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Evaluation of the consequences of size based limits and catch retention

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1 Introduction

The Pacific Community (SPC) was asked by the Parties to the Nauru Agreement (PNA) to investigate the potential for size limits and catch retention to enhance longline management measures to reduce the fishing mortality on bigeye (*Thunnus obesus*), yellowfin (*T. albacares*) and albacore tunas (*T. alalunga*).

Size limits are frequently used to manage recreational and small scale commercial fisheries. Size limits aim to allow fish to reach maturity before being caught (Williams et al., 2008). The main premise of a size limit is that a large proportion of the fish will survive the capture and release process, and that these fish will reproduce at least once before being caught and retained (Brouwer and Griffiths, 2006). In order to achieve this size limits are normally set at the size at 50% maturity (L_{50}) (Griffiths, 1997). Catch retention has a less direct effect. Catch retention is designed to reduce waste where dead or undesirable fish cannot be discarded and to achieve a balanced harvest if it includes all species (Borges et al., 2016). The indirect impact of this is that the vessel's hold will fill up faster and once full the vessel will return to port to unload. This reduces the vessels efficiency as it will need to return to port more frequently and thereby have less time available to fish; on the other hand over time this may lead to better targeting of target size ranges. In addition, a retention policy (if it impacts the fishing operation) could provide incentives for fishers to develop and use more selective techniques to avoid unwanted species and size classes of target species (Chan et al., 2014).

2 Methods

In order to investigate the feasibility of size limits and their possible use as management tools, an investigation was undertaken into the size range of albacore, bigeye and yellowfin caught by longline gear in the waters of the PNA member countries (and Tokelau). The samples were collected by on-board observers and included all observed longline sets held by the SPC on behalf of the PNA membership from 1992-2016. The fate of observed fish was assessed as was the condition of each fish at capture and release. The reasons for discarding are collated and size range and proportion discards is presented for albacore, bigeye and yellowfin tuna.

For each species, fish were recorded as discarded or retained. The condition on capture and release was recorded by observers, for this analysis these were collated into three groups: A1 (alive and healthy) - these are fish likely to survive release; A2 (alive and injured) - this class pools two observer codes (A2 and A3) and included injured fish, distressed fish and dying fish; and finally D (dead fish). The size range of fish for each species in each life state class are presented as length frequency histograms. Also included is a possible limit; the limit is not a recommendation but rather a suggested size for testing a management scenario. At the request of the PNA, for each species, the size limit to be evaluated was equivalent to 90% of the L_{50} ($L_{50-90\%}$).

The condition on landing and release of observed fish are presented for each species along with the number of observations. These are then used to assess the proportion of fish discarded for each life state and the proportion below each limit for each life state. Finally the reasons given for each discard event are collated and presented by year.

3 Results and Discussion

3.1 Size, fate and condition

The length samples were fairly consistent from 2001-2016 for all species (Figure 1 - Figure 3). Landed albacore and bigeye tuna were largely above $L_{50-90\%}$ while yellowfin were evenly distributed around the $L_{50-90\%}$ in most years (Table 1).

For all three species the size of the fish does not determine its life status on capture and fish of all sizes appear in all life states (Figure 4 - Figure 6). Few (13%) albacore arrive at the side of the vessel alive and healthy on capture, and only 40% of bigeye and 33% of yellowfin are alive and healthy when captured (Figure 4 - Figure 6).

While many fish are observed and have their condition recorded on landing, few are observed/recorded upon release/discard (Figure 7 - Figure 9 top panels). Most albacore are dead or dying on capture and almost all are discarded dead (Figure 7). These trends have persisted through time, however, only in the last two years are there reasonable records of discarded albacore. Approximately 40% of bigeye are alive and healthy on landing but most discards are dead or dying (Figure 8). Like albacore these trends have persisted through time for bigeye, and only in the last two to three years are there reasonable records of discards. For yellowfin about half the fish are dead on landing and most discards are dead (Figure 9).

If a size limit at $L_{50-90\%}$ was set for the WCPFC longline fisheries this would result in 11.5%, 22.3% and 28.7% (by number) of albacore, bigeye and yellowfin respectfully needing to be returned to the ocean. But these fish are mostly small and their proportion by weight would be relatively minor (Figure 10 - Figure 12). However, if the intent of such a measure is to ensure survival until reproduction then it must be noted that only 0.51%, 4.75% and 7% albacore, bigeye and yellowfin respectfully would be released likely and survive.

3.2 Discarding

The size of the discarded albacore was not different from those of the retained fish (Figure 10) with about 2% by number being discarded. For bigeye and yellowfin, most of the discards are small fish and only 1% and 2% are discarded for each species (Figure 11 and Figure 12). Of the discarded fish, only about 2% of the albacore were alive and healthy, while 15% of bigeye and 7% of yellowfin were alive and healthy on release (Figure 13 - Figure 15). For bigeye and yellowfin there is a tendency to discard smaller fish alive while dead discards consisted of small and large fish.

Over the period assessed, albacore were predominantly discarded as they are considered to be uneconomic species, although in recent years they are discarded more due to being damaged (Figure 16). Most bigeye and yellowfin are discarded if they are small, but yellowfin are also frequently discarded due to being damaged (Figure 17 and Figure 18). There are no detectable trends in fish being discarded due to shark or whale damage. Pooling the annual data (Figure 19 to Figure 21) shows that albacore are discarded as unwanted fish (65%), while bigeye and yellowfin are mostly discarded when small (82% - bigeye; 67% - yellowfin) or damaged (11% - bigeye; 21% - yellowfin).

In order to place the longline discards into context, the discard proportions from the longline fishery were added to each 2cm size class for the WCPFC longline fleets for each species and then plotted along with the other major fleets catching that species (Figure 22 to Figure 24). While small numbers are detectable for albacore (Figure 22) their numbers are likely to have little consequence for overall fishing mortality. For bigeye and yellowfin the discards are hardly detectable, as they are a small proportion of individuals at the left of the longline size distribution (Figure 17 and Figure 18). However, there is a potential for substantial underestimation here due to low levels of observer coverage on most longline fleets (Williams et al., 2016) and this analysis should therefore be repeated using only years and fleets with high levels of observer coverage.

When considering a catch retention policy one needs to consider what is being discarded and what would end up being retained under such a policy. Noting that only a small percentage of fish are being discarded (albacore - 2.52%, bigeye - 1.01% and 1.65% - yellowfin) a catch retention policy is likely not to have strong impacts on fishing operations. This could be considered a positive where the fish are retained and waste is minimised with little impact on the vessel operations; or a bad thing where incentives to modify fishing behaviour to avoid small fish are not strong and therefore unlikely to change behaviour.

4 Conclusions

As albacore are mostly landed dead, a size limit will be of little management value for this species. Albacore are discarded at all sizes and mostly as they are considered low value when compared to bigeye and yellowfin tunas. Only a small proportion of the bigeye and yellowfin are discarded alive and likely to survive (1% and 2% respectively). Given these low numbers, a size limit again may not be of great management value if the aim is mortality reduction. If a specific size limit is proposed this analysis could be repeated to estimate the number of fish below that size limit that would need to be released to evaluate the potential impact on fishing operations.

Catch retention may impact the vessels but as the discard rates are so low (1-2%), the value of this measure in terms of reducing effort may be limited, and likely only to impact the vessels when catch rates are high and the vessel fills up fast or the trips are very long and low value species or unwanted sizes could otherwise be discarded to make space in the freezers. Investigating when fish are discarded may help to clarify this.

If food security is a management objective and vessels offload low value species/size classes/damaged fish in port this may create opportunities for low cost fish for local communities. Given the low numbers of discards, the inconvenience of retaining these is likely to be slight for the vessels and this type of measure may have some benefit for coastal communities while reducing waste of usable protein.

Table 1: The percent of each species caught below the $L_{50-91\%}$, the percentage discarded and the percent of the discards that were observed as dead when returned to the water for the main tuna species in the PNA longline fisheries.

Species	Percent caught below $L_{50-91\%}$	Percent discarded below $L_{50-91\%}$	Percent discsarded dead below $L_{50-91\%}$
ALB	11.5	7.1	5.8
BET	22.3	83.6	44.1
YFT	28.7	77.2	38.4

Acknowledgements

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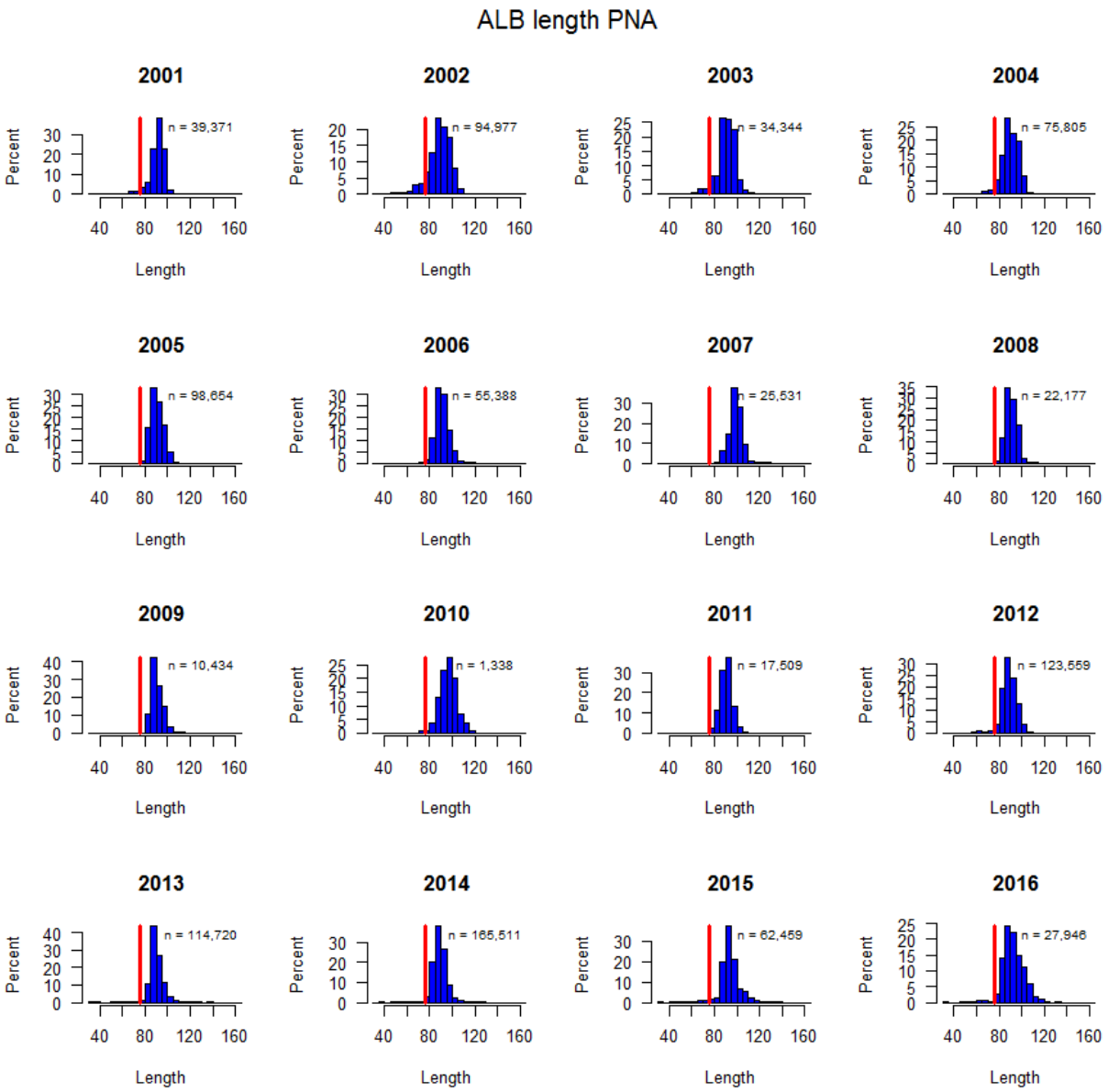

Figure 1: Annual length samples (% of the total annual by 5cm size bin) of albacore tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. The red line represents the size limit at 90% of the size-at-50% maturity.

