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Understanding and mitigating seabird bycatch during the pelagic longline soak period

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SUMMARY

Pelagic longline vessels fishing in New Zealand must use a tori line, line weighting, and set at night, or employ hook shielding devices, to minimise bycatch during the setting period. However, captures of seabirds also occur during the fishing (soak) period or on hauling of longlines in New Zealand, and mitigation measures for these periods are less well developed.

Data were collected on fishing depth during the soak period on four vessels operating in the pelagic longline fishery. Wet Tags (ZebraTech, Nelson, New Zealand) were deployed by the crew on two vessels to measure mainline depth. The data were automatically downloaded using existing infrastructure on the vessels. This provided useful longer-term data sets at minimal cost and with minimal inconvenience for fishers. The data showed variations in fishing depth between baskets, lines, trips and vessels. This approach has the potential to provide insights into how fishing depth may influence protected species capture rates and risk profiles of different vessels.

More intensive data collection and manipulation of the fishing gear setup were completed on four at-sea trips using Time Depth Recorders (TDRs) to measure hook depth. Modifications to gear setup increased fishing depth and longer float ropes were the most effective and easiest way to increase hook depth. Hook depth throughout the soak was variable within and between baskets, sets, gear setups, and vessels. Hook availability to birds during the soak period was almost exclusively linked to fish catch on nearby branch lines, and was greater in shallower-set gear.

Increasing fishing depth is likely to reduce risk to seabirds and turtles and may be best achieved by employing longer float ropes. Additional recommendations to reduce hook availability to seabirds include; weighted gear, longer minimum branch line length, and increased branch line spacing.

As is typical in pelagic longline fisheries, catch per basket was patchy, somewhat confounding catch rate comparisons between treatments. However, there was some indication that setting deeper reduced catch rates on the deepest hooks. Consequently, when employing longer float ropes basket size may need to be reduced, or small subsurface floats added to the middle of larger baskets to maintain similar catch rates and similar maximum soak depths to current gear setups. Longer-term data sets would be required to fully examine the effect of increasing float rope length on catch rates.

Encouraging and incentivising fishers to employ these measures proactively and/or reactively in response to captures should be explored and considered in the context of minimising seabird bycatch.

RECOMMENDATIONS

That SBWG:

1. *Note* that sections of pelagic longlines were recorded being brought to the surface during fishing (soak) periods in New Zealand, posing bycatch risk by making hooks available to seabirds.
2. *Note* that availability of hooks to birds during the soak period was almost exclusively linked to fish catch on nearby branch lines and was greater in shallower-set gear.
3. *Note* that employing longer float ropes, together with using weighted branch lines, longer minimum branch line length, and increased branch line spacing can reduce the availability of hooks to seabirds during the soak period.
4. *Amend* ACAP Best Practice Advice for Reducing the Impact of Pelagic Longline Fisheries on Seabirds to include additional recommendations to reduce hook availability to seabirds during the soak period.
5. *Encourage* further data collection and research to understand the prevalence of hook availability to seabirds during the soak period of pelagic longlines, and methods to mitigate such risks.

Comprender y mitigar la captura secundaria de aves marinas durante el período de inmersión de los palangres pelágicos

RESUMEN

Las embarcaciones de palangre pelágico que pesquen en Nueva Zelanda deben utilizar una línea tori, lastrado de brazoladas y calado nocturno, o bien emplear dispositivos de protección de anzuelos, con el fin de minimizar las capturas secundarias durante el período de calado. Sin embargo, también se producen capturas de aves marinas durante el período de pesca (inmersión) o durante el virado de los palangres en Nueva Zelanda, y las medidas de mitigación para estos períodos están menos desarrolladas.

Se recopilaron datos sobre la profundidad de pesca durante el tiempo de inmersión en cuatro embarcaciones que operan en la pesquería de palangre pelágico. La tripulación instaló dispositivos Wet Tags (ZebraTech, Nelson, Nueva Zelanda) en dos embarcaciones

para medir la profundidad de la línea principal. Los datos se descargaron automáticamente utilizando la infraestructura existente en las embarcaciones. Esto permitió obtener conjuntos de datos útiles a largo plazo con un costo mínimo y casi sin causar molestias a los pescadores. Los datos revelaron variaciones en la profundidad de pesca entre las cestas, las líneas, las expediciones y las embarcaciones. Este enfoque puede aportar información sobre cómo la profundidad de pesca puede influir en las tasas de captura de especies protegidas y en los perfiles de riesgo de las distintas embarcaciones.

Se llevó a cabo una recopilación de datos más exhaustiva y se realizaron ajustes en la configuración de los artes de pesca durante cuatro salidas al mar, utilizando registradores de tiempo y profundidad para medir la profundidad de los anzuelos. Las modificaciones en la configuración de los artes de pesca permitió pescar a mayor profundidad, y el uso de cuerdas flotantes más largas resultó la forma más eficaz y sencilla de aumentar la profundidad del anzuelo. La profundidad del anzuelo durante la inmersión varió tanto dentro de cestas, conjuntos, configuraciones de artes de pesca y embarcaciones y entre estos. La disponibilidad de anzuelos para las aves durante el período de inmersión estaba relacionada casi exclusivamente con las capturas de peces en brazoladas cercanas, y era mayor en los artes de pesca colocados a menor profundidad.

Es probable que aumentar la profundidad de pesca reduzca el riesgo para las aves marinas y las tortugas, y la mejor forma de lograr esto podría ser utilizando cuerdas flotantes más largas. Otras recomendaciones para reducir la disponibilidad de anzuelos para las aves marinas son el uso de artes de pesca lastrados, una longitud mínima mayor de las brazoladas y una mayor separación entre ellas.

Como es habitual en las pesquerías de palangre pelágico, la captura por cesta fue irregular, lo que dificultó en cierta medida la comparación de las tasas de captura entre los distintos tratamientos. Sin embargo, había indicios de que el calado a más profundidad reducía las tasas de captura en los anzuelos situados a mayor profundidad. Por lo tanto, al utilizar cuerdas flotantes más largas, puede que sea necesario reducir el tamaño de las cestas o añadir pequeños flotadores bajo la superficie en el centro de las cestas más grandes para mantener tasas de captura y profundidades máximas de inmersión similares a los de las configuraciones actuales de los artes de pesca. Se necesitarían series de datos a mayor plazo para analizar en profundidad el efecto del aumento de la longitud de la cuerda flotante en las tasas de captura.

Se debería estudiar y considerar la posibilidad de animar e incentivar a los pescadores a emplear estas medidas de forma proactiva o reactiva en respuesta a las capturas, con el fin de minimizar la captura secundaria de aves marinas.

RECOMENDACIONES

Que el GdTCS:

1. Tome nota de que se ha registrado cómo, durante los períodos de pesca (inmersión) en Nueva Zelanda, algunos tramos de palangres pelágicos subían a la superficie, lo que supone un riesgo de captura secundaria, ya que los anzuelos quedan al alcance de las aves marinas.
2. Tome nota de que la disponibilidad de anzuelos para las aves durante el período de inmersión estaba relacionada casi exclusivamente con las capturas de peces

en las brazoladas cercanas y era mayor en los artes de pesca colocados a menor profundidad.

3. Tome nota de que el uso de cuerdas flotantes más largas, junto con el empleo del lastrado de brazoladas, una longitud mínima mayor de las brazoladas y una mayor separación entre ellas, puede reducir la posibilidad de que las aves marinas queden enganchadas durante el período de inmersión.
4. Enmiende las recomendaciones de mejores prácticas del ACAP para reducir el impacto de las pesquerías de palangre pelágico en las aves marinas para incluir recomendaciones adicionales destinadas a reducir la disponibilidad de anzuelos para las aves marinas durante el período de inmersión.
5. Fomente la recopilación de más datos y la realización de más investigaciones para comprender la prevalencia de la disponibilidad de anzuelos para las aves marinas durante el período de inmersión de los palangres pelágicos, así como los métodos para mitigar dichos riesgos.

Comprendre et réduire les captures accessoires d'oiseaux marins pendant la période d'immersion des palangres pélagiques

RÉSUMÉ

Les palangriers pélagiques opérant en Nouvelle-Zélande doivent utiliser une ligne tori, le lestage des lignes et effectuer la mise à l'eau de nuit, ou recourir à des dispositifs de protection des hameçons, afin de réduire au minimum les captures accessoires pendant la phase de mise à l'eau. Cependant, des captures d'oiseaux marins ont également lieu pendant la période d'immersion (soak) ou lors de la remontée des palangres en Nouvelle-Zélande, et les mesures d'atténuation pour ces phases sont moins développées.

Des données ont été recueillies sur la profondeur de pêche pendant la période d'immersion à bord de quatre navires opérant dans la pêcherie à la palangre pélagique. Des balises Wet Tags (ZebraTech, Nelson, Nouvelle-Zélande) ont été déployées par l'équipage sur deux navires afin de mesurer la profondeur de la ligne mère. Les données ont été téléchargées automatiquement à l'aide de l'infrastructure existante à bord. Cette approche a permis d'obtenir des séries de données utiles à long terme, à faible coût et avec un impact minimal pour les pêcheurs. Les données ont révélé des variations de profondeur de pêche entre les paniers, les lignes, les sorties de pêche et les navires. Cette approche pourrait permettre de mieux comprendre comment la profondeur de pêche influence les taux de capture des espèces protégées et les profils de risque des différents navires.

Une collecte de données plus intensive et des modifications de la configuration des engins de pêche ont été réalisées lors de quatre sorties en mer, à l'aide d'enregistreurs temps-profondeur (TDR) pour mesurer la profondeur des hameçons. Les modifications apportées à la configuration des engins ont permis d'augmenter la profondeur de pêche, et l'utilisation de cordes de flottaison plus longues s'est avérée le moyen le plus efficace et le plus simple d'augmenter la profondeur des hameçons. La profondeur des hameçons pendant la période d'immersion variait au sein des paniers et entre les paniers, les mises à l'eau, les

configurations d'engins et les navires. La disponibilité des hameçons pour les oiseaux pendant la période d'immersion était presque exclusivement liée aux captures de poissons sur les avançons voisins, et elle était plus élevée avec des engins calés à faible profondeur.

L'augmentation de la profondeur de pêche devrait réduire les risques pour les oiseaux marins et les tortues, et pourrait être obtenue au mieux en utilisant des cordes de flottaison plus longues. Parmi les autres recommandations visant à réduire la disponibilité des hameçons pour les oiseaux marins figurent : l'utilisation d'engins lestés, l'augmentation de la longueur minimale des avançons et l'augmentation de l'espacement entre les avançons.

Comme c'est souvent le cas dans les pêcheries à la palangre pélagique, les captures par panier étaient hétérogènes, ce qui a quelque peu compliqué les comparaisons des taux de capture entre traitements. Cependant, certains éléments indiquaient que le calage à plus grande profondeur réduisait les taux de capture sur les hameçons les plus profonds. Par conséquent, lors de l'utilisation de cordes de flottaison plus longues, il peut être nécessaire de réduire la taille des paniers ou d'ajouter de petits flotteurs subsuperficiels au centre des paniers plus grands afin de maintenir des taux de capture et des profondeurs maximales d'immersion similaires à ceux des configurations actuelles. Des séries de données à plus long terme seraient nécessaires pour évaluer pleinement l'effet de l'allongement des cordes de flottaison sur les taux de capture.

Il conviendrait d'examiner et d'envisager des mesures visant à encourager et à inciter les pêcheurs à mettre en œuvre ces pratiques de manière proactive et/ou réactive en réponse aux captures, dans le but de réduire au minimum les captures accessoires d'oiseaux marins.

RECOMMANDATIONS

Que le SBWG :

1. prenne note qu'en Nouvelle-Zélande, des sections de palangres pélagiques ont été observées remontant à la surface pendant la période d'immersion (soak), ce qui pose un risque de captures accessoires en rendant les hameçons accessibles aux oiseaux marins.
2. prenne note que la disponibilité des hameçons pour les oiseaux pendant la période d'immersion était presque exclusivement liée aux captures de poissons sur les avançons voisins et était plus élevée avec des engins calés à faible profondeur.
3. prenne note que l'utilisation de cordes de flottaison plus longues, associée au lestage des avançons, à une augmentation de leur longueur minimale et à un espacement accru, peut réduire la disponibilité des hameçons pour les oiseaux marins pendant la période d'immersion.
4. modifie les conseils de meilleures pratiques de l'ACAP visant à réduire l'impact de la pêche à la palangre pélagique sur les oiseaux marins afin d'y inclure des recommandations supplémentaires pour réduire la disponibilité des hameçons pendant la période d'immersion.
5. encourage la poursuite de la collecte de données et de la recherche afin de mieux comprendre la fréquence de la disponibilité des hameçons pour les oiseaux marins pendant la période d'immersion des palangres pélagiques, ainsi que les méthodes permettant d'atténuer ces risques.

Understanding and mitigating seabird and turtle bycatch during the pelagic longline soak period

MIT2023-02 and MIT 2024-02 Final Report

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Executive Summary

Data were collected on fishing depth during the soak period on four vessels operating in the pelagic longline fishery.

Wet Tags (ZebraTech, Nelson, New Zealand) were deployed by the crew on two vessels to measure mainline depth. The data were automatically downloaded using existing infrastructure on the vessels. This provided useful longer-term data sets at minimal cost and with minimal inconvenience for fishers. The data showed variations in fishing depth between baskets, lines, trips and vessels. This approach has the potential to provide insights into how fishing depth may influence protected species capture rates and risk profiles of different vessels.

More intensive data collection and manipulation of the fishing gear setup were completed on four at-sea trips using Time Depth Recorders (TDRs) to measure hook depth. Modifications to gear setup increased fishing depth and longer float ropes were the most effective and easiest way to increase hook depth. Hook depth throughout the soak was variable within and between baskets, between sets and between vessels. Hook availability to birds during the soak period was almost exclusively linked to fish catch on nearby branchlines, and was greater in shallower-set gear.

Increasing fishing depth is likely to reduce risk to seabirds and turtles and may be best achieved by employing longer float ropes. Additional recommendations to reduce hook availability to seabirds include; weighted gear, longer minimum branchline length, and increased branchline spacing.

As is typical in pelagic longline fisheries, catch per basket was patchy, somewhat confounding catch rate comparisons between treatments. However, there was some indication that catch rates for the deepest hooks were lower indicating that when employing longer float ropes basket size may need to be reduced, or ‘moneymaker’ floats added to larger baskets to maintain similar maximum soak depths to current gear setups. Longer-term data sets would be required to examine the effect of increasing float rope length on catch rates.

Encouraging and incentivising fishers to employ these measures proactively and/or reactively in response to captures should be explored and considered in the context of minimising protected species bycatch on a seasonal basis.

Introduction

The risk of seabird captures during the deployment or setting of pelagic longlines are well documented in the literature (e.g. Clarke et al., 2011; Anderson et al., 2016). Best practice methods for mitigating these captures are widely accepted (ACAP, 2024) and are supported by a substantial body of literature (e.g. Robertson et al., 2013; Domingo et al., 2017). As of September 2024, pelagic longline vessels fishing in New Zealand must use a tori line, line weighting, and set at night, or employ hook shielding devices (MPI, 2024).

Captures of seabirds also occur during recovery or hauling of longlines in New Zealand, often with birds released alive but with largely unknown survival rates (Edwards et al. 2023). Mitigation measures addressing haul captures are less well-developed, but comparatively straightforward (Gilman et al., 2014, Goad & Peatman, 2021). There are no legal requirements for mitigating hauling captures, though voluntary measures are encouraged, for example, in mitigation standards published by MPI & DOC (2024) and in codes of practice.

Seabirds are also vulnerable to capture during the soak period, between setting and hauling, especially if baited hooks are close to the surface. Other vulnerable and unmarketable taxa, notably marine mammals, turtles, and sharks may be caught during the soak period.

Following the adoption of Hookpods in the "East Coast South Island" (ECSI) bluefin tuna (*Thunnus maccoyii*) fishery, and verifiable protected species bycatch reporting via electronic monitoring, efforts to reduce bycatch of seabirds have shifted to captures during the soak. Assuming Hookpods largely eliminate seabird bycatch during the setting process, and captures during hauling are generally alive and relatively easy to identify, it follows that any 'residual' dead captures can be attributed to the soak period.

The diving ability of seabirds varies between species, and although maximum dive depth can be considerable, most foraging is relatively shallow (e.g. Düssler et al., 2024; Bell, 2016; Rayner et al., 2011). Depths of five or ten metres have been considered suitable targets to protect hooks (MPI & DOC, 2024). Consequently, the amount of time hooks spend in surface waters, especially shallower than ten meters, determines the risk of capture during the soak period.

Following a recent increase in reported turtle captures, particularly of leatherback turtle (*Dermochelys coriacea*), in the East Coast North Island (ECNI) bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares)*, and swordfish (*Xiphias gladius*) fishery (Dunn et al., 2023), there has also been an increased interest in gear depth during the soak and how this, among other gear variables, may influence the risk to turtles.

Since leatherback turtles forage underwater for longer periods and at greater depths than seabirds the overlap with fishing gear is more complex. Several studies have looked at diving behaviour in leatherback turtles but these may have been constrained by how depth data were recorded and summarised 'onboard' by tags (e.g. Houghton et al. 2008). However, Wit et al. (2011) provide depth band utilisation data indicating that the majority of the time is spent above 10 m, with dives below 50 m being relatively rare. Similarly, Hawaii has much higher interaction rates with leatherback turtles in its shallow-set fishery (less than 15 hooks between floats) than in the deep-set fishery, indicating that deeper sets pose less risk. Peatman et al. (2019) noted the importance of setting depth when modelling bycatch rates (and defined shallow sets as those with less than ten hooks between floats).

