Analyses of Hawaii Tuna Tagging Program Data: Tag-attrition analysis and application of the results to estimate yield-per-recruit

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Hawaii Tuna Fishery

- Tuna Fishery is one the most important segment of the Hawaii Pelagic Fishery
- Two main sectors
  - Longline → mainly tuna targeted sets
  - Handline and Troll →
    - Inshore → diverse small boat fleet ; operates within close range of the MHI
    - Offshore → An offshoot of the inshore component; Targets very specific aggregations: Cross Seamount + NOAA weather monitoring buoys

Estimate of 1998 landings (both species)

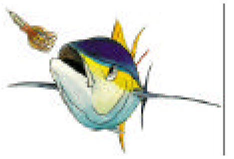
	Total (Mt)	Percent
Longline	3864	69
Inshore	1227*	22
Offshore	500*	9
TOTAL	5591	100
Average for ’92-’98	4600	

Source: NMFS (unpublished), WPFMC (Annual Reports)

* Underestimated ?

Issues..

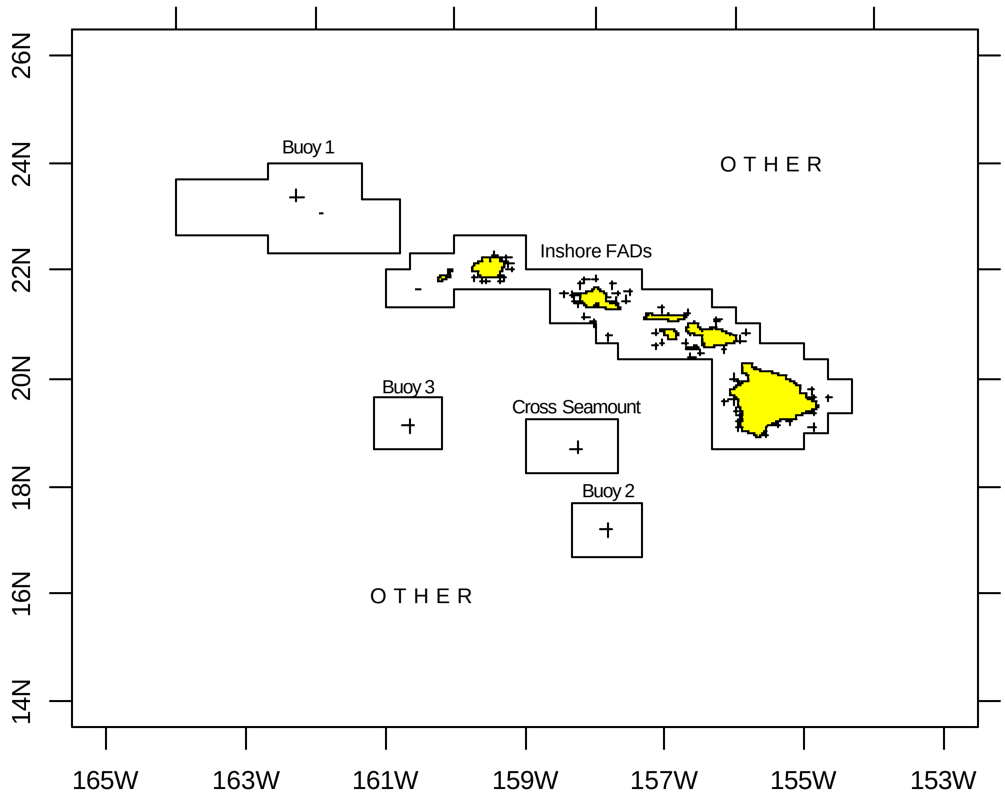
- Mainly relate to thee Offshore Fisheries
  - General feeling among fishing community that CROSS SEAMOUNT fishery intercepts too may juvenile and sub-adults.
  - Affects local recruitment (?)
  - Local over-exploitation (?)
  - Gear conflicts (handline and longline)



Tagging

- HTTP started in 1995
  - Tagged > 17,000 bigeye and yellowfin throughout the range of the fishery
  - Up to end of December 2000 more than 2000 of these have been recovered.

