Purse-seine discards

1st External review of data used in stock assessments of tropical tuna in the eastern Pacific Ocean
Oct 2-6 2023

Discards

- Fish that are caught, but not landed, and are assumed to die.
- Need to be incorporated in the assessment to avoid underestimating the total removals from the population
- Useful to model discard fisheries to enable the estimation of impacts caused by management strategies that modify the amount of discards

Types of discards

Two types of discards are considered:

- Independent of size/age - those resulting from inefficiencies in the fishing process:
    - catch from a set exceeding the remaining storage capacity of the fishing vessel
    - dumping unwanted bycatch species
    - considered as a proportion of the retained catches
- Dependent of size/age - those related to the sorting of catches:
    - when fishers discard tuna that are under a certain size
    - considered as independent fisheries

How purse-seine discards are treated in the assessment:

Removals for purse-seine fisheries in the assessment are:

- For floating object sets:
    - retained catch + discards resulting from inefficiencies in the fishing process.
- For unassociated and dolphin sets:
    - retained catch + some discards resulting from inefficiencies in the fishing process + discards from sorting the catch.

Discards fisheries in the assessment are:

- Those that result from the process of sorting the catches in the floating object sets
- These discards are assumed to be composed only of fish that are 1-3 quarters old.
- Sorting is infrequent in the other purse-seine fisheries.
- Need to be treated as separate fishery as the port sampling will not provide information about the size distribution, which needs to be collected at sea

Method to estimate discards

- Estimated with information collected by IATTC or national observers
- Observer program class VI vessels 100% coverage n 1993 with the AIDCP, no information to estimate discards prior to 1993
- Discards assumed to be null before 1993
- For other periods with insufficient data, the discard rate (discards/retained catches) is equal to the discard rate for the same quarter in the previous year or, if quarterly data are not available, a proximate year.
- Discards recorded in three size groups: small fish (<2.5 kg), medium fish (2.5-15.0 kg), and large fish (>15 kg).
- These data are used to determine discard rates to scale the total discards based on the total purse-seine landings by fishery.

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Method to estimate discards

- All that is known about the fish that are discarded during sorting is that they are mostly small fish that weigh less than about 2.5 kg.
- By creating fisheries whose catch is composed exclusively of small, discarded
- fish, it is possible to conduct a stock assessment without detailed data on the size composition of
- the discards.
- This is possible because the small fish that are discarded during sorting are likely to belong
- to only a few age classes.
- Thus the establishment of "discard fisheries in the models" to include the best estimates
- of the amount of fish discarded by sorting the catches taken by the floating objects fisheries
- IATTC observers collect information on the size composition of the discards, but they do not currently measure the fish.
- The observers categorize the fish into the
- following groups: large (greater than 15 kg), medium (2.5-15 kg), and small (less than 2.5 kg).
- It is assumed the "Discard fisheries" are composed entirely of fish in the small category.
- Thus, using the weight-length relationship for yellowfin tuna, it follows that the yellowfin would be less than 51 cm in length (less than about 1 year old, according to the growth curve of Wild (1986)).
- It is assumed that yellowfin are recruited to the discard fisheries when they are about 6 months old and about 33 cm in length

Method to estimate discards

A base discard rate is determined from the medium and large categories, and this is subtracted from the discard rate of small bigeye to determine the discard rate of small fish due to size sorting.

The complicated description of Maunder and Watters (2003) can be simplified to the following equations. The total catch related to the selectivity corresponding to the landings is (*i.e.* landings plus discards due to inefficiencies)

$$C_B = landings \times (1 + \lambda_B)$$

$$\lambda_B = \frac{D^o_{m\&l}}{C^o_{m\&l} - D^o_{m\&l}}$$

$$D^o_{m\&l} = observed\ discards\ of\ medium\ and\ large\ bigeye$$

$$C^o_{m\&l} = observed\ catch\ of\ medium\ and\ large\ bigeye$$

The total catch related to the selectivity corresponding to the discards sorted by size is

$$D_E = landings \times \lambda_E$$

$$\lambda_E = \frac{D^o_S}{C^o_T - D^o_T} - \lambda_B$$

$$D^o_S = observed\ discards\ of\ small\ bigeye$$

$$C^o_T = observed\ catch\ of\ all\ bigeye$$

$$D^o_T = observed\ discards\ of\ all\ bigeye$$

These calculations are done separately for each stock assessment fishery by quarterly time step.