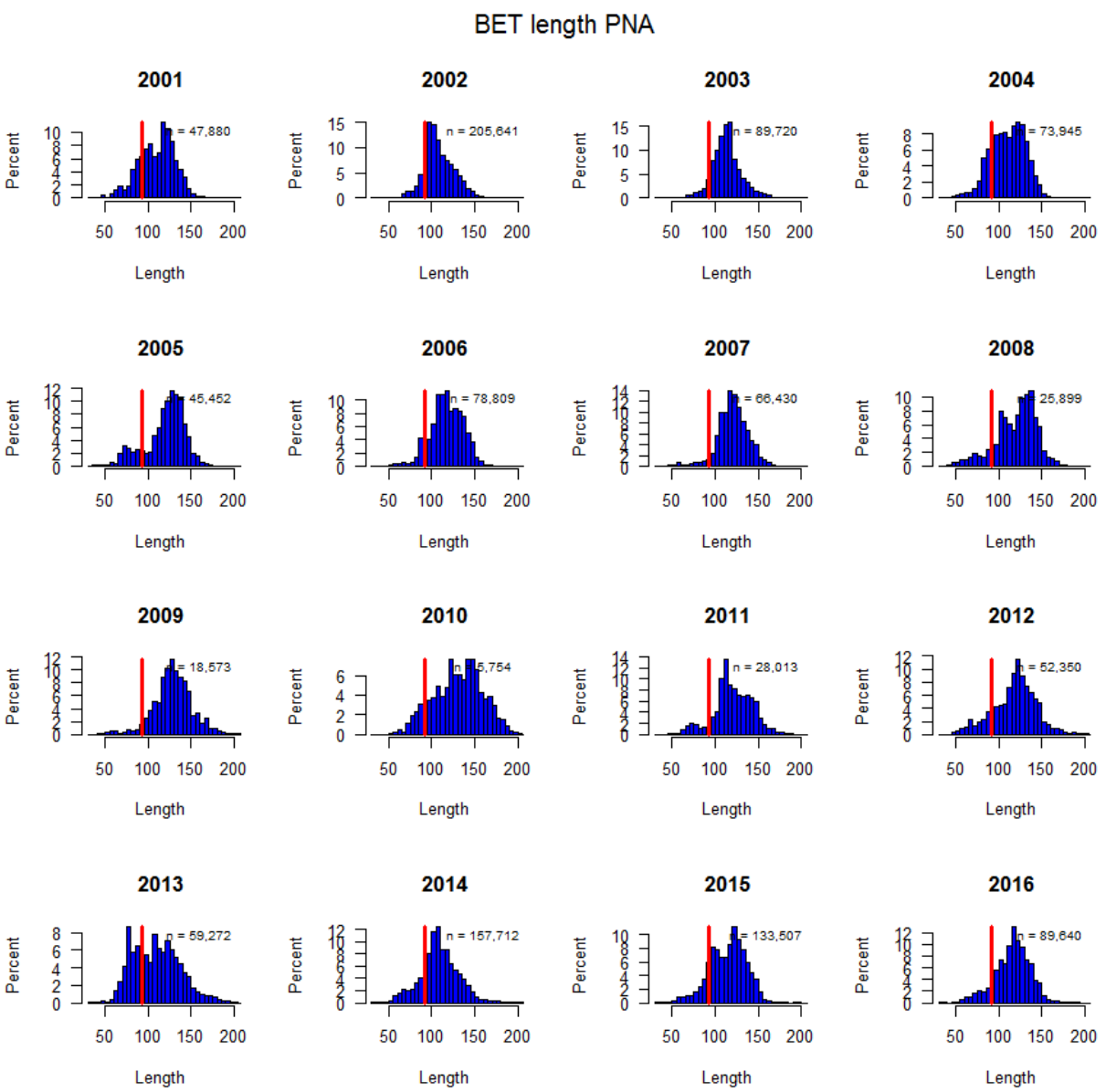

Figure 2: Annual length samples (% of the total annual by 5cm size bin) of bigeye tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. The red line represents the size limit at 90% of the size-at-50% maturity.

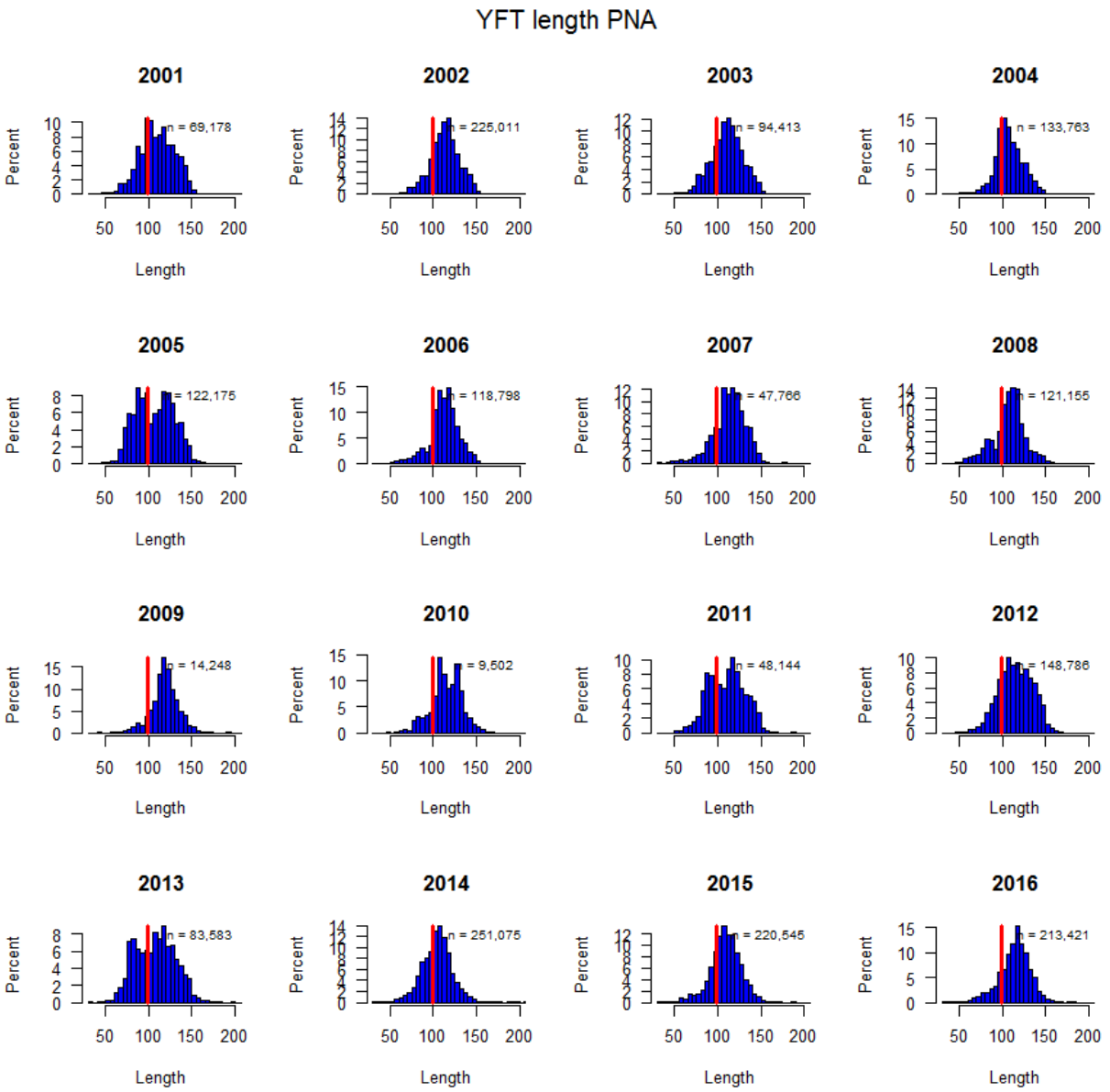

Figure 3: Annual length samples (% of the total annual by 5cm size bin) of yellowfin tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. The red line represents the size limit at 90% of the size-at-50% maturity.

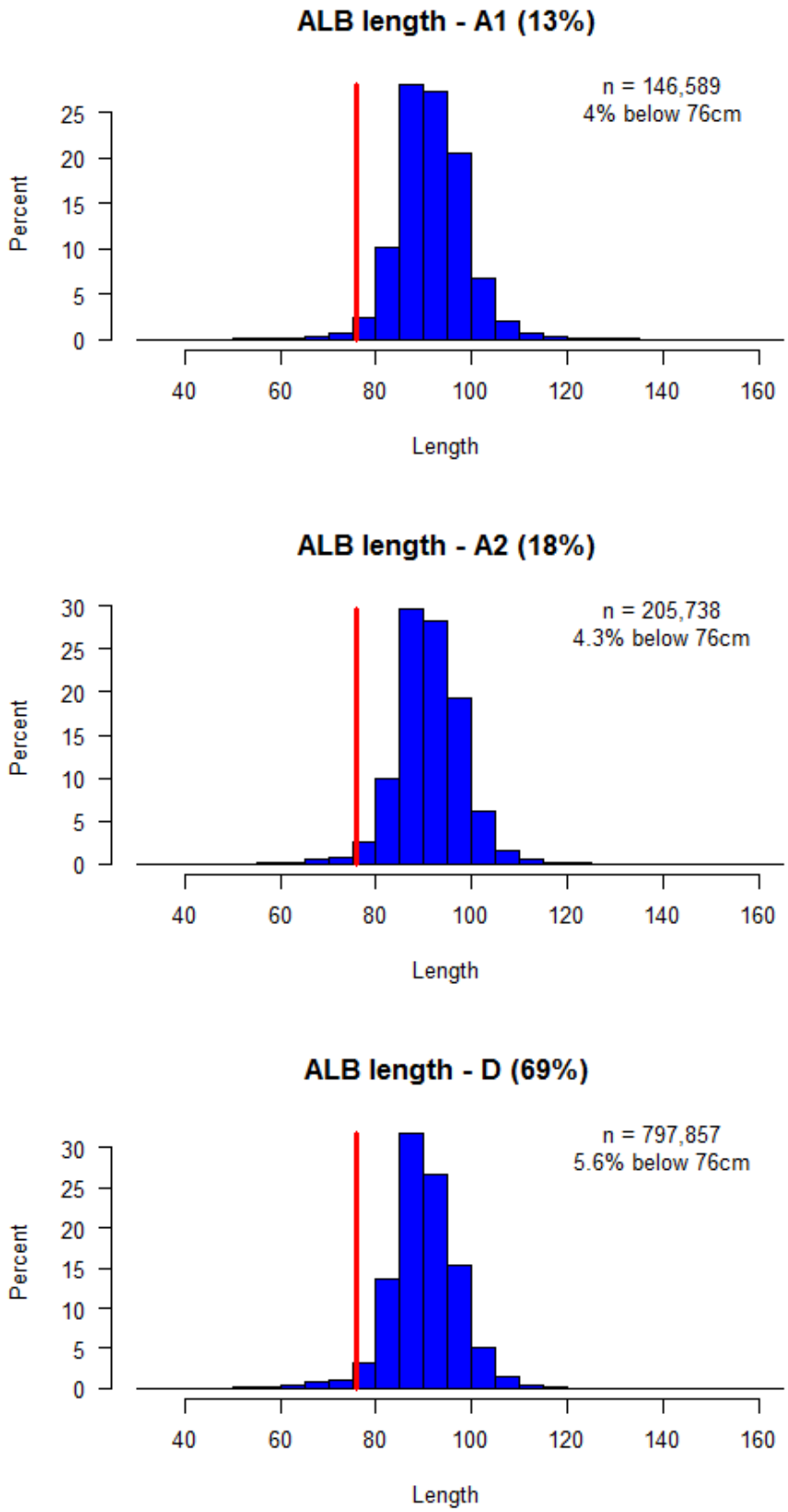

Figure 4: Combined length samples of albacore tuna from observed vessels fishing in PNA Member waters from 2001 - 2016, showing size and condition of the fish on landing. The red line represents the size limit at 90% of the size-at-50% maturity. In each plot the proportion below the size limit is shown as a percentage. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