‘Bulk transfer’ model with explicit transfer and size specific attrition



Size and site specific tag-attrition model

$$\frac{dN_{ki}}{dt} = -\left[F_{i,L(l_k,t)} + M + M_{L(l_k,t)} + \sum_{j=1}^{n} T_{i\to j}\right] N_{ki} + \sum_{j=1}^{n} (T_{j\to i} N_{kj})$$

$$\text{at } t = 0; \quad N_{ki} = aR_{ki}$$

$$T_{i\to i} = T_{j\to j} = 0$$

$$\hat{L}_t = \left(\bar{L}_\infty - l_k\right)\left(1 - \exp[-K\bar{t}]\right) + l_k$$

$$\frac{dC_{ki}}{dt} = F_{i,L(l_k,t)} N_{ki} \qquad \text{at } t = 0; \quad C_{ki} = 0$$

Model contd..

$$\frac{dN_{ki}}{dt} = -\left[F_{i,L(l_k,t)} + M_{L(l_k,t)} + l + \sum_{j=1}^{n} T_{i\to j}\right] N_{ki} + \sum_{j=1}^{n} (T_{j\to i} N_{kj})$$

$$\text{at } t = 0; \quad N_{ki} = aR_{ki}$$

$$\hat{L}_t = \left(\overline{L}_\infty - l_k\right)\left(1 - \exp[-K\bar{t}\,]\right) + l_k$$

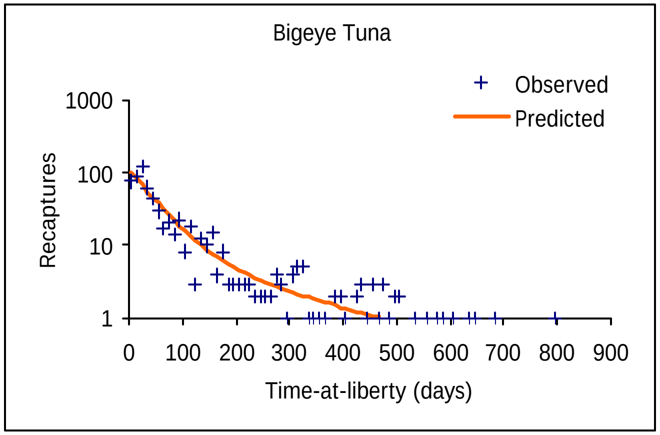
$$S_{[n_{\hat{L}}]} = F_{[n_s]} \text{ or } M_{[n_s]}; \quad \text{where } n = L_{\min} \text{ to } 2L_{\max}\ ;\ s = 1 \text{ to } 3$$

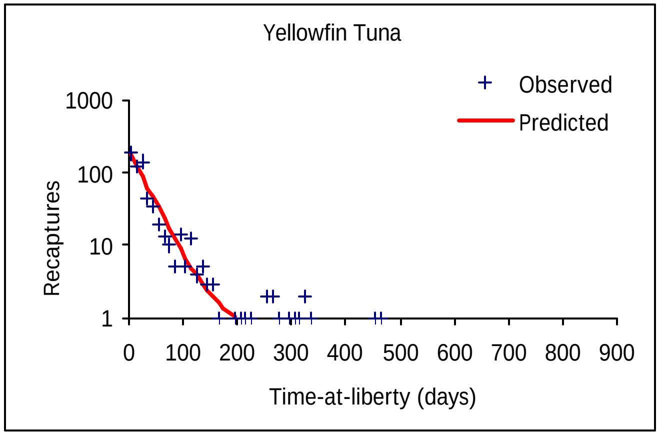
$$\text{BET} \ : F_{[n_s]} \ \text{ or } \ M_{[n_s]} = \underbrace{40, 41, \ldots 60}_{s=1}\ ;\ \underbrace{61, 62, \ldots 80}_{s=2}\ ;\ \underbrace{81, 82 \ldots 2L_{\max}}_{s=3}$$

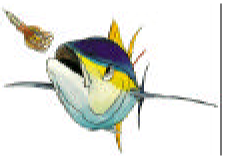
Data: releases/recoveries

	Release	Recovery
BIGEYE		
B2	1493	317
B3	326	29
Cross	5371	653
Inshore	160	50
Other	0	48
TOTAL	7350	1097
YELLOWFIN		
B1	247	20
B2	260	40
B3	59	9
Cross	3423	635
Inshore	1239	254
Other	0	12
TOTAL	5228	970
Grand Tot	12578	2067