Maunder and Watters (2003).

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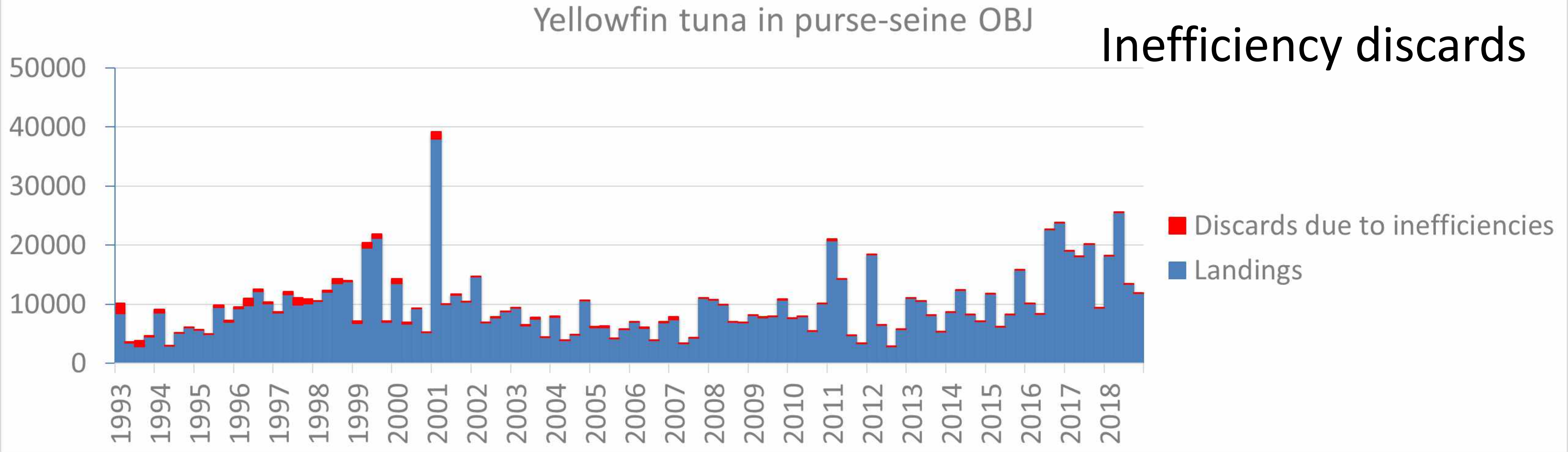
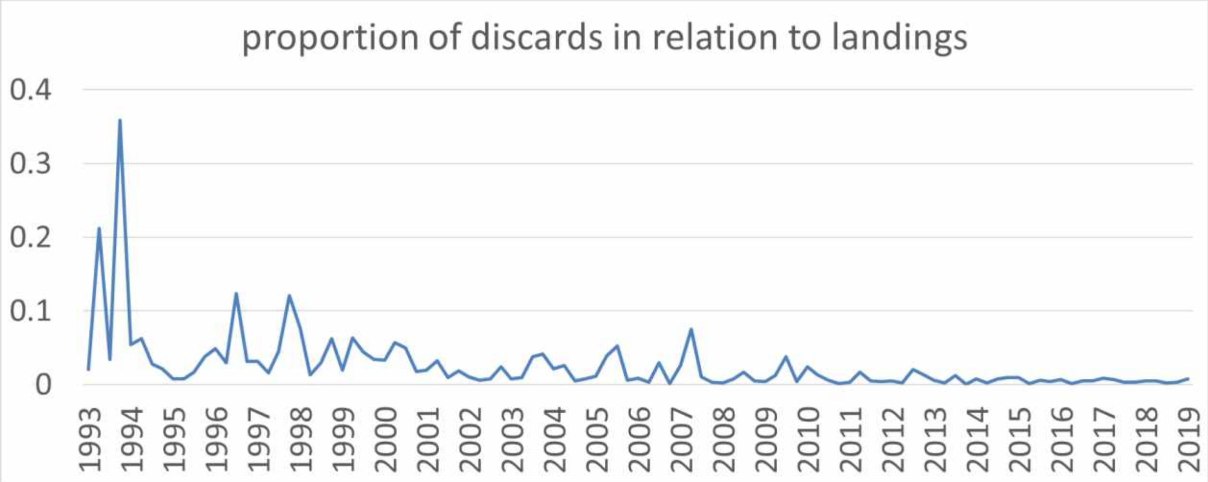
Trends in discards: yellowfin tuna