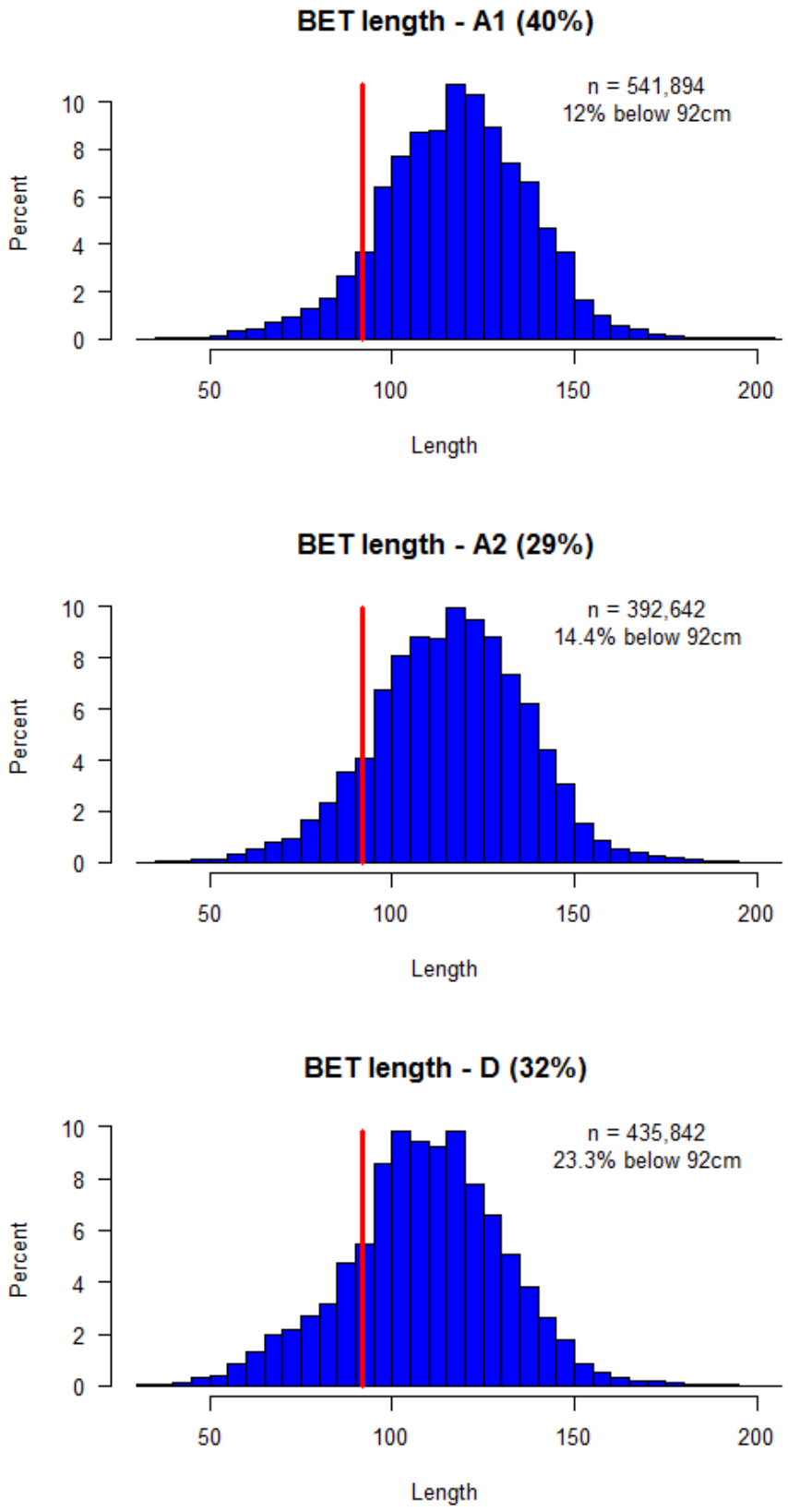

Figure 5: Combined length samples of bigeye tuna from observed vessels fishing in PNA Member waters from 2001 - 2016, showing size and condition of the fish on landing. The red line represents the size limit at 90% of the size-at-50% maturity. In each plot the proportion below the size limit is shown as a percentage. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

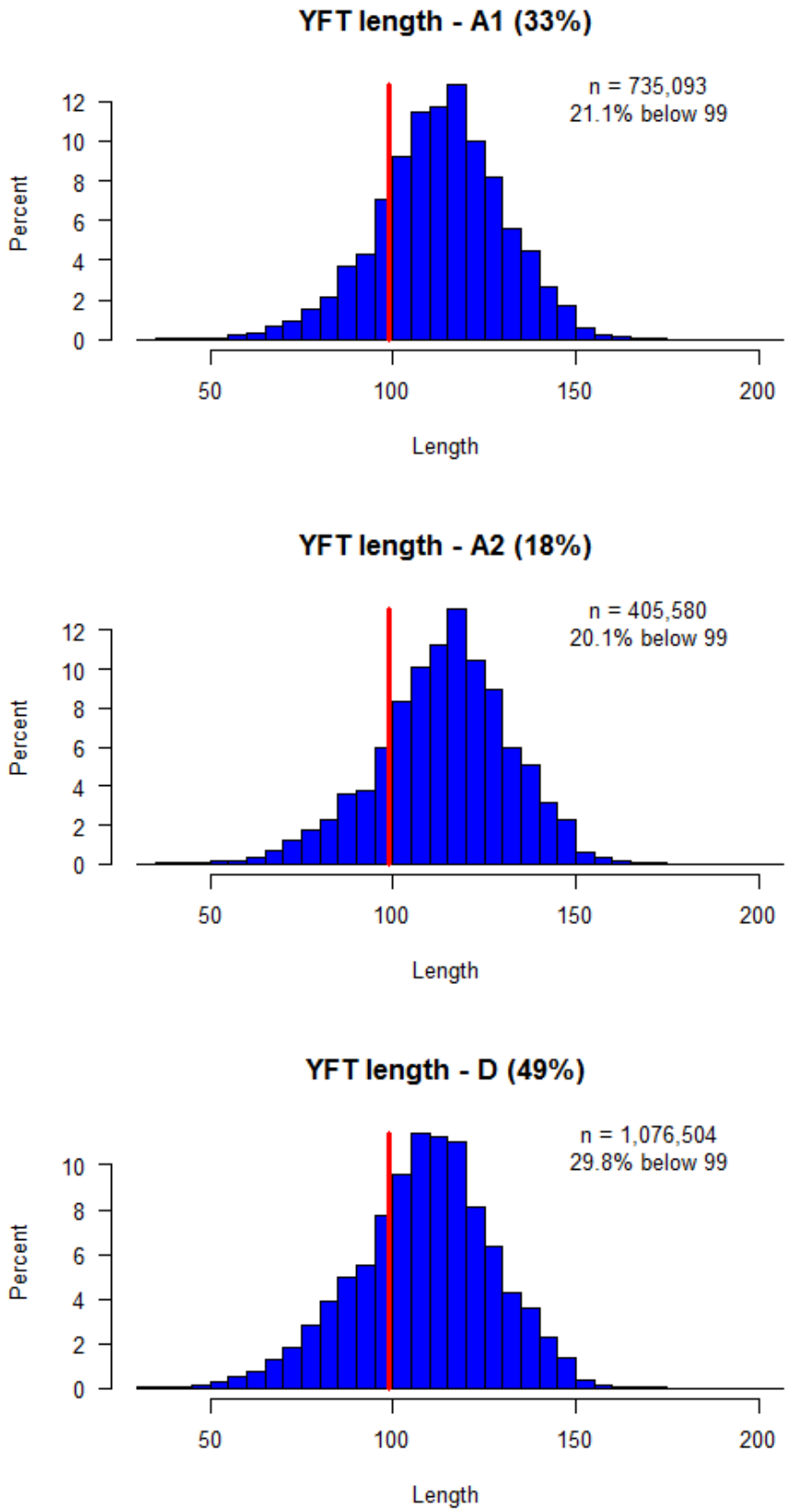

Figure 6: Combined length samples of yellowfin tuna from observed vessels fishing in PNA Member waters from 2001 - 2016, showing size and condition of the fish on landing. The red line represents the size limit at 90% of the size-at-50% maturity. In each plot the proportion below the size limit is shown as a percentage. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

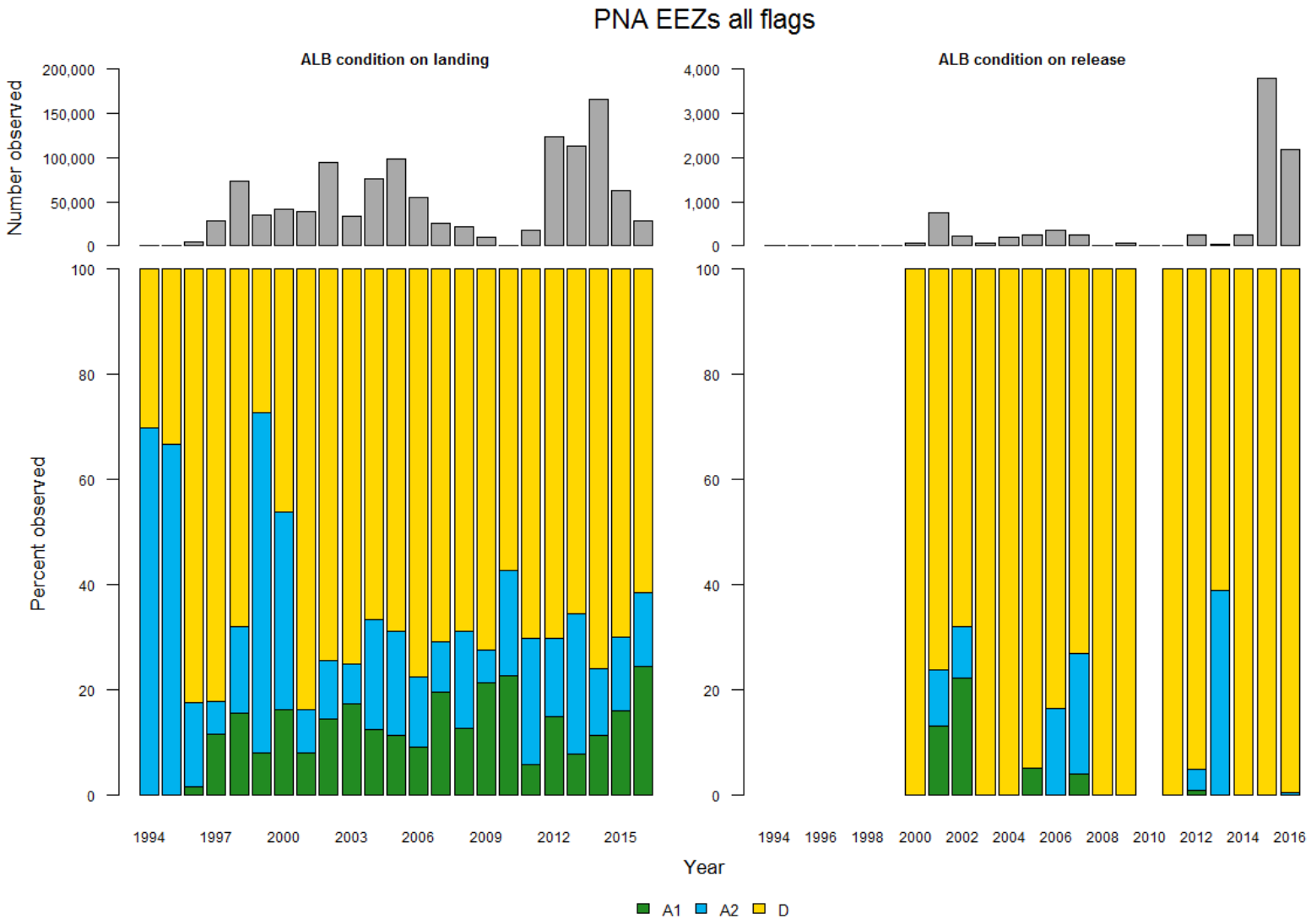

Figure 7: Albacore tuna condition observed (top two panels) on landing (left) and release/discard (right) and the condition of the fish (bottom two panels) on landing (left) and release/discard (right) by vessels fishing in PNA Member waters from 1994 - 2016. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

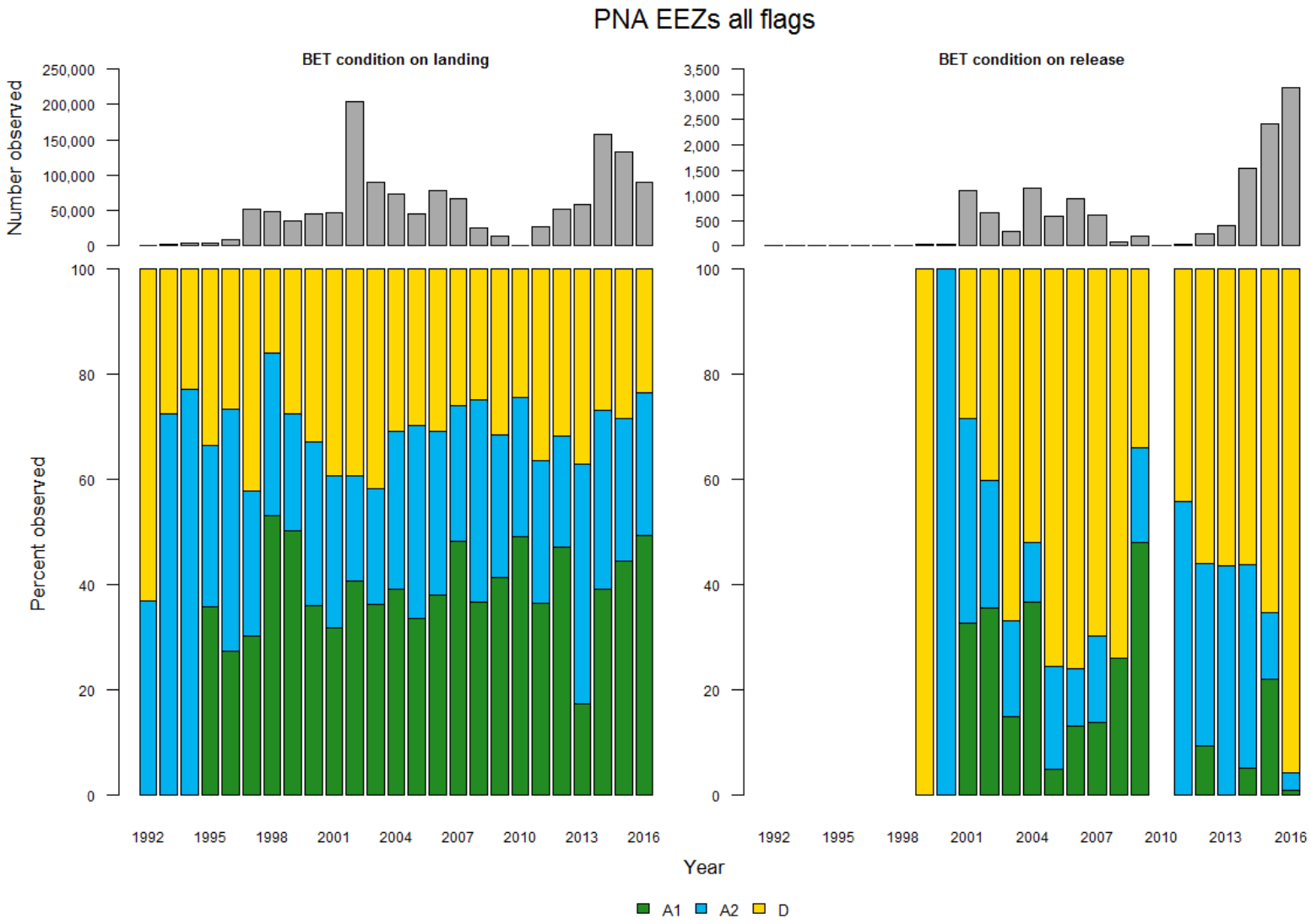

Figure 8: Bigeye tuna condition observed (top two panels) on landing (left) and release/discard (right) and the condition of the fish (bottom two panels) on landing (left) and release/discard (right) by vessels fishing in PNA Member waters from 1992 - 2016. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