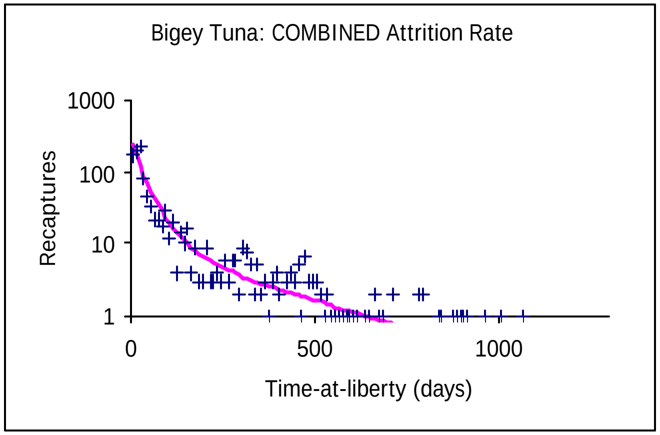
RESULTS: CROSS SEAMOUNT observed and predicted tag returns

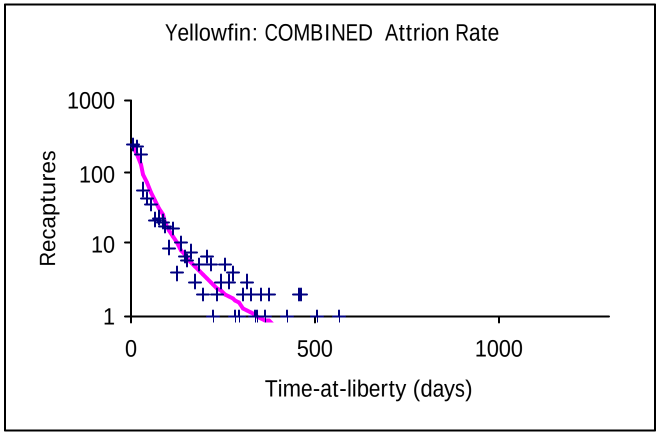




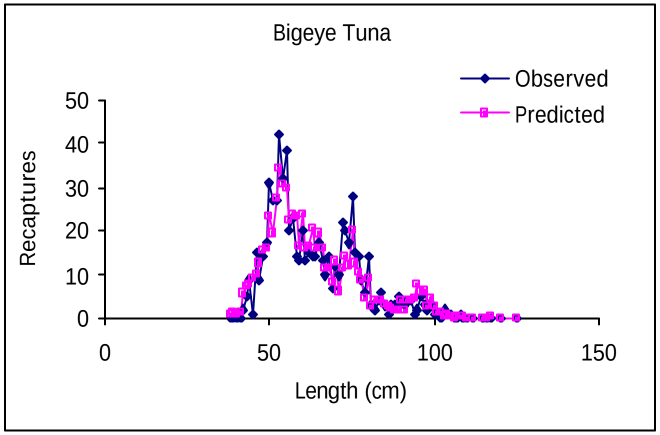


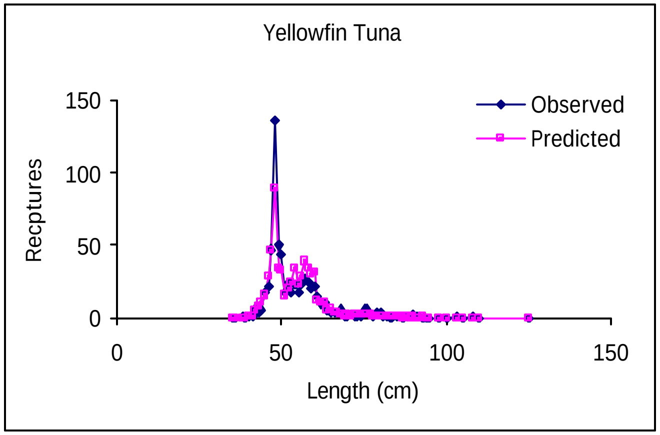
RESULTS: Observed and predicted for the ENTIRE MODEL AREA (all areas combined)



