Report of length-based spawning potential ratio (LB-SPR) analysis (2024)

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Areas: Surat Thani and Nakhon Si Thammarat provinces

Data Collection: BSC length data (outer carapace width) were measured from the fields, three sampling stations each province, in every two months between February and December 2024)

Background: The length-based spawning potential ratio (LB-SPR, Hordyk et al. 2016) will be conducted to assess the stock status of the blue swimming crab (BSC) in Surat Thani and Nakhon Si Thammarat fishing ground. LB-SPR, in this study were estimated by using biological data of BSC in the same fishing areas to make sure that the LB-SPR value represents the real fishing and biological condition of BSC in the study area. Comparing LB- SPR value among countries should be careful due to different locations theoretically present differences in fishing contexts, i.e. fishing mortality, biological parameters based on various environmental conditions, reproductive and other stock assessing indicators. Therefore, as we aim to use LB-SPR value as an indicator of specific fishing stock, it can be confirmed that LB-SPR analysis,

based on specific biological and fishing data in the study areas, will be suitable for using as fishing management indicator in the study areas.

Sources of data: The BSC samples were collected from the fisherman landing sites both of small and large vessels in the areas of Surat Thani and Nakhon Si Thammarat provinces. 3 samplings stations each province were assigned to cover all type of fishing gears (gillnet and trap) and size (small and large) of vessels. Moreover, to cover seasonal variation that, in theory, it is really important for biological and stock assessment, the BSC samples were conducted and Outer carapace width (OCW) were measured between February and June 2024. To have statistically approve in term of sample numbers, Taro Yamane table at 95% confidence and allowance of ± 2% error from samplings were using as suitable sample size, required at least 2,500 individuals for the study. However, in this study, 6,209 individuals were collected for measurement. The summary and length frequency data of BSC samples collected from Surat Thani and Nakhon Si Thammarat province were showed in Table 1-3

Table 1 Summary of numbers and size of BSC samples collected from Surat Thani province and Nakhon Si Thammarat provinces

Areas	Number (individuals)	Min-length (cm.)	Max-length (cm.)	Average (cm.)
Surat Thani province	2,895	6.00	17.00	11.58
Nakhon Si Thammarat	3,314	4.50	17.40	11.60
Total	6,209	4.50	17.40	11.59

Table 2 Length frequency data collected from Surat Thani province during February to December 2024

OCW mid-length	Month (2024)						Total	% Catch_Acc
ML	Feb	Apr	Jun	Aug	Oct	Dec		
5.5		4					4	0.13
6.5		13					13	0.58
7.5	4	7	5				22	1.34
8.5	15	7	34	5	1		62	3.48
9.5	63	34	128	27	15	3	270	12.81
10.5	149	140	179	103	120	50	741	38.41
11.5	151	156	104	120	165	129	825	66.90
12.5	85	61	27	117	155	145	590	87.28
13.5	17	13		71	53	101	255	96.09
14.5	4	14	1	17	10	44	90	99.20
15.5	1	12			1	8	22	99.96
16.5		7					7	100.00
Total	489	468	478	460	520	480	2,895	

Remark: OCW is Outer carapace width, %Catch_Acc is catch accumulation

Table 3 Length frequency data collected from Nakhon Si Thammarat province during February to December 2024

OCW mid-length	Month (2024)						Total	% Catch_Acc
ML	Feb	Apr	Jun	Aug	Oct	Dec		
4.5	1						1	0.03
5.5						1	1	0.06
6.5		1		1			2	0.12
7.5	2	10	13	8	1		34	1.15
8.5	7	34	23	10	2	2	78	3.50
9.5	16	97	144	56	27	10	350	14.06
10.5	31	171	234	159	113	78	786	37.78
11.5	25	74	143	166	300	205	913	65.33
12.5	72	23	24	50	283	183	635	84.49
13.5	120	7	1	9	109	73	319	94.12
14.5	105	4		2	24	12	147	98.55
15.5	31			1	4	4	40	99.76
16.5	4				1	1	6	99.94
17.5	1					1	2	100.00
Total	415	421	582	462	864	570	3,314	