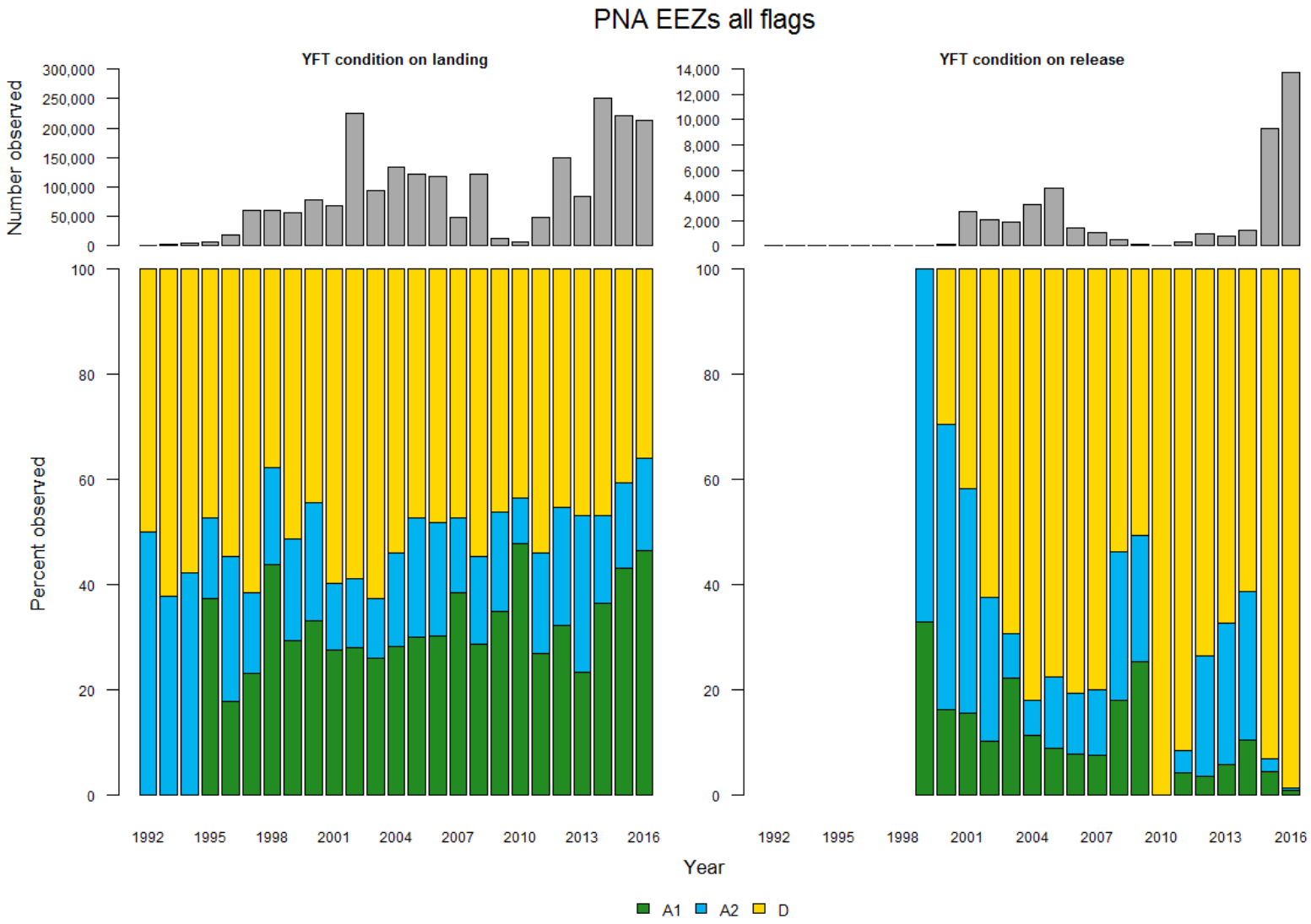

Figure 9: Yellowfin tuna condition observed (top two panels) on landing (left) and release/discard (right) and the condition of the fish (bottom two panels) on landing (left) and release/discard (right) by vessels fishing in PNA Member waters from 1992 - 2016. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

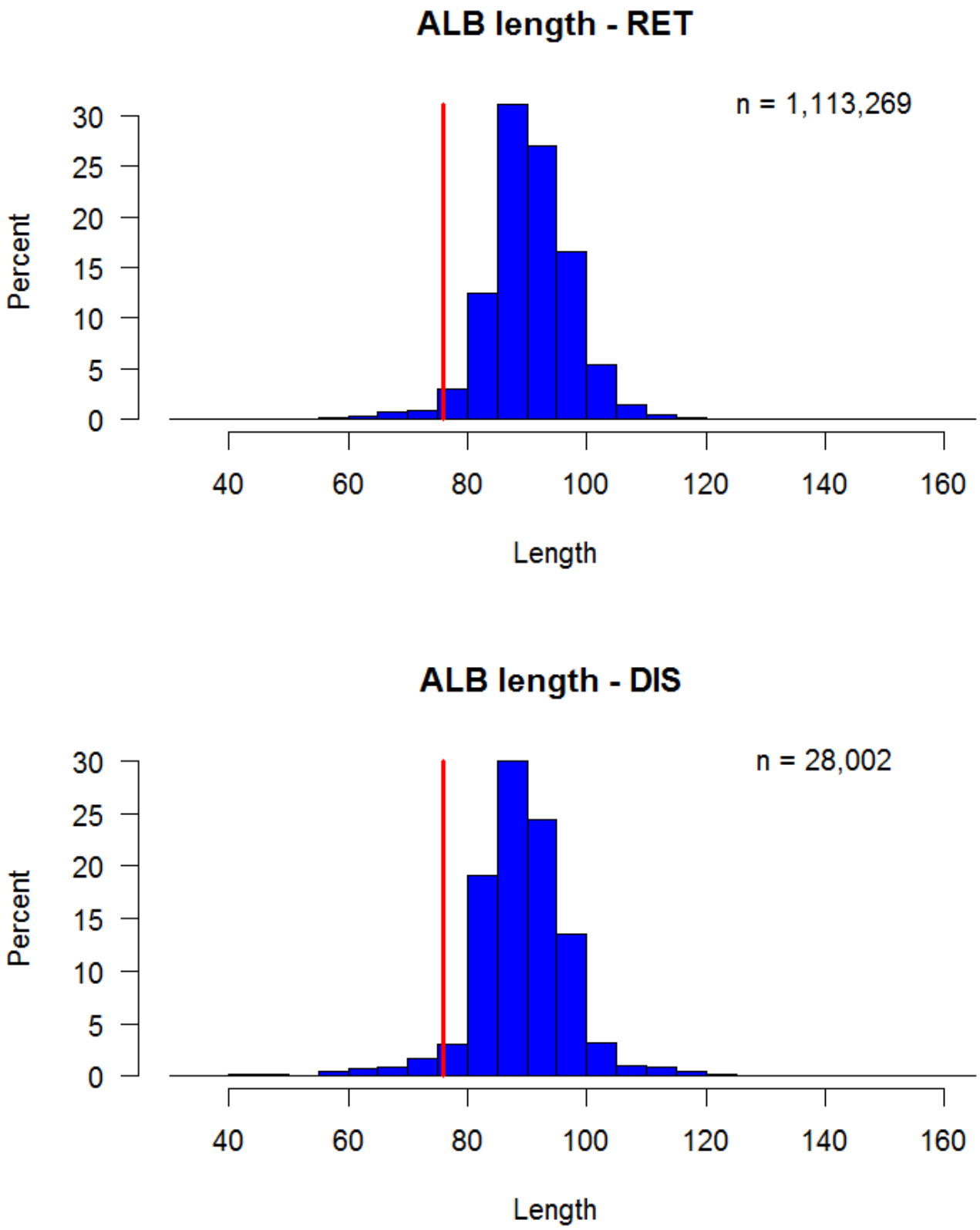

Figure 10: Length samples of albacore tuna that were retained or discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. RET = Retained; DIS = Discarded.

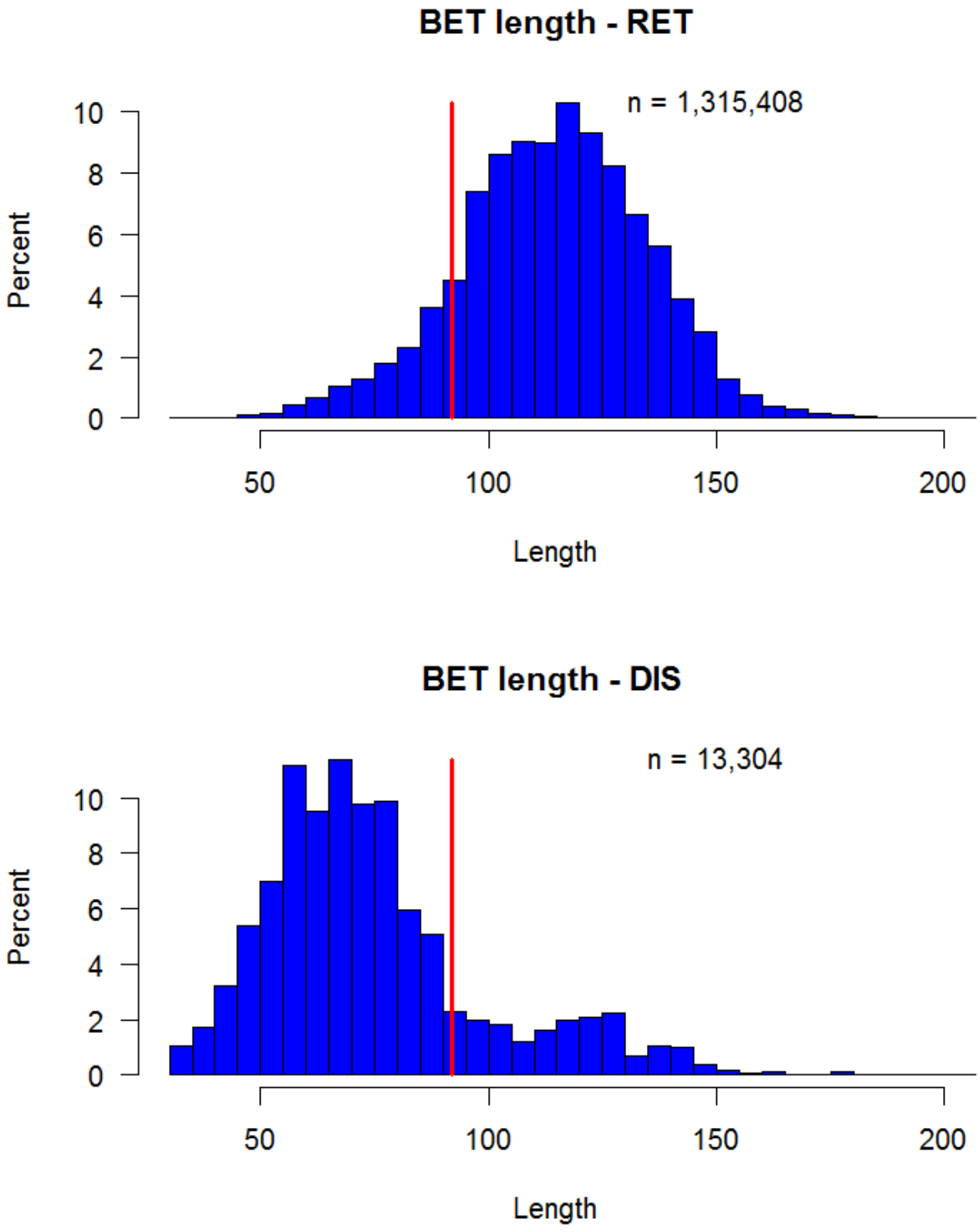

Figure 11: Length samples of bigeye tuna that were retained or discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. RET = Retained; DIS = Discarded.