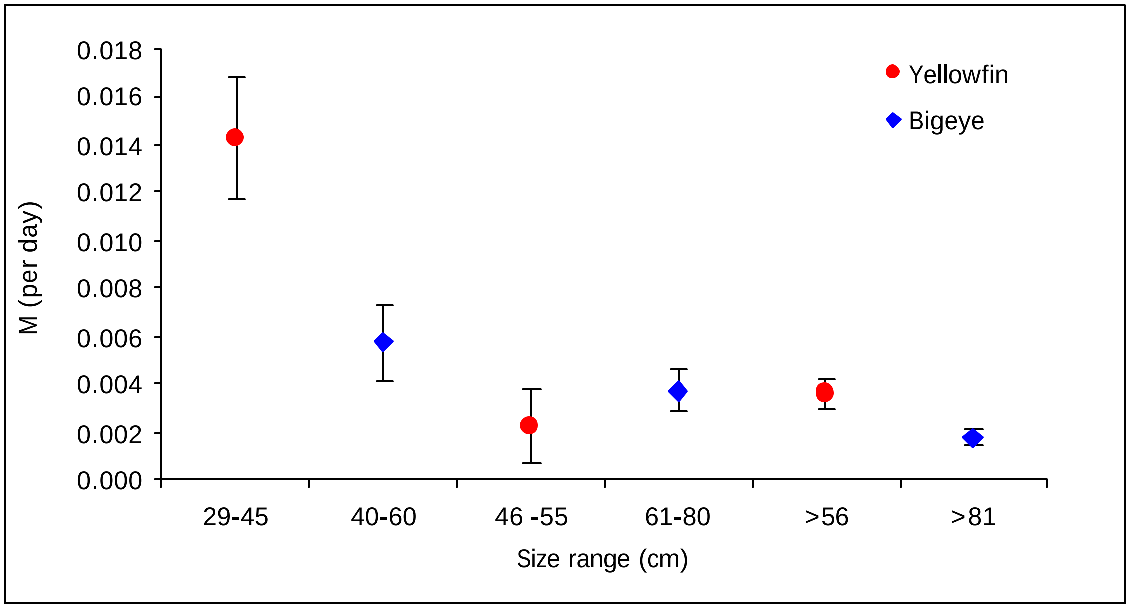


RESULTS: CROSS SEAMOUNT observed and predicted returns by initial length of release

