



BAIT SELECTION AND TARGET NON-TARGET CATCH TRADE-OFFS IN THE SRI LANKAN YELLOWFIN TUNA LONGLINE FISHERY

S.S. GUNASEKARA, R.P.P.K. JAYASINGHE

Purpose, expectation and action intended (select one or more and include corresponding text)

Discussions (for information and open discussion):

The paper is to inform meeting members of the effects of bait type on yellowfin tuna catch rates and associated billfish and shark bycatch in the Sri Lankan longline fishery, based on standardized analysis of commercial logbook data, and to facilitate discussion on the implications for multispecies selectivity and sustainable longline fisheries management, as set out in Sections Results and Discussion and Conclusion.

Feedback (to collect input and suggestions)

The paper is to request review and comments on the observed target–bycatch trade-offs among bait types, particularly the potential benefits of flying fish and bigeye scad in reducing shark bycatch while maintaining yellowfin tuna catch rates, and on the implications for future research and fisheries management, as set out in Sections Results and Discussion and Conclusion.

Conclusion (to record a concluded position or summary)

Recommendation (to ask the meeting to endorse a recommendation)

The paper is to seek endorsement on the recommendation that bait type be recorded at set level in CPC logbooks and observer programmes, so that the effect of bait on billfish and other bycatch can be evaluated across Indian Ocean longline fleets.

Decisions (to request formal approval of actions)

The paper is not seeking formal approval or adoption of a management measure; it is submitted for information, discussion and feedback on the findings and their implications for sustainable management of the Sri Lankan longline fishery.

Abstract

The choice of bait is an important factor in pelagic longline fishing because it can influence both target catch rates and the composition of bycatch. However, the effects of different bait types on yellowfin tuna (*Thunnus albacares*) catch and associated bycatch in the Sri Lankan longline fishery have received limited attention. This study examines the relationship between bait type, yellowfin tuna catch rates, and the catch of major bycatch groups, particularly billfishes and sharks, using commercial logbook data from the Sri Lankan longline fleet collected during 2016–2019. Following rigorous spatial filtering and quality control screening across 119,623 commercial operations, catch rates were standardized using spatial Generalized Additive Models (GAMs) incorporating vessel random effects, location, season, and year with the number of hooks as an effort offset. Model-adjusted catch rates indicated statistically significant differences in yellowfin tuna catch rates among bait categories. Locally farmed milkfish (*Chanos chanos*) and flying fish (Exocoetidae) achieved the highest standardized yellowfin tuna catch rates (0.668 and 0.659 fish per 100 hooks, respectively), significantly outperforming the reference squid category (0.633 fish per 100 hooks; Dunnett-adjusted $p = 0.0012$). Model contrasts indicated modest overall increases in yellowfin tuna catch rates for milkfish (rate ratio = 1.055) and flying fish (rate ratio = 1.040) compared with squid. Seasonal interaction models revealed that this efficiency varies dynamically, with milkfish peaking during the Inter-monsoon (+19.0%) and Southwest monsoon (+12.4%), but

underperforming squid during the Northeast monsoon (-7.4%). However, target catch advantages were accompanied by critical bycatch trade-offs. Milkfish significantly elevated shark catch rates by +53.4% relative to squid ($p = 0.0001$), while sardinella nearly tripled shark bycatch (rate ratio = 2.908, $p < 0.0001$). *Linna* (*Decapterus spp.*) yielded no target yellowfin advantage over squid but generated the highest billfish bycatch across the fleet (+38.0% count increase, $p < 0.0001$). Conversely, flying fish (-28.5%) and bigeye scad (-58.7%) significantly reduced shark bycatch relative to squid. These findings demonstrate that bait choice substantially influences both catching efficiency and multispecies selectivity in the Sri Lankan longline fishery, highlighting flying fish and bigeye scad as balanced bait options to optimize yellowfin tuna target catches while curbing non-target bycatch.