Although there is a lack of data on foraging behaviours, and depth and temperature band utilisation, for leatherback turtles in New Zealand, international work provides enough insight to reasonably assume that, all other factors being equal, deeper sets are likely to pose less risk to leatherback turtles.

Skippers control the depth of pelagic longline gear by varying float rope length, basket size (number of hooks between floats), branchline spacing, and any slack or tension in the mainline (FAO, 2003; Ward & Hindmarsh, 2007). Once they have set the longline, skippers have no further control over the fishing depth until the line is hauled.

In New Zealand there are currently no specific recommendations for mitigating captures of birds or turtles during the soak period. However, it is suggested that setting hooks deeper and adding weight near the hook are options to reduce risk to birds during setting of longlines (DOC, 2025). These measures will increase hook depth during the soak and likely reduce the bycatch of turtles, mammals, and birds.

This project aimed to better understand the depth of pelagic longline hooks during the soak period, and the frequency at which they are brought close to the surface. Similarly, the project sought to identify factors influencing depth, particularly those under the control of skippers, which may help reduce bycatch risk.

Project Objectives

1. Characterise surface longline hook depth profiles throughout the fishing period via the deployment of TDRs.
2. Assess risk of captures during the soak period by identifying incidents of exposed hooks at the surface during the 'soak period'.
3. Compare depth profiles of sets with and without protected species captures and identify any apparent patterns.

(Conservation Services Programme Annual Plan 2023/24 (DOC, 2023))

Methods

Data were collected between March 2024 and April 2025, through two separate approaches to address the objectives.

Fisher-collected 'Wet Tag' data

Wet Tags (Zebra-Tech, Nelson, New Zealand) originally purchased by the Department of Conservation for a previous CSP project (Development of an adaptive management tool for line setting. MIT2018-03) but no longer used were repurposed and distributed to pelagic longline skippers. This approach aimed to provide ongoing data collection across multiple vessels, sets, and trips, at minimal cost. Of 90 wet tags purchased, 30 were recovered from Seafood New Zealand and fishers. As the batteries had prematurely discharged these were all returned to Zebra-Tech for battery replacement and recalibration. Four were unrepairable, leaving 26 available for redeployment.

Wet Tags were split between four vessels; three vessels were each given six Wet Tags and one was given eight. Skippers and crew were given brief instructions including protocols and a booklet for recording deployments. The protocol requested two Wet Tags to be deployed in a basket, one on a branchline beside a float and one on a branchline in the middle of the basket. The three or four baskets sampled were spread along the line, but avoiding the ends. Wet Tags were attached to the clip of normal branchlines (Figure 1) whilst setting the gear, detached during the haul, and placed aside for automatic data download. Wet tags were activated by immersion to 1.5 m depth and then recorded at five-second intervals to 20 m depth and then at one-minute intervals until recovery. The placement of the Wet Tags means that these measured the depth of the mainline, rather than of the hooks.

Researcher-collected 'Time Depth Recorder (TDR)' data

Additionally, four trips to sea were conducted to collect data more intensively and to compare modified gear setups to further understand how skippers can influence soak depth (Table 1).

Two trips were undertaken in the ECSI southern bluefin tuna fishery, one in March 2024 and the second in April 2025. Two further trips were undertaken in the North Island fisheries, one on the east coast, targeting bigeye and yellowfin tuna, and one on the west coast, targeting swordfish.

Table 1. Trip details, including gear configurations tested. Branchlines were shortened over time and minimum lengths are recorded in brackets. Baskets containing 150 mm hard floats at the midpoint are suffixed "m". Other mitigation comprised 250 g of lead weight added to the clip of the float rope (trip A), and different branchline weighting regimes (trip B). Mitigation is coded as hp & w = Hookpod with 60 g siding lead at 1.8 m from hook, w at hook = 40 g leaded swivel at the hook. Baskets were separated by 300 mm diameter hard floats.

Vessel trip	Date	Target species	Branchline length (m)	Branchline timer (s)	Branchline mitigation	Basket size (hooks)	Speed (knots)	Float rope length (m)	Other mitigation
A	Mar 24	bluefin	13 (8)	14	hp & w	11, 12, 13, 14	5.6 - 6.5	10, 13	weight
C1	Apr 25	bluefin	11 (9)	14	hp & w	12	6.7 - 6.9	9-12, 14, 16	
B	Feb 25	bigeye	10 (8)	12	w at hook	10, 20 m	6.2 - 6.8	9-12, 8, 16	weight
C2	Mar 25	swordfish	11 (9)	18	hp & w	8 m, 10 m	6.5 - 7.3	9-12, 12, 14	

A set of new branchlines was constructed at the beginning of each trip for TDR deployments, and these were stored separately. TDRs were taped onto the branchline 0.5 m from the hook, and then hooks were baited and deployed as per normal operations. Fishing depth was measured using CEFAS G5 (Lowestoft, UK) and Star-Oddi DST Centi (Garðabær, Iceland) TDRs taped directly onto to branchlines, 0.5 m above the baited hook. CEFAS TDRs weighed 2.5 g in water and Star Oddi TDRs weighed 12 g. For trips B, C1, and C2 Star-Oddi TDRs were deployed with a float, making them neutrally buoyant. TDRs were configured on a per-set basis and pre-programmed to record at one second intervals to capture the initial deployment and then one-minute intervals for the soak period. Deployment times, position in the basket, and gear setup were recorded during the set.

Different gear configurations were tested in blocks, starting and finishing at least ten baskets from the end of the line. TDRs were deployed in the middle of each treatment block. TDRs were deployed on branchlines beside the float, a quarter of the way into a basket, and midway into a basket (Figure 1). Two to six repeats of each basket position were deployed, per treatment, depending on the number of treatments tested on a line and the number of TDRs available. TDRs were deployed least one basket after the changeover to a new setup, and treatments were generally adjacent, though when separated by a GPS beacon TDRs were not deployed in baskets adjacent to the beacon. TDRs were programmed and data were downloaded on a set-by-set basis. Between sets, TDR clocks were reset to the PC time and this was checked against the clock used on deck to manually record clip-on times.

For 25 deployments TDRs were also attached immediately below the clip to measure the difference between hook and mainline depth.

Catch on each branchline was recorded during the haul for at least half of the line, after which TDRs were downloaded and re-programmed for the following set.

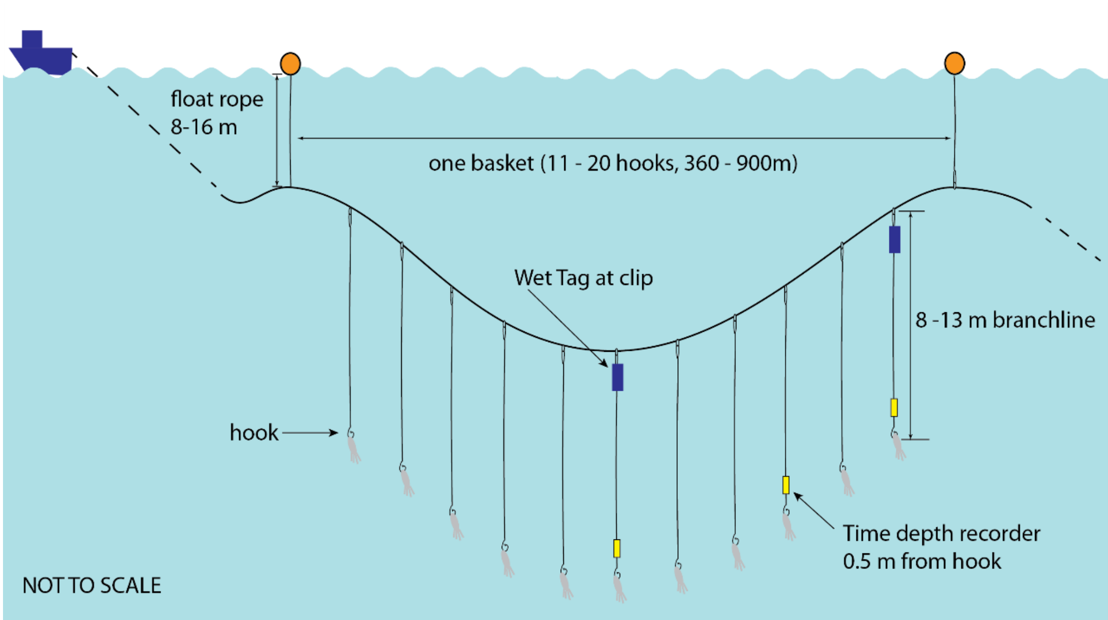

Figure 1. TDR and Wet Tag placement in a 12-hook basket.

Data processing

Data were manipulated and plotted in R (R Core Team 2021).

Fisher-collected Wet Tag data

Data were recovered using existing infrastructure on the vessels, installed as part of the Moana project (www.moanaproject.org). The Liner package was used to identify individual deployments, and record per-deployment summaries; data were then saved as an R workspace file.

Fisher-reported data were extracted from the Ministry for Primary Industries' Enterprise Data Warehouse, including times and locations of sets and hauls, effort variables, and protected species captures. These records were matched to Wet Tag data using vessel identifiers and by comparing set start and end times to Wet Tag deployment times. Per set histograms were plotted of the proportion of each deployment in each five-metre depth band and one-degree temperature band, and flagged with reported bycatch when available.

Data received from the Wet Tags were retained from periods when the Wet Tags were deployed on vessels participating in the study. Tag deployments were identified as series of data recorded with no more than six minutes between records. Deployments were required to have at least 35 readings and to reach a depth of at least 8 metres to be considered a real deployment; this eliminated cases where the Wet Tags turned on automatically due to changes in atmospheric pressure.

Researcher-collected TDR data

Initially, Star-Oddi TDR records were reformatted to match CEFAS TDR outputs. TDR depth was then adjusted with an offset derived from mean readings from one to two minutes prior to deployment. Individual sink profiles were examined to ensure clip-on times were recorded accurately. To monitor depth during the soak, depths were extracted at one-minute intervals. Records prior to five minutes after branchlines were clipped on were discarded to allow the gear to settle. To remove records once TDRs were back onboard the vessel, any records with a depth less than 1.5 m were discarded. Individual TDR profiles were examined to ensure that this filtering was appropriate and adjustments were made on a per-line or per-TDR record basis to ensure that the soak period was appropriately extracted.

Histograms of depth and temperature were plotted for the whole soak period using five-metre bins and of temperature using one-degree bins. Depth histograms were repeated for just the first ten minutes of the soak when depth was more closely related to gear configuration. Histograms were weighted to give equal consideration to different TDR positions within baskets. Histograms were split by line and treatment for trip one and set and float rope length for trips two to four. Temperature-depth plots were also produced, by set.

Summary data across all trips by classifying treatments into 'shallow' 'normal' and 'deep' based on float rope length for trips B, C1 and C2 and additionally basket size and weight for trip A.

Results

Summarised data and selected examples from all four trips are presented in the body of the report. Finer, per-set, resolution is explored in per-trip appendices.

Researcher-collected TDR data

A total of 944 TDR deployments were conducted across the four trips. The effect of treatment on soak depth was much clearer when considering TDR records taken during the first 10 minutes of the soak (Figure 2 vs. Figure 3). As the soak progressed the influence of current and catch often dominated fishing depth, and resulted in large variation between baskets, treatment blocks, and lines (Figure 3). This was also apparent when hauling the gear, with deeper sections hauled more slowly and the mainline at steeper angles.

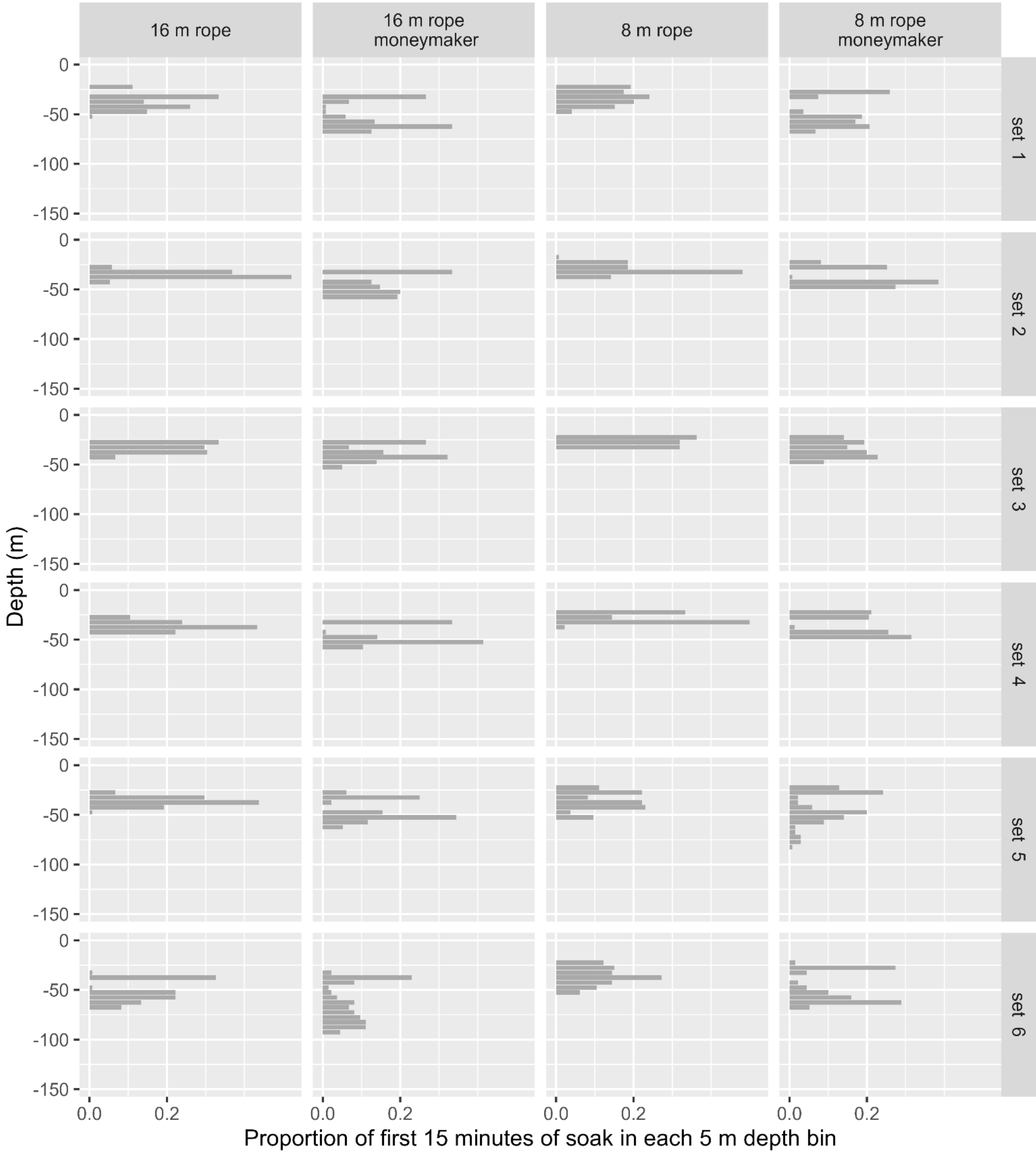

Figure 2. Histograms of TDR depth during the first ten minutes of the soak, by set, basket type and float rope length on Trip B. Moneymaker baskets comprised 20 hooks with a 150mm hard float midway through the basket and other baskets were 10 hooks.