Remark: OCW is Outer carapace width, %Catch_Acc is catch accumulation

Data analyses: The asymptotic length was estimated by $Lmax$/0.95 and the curvature parameters was adjusted by using growth performance index (ϕ', Munro and Paly, 1983). The total, Z, mortality coefficient was estimated by the length converted catch curve (Pauly, 1984). Meanwhile, the natural, M, mortality coefficient was estimated by Rikhter and Efanov's Formula (Rikhter and Efanov, 1976) using size at 50% maturity from historical data collected in this fishing area as we strongly believed that there is no significantly change of biological parameters especially reproductive parameters in same fishing area during a few years. The fishing, F, mortality coefficient was estimated as Z-M. Size at selectivity was estimated through probability of capture curve (Pauly, 1984). The mentioned input parameters were estimated by using the FiSAT II package (FAO-ICLARM Stock Assessment Tool, Gayanilo et al., 2005). Meanwhile, the LB-SPR was estimated by using Package "LBSPR" for Program R (Hordyk, 2019).

As previously mentioned, to cover and minimize seasonal variation and error of samplings, BSC samples were sampled from the same sources i.e. same fishermen and same landing sizes. The crab were not sorted in size before sampling. Therefore, the crab were samples as real size composition from fishing. To analyze biological and fishing parameters, 6,209 individuals were collected based on including all size class, smallest to biggest relate to proportion of catch composition, to make sure we prepared high quality of LFD set for assessing biological and fishery parameters. To make sure that the protocol of study was conducted correctly and scientifically, we worked with many researchers who are lecturers in big name universities of Thailand and they archived Ph.D. in Ocean and Fishery Science. Moreover, they have many experiences to finish several researches in animal biology and population dynamics. The names of researcher were mentioned above.

Results:

The maximum- and asymptotic- OCW of the samples collected from Surat Thani and Nakhon Si Thammarat were 17.0, 17.89 cm and 17.4, 18.3 respectively (Table 2). The curvature parameter (K) was 1.6 year^{-1} (Fig. 1).