Keywords: Yellowfin tuna; Longline fishery; Bait type; Catch rate; Bycatch

Introduction

Tunas, bonitos, and billfishes account for 9% of global export value in internationally traded aquatic products, making them one of the most valuable fishery species groups in a global trade market that reached a record high of \$192 billion (FAO 2024). Operating across both the Exclusive Economic Zone (EEZ) and high seas, Sri Lanka's commercial longline fleet targets tropical tunas using diverse operational practices and gear configurations (Hewapathirana and Gunawardane 2016). Yellowfin tuna (*Thunnus albacares*) is the main target species of longliners, serving as a main contributor to Sri Lanka's national economy through export earnings and domestic food security. Sri Lanka's pelagic longline fleet is predominantly composed of small-to-medium vessels, with approximately 94% measuring under 15 meters in length (Hewapathirana et al. 2025). These smaller vessels frequently operate with limited deck space and rely on manual gear handling, which constrains overall hook capacity and trip endurance. Conversely, larger offshore and high-seas longliners employ mechanized winches capable of deploying and hauling large longlines ranging from 1,000 to 2,500 hooks per set, significantly increasing their fishing power and operational range.

Bait plays a crucial role in both recreational and commercial fishing, as its effectiveness significantly influences the overall success of a fishing operation. Because longline fishing is highly dependent on the feeding behaviour of the target species, bait choice serves as a key determinant of catch rates (Bach et al. 2008; Løkkeborg et al. 2014). Various bait types are utilized across commercial fisheries, making the relationships between bait characteristics and target species complex (Lennox et al. 2017; Lowry et al. 2006). Beyond target catch efficiency, managing bait type offers a valuable tool to control species selectivity (Gilman et al. 2020). The unintentional capture of non-targeted species, known as "bycatch," has become a major challenge in global fisheries management and conservation (Fernandez-Carvalho et al. 2015; Gilman et al. 2020, 2006). A qualitative literature review done by Gilman et al. (2020) suggests that tunas and istiophorid billfishes may have higher catch rates on squid than on fish bait, creating a management conflict with efforts to reduce marine turtle and blue shark catch rates. In local feeding studies, Dissanayake et al. (2008) suggested using pelagic swimming crabs, Sphyrnids alongside clupeids and carangids as bait based on gut content analyses of yellowfin tuna.

The use of live milkfish as tuna bait has been documented in numerous studies (FitzGerald 2004). In Sri Lanka, the use of artificial baits in the fishery has been abandoned since 2018, coinciding with the start of local, low-cost milkfish bait production. Squids were historically the prominent bait used, but their share has reduced from 48% in 2017 to 35% in 2019 due to the increased adoption of milkfish, which grew from 2% in 2017 to 19% in 2019 (Gunasekara & Haputhantri, 2021).

Despite these rapid shifts in bait usage across the Sri Lankan fleet, empirical evaluations of how different bait types perform under commercial longline conditions remain limited. Specifically, there is a critical need to evaluate whether alternative natural baits such as locally farmed milkfish can maintain or enhance target yellowfin tuna catch rates while simultaneously minimizing the capture of vulnerable bycatch species across varying monsoonal seasons. To address this gap, this study evaluates the relative catch performance and species selectivity of distinct bait categories using

standardized commercial longline logbook data (2016–2019) spanning 119,623 fishing operations across 3,073 vessels. Using Generalized Additive Models (GAMs) incorporating spatial, temporal, and vessel-level controls, we quantify bait-specific catch rates for target yellowfin tuna (*Thunnus albacares*) as well as major bycatch groups (billfishes and sharks) to assess seasonal efficiency trade-offs and inform sustainable longline management strategies.

Methods

Fishery data

Longline fishing operations from the Sri Lankan fishery from 2016 to 2019 obtained from the Department of Fisheries and Aquatic Resources were used in the analysis. Fishing operations were filtered and duplicated records were removed. Vessel, species and bait fields were standardised (trimmed, case-harmonised). Records were restricted to the legal fishing area, defined as the Sri Lankan Exclusive Economic Zone plus the permitted international waters, with the land area of Sri Lanka excluded. Of 264,034 records, 7,904 (2.99%) fell outside this area and were removed before aggregation.