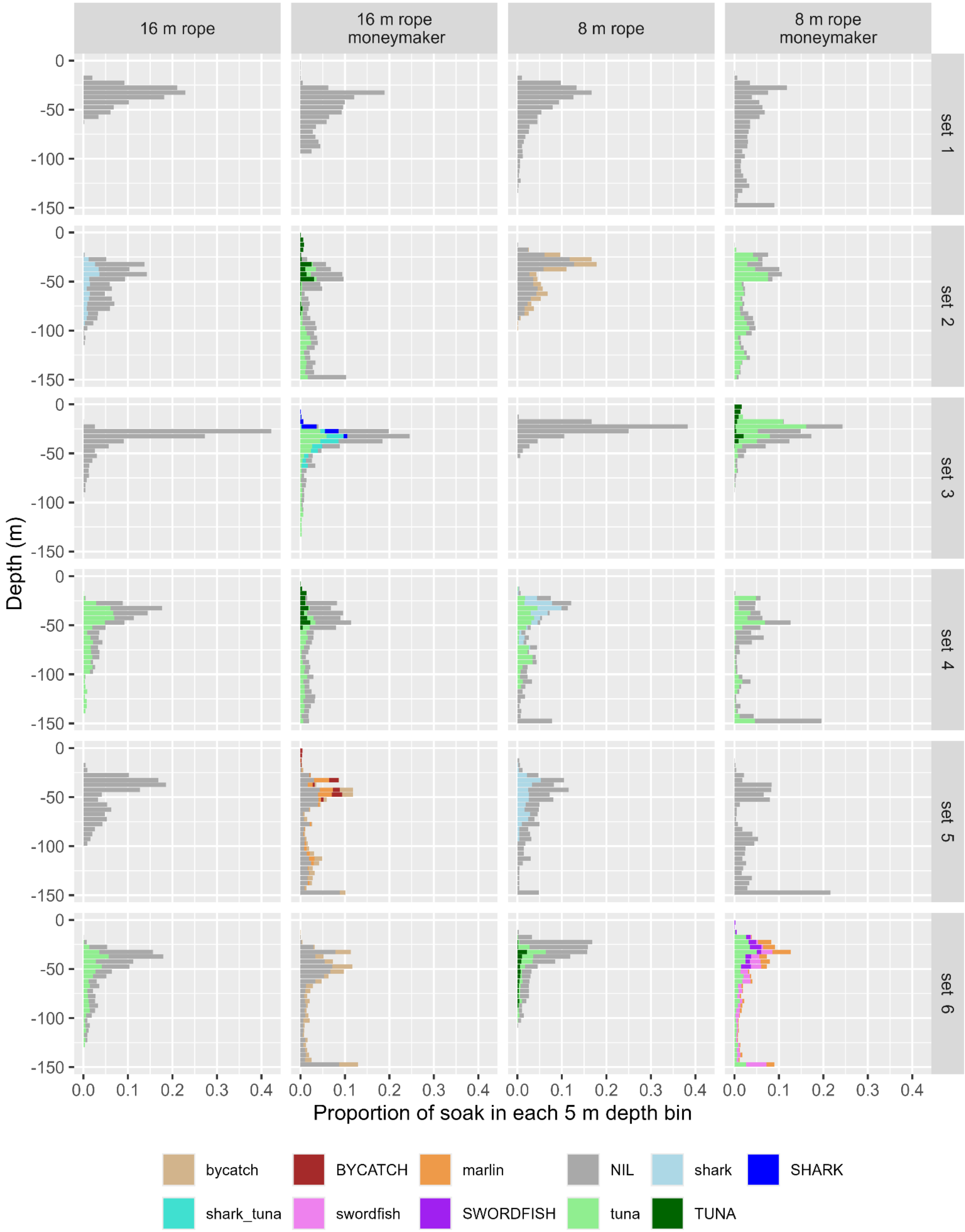

Figure 3. Histograms of TDR depth during the whole soak, by set, basket type and float rope length on Trip B. Darker colours and capital letters indicate catch on the TDR branchline, and weaker colours and lowercase letters indicate catch in the same basket, NIL = no catch in the TDR basket. Moneymaker baskets comprised 20 hooks with a 150mm hard float midway through the basket and other baskets were 10 hooks.

Of the options for increasing soak depth trialled during trip one, increasing float rope length proved to be the simplest and most practical. Increasing basket size produced more drawn-out depth distributions, with hooks fishing a broader range of depths. Weight at the float rope clip appeared to have negligible effect on depth (Figure 4).

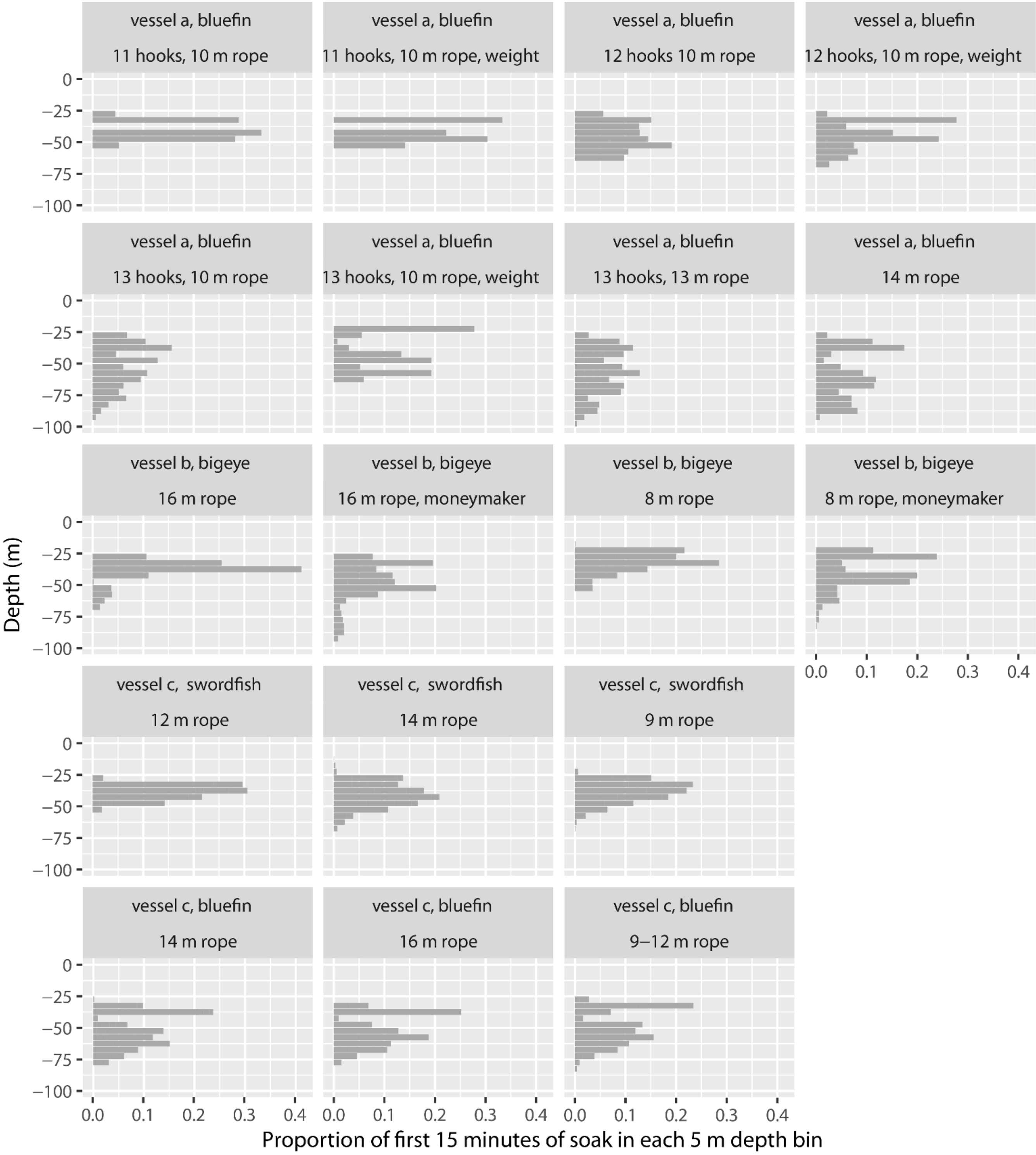

Figure 4. Histograms of TDR depth during the first 15 minutes of the soak by trip and treatment.

Hook availability to seabirds, measured by time spent at depths of less than 10 m, was largely dictated by catch. Instances of shallow hooks were generally less on sections of the line fishing deeper, with the exception of the swordfish trip on Vessel C where a swordfish caught on a deeper section of the gear was dead and floating at the haul (Figure 5).

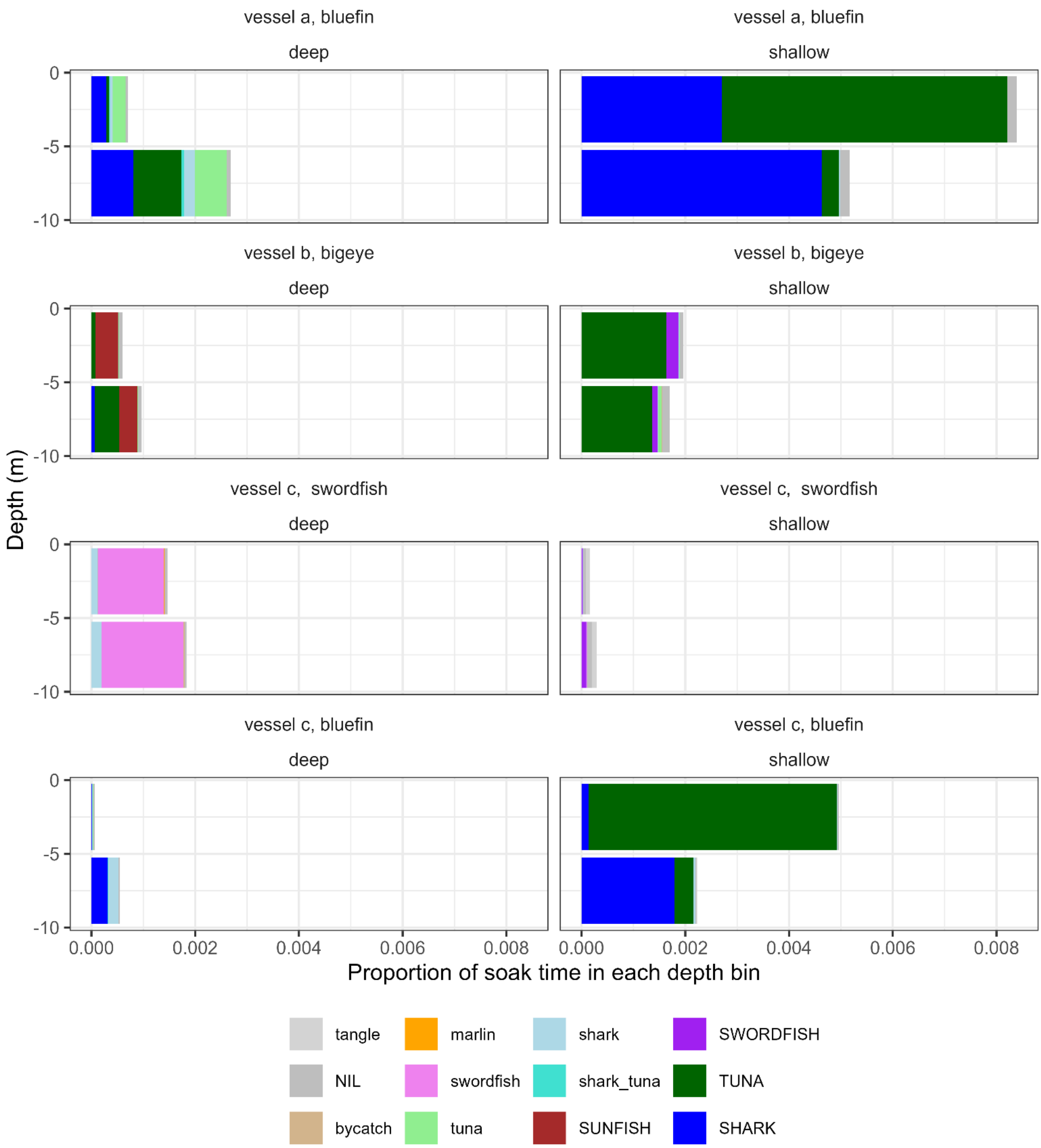

Figure 5. Proportion of soak time spent in 0-5 and 5-10 m depth bins, by trip and treatment. Colour indicates catch on the TDR branchline (capitals) or in the same basket (lowercase). Treatment has been simplified to 'deep' indicating modified sections, and shallow indicating normal gear setups, except for the bigeye target trip where shallow gear represented the shallowest baskets of the vessel's normal setup.

Factors influencing hook depth

Examining individual TDR records provided some insight into how catch affected gear depth. For example, in one instance a tuna was caught on a TDR branchline in the middle of a basket and spent considerable time at the surface (Figure 6). Whilst TDRs on branchlines one and three were also brought closer to the surface they were not above 20 m, indicating that the tuna had a very localised effect on hook depth.

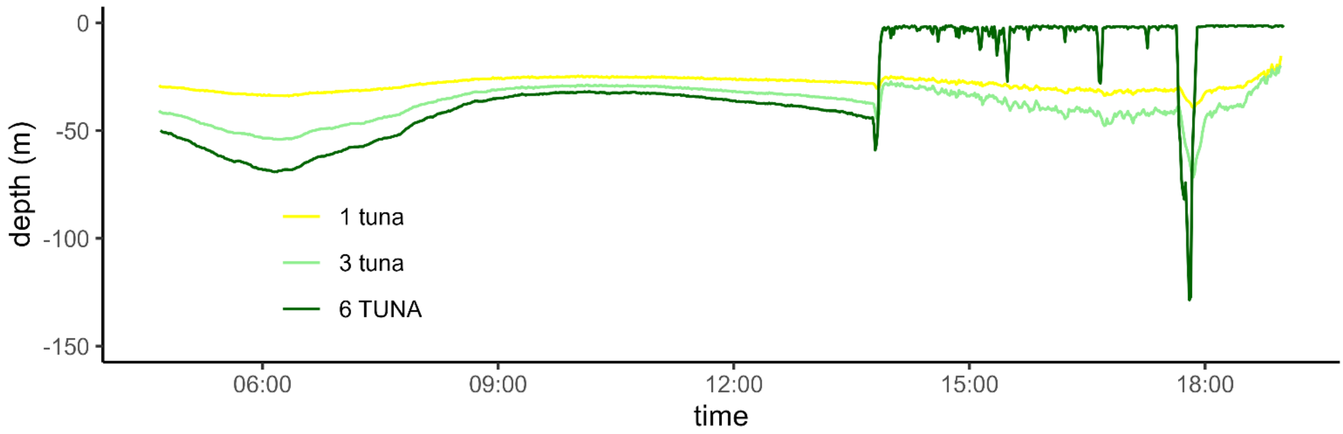

Figure 6. Plot of TDR depth over time for three branchlines in the same basket in positions one, three, and six which caught a tuna. Data from Vessel A, targeting bluefin tuna.

Similarly, a blue shark (*Prionace glauca*) also had a localised effect on TDR depth (Figure 7).

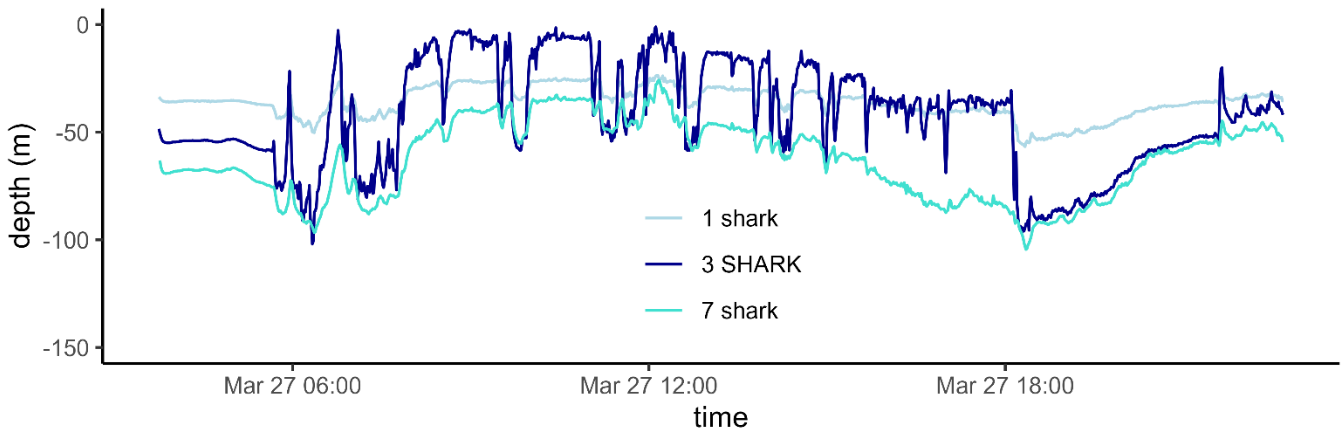

Figure 7. Plot of TDR depth over time for three branchlines in the same basket in positions one, three, which caught a blue shark, and seven. Data from Vessel A, targeting bluefin tuna.

Tuna, swordfish, and sharks did not always bring gear closer to the surface (Figure 8).

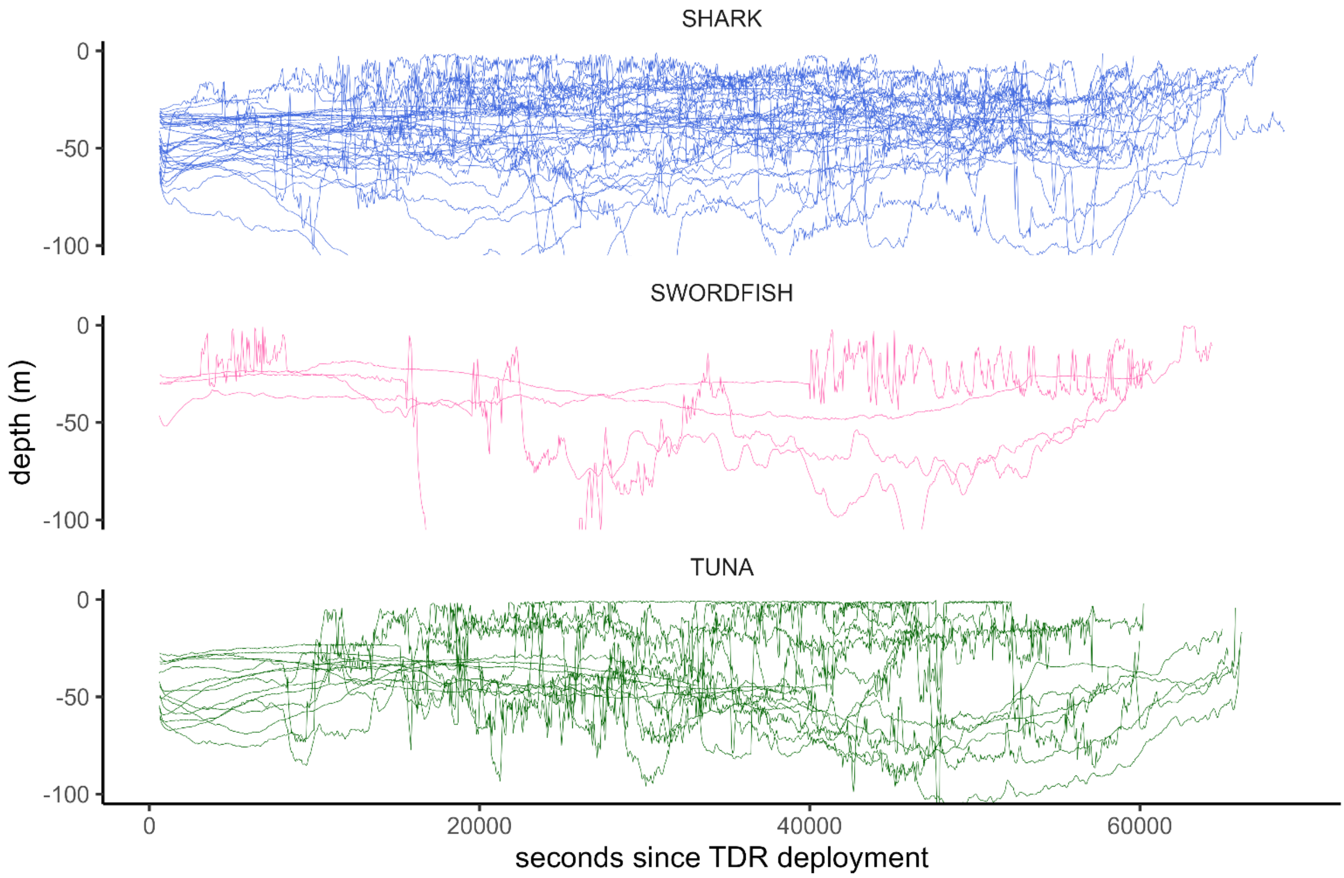

Figure 8. Plot of TDR depth over time for all branchlines across all treatments which caught sharks, tuna or swordfish.