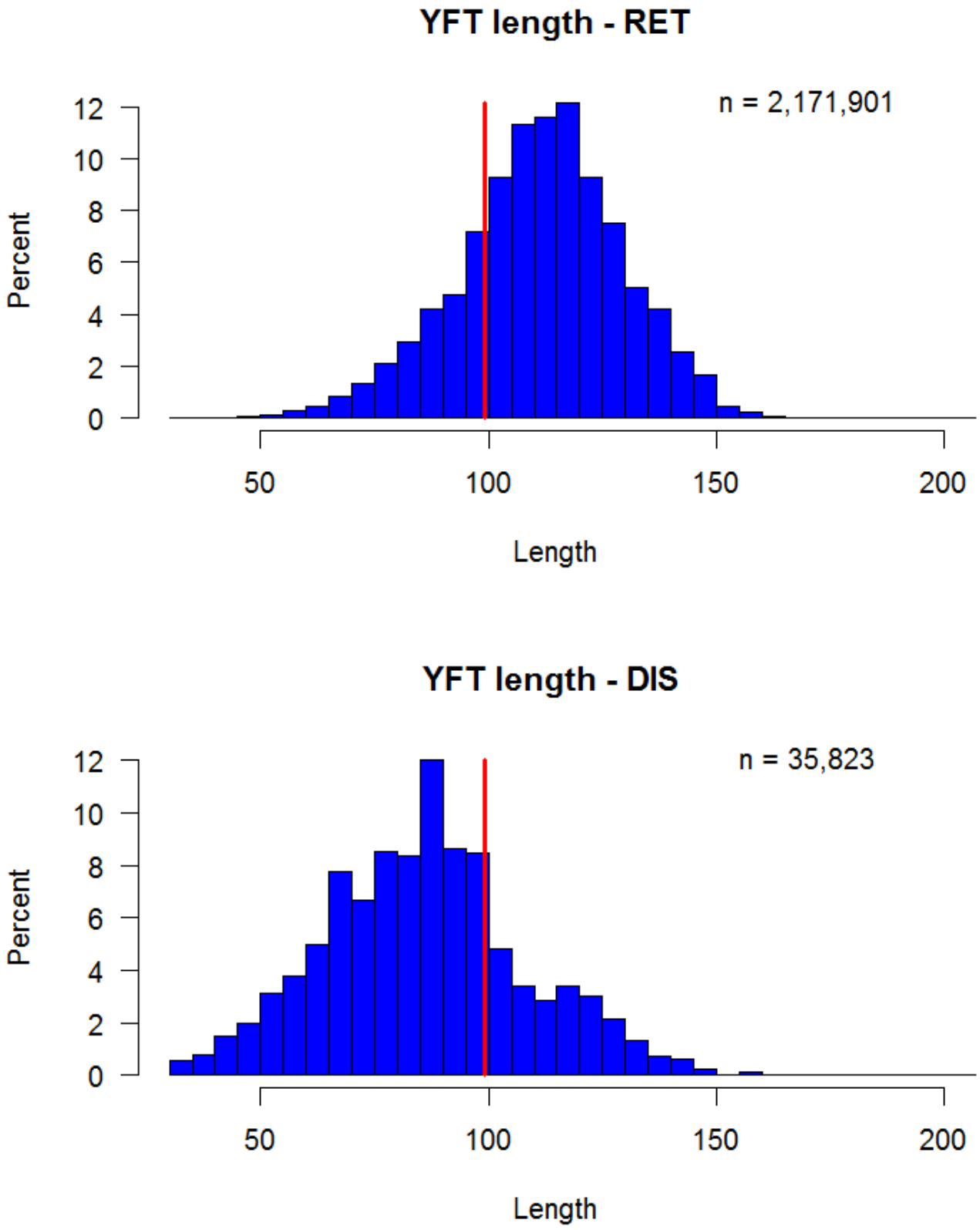

Figure 12: Length samples of yellowfin tuna that were retained or discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. RET = Retained; DIS = Discarded.

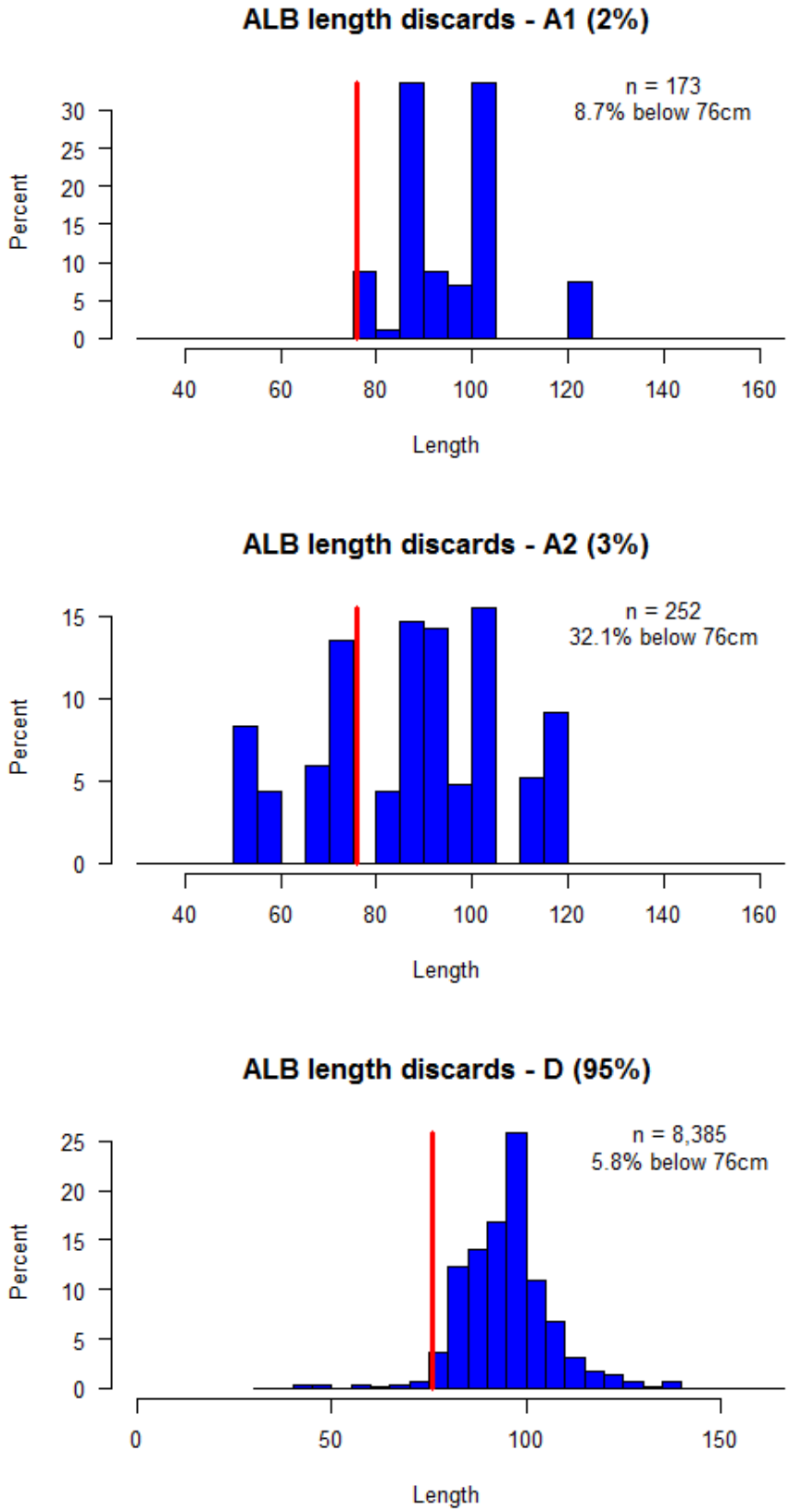

Figure 13: Length sample and condition of albacore tuna that were discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

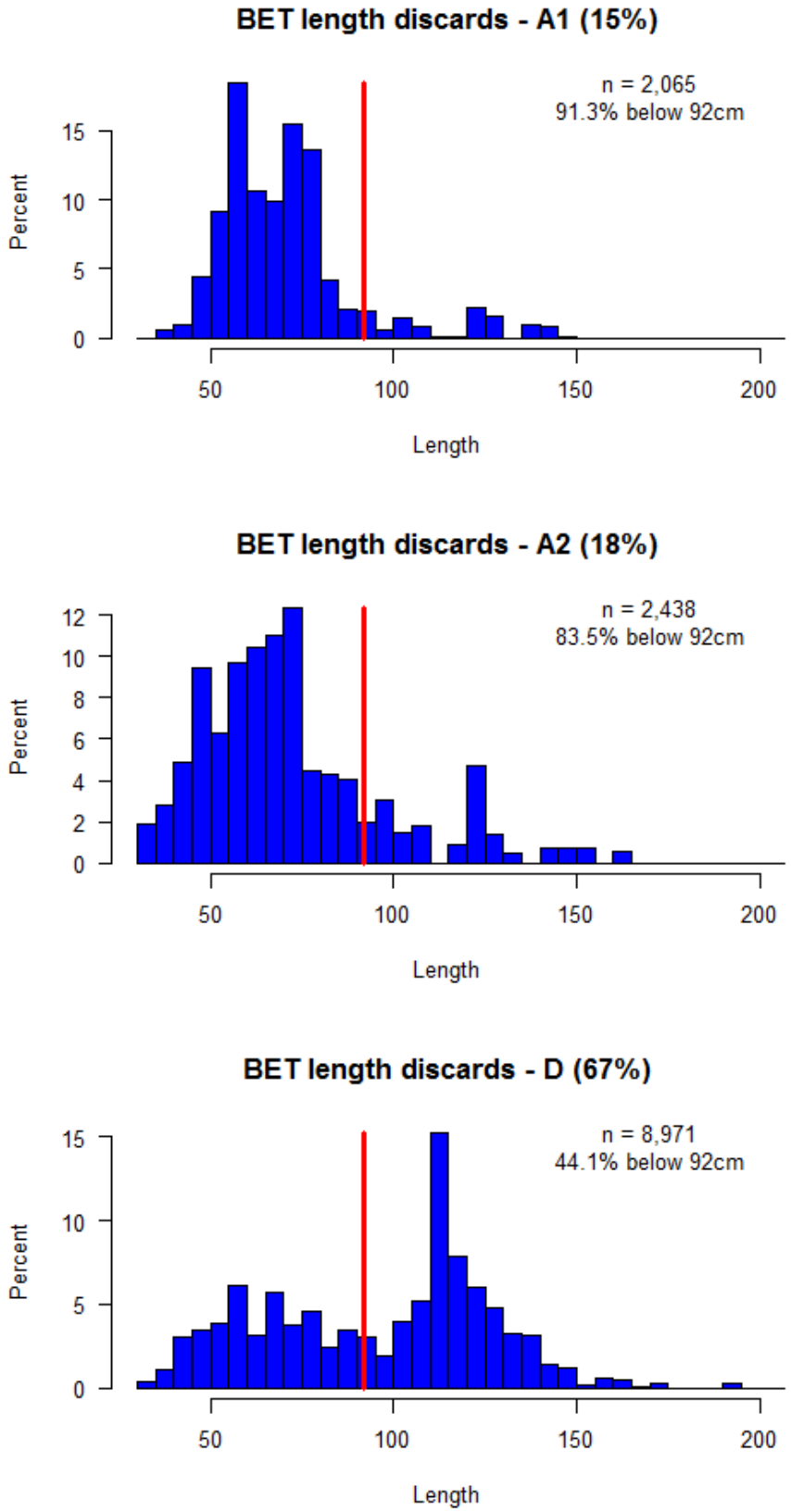

Figure 14: Length sample and condition of bigeye tuna that were discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