Bait and species classification

Free-text bait entries (including local names and spelling variants) were mapped to eight categories: squid (including cuttlefish), flying fish (Family: Exocoetidae), Indian mackerel (*Rastrelliger kanagurta*), milkfish (*Chanos chanos*), Indian scad (*Decapterus spp.*), bigeye scad (*Selar crumenophthalmus*), sardinella (*Sardinella spp.*) and artificial bait. Generic "fish", mixed-bait, numeric and missing entries were set to missing and excluded, as were categories with fewer than 3,000 records. The target species was yellowfin tuna (*Thunnus albacares*). Bycatch was analysed in two groups: billfish (swordfish, sailfish, and black, blue and striped marlin) and sharks (blue, silky, mako, hammerhead, kundan and spinner sharks). Records labelled "other sharks" were excluded from the shark group (60 records, 3,232 individuals) as confirmed data-entry errors. Other tunas and other species landed by the fishery were excluded. Fishing operations were identified from catch records of all species, so operations that caught only non-analysed species were retained with zero counts for the species of interest.

Fishing operations and quality control

A fishing operation was defined as a unique combination of vessel, record number, date and position. Operations with more than one bait category or more than one hook number were excluded. Operations with fewer than 100 hooks ($n = 1,558$) and operations with yellowfin catch rates above 30 fish per 100 hooks ($n = 31$) were removed. The final dataset contained 119,623 operations by 3,073 vessels, with 77.3 million hooks. Season was assigned from the fishing month: northeast monsoon (December–March), southwest monsoon (April–September) and inter-monsoon (October–November).

Statistical analysis

For the bycatch analyses, 61 operations whose date was inconsistent with the recorded year or month (mixed day/month formats) were also removed, leaving 119,562 operations. Bycatch catch rates were capped at 30 fish per 100 hooks, the same rule used for yellowfin tuna; this removed 14 billfish operations and 1 shark operation. Two sensitivity analyses used a stricter cap (10 per 100 hooks) and no cap.

Catch counts per operation were modelled with negative binomial generalised additive models (GAMs; mgcv::bam, fast REML, discretised covariates) using a log link and log(hooks) as an offset, so coefficients describe catch per hook:

$$\log(E[\text{catch}_i]) = \log(\text{hooks}_i) + \text{bait} + \text{season} + \text{year} + f_{\text{season}}(\text{longitude}_i, \text{latitude}_i) + u_{\text{vessel}[i]}$$

Bait, season and year were fixed factors (squid as the reference bait). A separate thin-plate spatial smooth ($k = 50$) was fitted for each season, and vessel identity was a random intercept. Because bait choice varies by vessel, bait effects are estimated mainly from vessels that used more than one bait (93% of operations).

We fitted additive models (as above) and bait $\times$ season interaction models to test whether bait effects varied among seasons.

For bycatch we also fitted presence/absence models (binomial family, complementary log-log link, $\log(\text{hooks})$ offset). Under a Poisson process the exponentiated coefficients are ratios of capture rates, so they are comparable with the count models. This checks that conclusions do not depend on how zeros (97% of shark and 48% of billfish operations) are modelled.

Adjusted catch rates and bait contrasts were estimated with *emmeans*, averaged over years with equal weights and with vessel effects set to zero, so that rates refer to a typical vessel. Each bait was compared with squid using ratios of catch rates, with Dunnett adjustment for the seven comparisons (within season for the seasonal models). We report ratios with 95% confidence intervals and emphasise effect sizes over individual p-values.