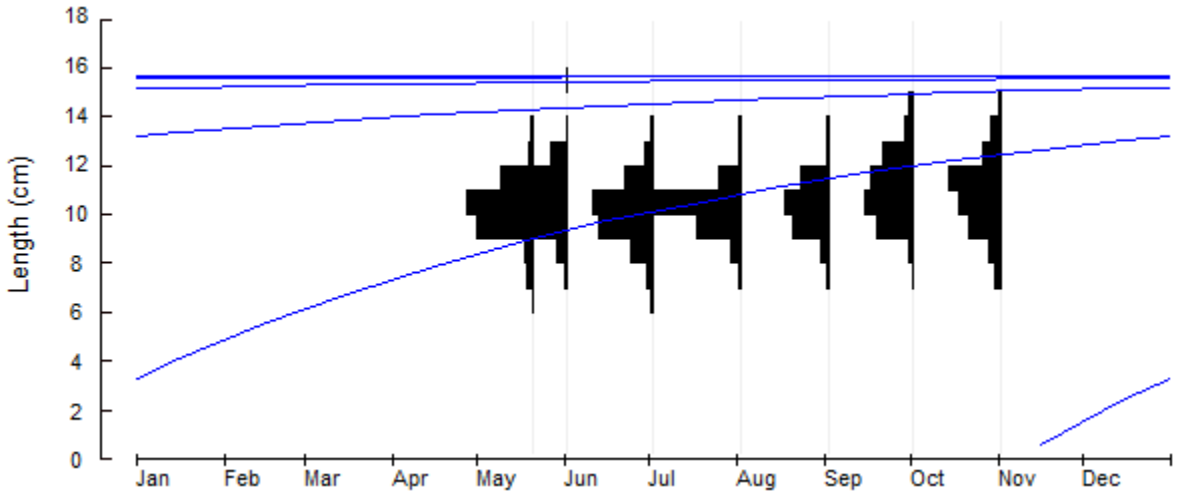
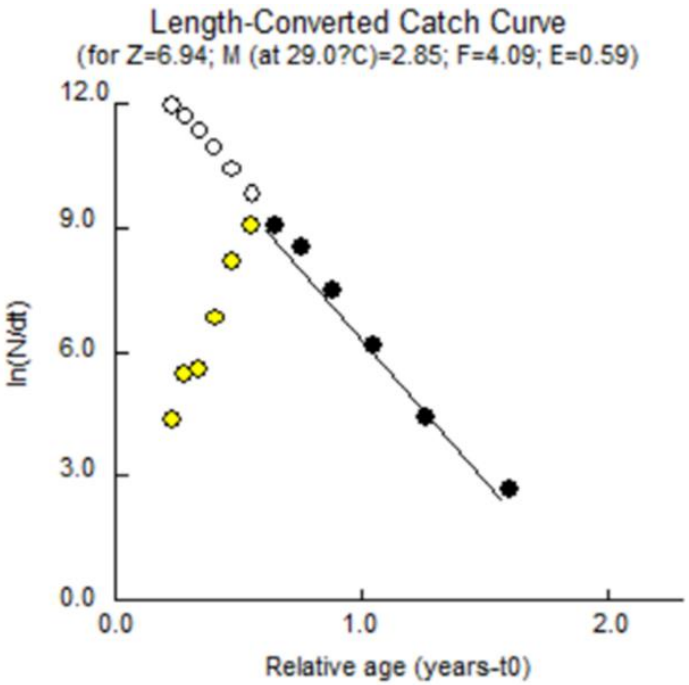
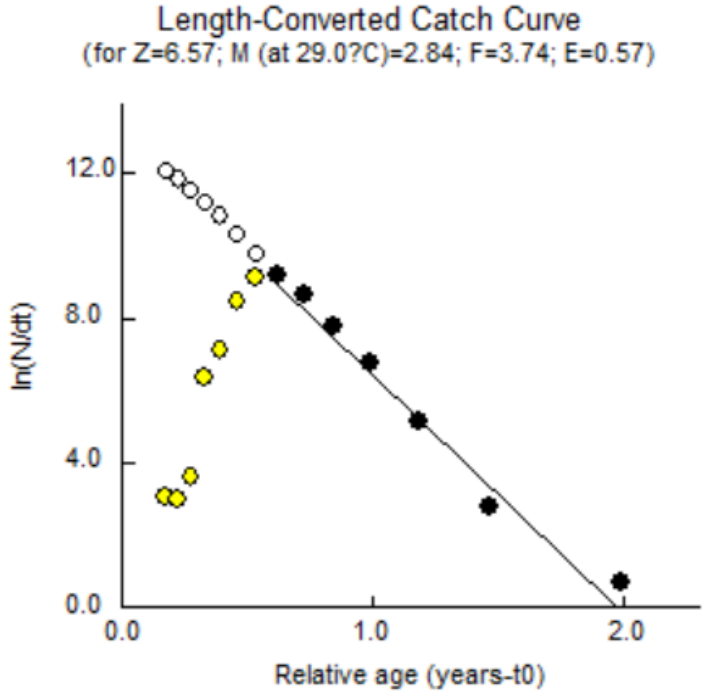


Fig. 1 Size distribution and growth curves of blue swimming crab, incorporated with the von Bertalanffy's growth curve.

The Z- and M- mortality coefficients for Surat Thani fisheries were estimated at 6.76 and 2.85 year^{-1}, respectively. While Z and M for Nakhon Si Thammarat were estimated at 6.57 and 2.84 year^{-1} and then F- mortality coefficients for Surat Thani and Nakhon Si Thammarat were 4.09 and 3.74 year^{-1} respectively (Fig2).