Inefficiency discards

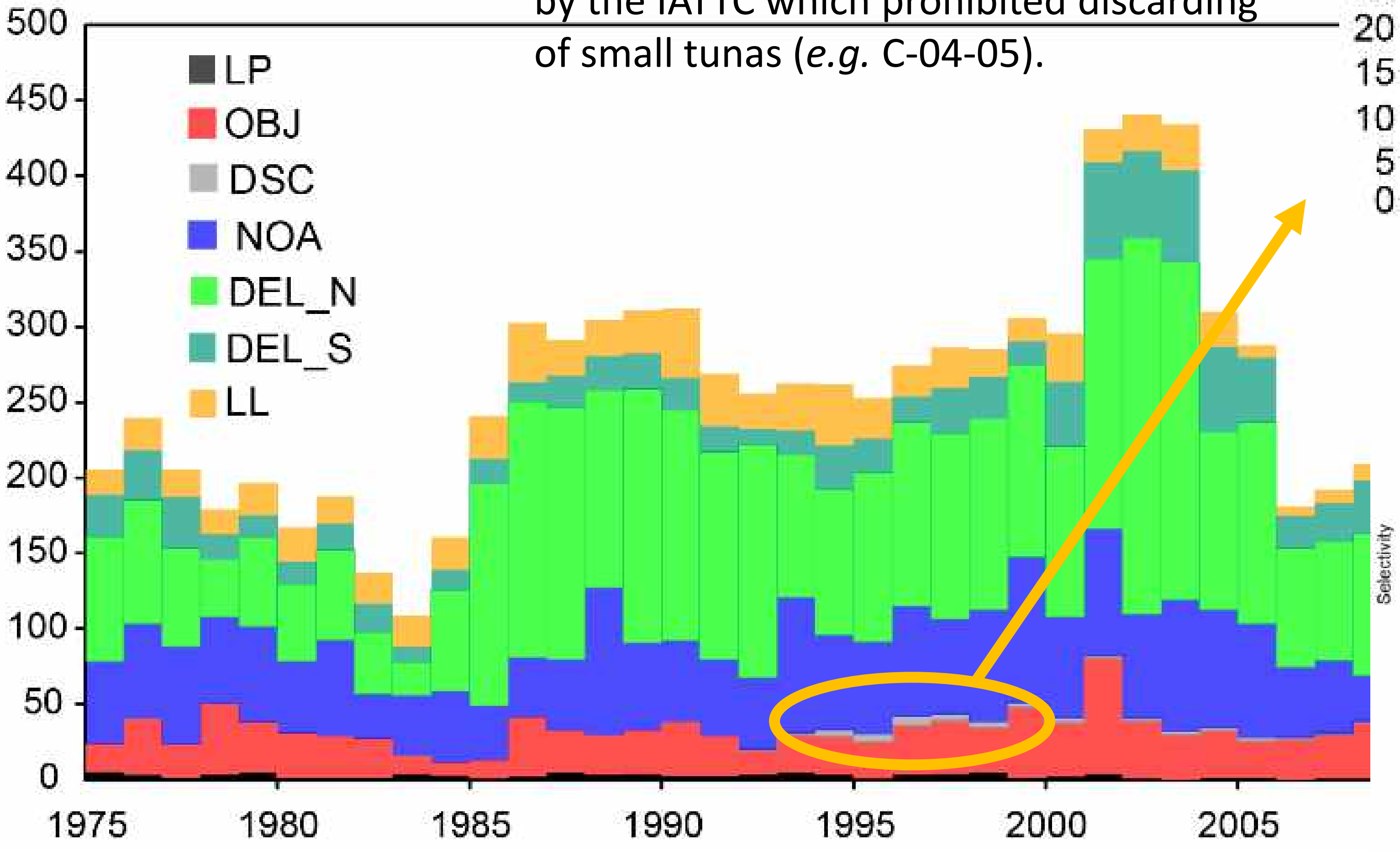


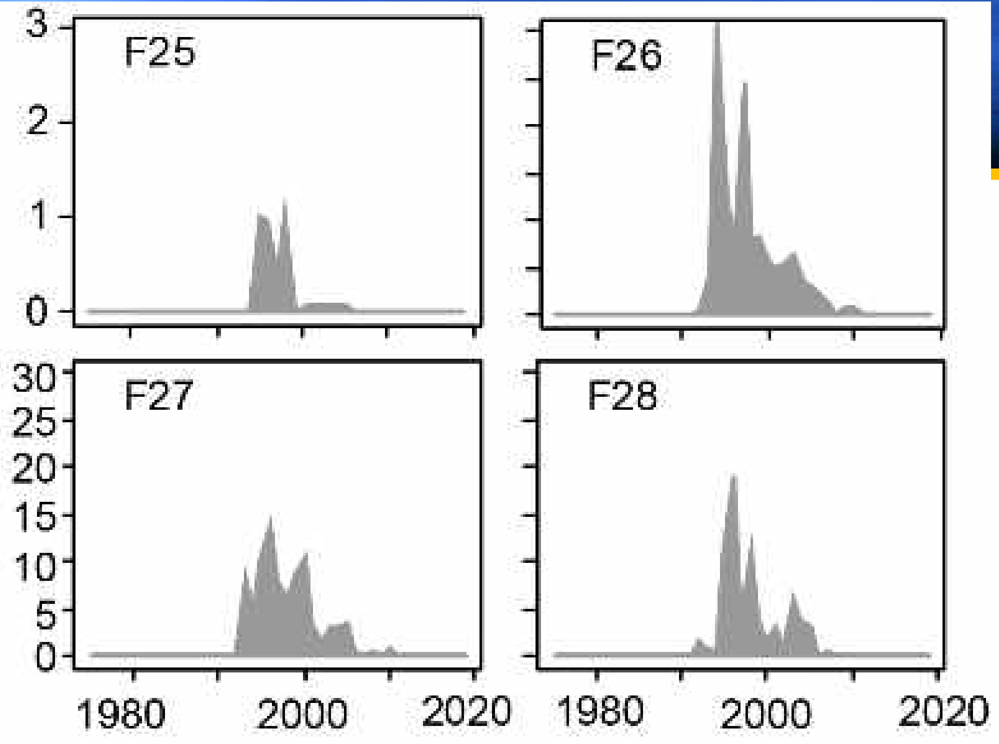


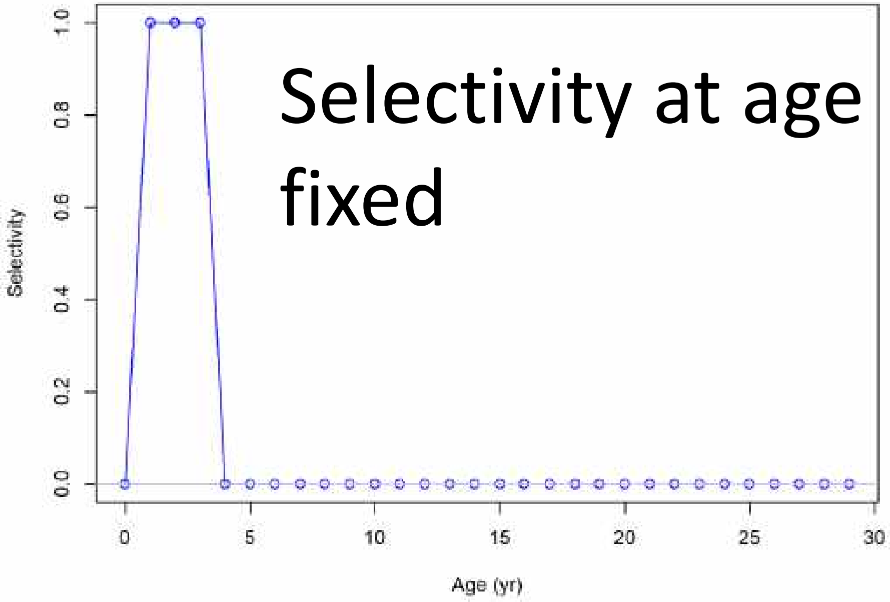
Trends in discards:yellowfin tuna

Sorting discards

The discards due to sorting in the floating-objects fisheries show a reduction beginning around 2001, and ceased almost completely following resolutions adopted by the IATTC which prohibited discarding of small tunas (*e.g.* C-04-05).