Variation in the depth of gear often occurred over time and along the line with line position occasionally determining depth, rather than gear setup (e.g. Figure 9).

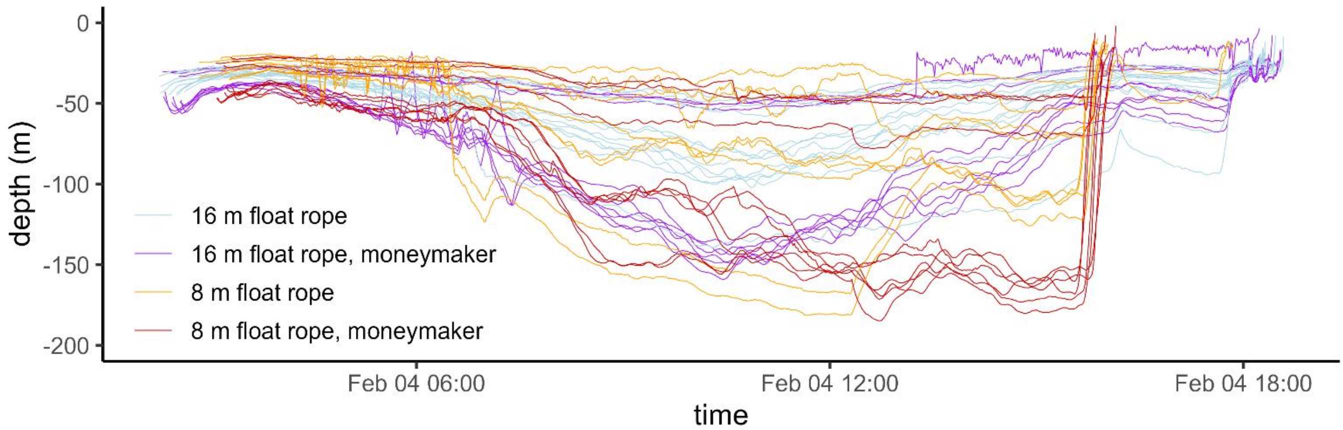

Figure 9. Plot of TDR depth over time for all TDR branchlines from set 4 on Vessel B, targeting bigeye tuna.

Fish catch

Catches were patchy along the lines with deeper sections of gear sometimes coinciding with patches of fish and sometimes not (Figure 10). Mean per-basket catch rates showed no clear relationship to gear setup for tuna-target trips. Swordfish catches were possibly slightly lower in deep sections. Deep treatment sections showed more variation due to smaller sample sizes (Table 2).

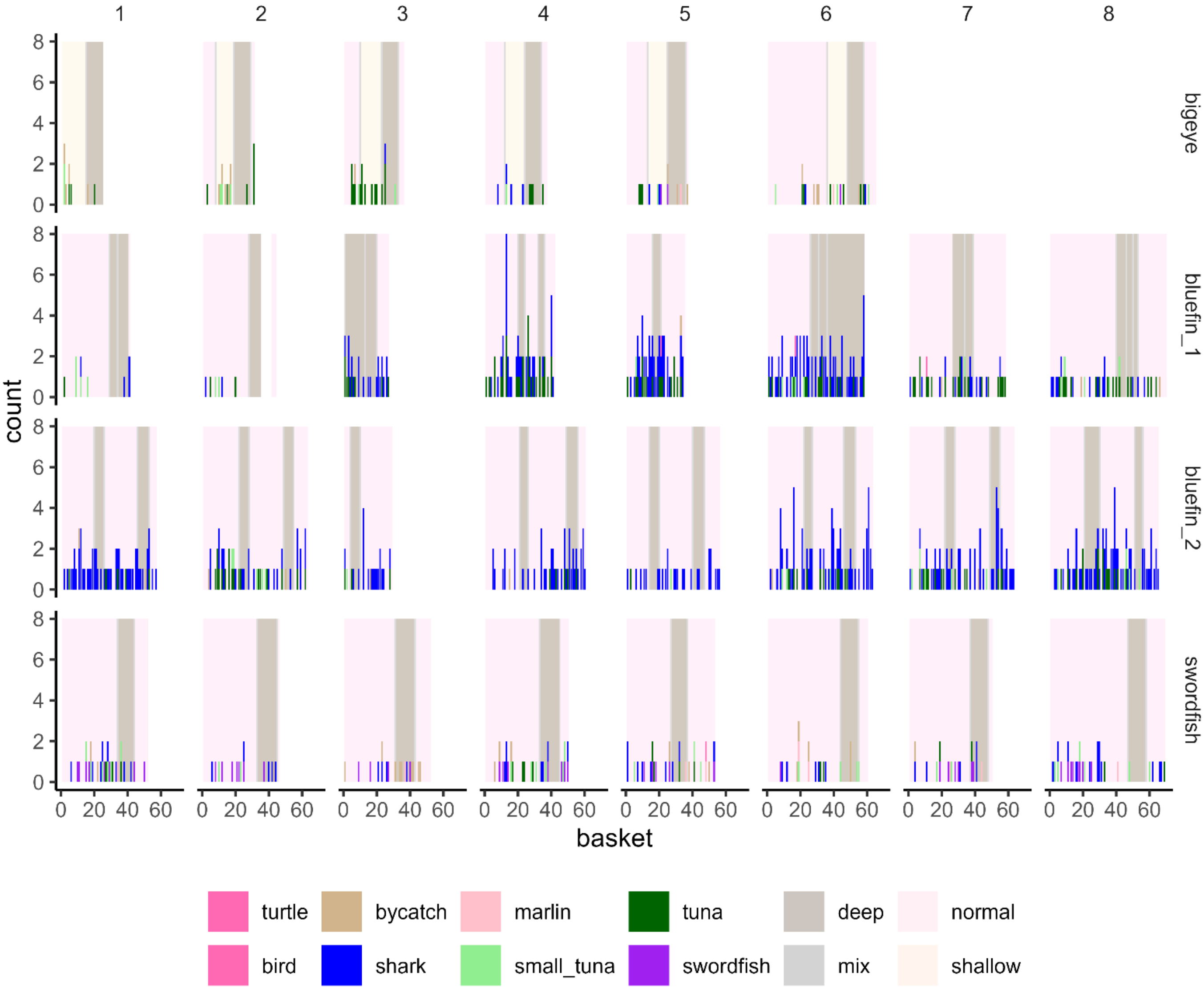

Figure 10. Fish catch by trip, set, basket, and species group. Background shading indicates treatment.

Table 2. Mean bigeye, yellowfin, bluefin, and swordfish catch per basket by trip and treatment

			set							
vessel	**treatment**	**mean**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
a bluefin	deep	0.31	0.00	0.00	0.24	1.00	0.25	0.27	0.45	0.30
	normal	0.28	0.03	0.07	0.29	0.66	0.45	0.24	0.33	0.21
c bluefin	deep	0.13	0.00	0.10	0.20	0.20	0.00	0.30	0.10	0.17
	normal	0.15	0.10	0.33	0.09	0.07	0.02	0.14	0.20	0.27
b bigeye	deep	0.15	0.10	0.11	0.22	0.33	0.00	0.11		
	normal	0.23		0.44	0.33	0.07	0.23	0.05		
	shallow	0.18	0.14	0.10	0.50	0.00	0.09	0.27		
c swordfish	deep	0.10	0.11	0.09	0.09	0.09	0.11	0.00	0.30	0.00
	normal	0.16	0.22	0.18	0.08	0.27	0.19	0.06	0.13	0.18

With such patchy catches of relatively few fish, and relatively small treatment blocks, drawing firm conclusions from catch rate comparisons is not possible. When considering branchline position in the basket there is, however, some indication that shallower hooks fished better, especially in baskets with longer float ropes, on the trip targeting bigeye (Figure 11). An increase from 9-12 to 14 m float ropes produced similar catch rates in the bluefin fishery, though 16 m float rope baskets had reduced catches, especially in the middle of the basket. On the swordfish trip longer float ropes may have slightly reduced catches (Figure 10).

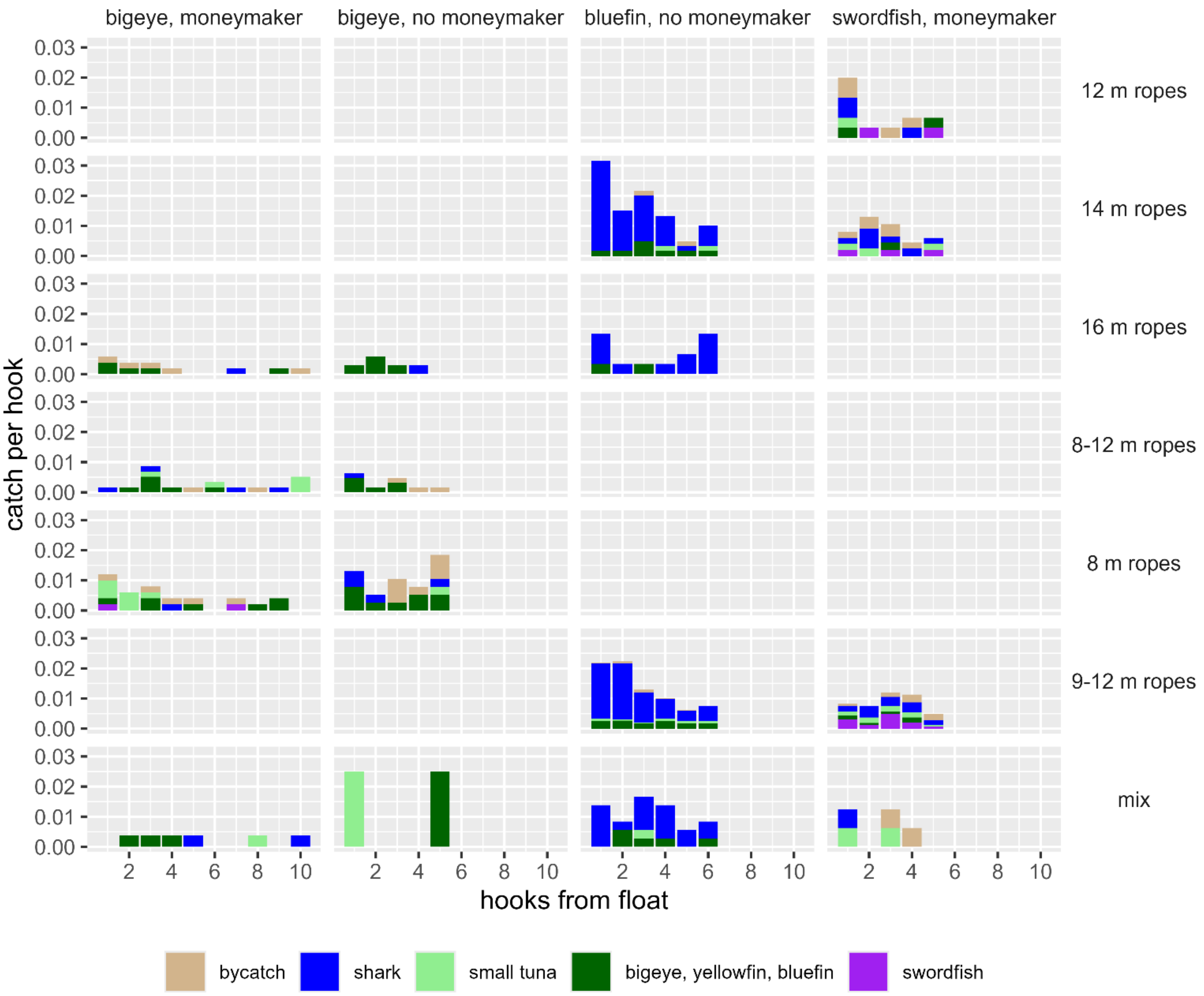

Figure 11. Catch rates per hook by location in basket, trip, and treatment.

When comparing hook and mainline depth three of the 25 paired TDR three records were discarded, one to spurious differences and two due to fish caught on the branchline. Despite pushing the stated accuracy and precision of TDRs, differences indicated that branchlines were not always hanging directly below the mainline and, in rare cases, were shallower and in some cases associated with sharks in the same basket (Figure 12).

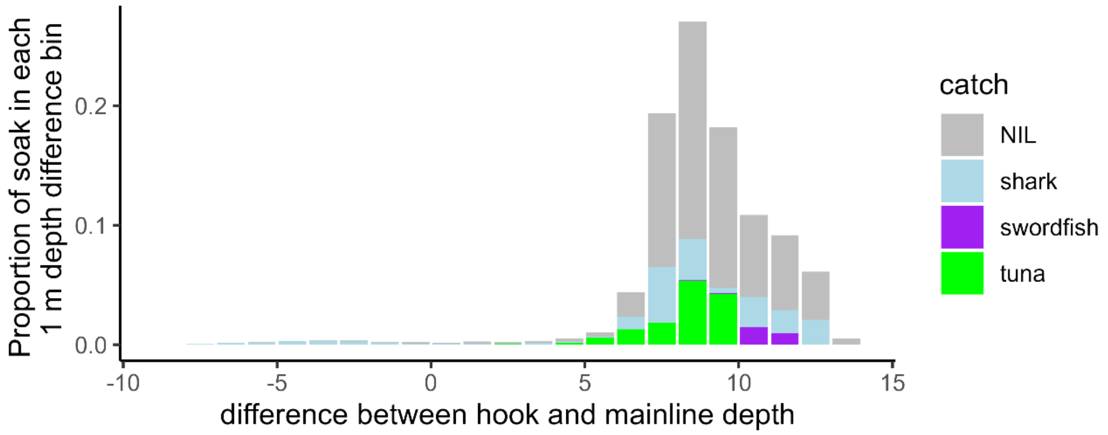

Figure 12. Difference between hook depth and mainline depth, by one-metre depth bin, for 22 10-13 m branchlines with TDRs deployed at the clip and hook. Positive values indicate a deeper hook. Branchline records were weighted equally to account for different soak times. Colour indicates catch on other branchlines in the same basket.

Fisher-collected 'Wet Tag' data

Data were collected from two vessels. Vessel A was set up with Wet Tags to continue data collection following the at-sea trip. Vessel D agreed to deploy tags and the skipper and crew were briefed in person. A further two vessels were set up with tags, one had a failure of the Moana deck unit and the second undertook only limited surface longline fishing.

Vessel A fished off the west coast of the South Island with data recorded during mid-2024. Birds were caught on 13 of 51 sets and captures were often clumped, within sets and on consecutive sets. There is little indication that shallower Wet Tag records coincided with captures (Figure 13).

Vessel D fished on the east coast of the North Island, and data were collected during mid 2024 (set 33 to 83) and the summer of 2024-2025 (sets 84 to 116). Birds were caught on three sets, turtles on five sets and fur seals on fifteen sets, for a total of 78 sets (Figure 13). Fur seals were caught in cooler water over winter, often with captures on consecutive sets. Sets with turtle captures were not so clumped but were more frequent in warmer water over summer (Figure 14). There was no clear indication of a relationship between depth and captures in data from Vessel C, however, sets were generally set shallower than those on Vessel A. The number of hooks between floats did correlate with depth to some extent on Vessel C, though mistakes such as one-hook baskets were apparent in the fisher-reported data.