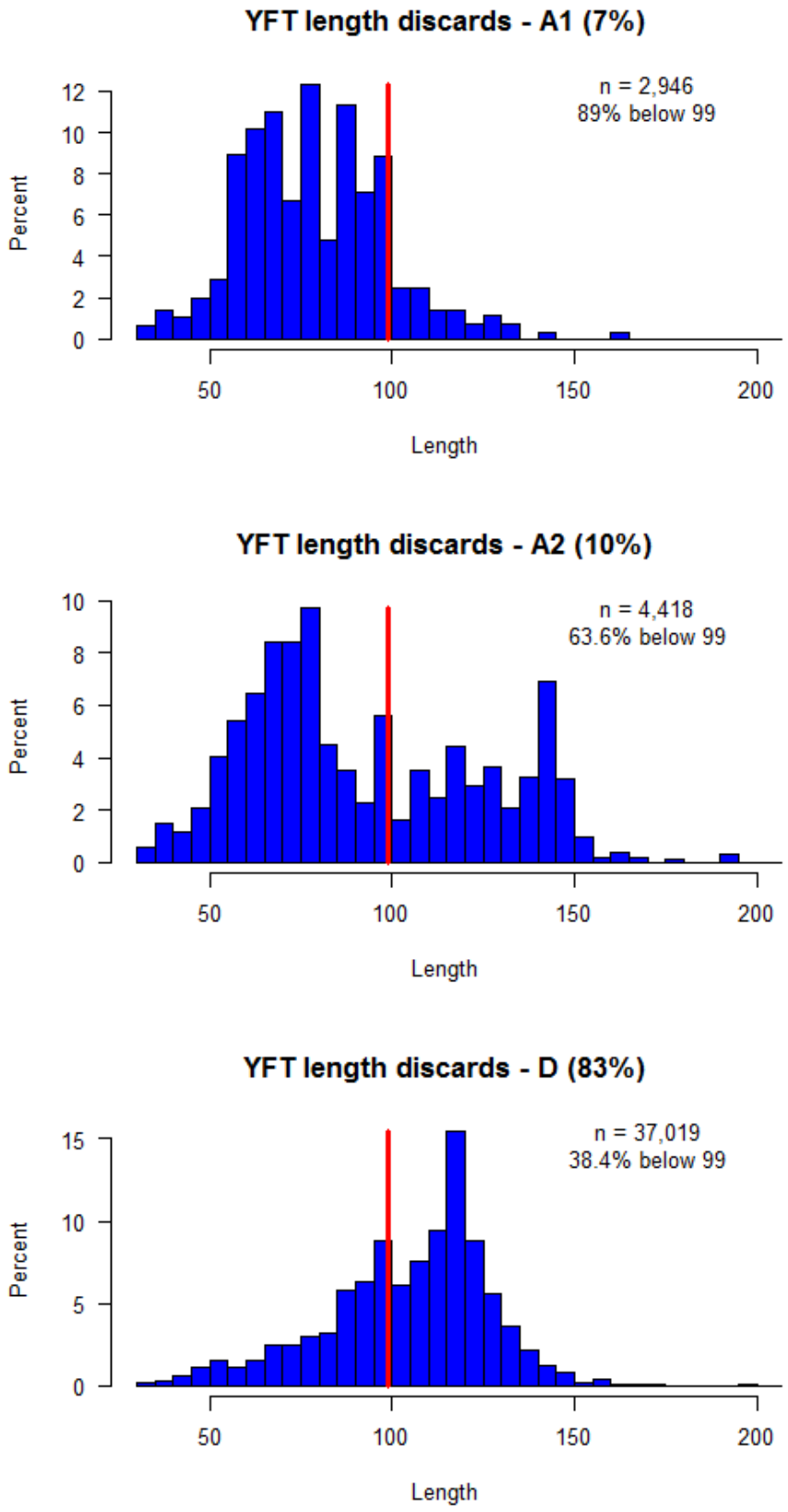

Figure 15: Length sample and condition of yellowfin tuna that were discarded from observed vessels fishing in PNA Member waters from 1995 - 2016, The red line represents the size limit at 90% of the size-at-50% maturity. A1 = Alive and healthy; A2 = Alive but injured or dying; D = Dead.

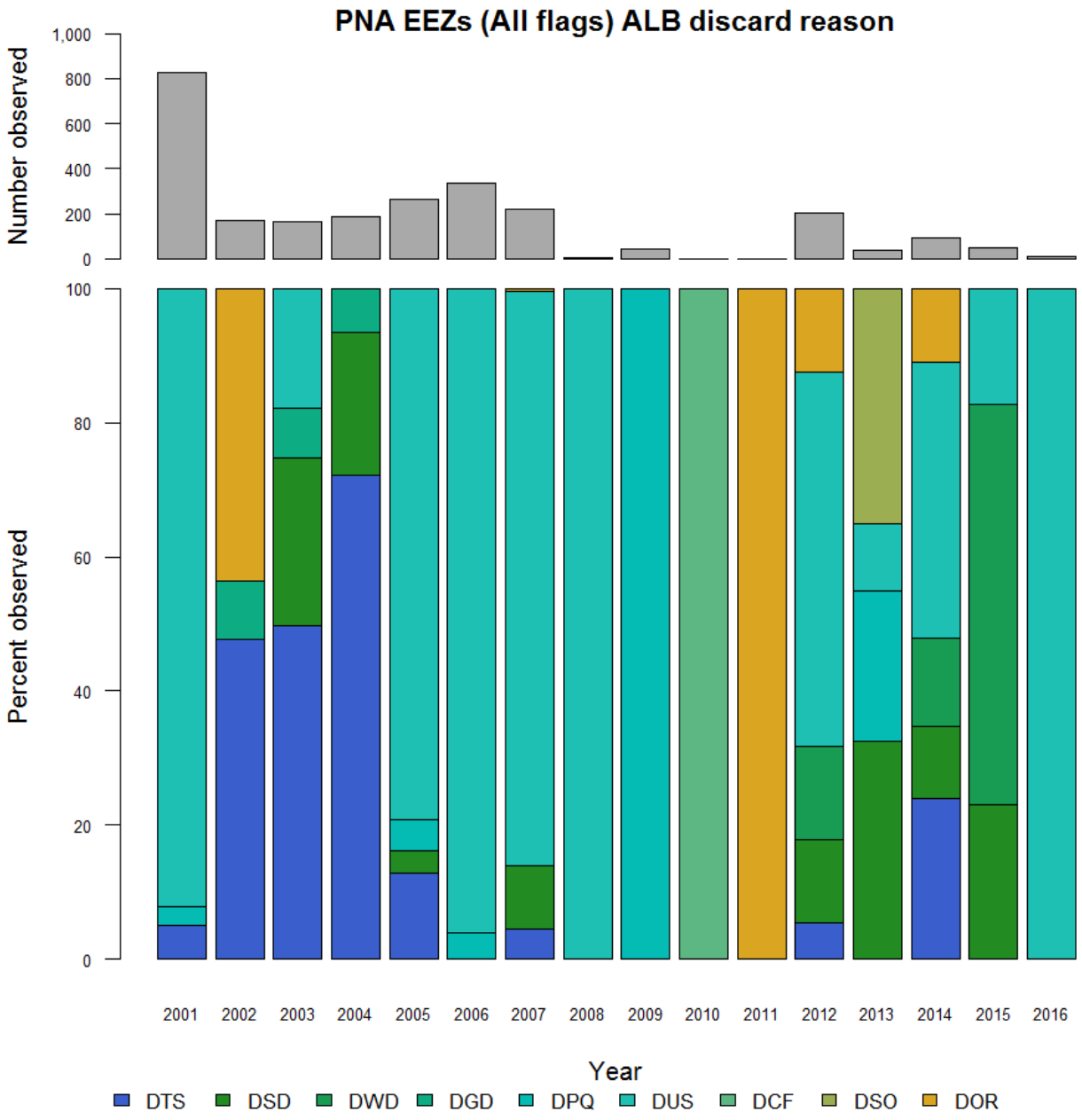

Figure 16: The reasons given for discarding albacore tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. DTS = Discarded too small; DSD = Discarded shark damage; DWD = Discarded whale damage; DGD = Discarded gear damage; DPQ = Discarded poor quality; DUS = Discarded uneconomic species; DCF = Cut free; DSO = Struck off; DOR = Other.

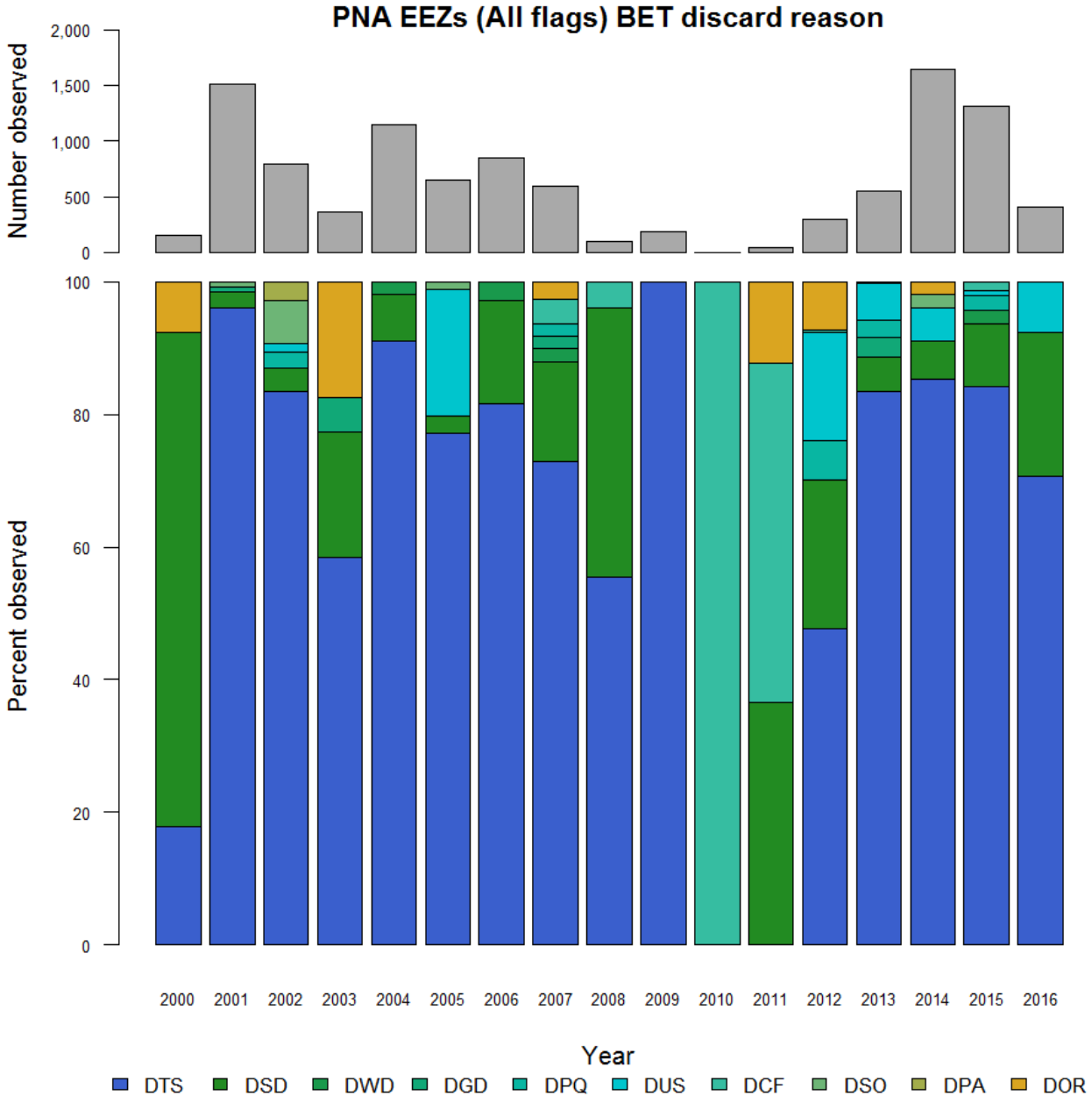

Figure 17: The reasons given for discarding bigeye tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. DTS = Discarded too small; DSD = Discarded shark damage; DWD = Discarded whale damage; DGD = Discarded gear damage; DPQ = Discarded poor quality; DUS = Discarded uneconomic species; DCF = Cut free; DSO = Struck off; DPA = released alive; DOR = Other.