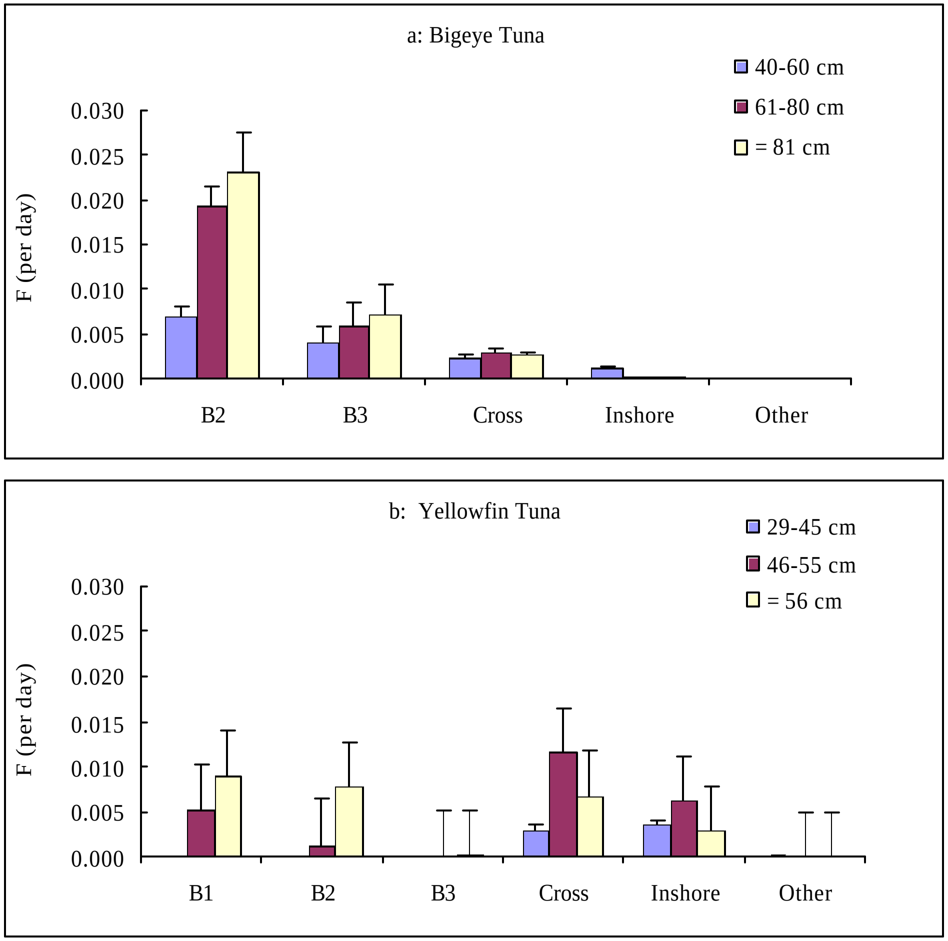


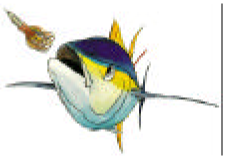


RESULTS: Estimates of Natural Mortality rate

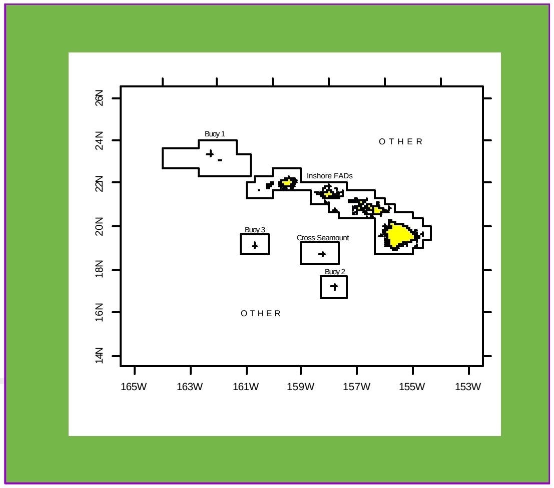


RESULTS: Estimates of Fishing Mortality rate





RESULTS: Transfer rates (per day)



BIGEYE

	B2	B3	Cross	Inshore	Other
B2	NA	0.00245	0.00113	0.00752	0.02707
B3	0.00000	NA	0.01111	0.01073	0.03927
Cross	0.00045	0.00026	NA	0.00464	0.01057
Inshore	**	**	0.00375	NA	**
Other	**	**	**	**	NA

YELLOWFIN

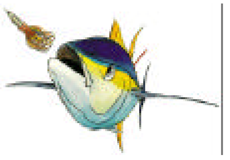
	B1	B2	B3	Cross	Inshore	Other
B1	NA	**	**	0.00648	0.01055	0.04935
B2	**	NA	0.04301	0.00217	0.00000	0.00024
B3	**	0.00036	NA	0.00205	0.00101	**
Cross	**	0.00226	**	NA	0.00136	0.02051
Inshore	0.00042	0.00069	**	0.00000	NA	0.00703
Other	**	**	**	**	**	NA

RESULTS: CSM attrition ratios (to the gross attrition rate, Z)

Size Class	M/Z	F/Z	E/Z	Z/Z
Bigeye Tuna				
40-50 cm	0.24	0.10	0.66	1.00
61-80 cm	0.16	0.13	0.71	1.00
> 80 cm	0.09	0.13	0.78	1.00
Yellowfin Tuna				
29-45 cm	0.35	0.07	0.59	1.00
46-55 cm	0.06	0.30	0.64	1.00
> 52 cm	0.10	0.20	0.70	1.00

Conclusions

- Transfer rates are minimal except from the Cross Seamount to longline areas
- Emigration is the major component of loss from Cross Seamount Fishery
- Exploitation rates in the Cross Seamount Fishery are moderate; but do not seem to have adverse impact on the fisheries
- Given the local fishery is only a sub-component of the ocean-wide fishery, and considering declining biomass and recruitment observed from ocean-wide assessments, it is prudent to increase monitoring of the fishery



Yield-per-recruit analysis

- Data stratified into three fisheries:
  - Inshore
  - Offshore
  - Longline
- Parameters re-estimated

Estimates of the BIGEYE attrition and transfer rate parameters for the three-fishery model