We checked model fit with simulation-based residuals (DHARMA; uniformity, dispersion and zero-inflation tests), the adequacy of the spatial basis dimension (*gam.check*), and spatial autocorrelation in residuals (Moran's I on location-level residuals). With more than 119,000 operations, small departures are statistically significant, so we judged them by effect size and by residual plots. Analyses used R version 4.4.3 (R Core Team 2025) with *mgcv*, *DHARMA*, *emmeans*, *data.table*, *sf* and *stringr* packages.

Results

After spatial and quality control filtering ($\text{hooks} \geq 100$, $\text{CPUE} \leq 30$ fish / 100 hooks), the final dataset comprised 119,623 operations across 3,073 vessels (2016–2019), deploying 77.27 million hooks. Squid was the predominant bait (43.1%), followed by flying fish (18.6%), Indian mackerel (15.6%), milkfish (7.9%), linna (4.9%), artificial (4.9%), bigeye scad (4.2%), and sardinella (0.9%). Overlap was high, with 93.4% of operations performed by multi-bait vessels.

Zero-catch rates varied markedly across species groups: 12.5% for target yellowfin tuna (*Thunnus albacares*; 540,767 fish), 48.0% for billfishes (238,599 fish; dominated by swordfish 65.4%), and 97.4% for sharks (10,851 fish; dominated by silky 47.5% and blue sharks 46.8%).

Yellowfin Tuna Catch Rates

The primary spatial GAM (*m_yft_sp_qc3_k50*) explained 31.1% of total deviance ($n = 119,623$, $\theta = 1.70$). Model-adjusted catch rates ranged from 0.555 (sardinella) to 0.668 (milkfish) fish per 100 hooks, relative to 0.633 for squid (Table 1).

Dunnett-adjusted contrasts revealed that milkfish (+5.5%, $p = 0.0012$) and flying fish (+4.0%, $p = 0.0012$) yielded significantly higher catch rates than squid. Conversely, artificial bait (−6.7%, $p = 0.0004$), Indian mackerel (−6.5%, $p < 0.0001$), and sardinella (−12.3%, $p = 0.0011$) performed significantly worse. Bigeye scad (−3.4%) and linna (−4.1%) showed non-significant reductions.

Table 1: Adjusted Yellowfin Tuna catch rates and contrasts vs. Squid control.

Bait Category	Adjusted CPUE (SE)	Rate Ratio vs. Squid	95% CI	Dunnett p
Squid (Reference)	0.633 (0.011)	1.000	[Baseline]	—
Milkfish	0.668 (0.014)	1.055	[1.016, 1.096]	0.0012 **

[IOTC-2026-WPTT28-xx]

Flying Fish	0.659 (0.012)	1.040	[1.012, 1.069]	0.0012 **
Bigeye scad	0.612 (0.014)	0.966	[0.923, 1.012]	0.2386
Linna	0.607 (0.013)	0.959	[0.919, 1.001]	0.0567 .
Indian Mackerel	0.592 (0.011)	0.935	[0.909, 0.961]	<0.0001 ***
Artificial	0.591 (0.014)	0.933	[0.892, 0.976]	0.0004 ***
Sardinella	0.555 (0.021)	0.877	[0.800, 0.961]	0.0011 **

Seasonal Dynamics

Including a bait * season interaction significantly improved model fit ($\Delta AIC = -221.4$, $p < 0.0001$). Milkfish performance varied strongly by season: it peaked during Inter-monsoon (+19.0%, $p < 0.0001$) and SW monsoon (+12.4%, $p < 0.0001$), but underperformed squid during NE monsoon (−7.4%, $p = 0.0020$). Flying fish maintained consistent superiority or parity across all seasons (+10.1% Inter-monsoon, +7.3% NE monsoon, +0.2% SW monsoon).

Table 2: Comparison of bait effect ratios (vs. Squid) across target and bycatch groups.