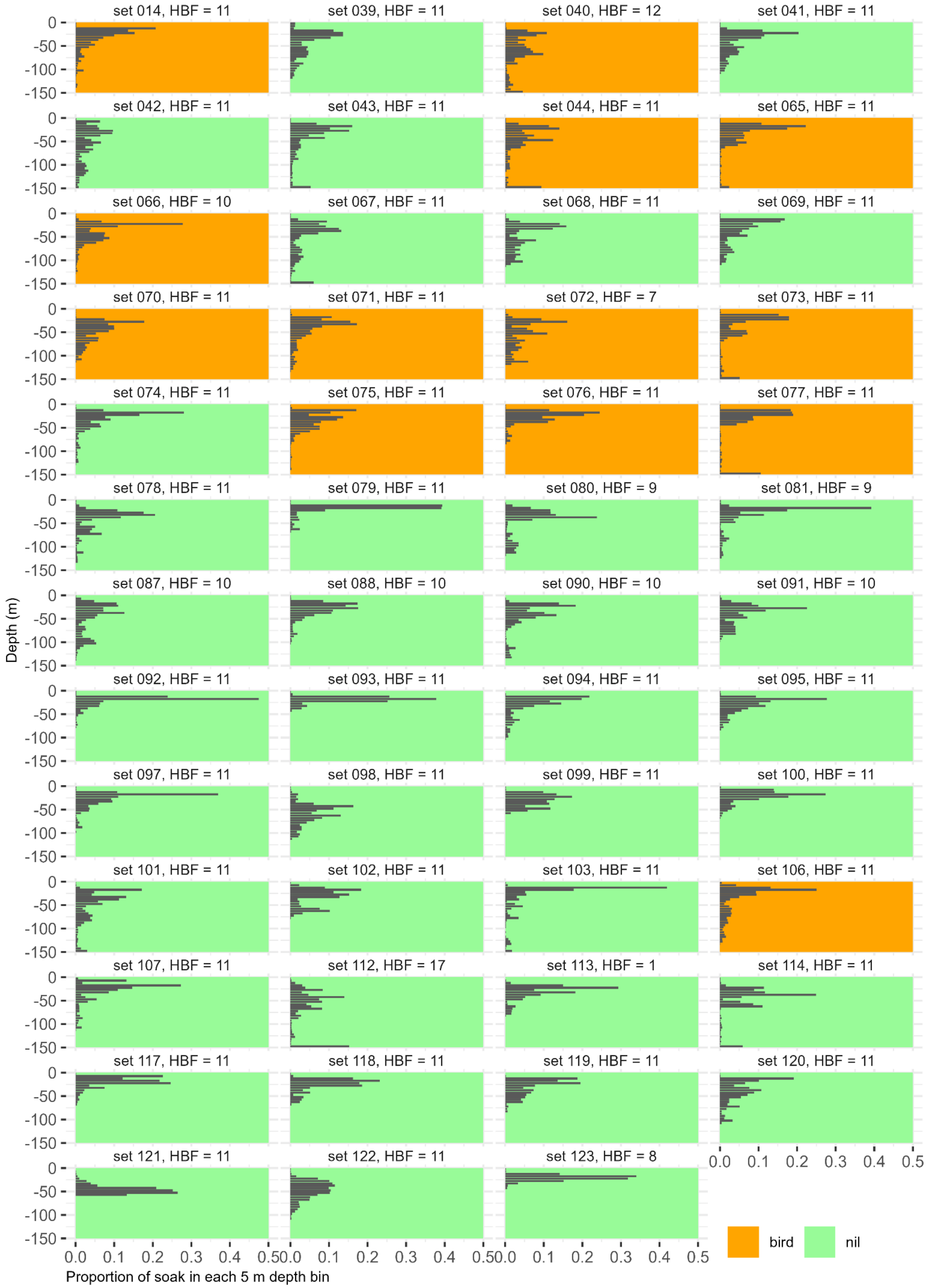

Figure 13. Histograms of Wet Tag depth from Vessel A, by set, with background colour indicating reported bycatch (pending data release from fishers). HBF = hooks between floats, based on fisher-reported effort data.

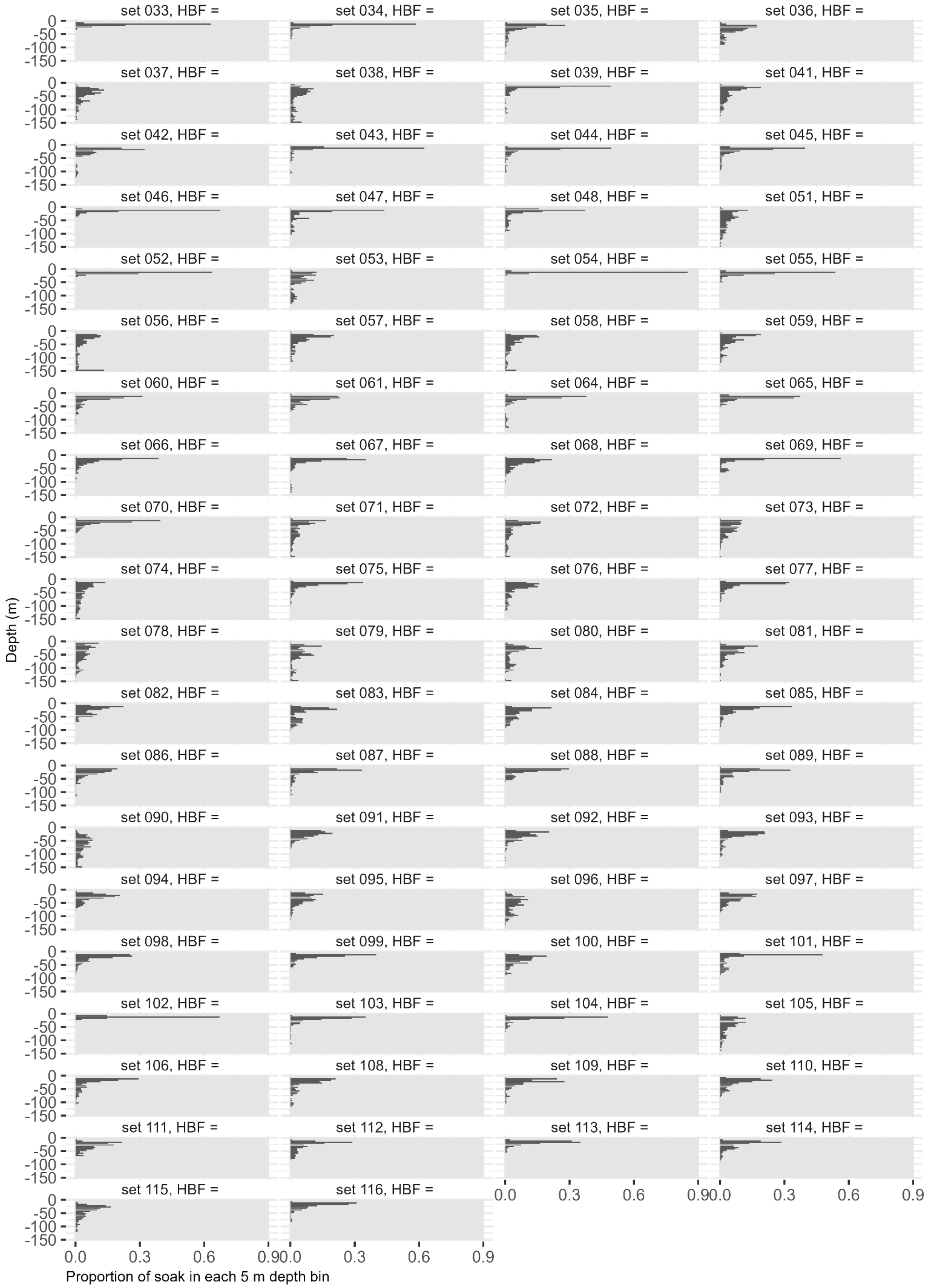

Figure 14. Histograms of Wet Tag depth from Vessel D, by set. HBF = hooks between floats, data not available.

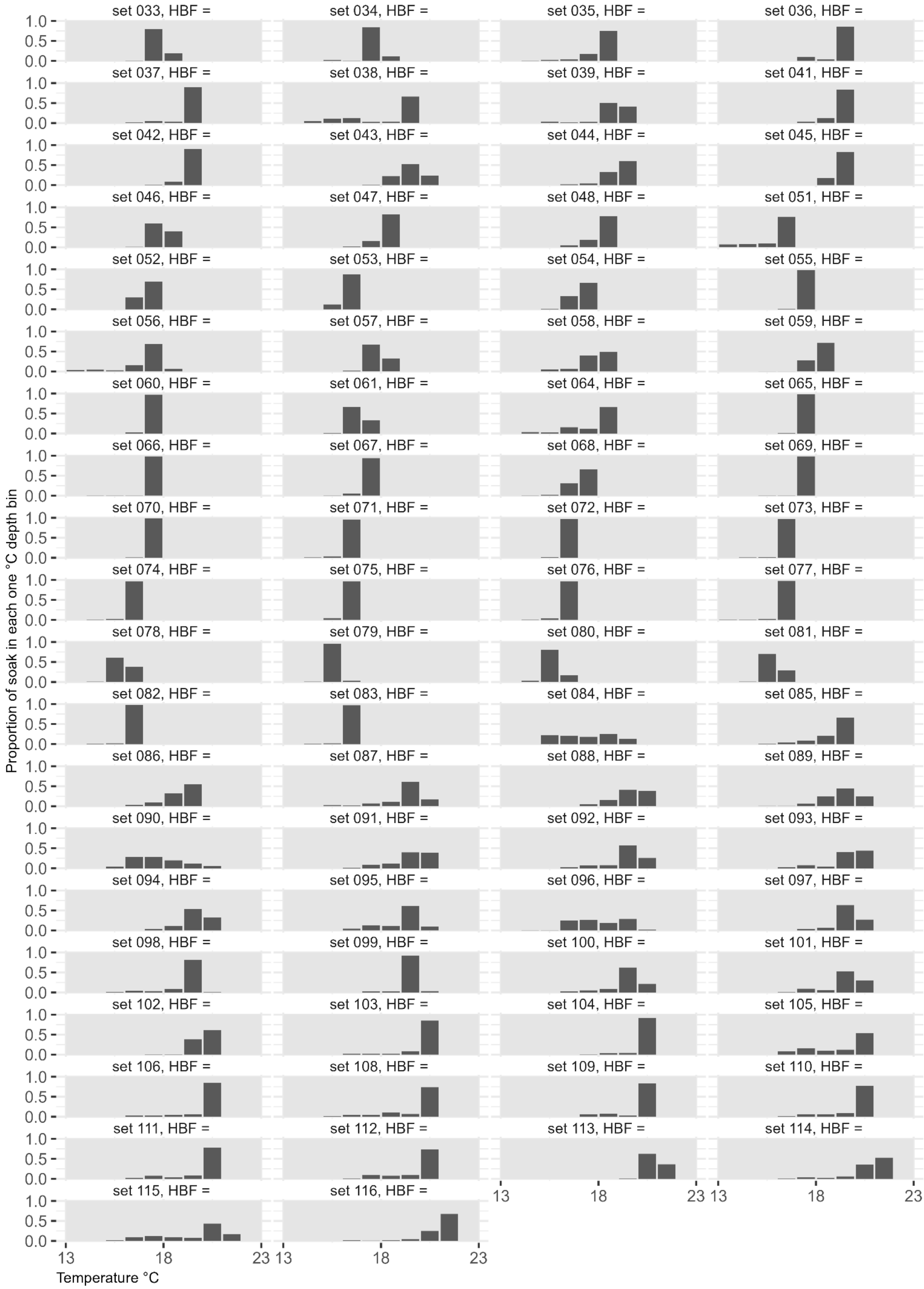

Figure 15 Histograms of Wet Tag temperature from Vessel D, by set. HBF = hooks between floats, data not available.

Wet tag depth profiles were generally more similar within baskets than between baskets. Within lines, wet tag depth profiles from different baskets were highly variable, with a few notable exceptions such as sets 79 and 93 (Figure 16).

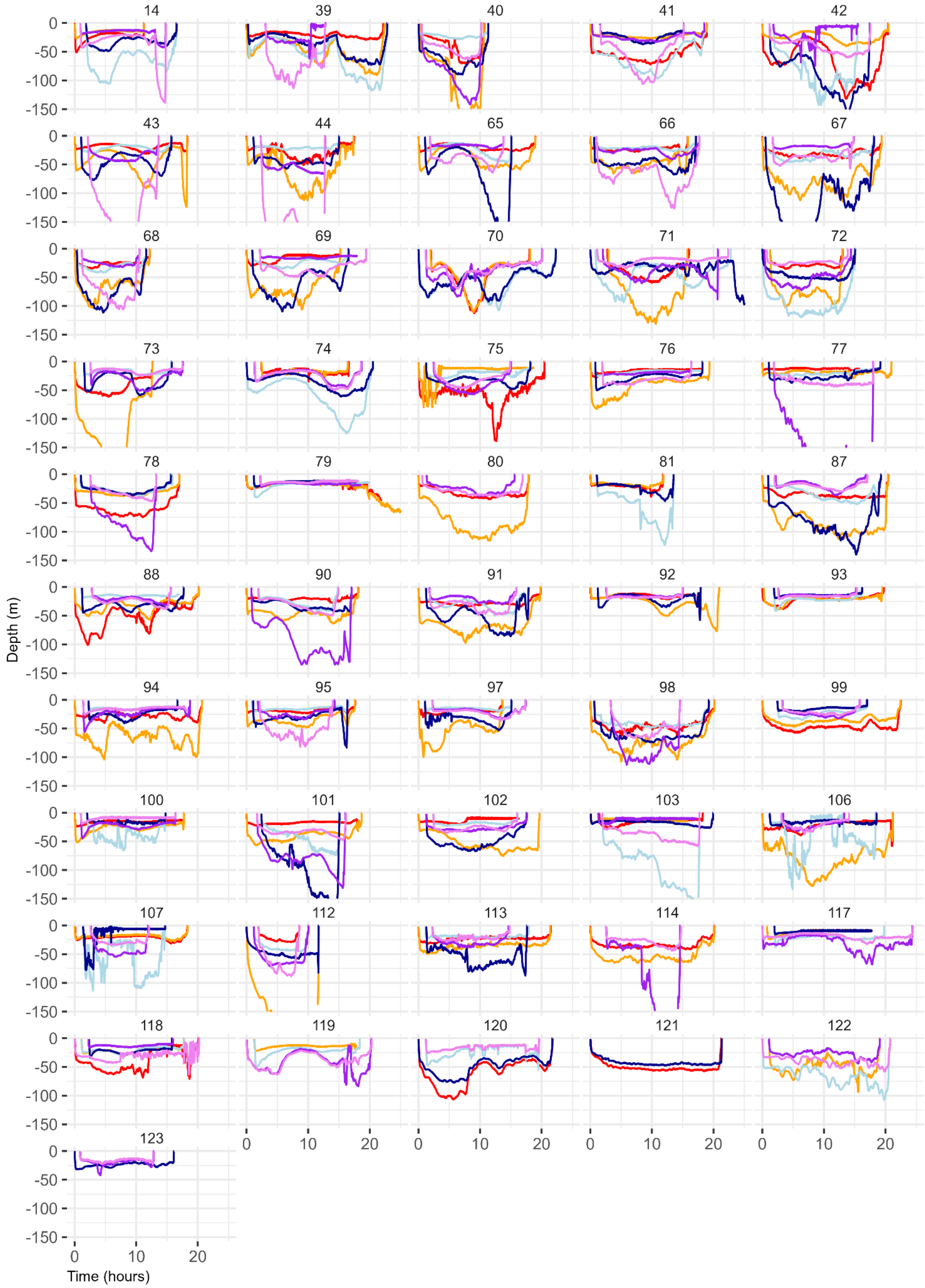

Figure 16. Time – depth plots from individual wet tag deployments, by set. Data from Vessel A.

Discussion

Whilst gear setup does influence soak depth it appears that other variables such as tide, weather, current and drift acting differently along different parts of the line during the soak are important factors. The nature of pelagic longlining is that skippers often actively target fish in patches of water where these variables change over relatively short spatial scales, resulting in different parts of the line moving in different directions. This results in some baskets being stretched out and fishing shallower and other baskets compressed and, hence, fishing deeper. This confounds the data presented here and is thought to generally result in 'longline shoaling' such that gear sits shallower than it would if set in a static body of water (Bigelow et al. 2006, Bach et al. 2009). Catch also influenced gear depth, especially for the shallowest hooks, further confounding comparisons between different treatments, baskets, and lines.

Consequently, gear depth measured in one basket cannot necessarily be considered representative of other baskets in the same line and, without TDR records very close to a capture, we cannot estimate gear depth. This is not particularly important for birds as we can assume that hooks close to the surface are accessible to birds and so pose a known risk. For turtle captures, however, the depth is of greater interest. These factors make addressing objective three (to compare depth profiles of sets with and without protected species captures and identify any apparent patterns) difficult.

Wet Tag data

In combination with the Moana deck units Wet Tags provided useful information with relatively little input from fishers, and at minimal cost.

Providing more immediate data feedback to skippers would potentially increase uptake as it would give fishers useful data to inform fishing strategy for subsequent sets. Monitoring fishing depth may also be beneficial to fishers as it would provide a quantifiable risk reduction when changes are made to fishing gear, either proactively or reactively in response to captures.

Wet Tag placement at the clip was simple for skippers and crew but this resulted in essentially a measure of mainline depth rather than hook depth as with the researcher-collected TDR data. Attaching Wet Tags to a snood either in place of or in addition to a hook would complicate the deployment and recovery process. Given their density and bulk, it would also be of limited value in estimating hook depth. Paired TDR deployments indicated that hooks do not consistently hang directly below the mainline. Figure 12 could be used to apply a correction to Wet Tag data to estimate absolute hook depth, noting that catch rates and species caught will alter this distribution. However, if comparing the relative depth of different gear configurations this is not necessary.

Wet Tags were deployed two-per-basket as opposed to TDRs which were deployed three-per-basket. It is, therefore, important to note that the Wet Tag data are comparable between sets and vessels but are not directly comparable with researcher-collected TDR data.