"Natural" Mortality

Size	M[size]
35-50	0.0107
51-65	0.0049
66-80	0.0043
81-95	0.0033
>96	0.0035

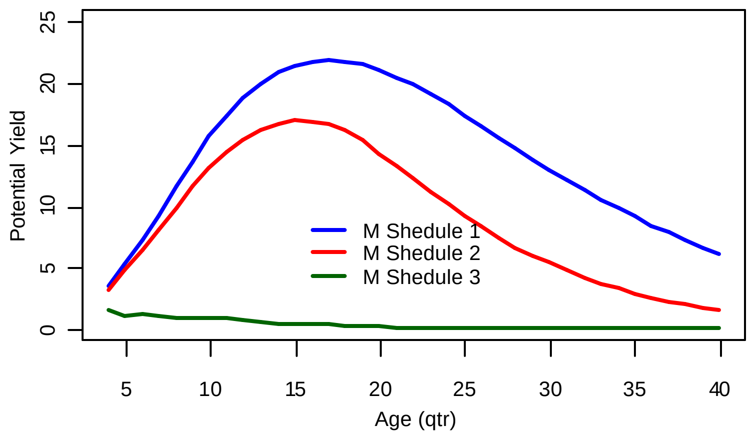
Fishing Mortality [size][site]

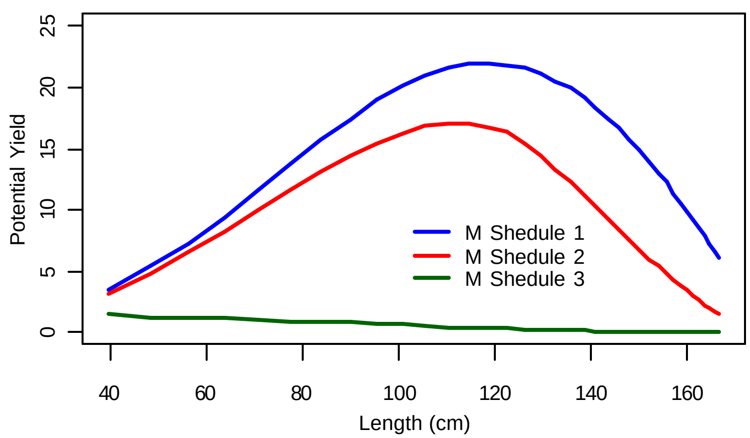
Size	Offshore	Inshore	Longline
35-50	0.0026	0.0000	0.0000
51-65	0.0054	0.0015	0.0000
66-80	0.0071	0.0004	0.0000
81-95	0.0058	0.0007	0.0001
>96	0.0030	0.0002	0.0001

Transfer rates

	Offshore	Inshore	Longline
Offshore	NA	0.00059	0.02484
Inshore	0.00000	NA	0.00000
Longline	0.00125	0.00011	NA

Potential yield of BET a cohort (recruited on an quarterly basis) for varying M-schedules