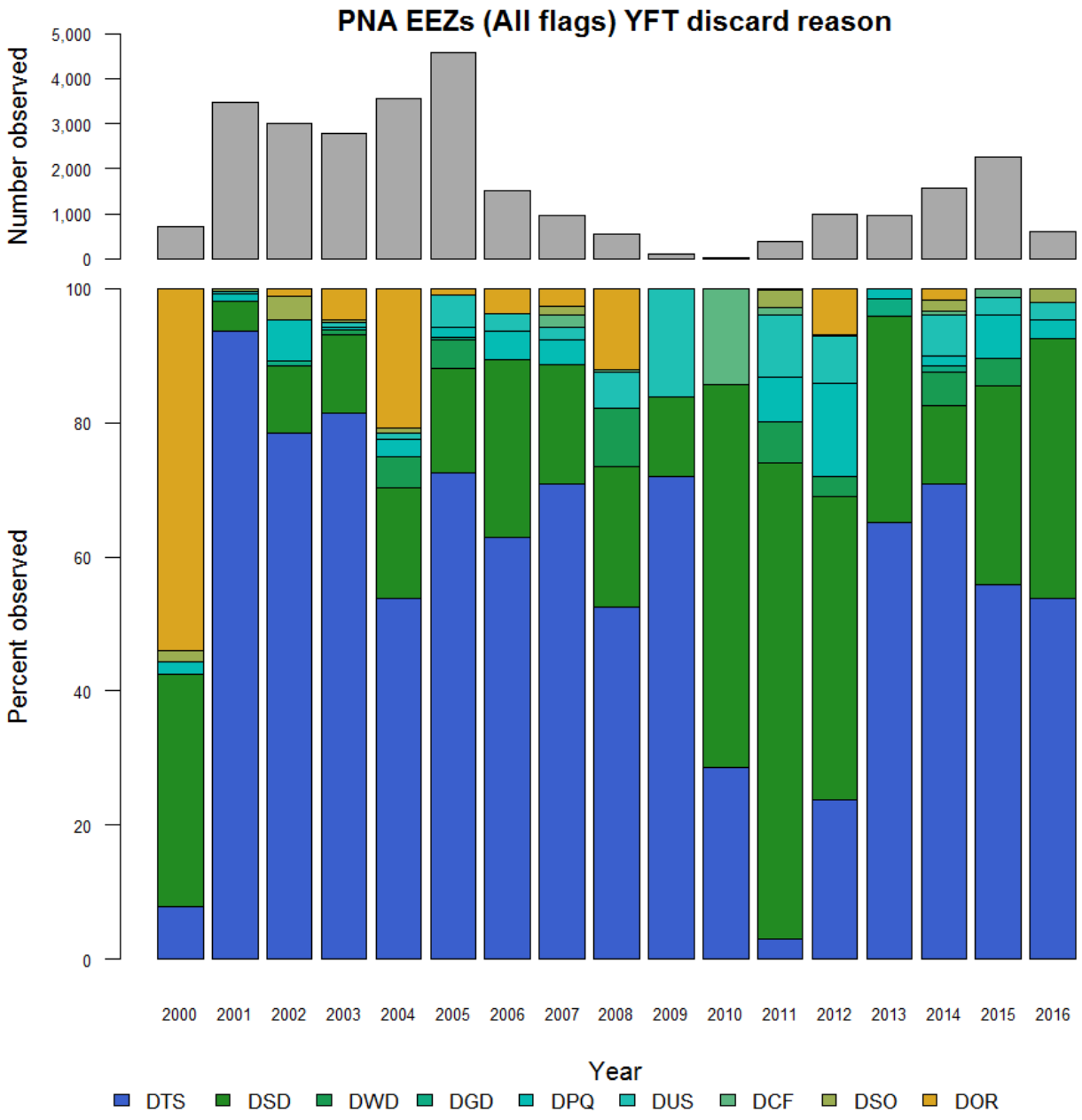

Figure 18: The reasons given for discarding yellowfin tuna from observed vessels fishing in PNA Member waters from 2001 - 2016. DTS = Discarded too small; DSD = Discarded shark damage; DWD = Discarded whale damage; DGD = Discarded gear damage; DPQ = Discarded poor quality; DUS = Discarded uneconomic species; DCF = Cut free; DSO = Struck off; DOR = Other.

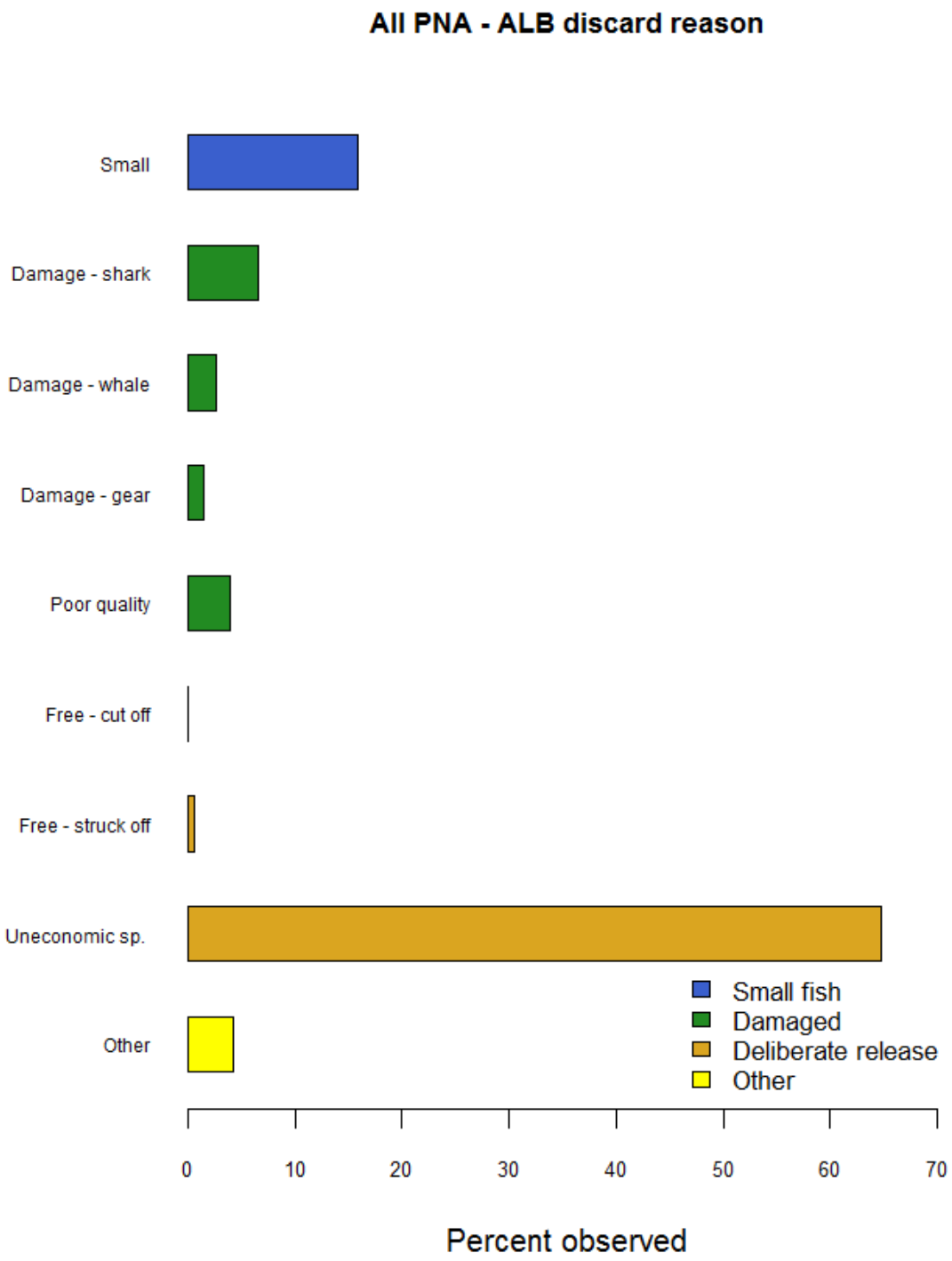

Figure 19: The reasons given for discarding albacore tuna from observed vessels fishing in PNA Member waters, data pooled from 2001 - 2016.

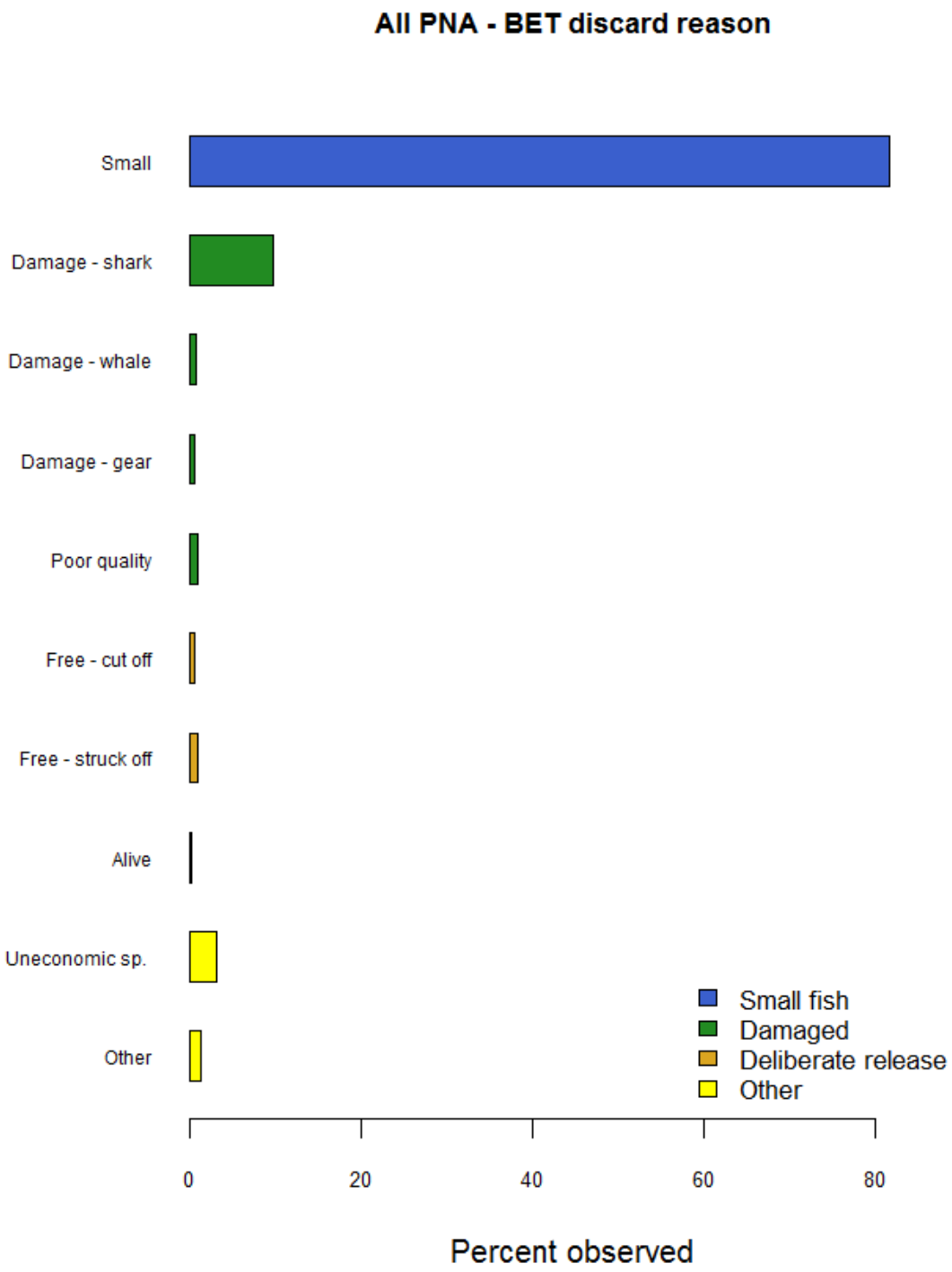

Figure 20: The reasons given for discarding bigeye tuna from observed vessels fishing in PNA Member waters data, pooled from 2001 - 2016.

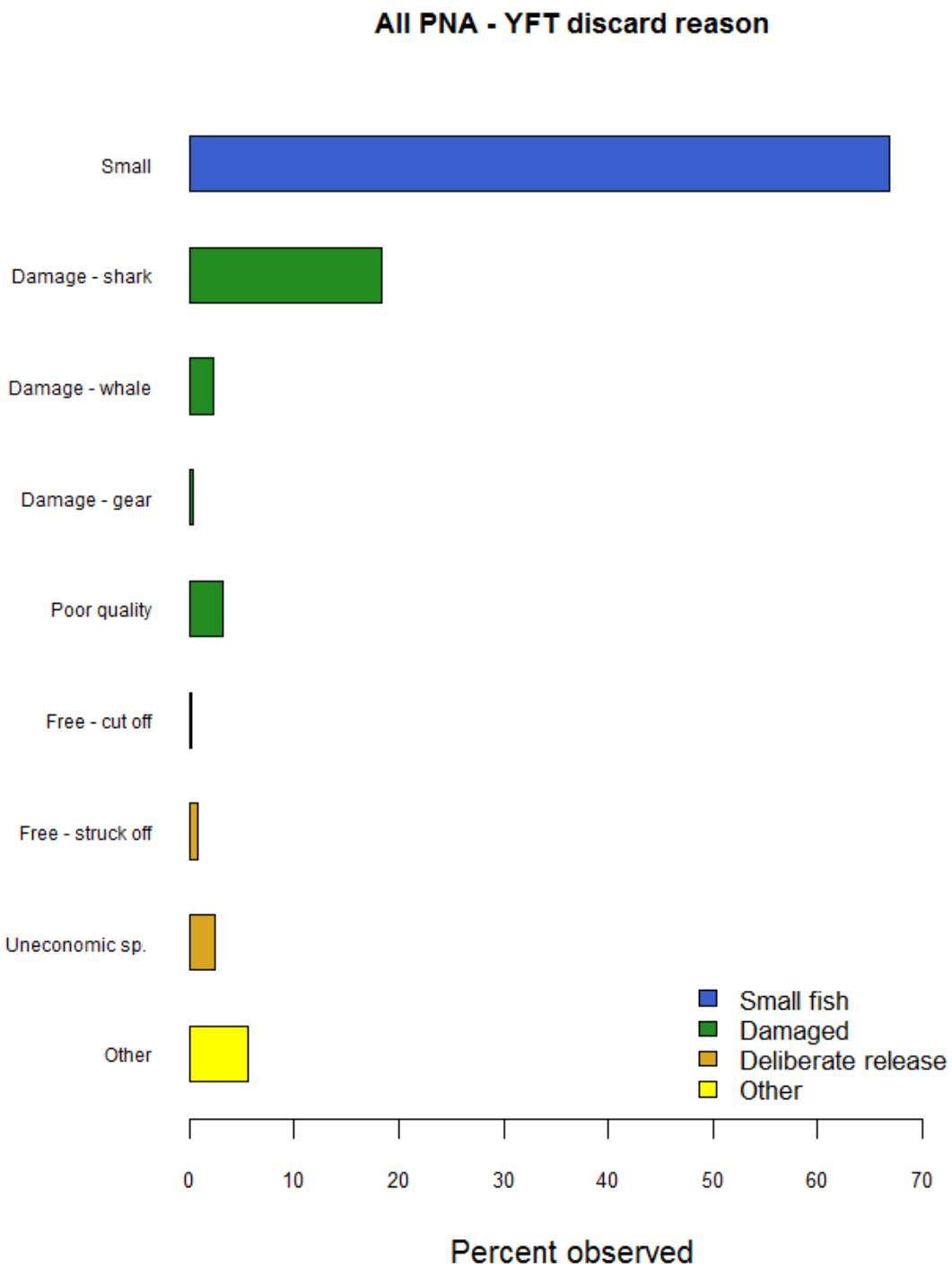

Figure 21: The reasons given for discarding yellowfin tuna from observed vessels fishing in PNA Member waters data, pooled from 2001 - 2016.