Bait Category	Yellowfin Tuna Ratio (p)	Billfish Ratio (p)	Shark Ratio (p)
Squid (Reference)	1.000 [Baseline]	1.000 [Baseline]	1.000 [Baseline]
Milkfish	1.055 (0.0012 **)	0.968 (0.3975)	1.534 (0.0001 ***)
Flying Fish	1.040 (0.0012 **)	0.998 (0.9999)	0.715 (0.0066 **)
Bigeye scad	0.966 (0.2386)	0.917 (0.0173 *)	0.413 (<0.0001 ***)
Linna	0.959 (0.0567 .)	1.380 (<0.0001 ***)	0.981 (0.9998)
Indian Mackerel	0.935 (<0.0001 ***)	1.022 (0.7110)	1.314 (0.0999 .)
Artificial	0.933 (0.0004 ***)	0.921 (0.0200 *)	1.201 (0.6756)
Sardinella	0.877 (0.0011 **)	1.087 (0.3163)	2.908 (<0.0001 ***)

Note: p-values are Dunnett-adjusted.

Billfish Bycatch

The billfish Negative Binomial GAM explained 29.2% of deviance ($n = 119,548$, $\theta = 0.809$). Linna generated the highest billfish bycatch, increasing catch per hook by +38.0% over squid (Ratio = 1.380, $p < 0.0001$; Table 2). Bigeye scad (−8.3%, $p = 0.0173$) and artificial bait (−7.9%, $p = 0.0200$) significantly reduced billfish bycatch. Milkfish (−3.2%) and flying fish (−0.2%) showed no significant difference from squid.

Shark Bycatch

The shark GAM explained 72.1% of deviance ($n = 119,561$, $\theta = 0.193$). Sardinella nearly tripled shark catch rates (Ratio = 2.908, $p < 0.0001$), and milkfish significantly increased shark bycatch by +53.4% (Ratio = 1.534, $p = 0.0001$). In contrast, bigeye scad (−58.7%, $p < 0.0001$) and flying fish (−28.5%, $p = 0.0066$) significantly reduced shark bycatch relative to squid.

Sensitivity and Diagnostics

Model diagnostics confirmed appropriate dispersion handling for all models (DHARMA dispersion $p > 0.05$). Residual spatial autocorrelation was negligible (Moran's $I \leq 0.008$). Sensitivity checks varying the upper CPUE filter threshold (primary cap = 30, strict cap = 10, no cap) showed negligible changes in bait ratios (< 0.01 shift on the log scale) and no change in statistical conclusions. Binomial cloglog presence/absence models confirmed identical directionality and significance ranks to the Negative Binomial count models, verifying robustness to zero-inflation modeling.

Discussion and Conclusion

Our earlier analyses of the same 2016–2019 national logbook data (Gunasekara and Haputhantri 2021; Gunasekara et al. 2024; Bandaranayake et al. 2023) compared raw catch rates among baits, or fitted GLMs with bait as the only predictor, after limited data cleaning. The present analysis uses the same logbooks with more extensive quality control (removal of positions outside the legal fishing area, duplicate and implausible records) and models that adjust for vessel, location, season and year. Several earlier conclusions changed.

Earlier Sri Lankan studies recommended Indian scad on the basis of high raw catch rates of yellowfin, bigeye and billfish. In our adjusted models Indian scad gave no yellowfin advantage over squid but was associated with the highest billfish bycatch (+24% to +38%), so the recommendation should consider the bycatch trade-off. Milkfish was introduced to reduce bait import costs ((Gunasekara et al. 2024), reporting about 1,200 million LKR in 2019). We find it is associated with slightly higher yellowfin catch rates, depending on season, but also with about 42% to 53% higher shark catch rates and a higher probability of billfish capture. Artificial bait has been abandoned since 2018, so its estimate rests on 2016–2017 operations.