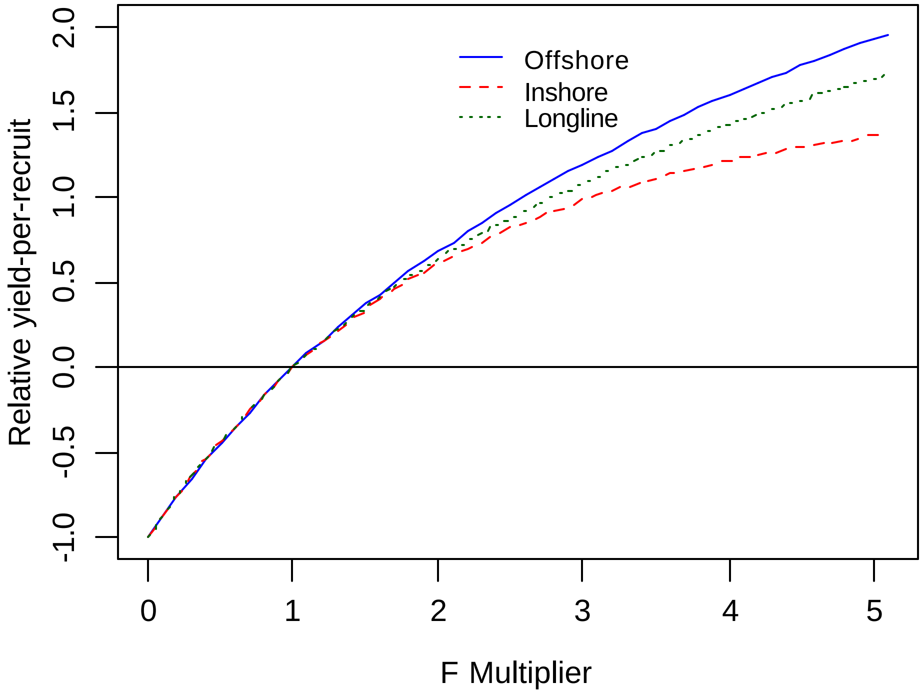




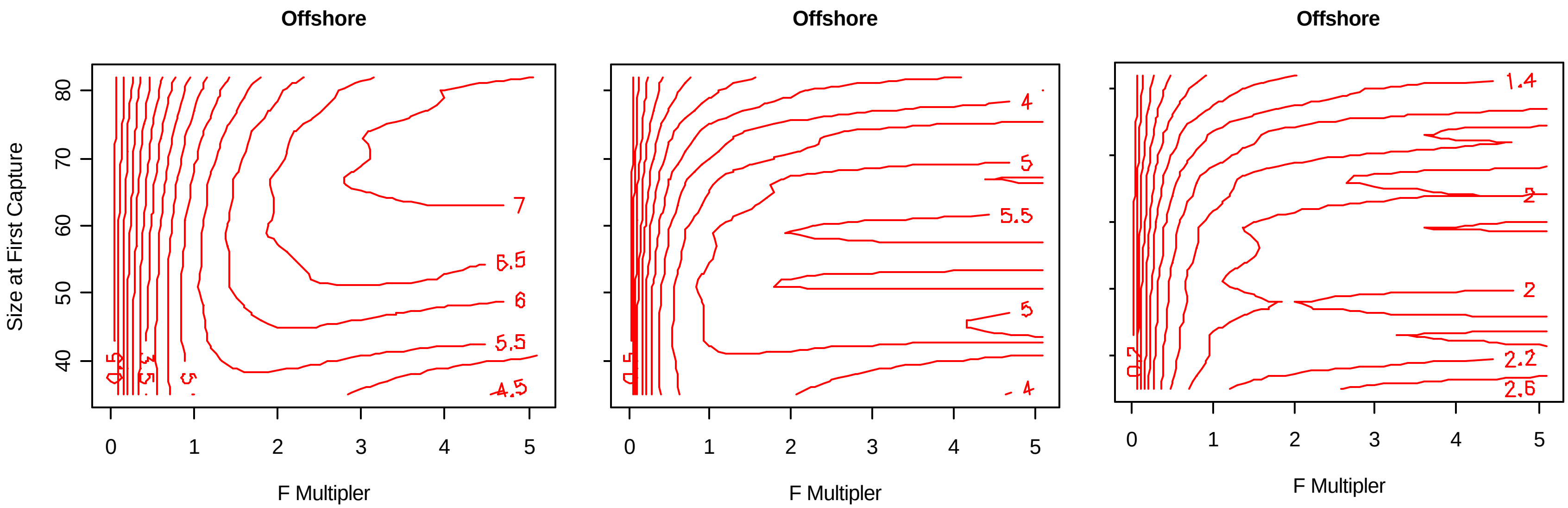
Mortality Schedules [per quarter]

Size-range	M1	M2	M3
45-50	0.15	0.22	0.97
54-65	0.15	0.15	0.44
66-80	0.10	0.12	0.39
81-95	0.10	0.11	0.30
96-110	0.10	0.11	0.31
111-125	0.10	0.12	0.31
> 125	0.10	0.15	0.31

Yield-per-recruit for three-fisheries



Effect on YPR isopleths for varying M-schedules.



Low (ICCAT Values)

Medium

Estimates from HTTP data

Relevant publications

1. Adam, M. S., J. R. Sibert, D. Itano, and K. Holland. [submitted to Fishery Bulletin], Dynamics of bigeye and yellowfin tuna in Hawaii's pelagic fishery: analysis of tagging data using a bulk transfer model incorporating size-specific attrition.
2. Sibert, J. R., Holland, K., and Itano, D. G.(2000). Exchange rates of Yellowfin and Bigeye Tunas and Fishery Interaction Between Cross Seamount and Near-shore FADs in Hawaii, *Aquatic Living Resources, 13*, 225-232.
3. Itano, D. G., and Holland, K.(2000). Movement vulnerability of bigeye (*Thunnus obesus*) and yellowfin tuna (*Thunnus albacares*) in relation to FADs and natural aggregation points, *Aquatic Living Resources, 13*, 213-223.
4. Holland, K., Kleiber, P., and Kajiura, S. M.(1998). Different residence times of yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *T. obesus*, found in mixed aggregations over a seamount, *Fisheries Bulletin, 97*, 392-395.