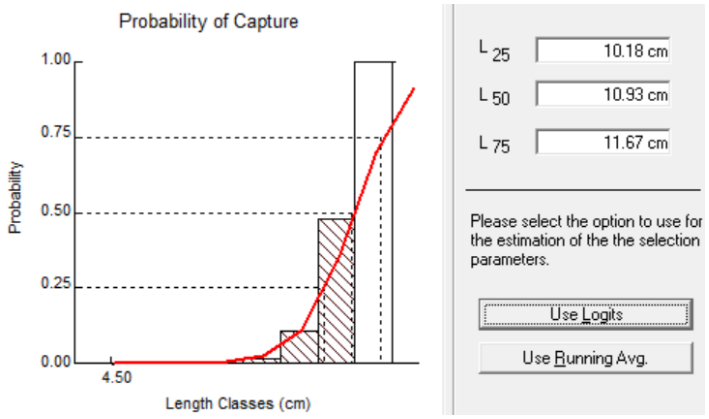
(A)



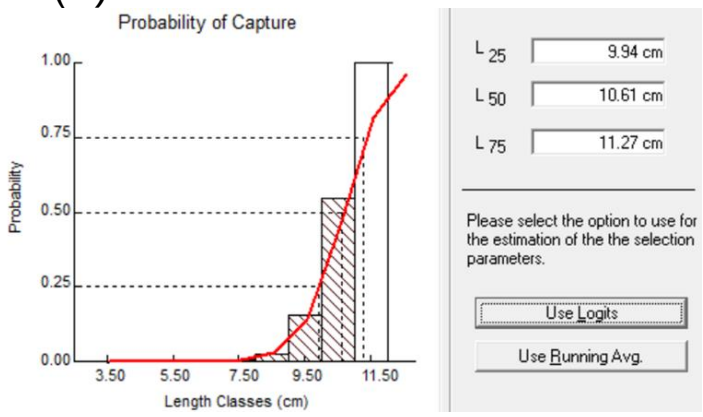
(B)

Fig. 2 Total mortality estimation from length converted catch curve in FiSAT from 6 months length frequency data used in this study (A) Surat Thani province (B) Nakhon Si Thammarat province

The probability of capture curve (Fig. 3) revealed that size at 50% and 75% selectivity for crab collected from Surat Thani and Nakhon Si Thammarat were 10.93, 11.67 cm. and 10.61, 11.27 cm respectively, while size at 95 % selectivity for both of BSC collected from Surat Thani and Nakhon Si Thammarat was 13.5 cm. Length at 50% maturity was 9.96 cm (OCW) (Fig 4), which took about 6 months to reach this size (Fig 1). From these obtained parameters (Table 2), the estimated spawning potential ratio (SPR) of the BSC fishing stock in Surat Thani and Nakhon Si Thammarat provinces were at 0.44 and 0.42, respectively (Fig. 5 and 6).



(A)



(B)

Fig. 3 Probability of capture of blue swimming crab calculated from 6 months length frequency data (A) Surat Thani province (B) Nakhon Si Thammarat province