Whilst data are unbiased, there can be huge variations in fishing depth along the line, between baskets, and with baskets. Consequently, Figures 13-15 are not representative of the whole line and should be interpreted with caution. Figure 16 shows that soak depths of different baskets in a line are typically very different. Consequently, unless a recorder is within a few branchlines of a capture then recorders elsewhere in the line do not provide a good predictor of depth. This is especially true for bird captures, where fish are likely to have brought a small section of line close to the surface.

Overlap is also not considered here. To fully evaluate the effect of fishing depth a modelling approach is probably required and would need to be spatial and temporal and consider other environmental covariates. Basket size or 'hooks between floats' does influence fishing depth, but it is an oversimplification; float rope length, setting speed, line tension, and snood timer interval are also important. Distribution layers are available for birds (Roberts et. al 2023), but not turtles, though data may be available from project POP2023-01.

In the shorter term, focusing on further Wet Tag data collection may be a better use of resources. The approach described here minimises hassle for fishers and is relatively low cost. A larger data set may also help explain different capture rates of different vessels and provide insights into lower-risk gear setups.

Longer time series of fisher-collected Wet Tag data have the potential to meet objective three, by characterising the soak depths of different vessels and line setups rather than relying on having a recorder on branchlines which catch protected species. This approach is most likely to produce useful management outcomes as, overlap differences aside, it has the potential to identify riskier and shallower gear setups.

TDR data

Despite the variation in depth between baskets, sufficient TDR data is presented here to show that longer float ropes produce a reasonably consistent increase in gear depth and so minimise risk. This approach unavoidably increases the depth of the shallowest hook. However, by reducing basket size or adding moneymaker floats the depth distribution and maximum depths fished could be controlled, thereby limiting the risk of altering catch rates of target species. Routine analysis of catch by position in basket may prove fruitful in maximising catch rates of target species whilst minimising risk to protected species. Data on catch by hook position could be collected as part of camera footage review.

Fish caught on the line also influenced neighbouring hook depth. Although initial indications are that this effect is localised and relatively rare it can still result in considerable 'hook-minutes-of availability-to-birds' (Figure 5). This 'soak hook availability' is likely greater than that at the set as a proportion of time at the surface in Figure 5 of 0.001 equates to a hook available to birds throughout he soak period, for a 1000 hook set. Given that these instances of shallow hooks are unmitigated, at least partially occur in daylight, and are associated with fish visible on or close to the surface, it unsurprisingly leads to bycatch of seabirds in areas of high overlap.

Mitigating these instances of shallow hooks is not straightforward as they are largely beyond the control of the skipper. However, all other factors being equal, both shooting deeper and with weight close to the hook are likely to help. This is supported by Figure 5, though it should be noted that this is driven by whether a reasonably small number of fish swam to the surface once hooked. Figure 5 is not normalised by catch rate, although these were similar for all trips except swordfish, where catch rates were somewhat lower for the deepest gear (Table 2).

It follows that risk during the soak period is proportional to catch – particularly of billfish, tuna, and sharks which regularly brought the gear to the surface. The frequency by which hooks adjacent to fish are brought close to the surface can be reduced by catching less sharks. Catching less target species would also reduce risk on a per set basis, but would likely result in more fishing effort so would not reduce overall risk. Considering bird catch rates in relation to fish catch rates is therefore important.

Catch rates and gear modification

When comparing the gear setups of the two bluefin trips Vessel C generally worked longer baskets and deeper gear and had fewer instances of shallow hooks. The deeper experimental gear setups also produced less shallow hook time. The relationship between trips in the North Island fisheries is less clear with different target species and areas fished. One dead floating swordfish capture dominates the shallow hook time for the deep gear in the swordfish trip in Figure 5. Although the shallower sections generally resulted in less shallow-hook-time these results are based on catch from relatively few branchlines and other factors contributed to variation in gear depth between treatments (e.g. Figure 9).

Increasing float rope length to 14 m in the bluefin fishery appeared to be a reasonable compromise between minimising risk to protected species whilst maintaining catch rates. Shallower gear appeared to fish better in the swordfish and bigeye fisheries so increases to float rope length may need to be accompanied by other changes to gear. The benefit of increasing float rope length is that it increases minimum hook depth as well as the depth of all the gear. If hooks in the middle of baskets are then fishing undesirably deep, reducing basket size or the addition of moneymaker floats would reduce maximum fishing depths. Fishers will, no doubt, 'feel' their way into fishing with longer float ropes and, whilst the number of hooks from a float is a good proxy for depth, hooks closer to floats are likely to be more dynamic in the water which may influence catch rates.

Longer float ropes are likely to be more acceptable to fishers than current recommendations to remove hooks close to floats during high-risk periods as it will likely have less impact on catch per set, especially as these hooks tend to fish well. Although when fishing into and below the thermocline temperature fished is a function of depth fished, longer float rope had little effect on temperature fished (Appendix 1). Between set variation in temperature fished was consistently greater than between treatment variation in all trips, and for fishers that target particular water temperatures this should provide some reassurance that modest increases to float rope length do not change the temperature fished.

Increasing minimum float rope length is straightforward, low cost, and easily checked alongside the wharf. It could also be relatively easily changed between sets, for example in reaction to a capture event. A separate set of longer ropes or, more economically, a set of extensions could be carried.

Longer (weighted) branchlines would reduce the chances of hooks adjacent to those with fish swimming close to the surface also being brought close to the surface. Longer branchlines would be marginally more expensive and may tangle more frequently. Typically, branchlines become damaged near the hook and are shortened several times before being discarded once they are too short. Consequently, a more practical approach may be to specify a minimum branchline length. However, longer branchlines will increase the vertical profile of the gear and so potentially increase the risk of entangling turtles. Consequently, they can reasonably confidently be recommended in areas with low overlap with turtles such as the South Island winter fisheries, but less confidently in the North Island fisheries where turtle overlap and bycatch is higher.

The implications of larger branchline spacing are unclear, as in order to fish the same number of hooks, longlines (and working hours) would have to be longer, and catch-per-hook may differ. Similarly, longer lines may pose a greater entanglement risk for turtles.

Considering turtle interaction is more complex than for seabirds as their use of the whole water column needs to be considered. Leatherback turtle dive depth and behaviour has been shown to vary with water temperature, prey availability, and migration (Okuyama et al. 2021). Without data on depth band utilisation by leatherback turtles in New Zealand it is not possible to quantify overlap with fishing gear. However, current information indicates that setting deeper will reduce overlap and so the methods above described in the context of reducing hook availability to birds equally apply to reducing risk to turtles. Increased mainline tension will result in shallower gear and may also influence the likelihood of entanglement. Fishers have some control over this with setting speed and they may occasionally apply brake. Other factors such as reduced drum diameter and associated increase in tension towards the end of a set are predictable but less controllable.

Where turtles are released alive the potential for deploying pop-off tags should be considered. This could provide useful information on depth band usage, behavioural patterns, and post-release survival.

Providing catch rates are maintained or higher, shooting shallower appears desirable in that skippers can haul faster, work more gear, cover more miles, catch more fish per set, and require fewer fishing days to catch a given portion of the Total Allowable Catch (TAC). This gain in efficiency should be considered with respect to any increase in risk to protected species due to shallower hooks.

More generally, mitigation should be considered in the context of how best to minimise risk to protected species per kilogram of fish caught. This is slightly different from minimising risk per hook and is important when fisheries operate with high catch rates and at times and in areas of high overlap. The goal should be to catch the TAC whilst catching the least number of protected species, with the least number of shallow hook soak hours, normalised by the overlap.

Recommendations

1. Continue to collect the 'Wet Tag' data to inform a more robust characterisation of the soak depths of different vessels and line setups.
2. Encourage fishers to use longer float ropes and set at least some sections of lines deeper, and to monitor catch and bycatch rates at different depths.
3. Consider fishing deeper, particularly when risk to birds or turtles is elevated, and when and where bycatch has been historically high.
4. Review the feasibility and practicalities of deploying satellite tags on leatherback turtles in New Zealand.
5. Data on catch by hook position should be collected as part of routine camera footage review as this can help estimate the effect of fishing deeper on catch rates.

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Appendix 1 Individual trip results

Trip 1, Vessel A, targeting bluefin tuna, April 2024

The trip commenced just after the full moon, east of Dunedin. The skipper had added weights into the gear, in addition to Hookpods, in response to captures on the previous moon. Despite having two potentially catchy additions to the branchlines the combination of weights and Hookpods proved to be workable with minimal bin tangles, and all hooks were released from Hookpods. The Hookpods and weights were set at 1.6 – 1.8 m from the hook, and branchline configuration was consistent throughout the trip.

The vessel was operating in line with an industry code of practice to reduce risk to seabirds. Mitigation measures employed by the vessel included tori lines, night setting, Hookpods, weighted branchlines, hauling mitigation streamers, bait retention, and holding and batch discarding of offal. Gear modifications were limited to those deemed to be likely to increase gear depth and hence further reduce risk.

Typical bird abundance around the vessel for the first few days was; 5-10 great albatross (*Diomedea spp.*), 5-10 Salvin's albatross (*Thalassarche salvini*), 5-10 white-capped albatross (*Thalassarche cauta*), 0-5 Buller's albatross (*Thalassarche bulleri*), 0-5 black-browed albatross (*Thalassarche melanophris*) and 20-50 White-chinned petrels (*Procellaria aequinoctialis*). Storm petrels, cape petrels (*Daption capense*) and prions (*Pachyptila spp.*) were seen occasionally. Generally, numbers of birds were lower in the second half of the trip, when other surface longliners were working in the same general area. One Buller's albatross, one white-capped albatross, and two white-chinned petrels were caught dead, all on separate sets and none in baskets with TDRs. All birds caught were hooked in the bill and had wet, but not completely waterlogged, plumage.

Eight lines were fished, typically set between 0100 and 0430, and hauling usually started at 1500. Sets comprised of approximately 900 hooks. The branchline timer was held constant at 14 seconds for the whole trip. Gear was modified for a portion of each set with two to four, usually three, different gear configurations tested. Altered gear sections were deployed for five to seven baskets, reverting to the skipper's normal setup between experimental sections. Basket size and float rope length were modified to examine the effect on fishing depth. The addition of a 250 g lead weight to float rope clips was also trialled. Setting speed varied between sets, and was partially dependent on weather conditions. Drift was variable between sets, in the order of 2 - 25 nautical miles in a northerly direction (Figure A1).

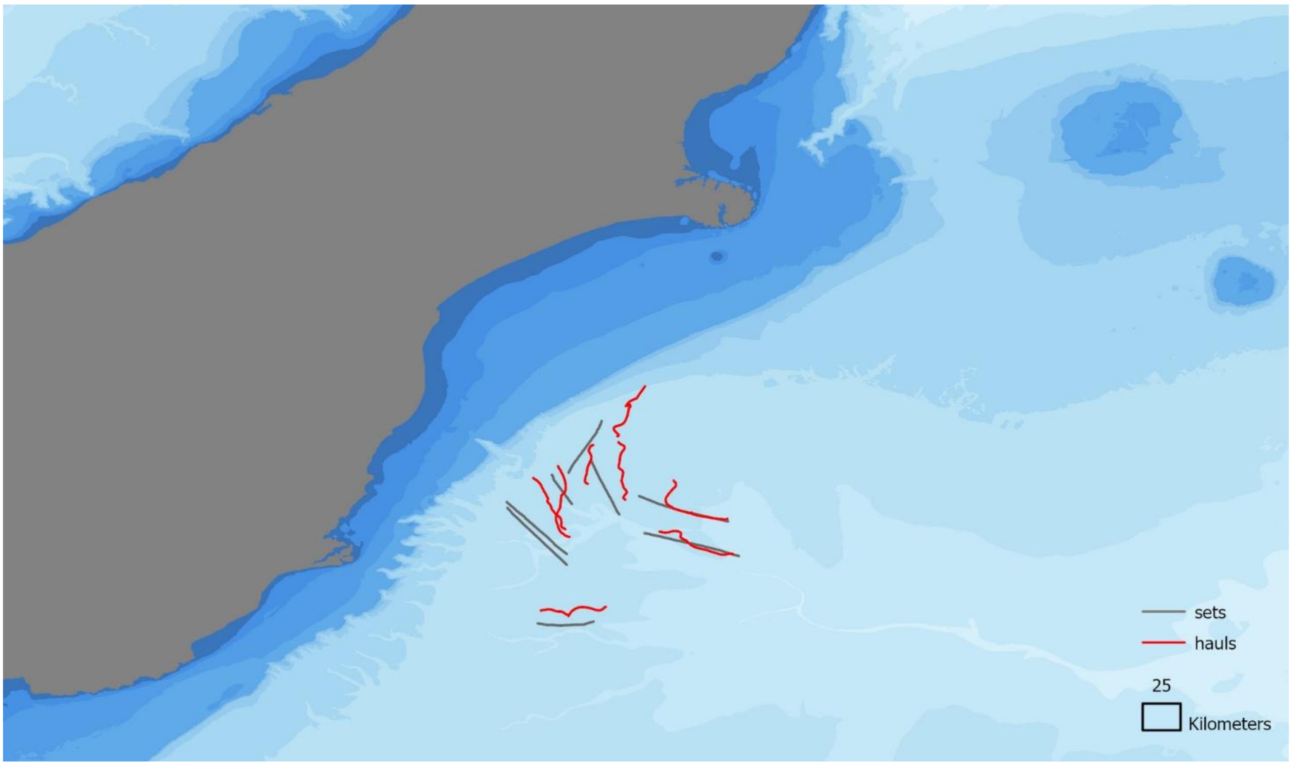

Figure A1. Set and haul locations for Trip one on Vessel A.

Time depth recorder data – trip A, Vessel A

A total of 200 valid TDR records were collected across eight treatments. Two TDRs were lost and one malfunctioned. All TDRs initially settled out below 20 m depth, and depth profiles over the first ten minutes reflected changes made to increase depth (Figure A2). However, as the soak progressed gear depth was influenced by current, drift, and catch which produced much more variation in depth and at times gear was above 20 m depth (Figure A3. Concentrating on time spent above 10 m, instances were almost exclusively around fish caught on the line (Figure A4).

Figure A2. Histograms of TDR depth during the first 15 minutes of the soak for Trip one on Vessel A targeting bluefin tuna, by set and treatment, weight = 250-gram weight on the float rope.

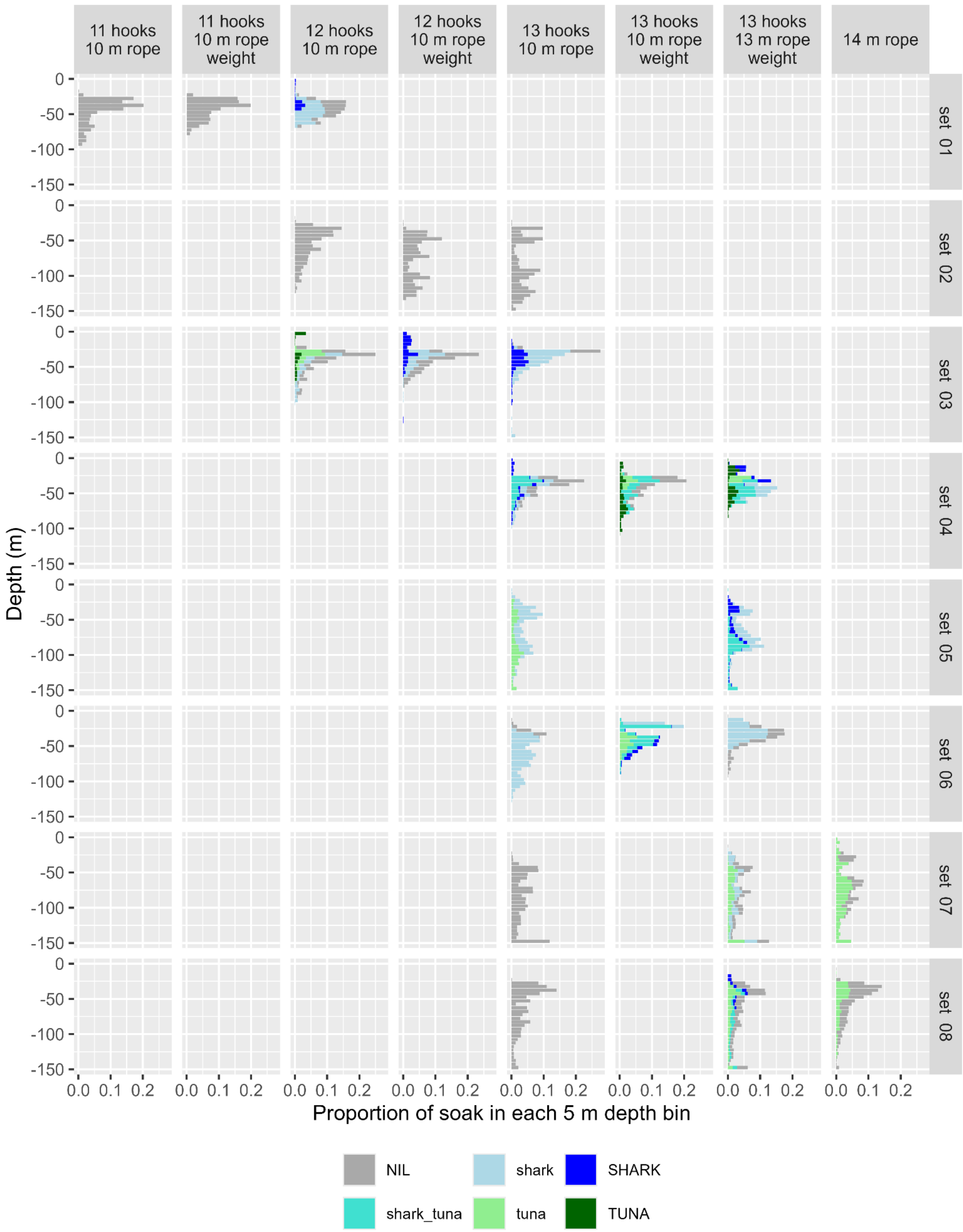

Figure A3. Histograms of TDR depth during the whole soak for Trip one on Vessel A, by treatment, with weight = 250 g weight on the float rope. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket. NIL = no catch in the TDR basket.