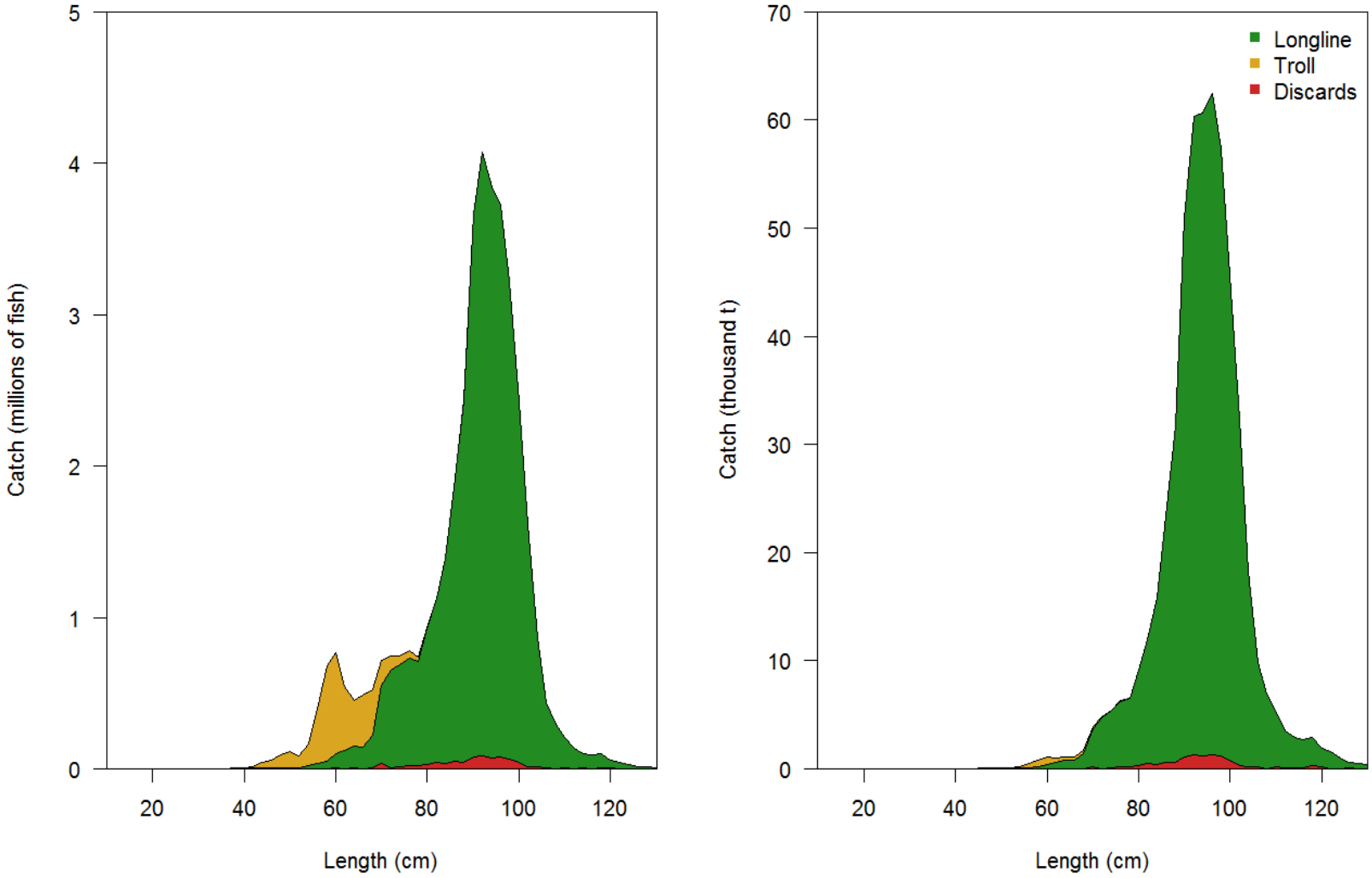

Figure 22: The length distribution of all South Pacific albacore tuna by fishing gear for the WCPFC fleets showing the level of discards from the longline fleet as estimated from the observer discard proportions by 2cm length class.

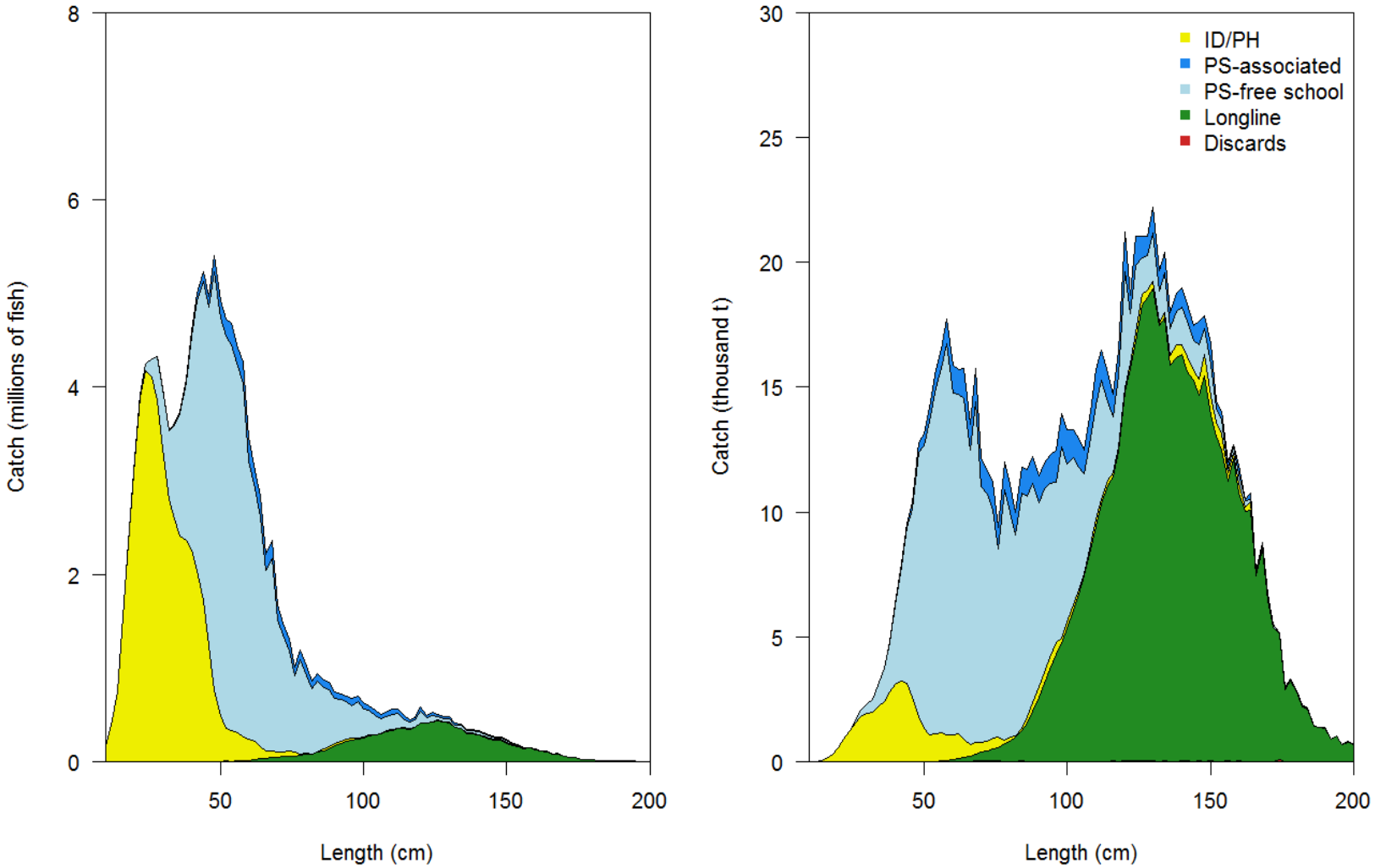

Figure 23: The length distribution of bigeye tuna by fishing gear for the WCPFC fleets showing the level of discards from the longline fleet as estimated from the observer discard proportions by 2cm length class.

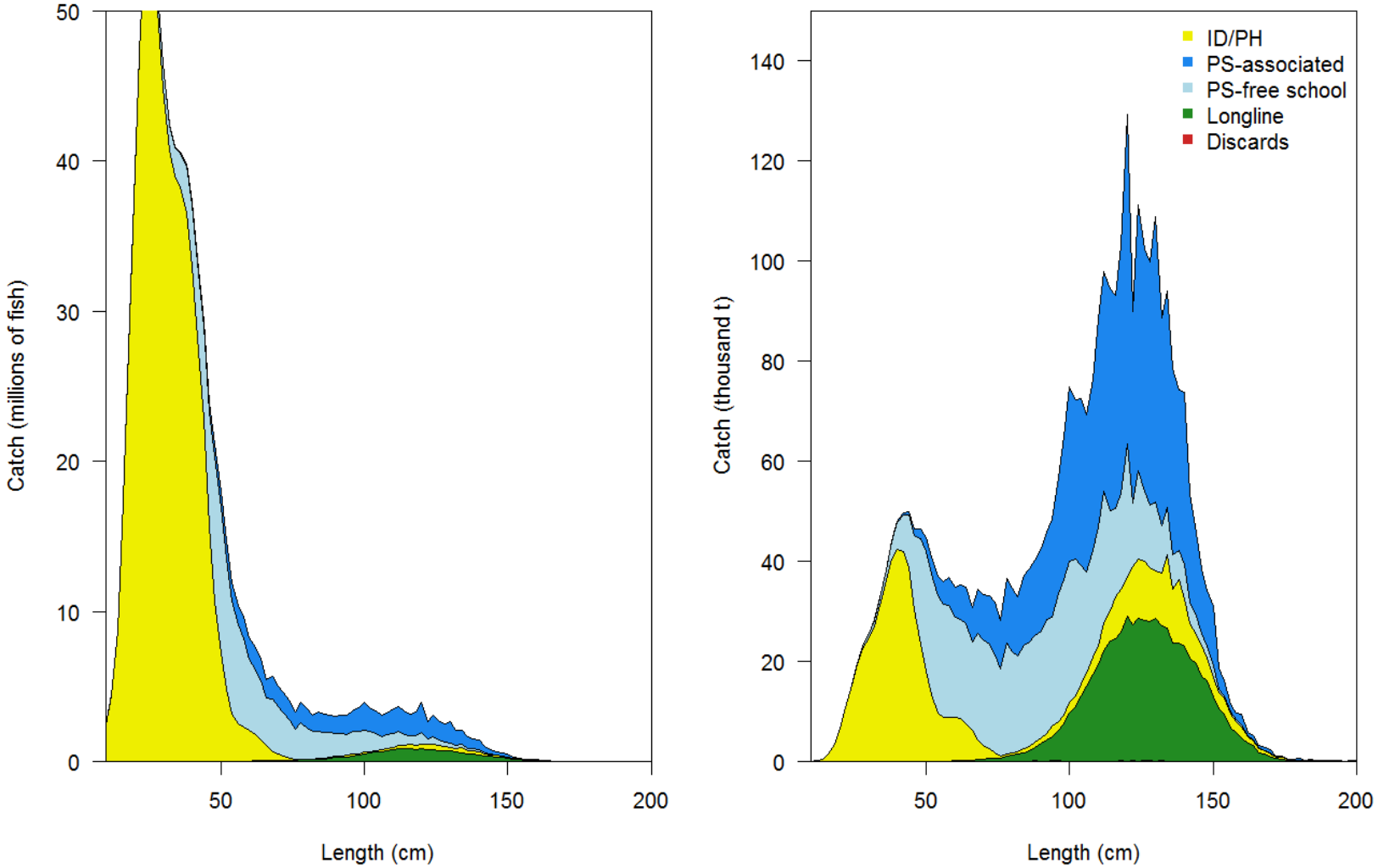

Figure 24: The length distribution of yellowfin tuna by fishing gear for the WCPFC fleets showing the level of discards from the longline fleet as estimated from the observer discard proportions by 2cm length class.