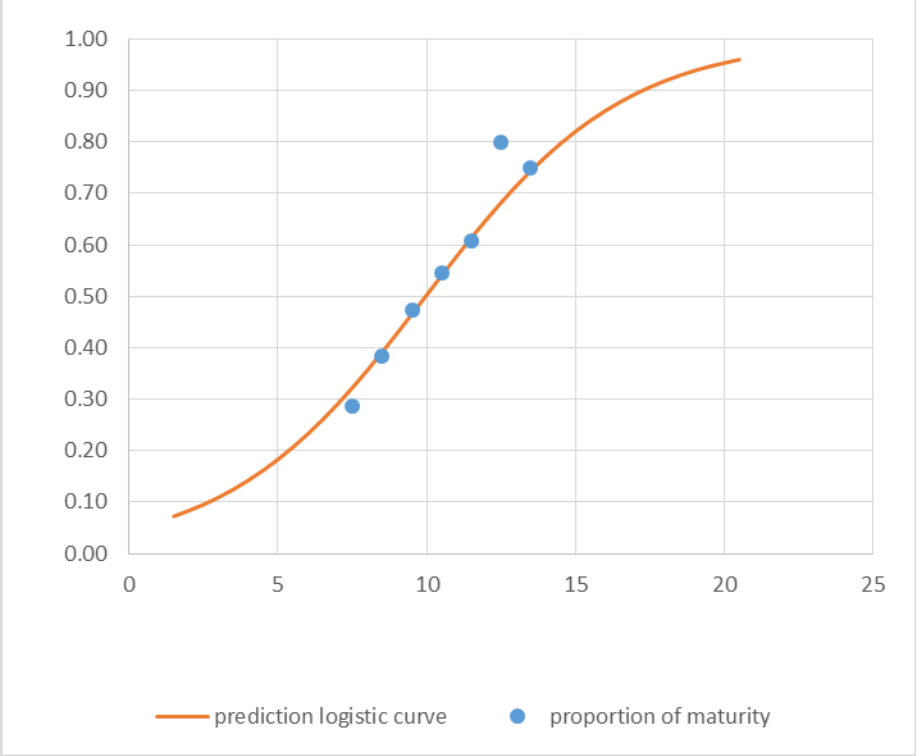


Fig. 4 Proportion of maturity of blue swimming crab calculated by logistic equation

Table 2 Input parameters and LB-SPR results separately in each area.

Areas	Max-length (cm.)	Asymptotic length (cm.)	K	Z	M	F	Lc 50	Lc 95	Lm	SPR	SPR (-5% F)	SPR (+5% F)
Surat Thani	17.0	17.89	1.60	6.76	2.85	4.09	10.93	13.50	9.96	0.44	0.45	0.43
Nakhon Si Thammarat	17.4	18.27	1.60	6.57	2.84	3.74	10.61	13.50	9.96	0.42	0.43	0.41

Remark: SPR(-5% F) is prediction if fishing mortality is reduced 5 percent and SPR(+5% F) is prediction if fishing mortality is increased 5 percent of current evaluation