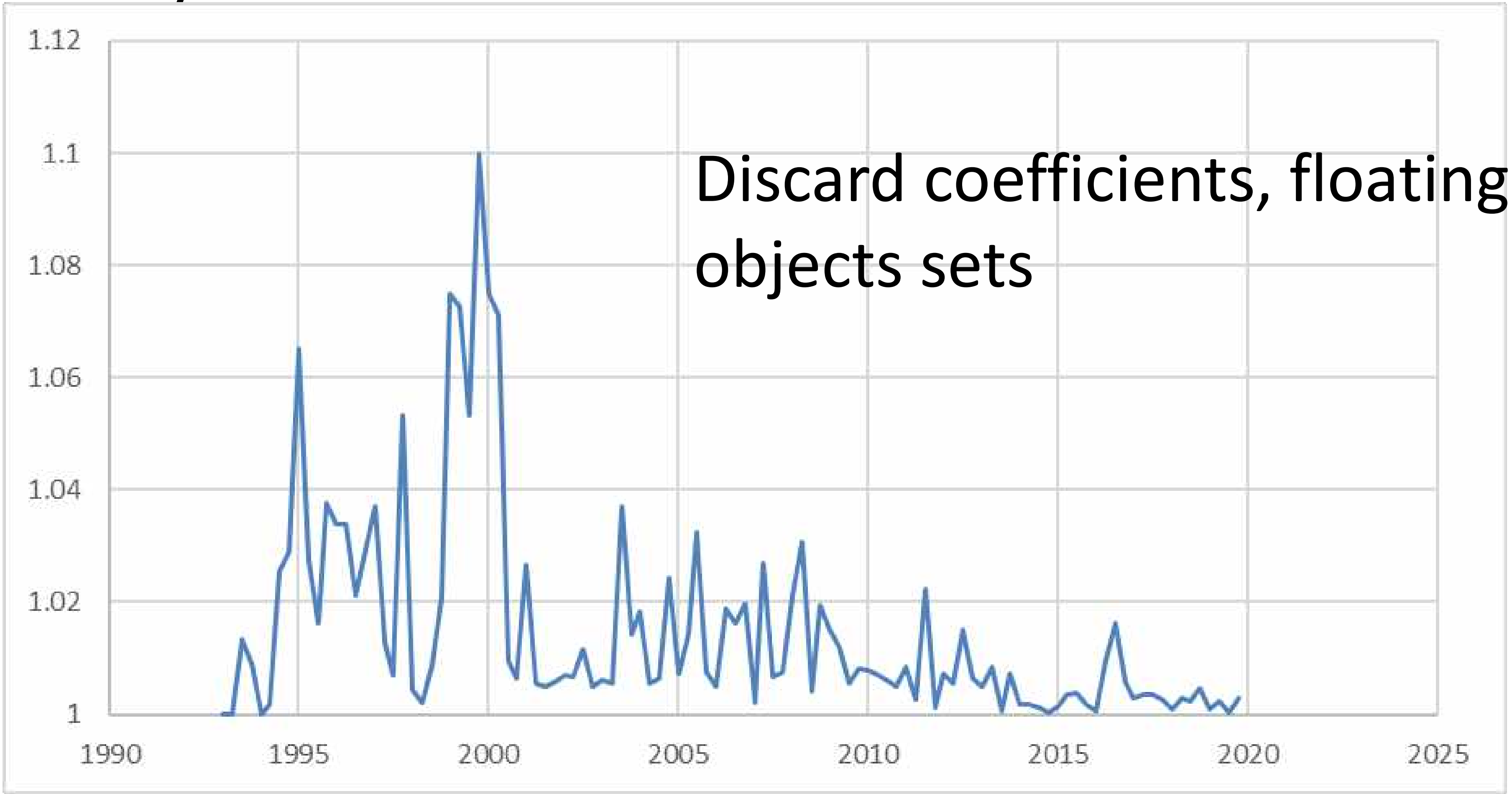




Selectivity at age fixed

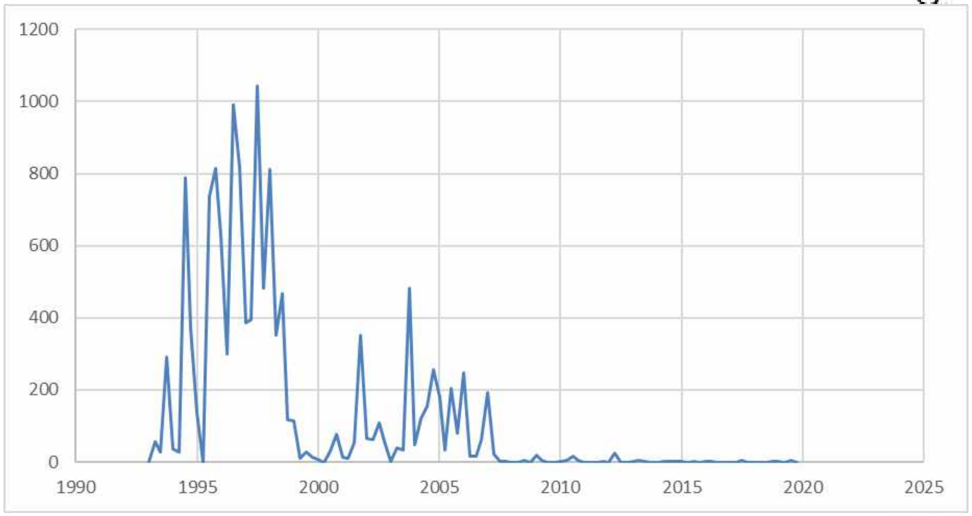
Trends in discards: bigeye tuna

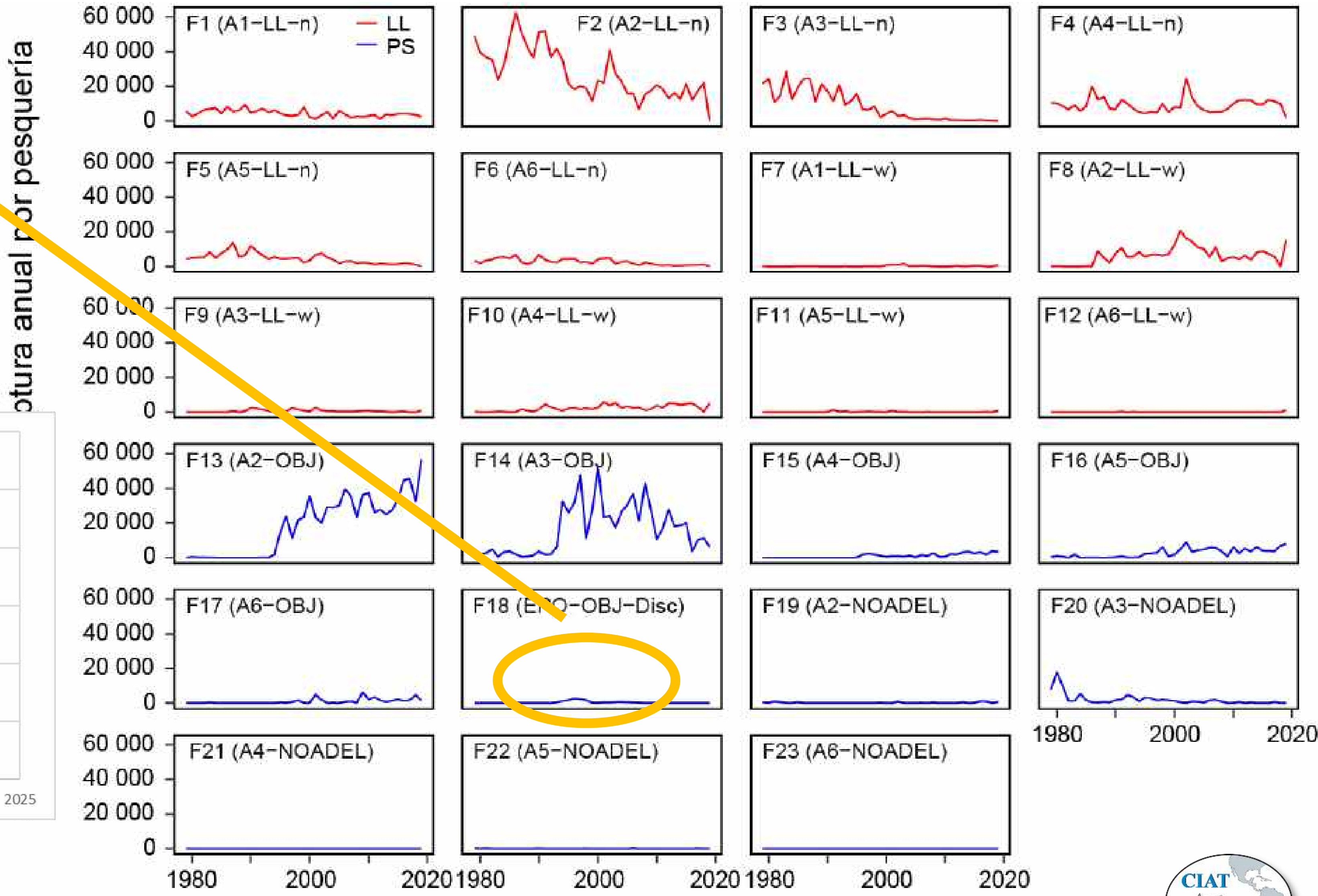
Inefficiency discards



Trends in discards:bigeye tuna

Sorting discards





Conclusion

- Discards were a problem in the early 2000’s
- Regulations were set in place restricting sorting discards, which are almost non-existent after 2010
- Inefficiency discards have decrease over time and are around 0.45% for yellowfin tuna and 0.25% for bigeye tuna in floating objects sets in recent years.

Extra: Method to estimate discards (Appendix G)

Method to estimate discards in
Appendix G of
Maunder and Watters (2003)

ANALYSIS FOR ASSESSING TUNA STOCKS IN THE EASTERN PACIFIC OCEAN

A-SCALA: UN ANÁLISIS ESTADÍSTICO DE CAPTURA A TALLA ESTRUCTURADO POR EDAD PARA LA EVALUACIÓN DE LAS POBLACIONES DE ATUNES EN EL OCÉANO PACÍFICO ORIENTAL

by—por

Mark N. Maunder and—y George M. Watters

La Jolla, California

2003

G.1. Data

IATTC observers routinely collect data on the discards of tunas from many of the purse-seine vessels operating in the EPO, and, for each observed set, the following data are contained in the IATTC Bycatch Database:

- set type,