Our standardized models show that natural pelagic baits specifically locally farmed milkfish (*Chanos chanos*) and flying fish (Family: Exocoetidae) yield modest overall increases in yellowfin tuna (*Thunnus albacares*) catch rates (+5.5% and +4.0%, respectively) compared to imported squid, aligning with global findings on the superiority of natural baits over artificial alternatives (Kumar et al. 2016). However, seasonal interaction models reveal that this efficiency is dynamic. Milkfish performance peaked during the Inter-monsoon (+19.0%) and Southwest monsoon (+12.4%), but reversed during the Northeast monsoon (-7.4%), where squid performed better. This likely reflects seasonal changes in thermocline depth, bait loss, and feeding behaviour, as squid offers higher visual contrast and physical durability during long soak times (Bach et al. 2008; Kumar et al. 2015). Flying fish provided consistent positive or neutral yellowfin catch rate ratios across all monsoonal periods, making it the most stable option year-round.

These results highlight important management trade-offs between target optimization and bycatch conservation (Gilman et al. 2020). Previous Sri Lankan studies recommended Indian scad (*Decapterus* spp.) based on high unadjusted catch rates across tunas and billfishes. In our standardized models, *Decapterus* spp. provided no yellowfin advantage over squid but generated the highest billfish bycatch across the fleet (+38.0%), demonstrating how unstandardized data can create misleading management signals. Meanwhile, the transition to milkfish saved an estimated 1,200 million LKR in foreign exchange in 2019 (Gunasekara et al. 2024), but increased shark bycatch rates by +53.4% relative to squid, with sardinella showing an even higher risk (+190.8%). This aligns with global findings that teleost fish baits elevate shark interactions and at-haulback mortality relative to squid (Gilman et al. 2020; Santos et al. 2024). Conversely, flying fish (-28.5%) and bigeye scad (-58.7%) significantly reduced shark catch rates.

Understanding species specific bait responses is essential for resolving multispecies conflicts in pelagic longlines (Gilman et al. 2020). While milkfish provides economic relief regarding import costs, its deployment elevates shark bycatch risks, particularly for vulnerable silky (*Carcharhinus falciformis*) and blue sharks (*Prionace glauca*). Where shark mitigation is prioritized by regional bodies such as the IOTC, promoting flying fish or bigeye scad presents an ecologically balanced alternative that maintains yellowfin tuna yield while suppressing shark capture risks. Non-luminous artificial baits used prior to 2018 underperformed across all groups (-6.7% for yellowfin), matching global

observations that unilluminated artificial baits are rarely economically viable (Gilman et al. 2020). Developing alternative baits from non-human food resources remains critical for long-term fleet viability (Løkkeborg et al. 2014), and recent innovations pairing artificial lures with illuminated attractants offer a promising pathway to maintain commercial tuna catches while curbing shark interactions (Fajardo-Yamamoto et al. 2026).