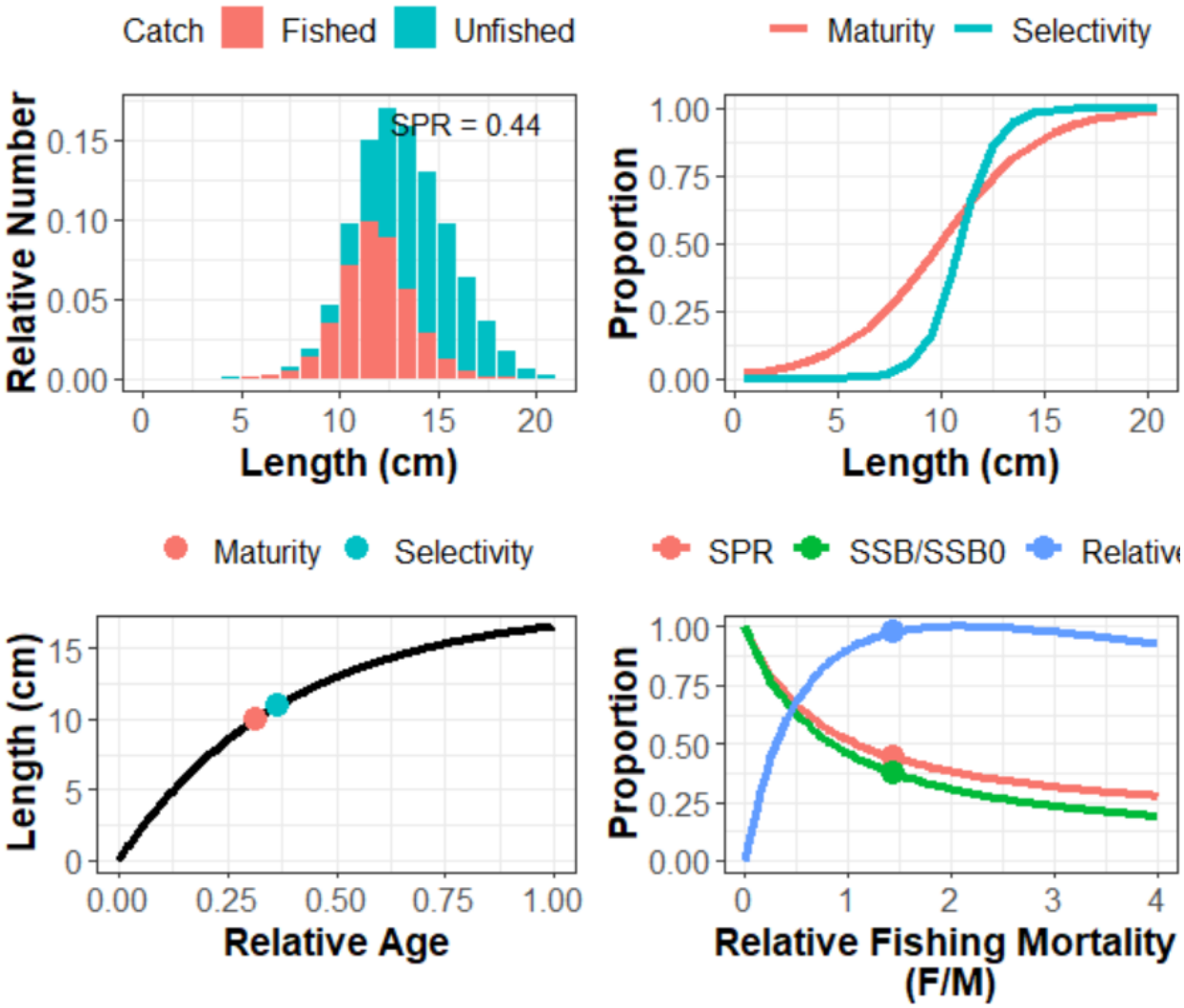


Fig. 5 Output from the LB-SPR analysis of blue swimming crab in Surat Thani.

(a) the expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population, (b) the maturity and selectivity-at-length curves, (c) the growth curve with relative age, and (d) the SPR and relative yield curves as a function of relative fishing mortality.