- position,
- date,
- catch (t) of small fish (< 2.5 kg),
- catch (t) of medium fish (2.5 - 15.0 kg),
- catch (t) of large fish (> 15 kg),
- total catch (t),
- discards (t) of small fish (< 2.5 kg),
- discards (t) of medium fish (2.5 - 15.0 kg),
- discards (t) of large fish (> 15 kg), and
- total discards (t).

Note that landings (or loadings) can be calculated from these data as catch minus discards. These observer data were used to estimate a time series of multipliers for each fishery represented in the stock assessment models. The definitions of small, medium, and large fish listed above are used throughout the following text.

G.2. Methods for fisheries that catch tunas in association with floating objects

Let D represent the event that a kilogram of fish is discarded and S the event that a kilogram of fish is composed of small fish. Then, from the rules of conditional probability,

$$(G.1)\quad \Pr(D|S)=\frac{\Pr(S|D)\Pr(D)}{\Pr(S)}.$$

The conditional probability that a kilogram of fish is discarded, given that it is composed of small fish, $\Pr(D|S)$, can be estimated empirically from the observer data.

$$(G.2)\quad \widehat{\Pr}(S|D)=\frac{\text{observed discards of small fish}}{\text{observed total discards}}\text{ ; where}$$

$$(G.3)\quad \widehat{\Pr}(D)=\frac{\text{observed total discards}}{\text{observed total catch}}\text{ ; and}$$

$$(G.4)\quad \widehat{\Pr}(S)=\frac{\text{observed catch of small fish}}{\text{observed total catch}}$$

Fisheries that catch tunas in association with floating objects discard tunas for two reasons: because of inefficiencies in the fishing process or because the catch is sorted to remove small fish. These two types of discard events are mutually exclusive (a kilogram of fish can be discarded either because of inefficiencies in the fishing process or because the catch has been sorted). Let B represent the event that a kilogram of fish is discarded because of inefficiencies in the fishing process and E represent the event that a kilogram of fish is discarded because the catch has been sorted. Then, according to our model of the discard process,

$$\text{(G.5)} \quad (\Pr(D|S) = \Pr(B|S) + \Pr(E|S) .$$

$\Pr(B|S)$ is the probability that a kilogram of fish is discarded because of inefficiencies in the fishing process given that it is composed of small fish and $\Pr(E|S)$ is the probability that a kilogram of fish is selectively discarded because it is composed of small fish.