References

- Bach, Pascal, C. Gamblin, and V. Lucas. 2008. "The Effect of Bait Type on Hooking Responses of Target and Non-Target Species on Pelagic Longlines: Preliminary Results from Fishing Experiments in the Seychelles." *Western Indian Ocean. Journal of Marine. Science* 7 (2): 151–61.
- Bandaranayake, K. H. K., R. P. P. K. Jayasinghe, and S. S. Gunasekara. 2023. "Effect of Bait Types on Catchability of Billfish in Tuna Longline Fishery in Sri Lanka." *Working Party on Billfish (WPB)*.
- Fajardo-Yamamoto, Arturo, Oscar Sosa-Nishizaki, Scott Aalbers, Junsei Megill, and Chuguey Sepulveda. 2026. "Testing Artificial Baits in the Mexican Shallow-Set Longline Fishery." *Fisheries Research* 303 (November): 107876. <https://doi.org/10.1016/j.fishres.2026.107876>.
- FAO. 2024. *In Brief to The State of World Fisheries and Aquaculture 2024. Blue Transformation in Action*. FAO. <https://doi.org/10.4060/cd0690en>.
- Fernandez-Carvalho, Joana, Rui Coelho, Miguel N. Santos, and Sérgio Amorim. 2015. "Effects of Hook and Bait in a Tropical Northeast Atlantic Pelagic Longline Fishery: Part II—Target, Bycatch and Discard Fishes." *Fisheries Research* 164 (April): 312–21. <https://doi.org/10.1016/j.fishres.2014.11.009>.
- FitzGerald, William J. 2004. "Milkfish Aquaculture in the Pacific: Potential for the Tuna Longline Fishery Bait Market." *Noumea, New Caledonia: Secretariat of the Pacific Community*.
- Gilman, Eric, Milani Chaloupka, Pascal Bach, et al. 2020. "Effect of Pelagic Longline Bait Type on Species Selectivity: A Global Synthesis of Evidence." *Reviews in Fish Biology and Fisheries* 30 (3): 535–51. <https://doi.org/10.1007/s11160-020-09612-0>.
- Gilman, Eric, Erika Zollett, Stephen Beverly, et al. 2006. "Reducing Sea Turtle By-catch in Pelagic Longline Fisheries." *Fish and Fisheries* 7 (1): 2–23. <https://doi.org/10.1111/j.1467-2979.2006.00196.x>.
- Gunasekara, S. S., K. H. K. Bandaranayake, and R. P. P. K. Jayasinghe. 2024. "Influence of Bait Type on Bigeye Tuna Catch Rates in Sri Lanka." Paper presented at IOTC Working Party on Tropical TunaAt: Seychelles. November 4.
- Gunasekara, S. S., and S. S. K. Haputhantri. 2021. "Effect of Bait Type on Catch Efficiency in the Sri Lankan Longline Fishery Operated Targeting Yellowfin Tuna (Thunnus Albacares)." Paper presented at Proceedings of the National Aquatic Resources Research and Development Agency Annual Scientific Sessions–2020. January 22.
- Hewapathirana, H. P. K., N. D. P. Gunawardane, T. M. D. T. Peiris, and R. P. P. K. Jayasinghe. 2025. *SRI LANKA NATIONAL REPORT Submitted to the Scientific Committee of the Indian Ocean Tuna Commission, 2025*. IOTC–2025–SC28–NR25. IOTC-2016-SC19-NR27. Indian Ocean Tuna Commission.
- Hewapathirana, H. P. K., and NDP Gunawardane. 2016. *Sri Lanka National Report to the Scientific Committee of the Indian Ocean Tuna Commission*. IOTC-2016-SC19-NR27. Indian Ocean Tuna Commission, Victoria.



Lennox, Robert J., Josep Alós, Robert Arlinghaus, et al. 2017. "What Makes Fish Vulnerable to Capture by Hooks? A Conceptual Framework and a Review of Key Determinants." *Fish and Fisheries* 18 (5): 986–1010. <https://doi.org/10.1111/faf.12219>.

Løkkeborg, Svein, Sten Ivar Siikavuopio, Odd-Børre Humborstad, Anne Christine Utne-Palm, and Keno Ferter. 2014. "Towards More Efficient Longline Fisheries: Fish Feeding Behaviour, Bait Characteristics and Development of Alternative Baits." *Reviews in Fish Biology and Fisheries* 24 (4): 985–1003. <https://doi.org/10.1007/s11160-014-9360-z>.

Lowry, Michael, Aldo Steffe, and Danielle Williams. 2006. "Relationships between Bait Collection, Bait Type and Catch: A Comparison of the NSW Trailer-Boat and Gamefish-Tournament Fisheries." *Fisheries Research* 78 (2): 266–75. <https://doi.org/10.1016/j.fishres.2005.11.014>.

R Core Team. 2025. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>.

Santos, Catarina C., Daniela Rosa, Jorge M. S. Gonçalves, and Rui Coelho. 2024. "A Review of Reported Effects of Pelagic Longline Fishing Gear Configurations on Target, Bycatch and Vulnerable Species." *Aquatic Conservation: Marine and Freshwater Ecosystems* 34 (1): e4027. <https://doi.org/10.1002/aqc.4027>.