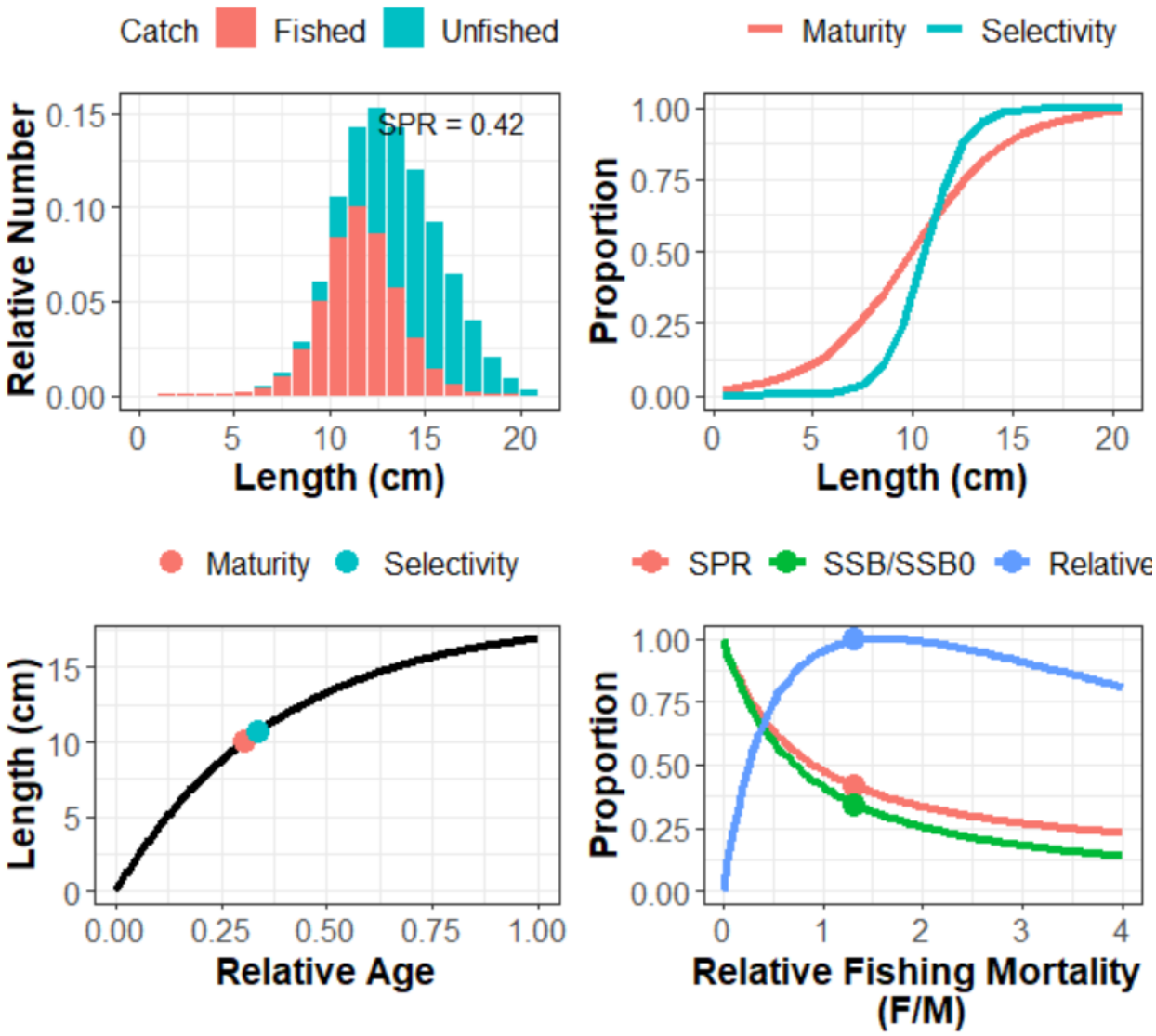


Fig. 6 Output from the LB-SPR analysis of blue swimming crab in Nakhon Si Thammarat.

(a) the expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population, (b) the maturity and selectivity-at-length curves, (c) the growth curve with relative age, and (d) the SPR and relative yield curves as a function of relative fishing mortality.

References

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Supplement 1 Script for LB-SPR analysis for crab collected from Surat Thani province

```
library(LBSPR)
### Make scenrio ###
MyBSC <- new("LB_pars")
MyBSC@L_units <- "cm"
MyBSC@BinWidth <- 1
MyBSC@BinMax <- 21
MyBSC@BinMin <- 0
### Biology parameters
MyBSC@Linf <- 17.89
MyBSC@L50 <- 9.96 ##Length at 50% maturity
MyBSC@L95 <- 17 ##Length at 95% maturity
MyBSC@MK <- 1.78 ##M/K ratio M=2.85, K = 1.6
### Exploitation
MyBSC@SL50 <- 10.93 # Probability of capture
MyBSC@SL95 <- 13.50 # Probability of capture
MyBSC@FM <- 1.43 ##F=4.09, M = 2.85, F (-5%Fishing
mortality)=3.89, F(+5%Fishing mortality)=4.29

### Run the LBSPR simulation model.
BSCSim <- LBSPRsim(MyBSC)
BSCSim@FM
plotSim(BSCSim)
```

Supplement 2 Script for LB-SPR analysis for crab collected from Nakhon Si Thammarat province

```
library(LBSPR)
### Make scenrio ###
MyBSC <- new("LB_pars")
MyBSC@L_units <- "cm"
MyBSC@BinWidth <- 1
MyBSC@BinMax <- 21
MyBSC@BinMin <- 0
### Biology parameters
MyBSC@Linf <- 18.27
MyBSC@L50 <- 9.96 ##Length at 50% maturity
MyBSC@L95 <- 17 ##Length at 95% maturity
MyBSC@MK <- 1.77 ##M/K ratio M=2.84, K = 1.6
### Exploitation
MyBSC@SL50 <- 10.61 # Probability of capture
MyBSC@SL95 <- 13.50 # Probability of capture
MyBSC@FM <- 1.32 ##F=3.74, M = 2.84, F (-5%Fishing
mortality)=3.55, F(+5%Fishing mortality)=3.93
### Run the LBSPR simulation model.
BSCSim <- LBSPRsim(MyBSC)
BSCSim@FM
plotSim(BSCSim)
```

Sampling Locations

Map showing blue swimming crab sampling points in Surat Thani province

Map showing blue swimming crab sampling points in Nakhon Si Thammarat province






Crab measurement at sampling points