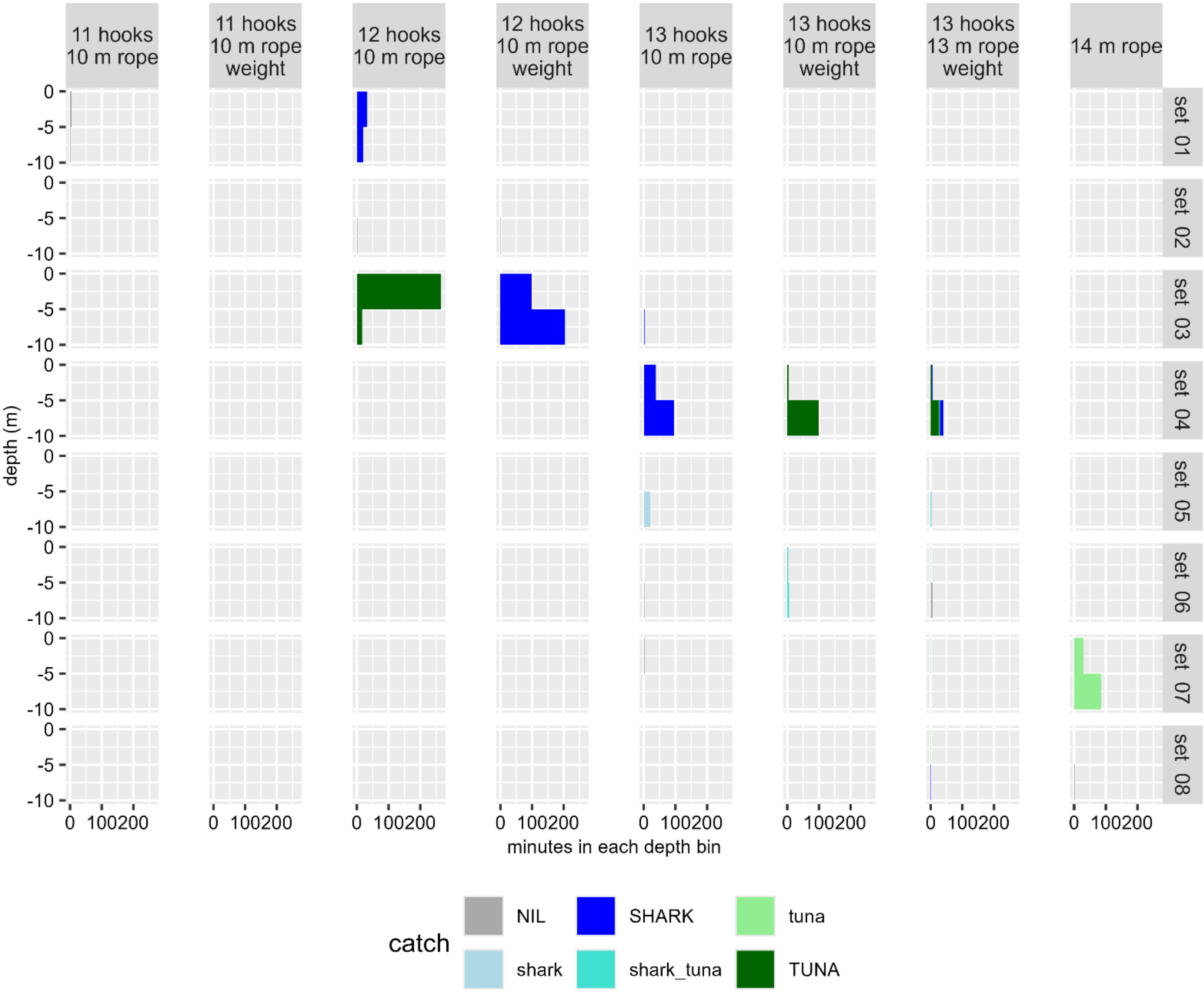

Figure A4. Histograms of time TDRs spent in the top 10 m during the whole soak for Trip one on Vessel A, by treatment with weight = 250 g weight on the float rope. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket. Total number of TDR deployments = 200.

Temperatures fished ranged from seven to fourteen degrees centigrade (Figure A5). Thermocline depth varied between set from 50-100m, and set two was across a temperature break, with two distinct bodies of water apparent in temperature-depth plots (Figure A6)

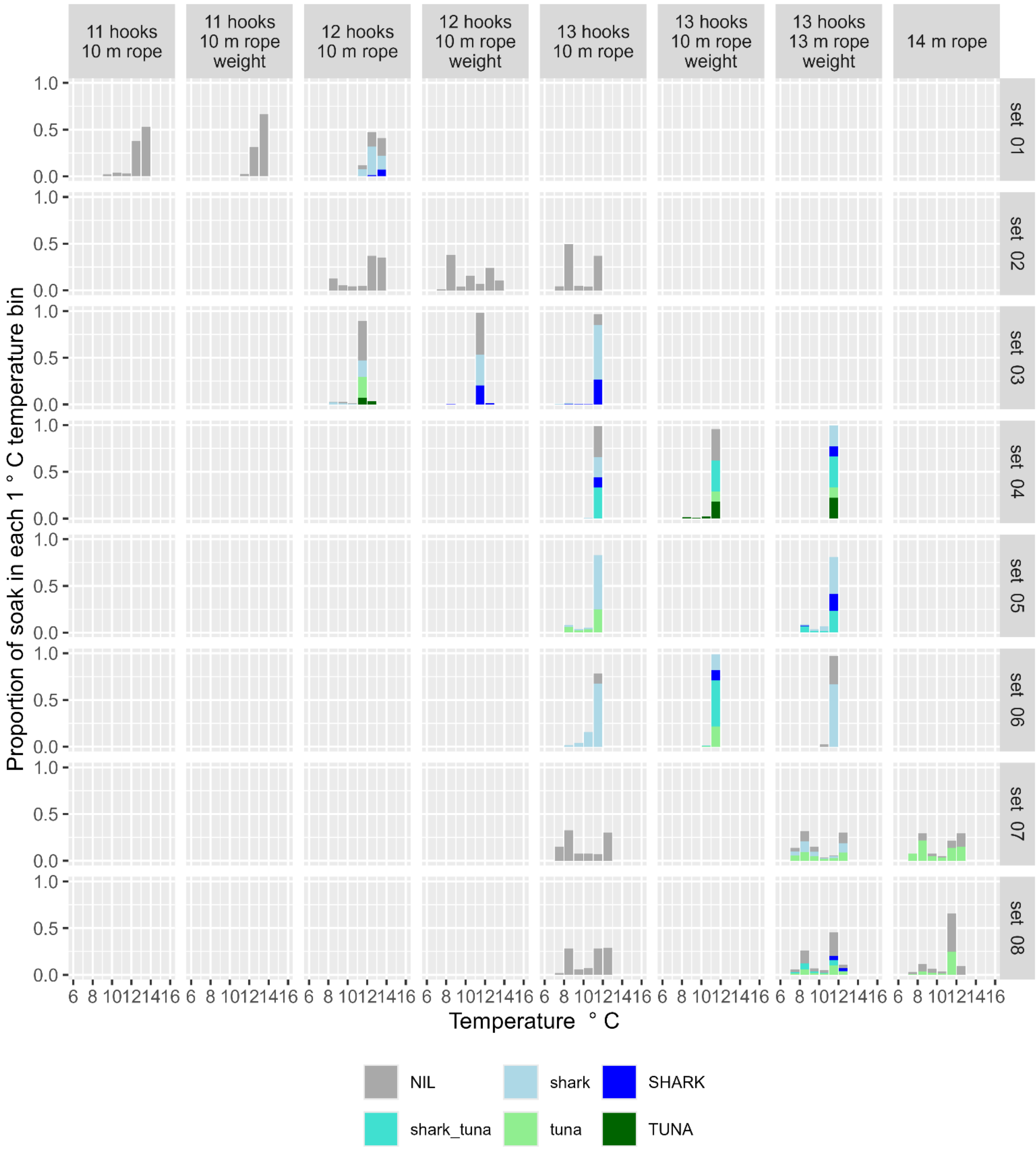

Figure A5. Histograms of TDR temperature during the whole soak for Trip one on Vessel A, by treatment. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

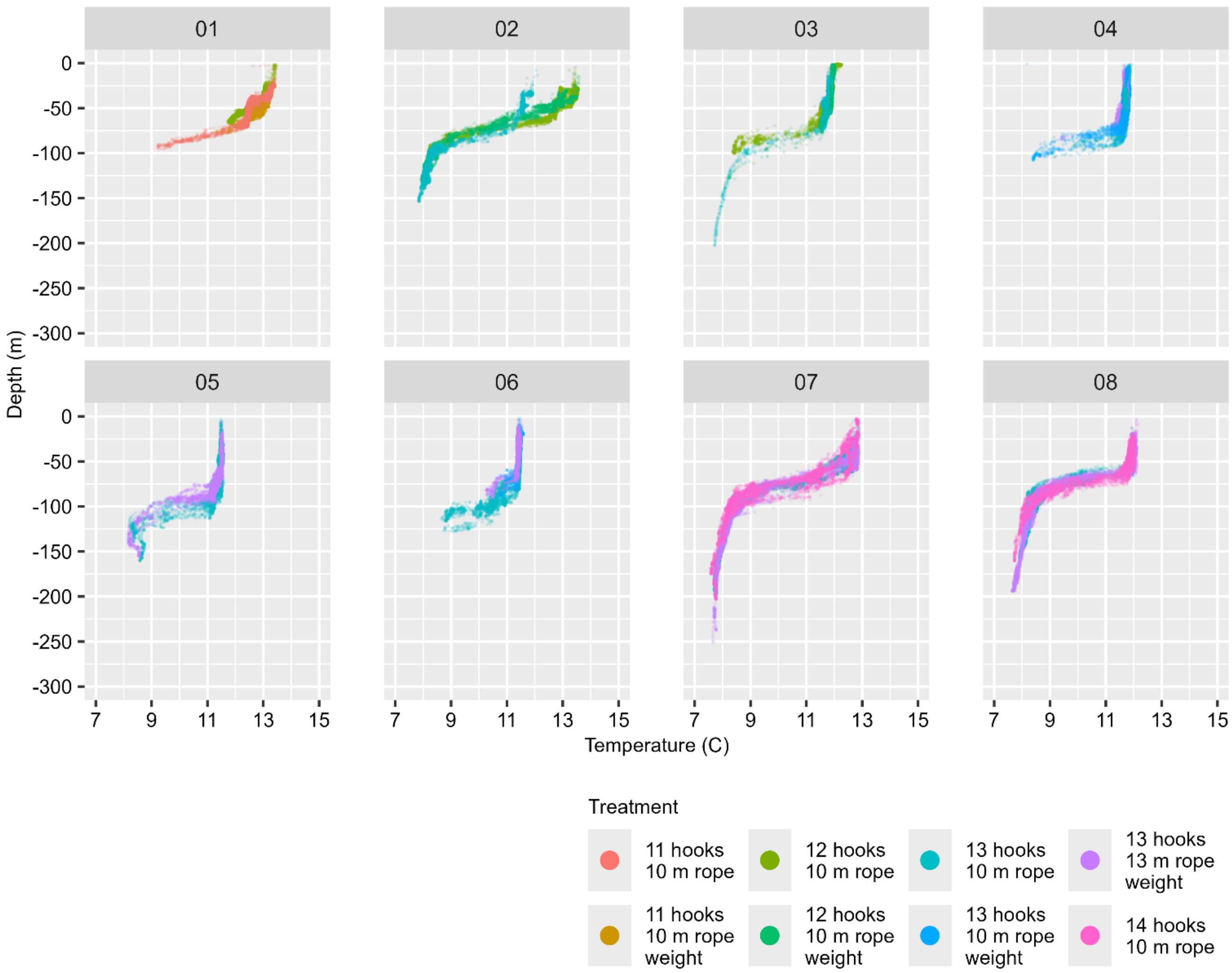

Figure A6. Temperature-depth plots, by set for Trip one on Vessel A. Colour indicates float rope length.

Trip B, Vessel B, targeting bigeye tuna, February 2025.

The trip comprised six longline sets over eight days, and commenced on the new moon. Lines were set north of Cape Runaway, targeting a mixture of bigeye and yellowfin tuna, and to a lesser extent swordfish. Mitigation measures employed by the vessel included night setting, tori line, line weighting, offal and returned bait retention, and a dropper and deck hose were employed to deter birds whilst hauling. Drift was to the south-east, and generally small (Figure A7).

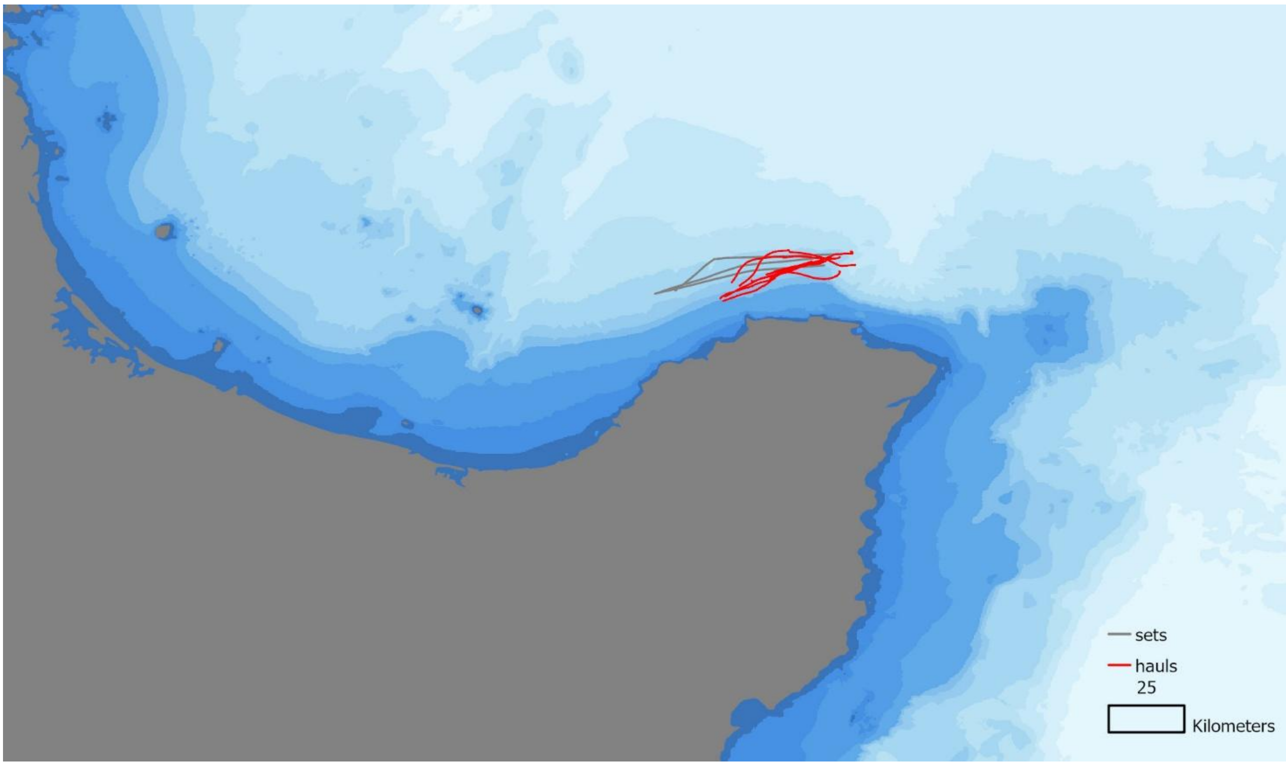

Figure A7. Set and haul locations for trip two on Vessel B.

A single wandering albatross (*Diomedea exulans*) was caught during the haul, on an experimental branchline which was recovered slightly slower than normal. It was hooked in the inside upper tip of the bill, brought slowly beside the sea door, and the hook was rolled out without touching the bird. A leatherback turtle was caught on a section of normal gear, on a hook next to a float. It was foul-hooked in the shoulder and, due to its relatively small size (estimated curved carapace length 1.0 m), was able to be brought slowly to the sea door and the branchline was cut with less than 10 cm of monofilament attached. This was deemed to pose less risk to the turtle than attempting to remove the hook.