We make two assumptions to estimate the probability that a kilogram of fish is discarded because of inefficiencies in the fishing process. First, we assume that the events B and S are independent (*i.e.* we assume that discarding fish because inefficiencies in the fishing process is independent of the size of the fish). This assumption implies that

$$\text{(G.6)} \quad \Pr(B|S) = \Pr(B) .$$

Second, we invoke the previously-mentioned assumption that fish that are discarded during sorting are discarded because they are too small. This assumption implies that medium and large fish are not discarded during sorting. We can, therefore, estimate $\Pr(B)$ from the observer data.

$$\text{(G.7)} \quad \widehat{\Pr}(B) = \frac{\text{observed discards of medium and large fish}}{\text{observed catch of medium and large fish}} .$$

The probability that a kilogram of fish is discarded because of sorting the catch is estimated by rearranging equation (5) and substituting from equations (1) and (6).

$$\text{(G.8)} \quad \widehat{\Pr}(E|S) = \frac{\widehat{\Pr}(S|D)\widehat{\Pr}(D)}{\widehat{\Pr}(S)} - \widehat{\Pr}(B) .$$

The objective of this analysis is to estimate a set of multipliers so that the total landings from floating-object fisheries can be used to estimate total discards. For a single-discard fishery (defined as fish that are discarded due to sorting), this multiplier can be written as

(G.9) $$\lambda_E = \frac{R_E}{L_T} ,$$

where R_E is the amount of small fish removed because the catch was sorted, and L_T is the total reported landings for a floating-object fishery that is represented in the assessment model. λ_E can also be estimated from the observer data.

(G.10) $$\widehat{\lambda_E} = \frac{\hat{R}_E}{L_{T,\text{Observed}}} .$$

The estimated amount of small fish removed because the catch was sorted is

(G.11) $$\hat{R}_E = \widehat{\Pr}\left(E|S\right)\cdot\left[\text{observed catch of small fish}\right],$$

and the observed landings is

$$\text{(G.12)}\quad L_{T,\text{Observed}} = [\text{observed total catch}] - [\text{observed total discards}] \,.$$

Thus, removals by discard fisheries are estimated by

$$\text{(G.13)}\quad R_E = \widehat{\lambda_E} \cdot [\text{total landings reported for the floating-object fishery}] \,.$$

These removals are used as catches by discard fisheries represented in the stock assessment models.

We also require a multiplier to estimate the amount of fish discarded because of inefficiencies in the fishing process. This multiplier can be written as

$$\text{(G.14)}\quad \lambda_B = \frac{R_B}{L_T} \,,$$

where R_B is the amount of fish discarded because of inefficiencies in the fishing process and L_T is the total landings for a floating-object fishery represented in the assessment model. λ_B can be estimated from the observer data.

$$\text{(G.15)}\quad \widehat{\lambda_B} = \frac{\hat{R}_B}{L_{T,\text{Observed}}} \,.$$

The amount of fish estimated to be discarded because of inefficiencies in the fishing process is

$$\text{(G.16)}\quad \hat{R}_B = \widehat{\Pr}(B) \cdot [\text{observed total catch}] \,.$$

Thus, for most floating-object fisheries (the regular fisheries), total removals are estimated by

$$\text{(G.17)}\quad R = [\text{total landings reported for the floating object fishery}] \cdot \left(1 + \widehat{\lambda_B}\right) \,.$$

G.3. Methods for other set types

We assume that all discards from dolphin sets and unassociated sets result from inefficiencies in the fishing process. This assumption simplifies the estimation method. A multiplier for estimating the total discards from dolphin sets and unassociated sets can be written as

$$\text{(G.19)} \quad \lambda_D = \frac{R_D}{L_T} \;,$$

where R_D is the removals from all discards and L_T is the total landings for the fishery represented in the assessment model. λ_D can be estimated from the observer data.

$$\text{(G.20)} \quad \widehat{\lambda_D} = \frac{[\text{observed total discards}]}{[\text{observed total catch}] - [\text{observed total discards}]} \;.$$

Thus, for purse-seine fisheries representing dolphin and unassociated sets, total removals are estimated by

$$\text{(G.21)} \quad R = [\text{total landings reported for the fishery}] \cdot \left(1 + \widehat{\lambda_D}\right) \;.$$

Again, this is equivalent to

$$\text{(G.22)} \quad R = L_T + R_B \;.$$