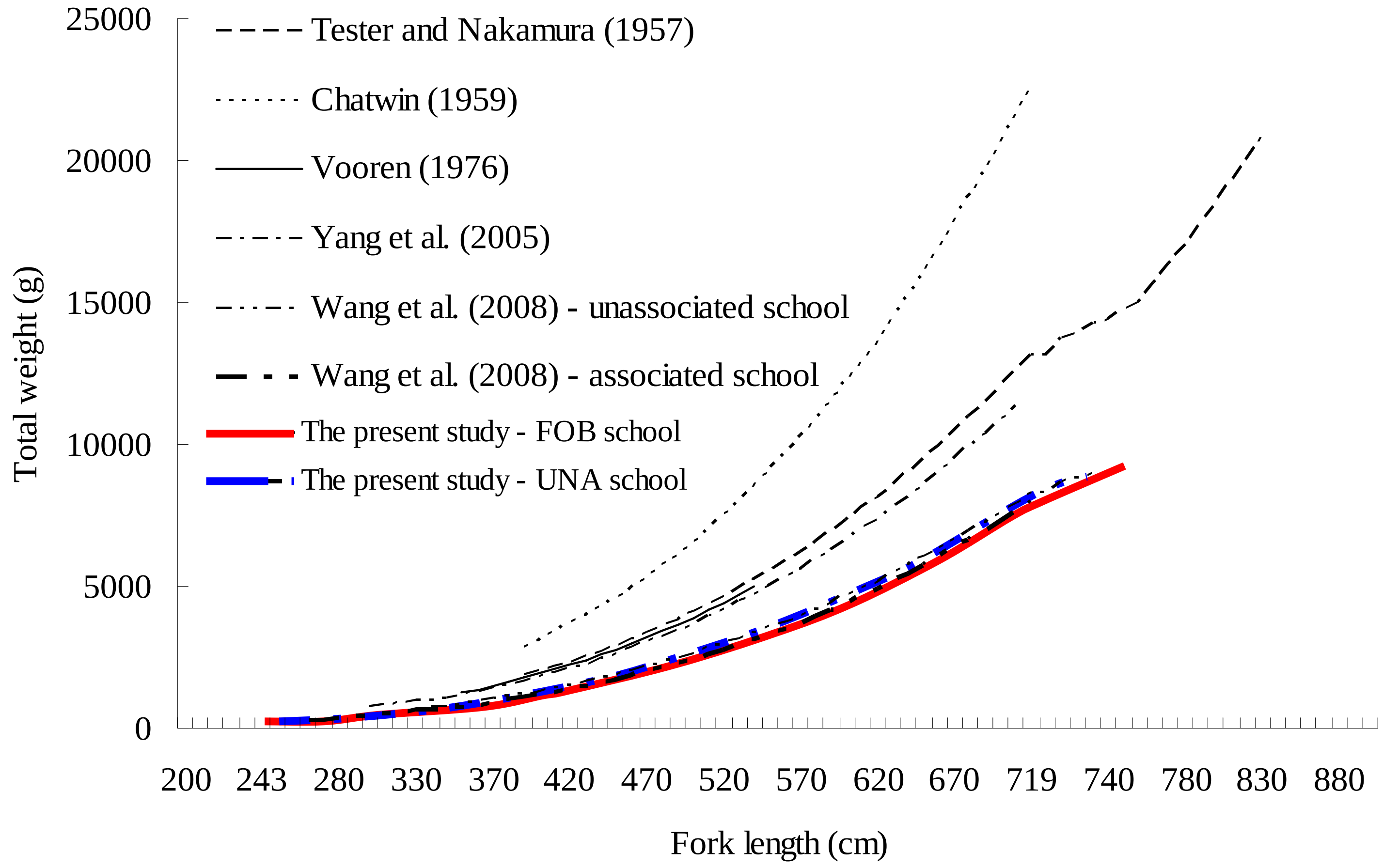
Size at 50% sexual maturity

Results



The analysis of two-factor contingency table indicate that significant difference occur for both the UNA school (χ^2=134.69, *P*=<0.001) and the FOB school (χ^2=91.36, *P*=<0.001) among each fork length classes .

Discussions



Comparison of the body weight – fork length relationship for skipjack tuna estimated in the present study (heavy line) with the body weight – fork length relationships estimated by other authors

Discussions

Comparison on sex ratios of Skipjack tuna from the Pacific Ocean. Partly reproduced from Table 4 of Wild and Hampton (1994)

Source	Study area	Female-male ratio	Comments
Brock（1954）	Hawaii	**1 : 1.16**	Baitboat
Habib (1978)	New Zealand	**1 : 0.76**	Purse seine
Marr（1948）	North of Marshall Isalands	**1 : 1.60**	-
Raju（1964）	Philippines	**1 : > 1.00**	Males dominant in older groups
Schaefer and Orange (1956)	Eastern Pacific	**1 : 0.73**	Small fish; sex indeterminate for large proportion
Tester and Namamura (1957)	Hawaii	**1 : 1.57**	Inshore trolling
Yoshida (1960)	Southern and Central Pacific	**1 : 1.05**	
Wade (1950)	Philippines	**1 : 0.86**	
Waldron (1963)	Japan	**1 : 1.09**	
Wang et al. (2008)	WCPO	**1 : 0.95**	UNA school
Wang et al. (2008)	WCPO	**1 : 0.60**	FOB school
The present study	**WCPO**	**1 : 0.95**	**UNA school**
The present study	**WCPO**	**1 : 0.83**	**FOB school**
		1 : 1.00	400 – 490 mm FL
Hu and Yang (1972)	Taiwan	**1 : 1.31**	500 – 590 mm FL
		1 : 1.00	600 – 690 mm FL

Sex ratio

Size at first maturity (L_{50}) and minimum length of sexually mature fish for skipjack tuna in the world.

Sources	Area	L_{50} (mm)	Minimum lengths of sexually mature fish (mm)	Comments
Batts (1972)	North Carolina Waters	500	454	Female
Batts (1972)	North Carolina Waters		435	Male
Matsumoto et al. (1984)		400 - 450	400	
Brock (1954)	Hawaiian waters	400 - 450		
Schaefer and Orange (1956)	the eastern Pacific	550		
Schaefer and Orange (1956)	off Central America	~ 500		
Raju (1964a)	the Indian Ocean	400 - 450		
Simmons (1969)	the Atlantic Ocean	410		
Stequert (1976)	off the northwest coast of Madagascar	410 - 430		
The present study	WCPO	498.64	342	Female, FOB
The present study	WCPO	488.51	433	Male, FOB
The present study	WCPO	427.55	413	Female, UNA
The present study	WCPO	448.99	434	Male, UNA

400 ~ 500 mm

L_{50}

Summary

- 1) **Mean fork length**: FOB $<$ UNA.
- 2) **Length-weight relationship**: Significant difference can be found between the FOB school and the UNA school.
- 3) **Sex ratio**: FOB$>$UNA. The number of male were lower than female for both fish schools.
- 4) **Size at 50% sexual maturity**: FOB $>$ UNA.

Conclusion, Maybe

- **"Ban the use of FADs in the PNA Members' EEZs in the third quarter of each year"** is a good approach to protect the skipjack tuna, and other issues also should be focused on in the future, such as bycatch of juvenile bigeye and yellowfin tunas in the purse seine fishery...

Thank You for your attention!

Source:
http://www.dfw.state.or.us/mrp/salmon/fishid/Euthynnus_pelamis.jpg

SHOU