Bird abundance and behaviour were reasonably consistent throughout the trip with birds aggressively attacking and removing baits from hooks as they were hauled, during the first part of the haul. Black petrels (*Procellaria parkinsoni*) and flesh-footed shearwaters (*Puffinus carneipes*) were observed diving on baited hooks beside the vessel 1-3 m outside of the hauling mitigation dropper, and on one calmer day in front of the line being hauled. Successful attacks on baited hooks resulted in the diving birds bringing loose baits back to the surface where they were often subject to secondary attacks by albatrosses or other petrels and shearwaters. White-capped and Salvin's albatross were also observed to remove baits from hooks underwater, albeit at much shallower depths than black petrels and shearwaters (one metre cf. five metres). After approximately an hour birds became less aggressive and would only attempt to take baits from the most accessible hooks. Typical maximum bird abundance within 100 m of the vessel, per haul, was 10 royal albatross (*Diomedea epomophora*), five wandering albatross, seven Salvin's albatross, two white-capped albatross, two Buller's albatross, two black-browed albatross, 50 black petrels, and 40 flesh-footed shearwaters. Storm petrels and Buller's shearwaters (*Ardenna bulleri*) were also seen occasionally.

Time depth recorder data – Trip B, Vessel B

TDRs were deployed on the second half of the gear set, and lines were all hauled from the last end set. This allowed sufficient time to detach TDRs from branchlines, download data, reprogram TDRs and reattach them to branchlines prior to redeployment. Consequently, some TDR branchlines were often recovered before dark and, generally catches were slightly better on the second half of the line which fully encompassed the 'evening bite'.

A total of 200 valid TDR records were collected. Two TDRs were lost; one to (almost certainly) a shark and one to a marlin, one battery ran flat, and one recorded spurious depths and was not deployed on subsequent sets.

Increases to float rope length increased fishing depth over the first 15 minutes of the soak period (Figure A8). In a similar manner to trip one, depth distribution covering the whole soak period had much longer tails (Figure A9). During set four the baskets with eight-metre ropes were generally deeper than those with 16 m ropes (Figure A9). Otherwise, 16 m float ropes generally produced deeper fishing depths. The time TDRs spent above 10 m was almost exclusively associated with fish caught on the 'TDR branchline' (Figure A10).

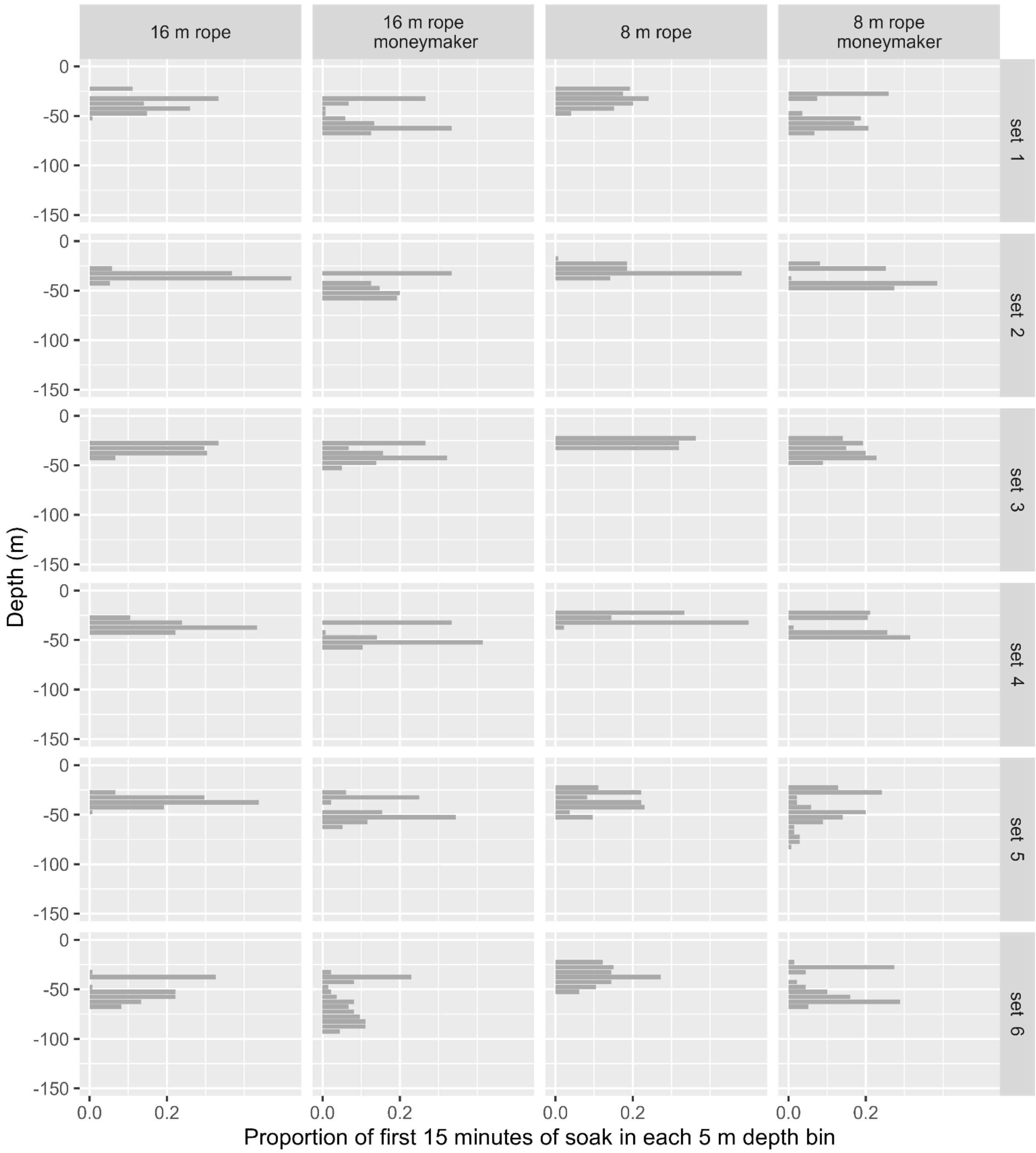

Figure A8. Histograms of TDR depth during the first fifteen minutes of the soak, by set and treatment

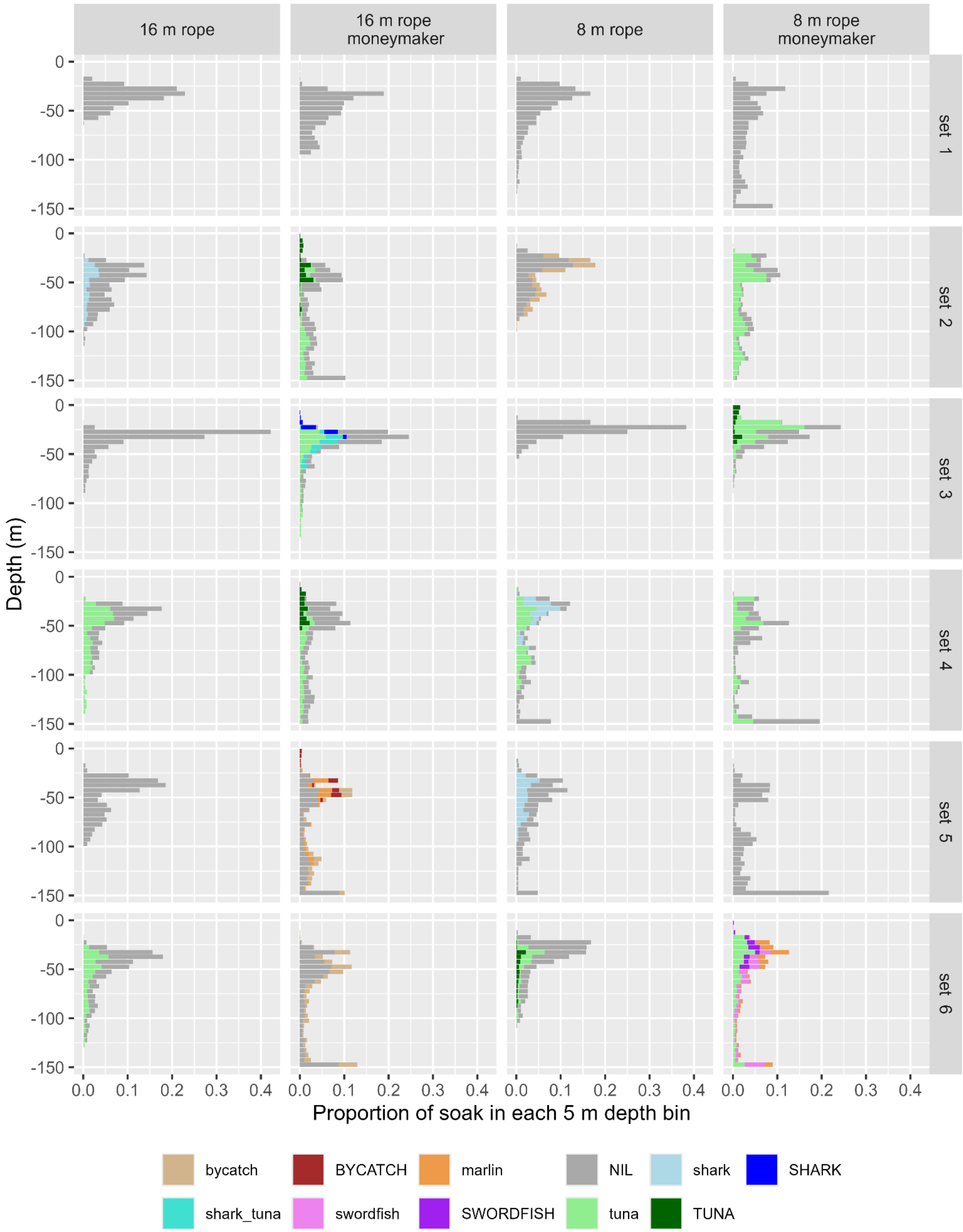

Figure A9. Histograms of TDR depth during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

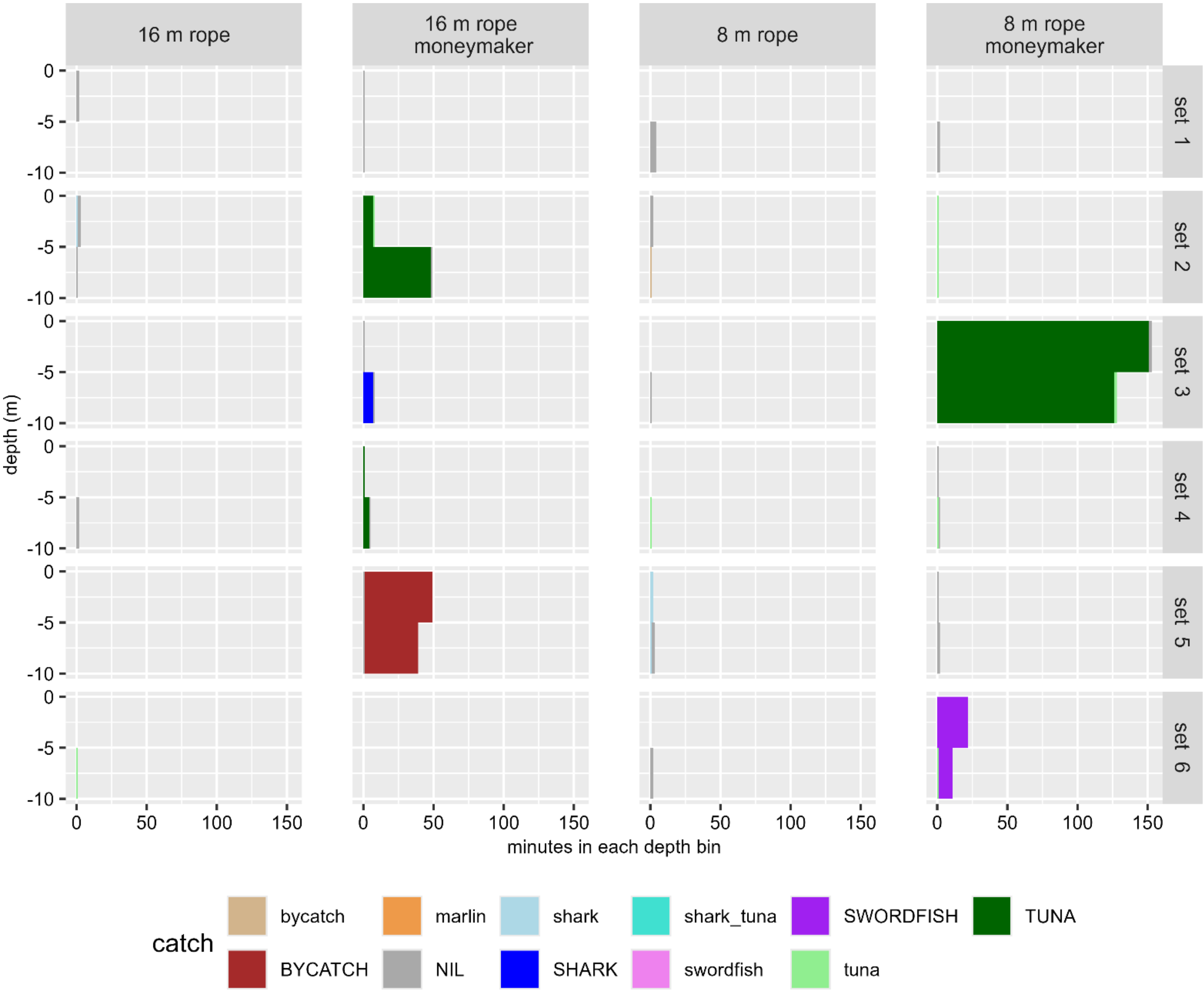

Figure A10. Histograms of time TDRs spent in the top 10 m during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket. Total number of TDR deployments = 234.

Temperature was generally a function of depth with no strong horizontal breaks in temperature along the longlines. Gear fished in temperatures between 14 and 22 degrees Celcius (Figure A11). Thermocline strength varied and stronger thermoclines generally tied up with depths of scattering layers on the echo sounder at night (Figure A12). Between set variation in temperature fished was greater than between treatment variation (Figure A11).

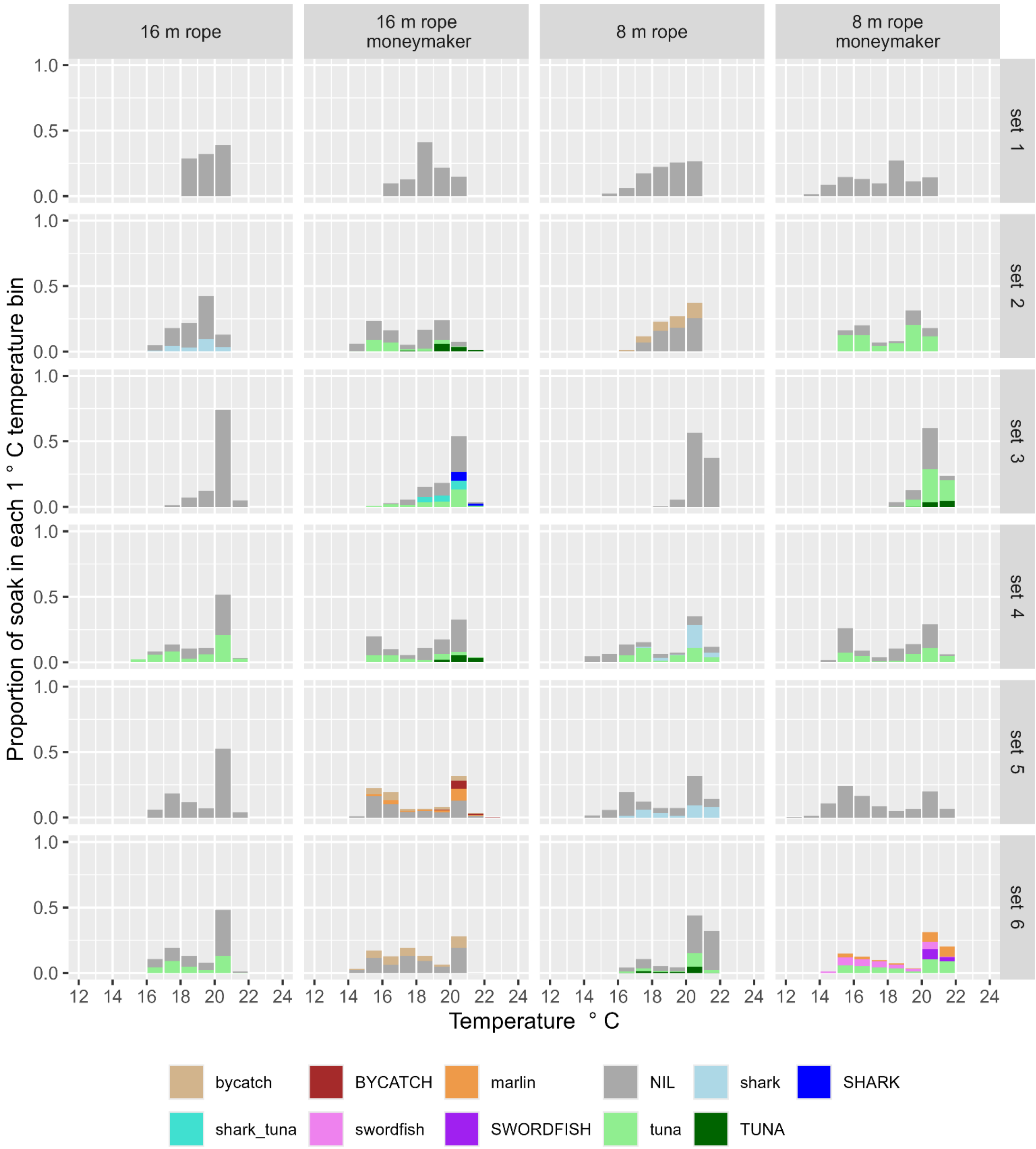

Figure A11. Histograms of TDR temperature during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR branchline, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

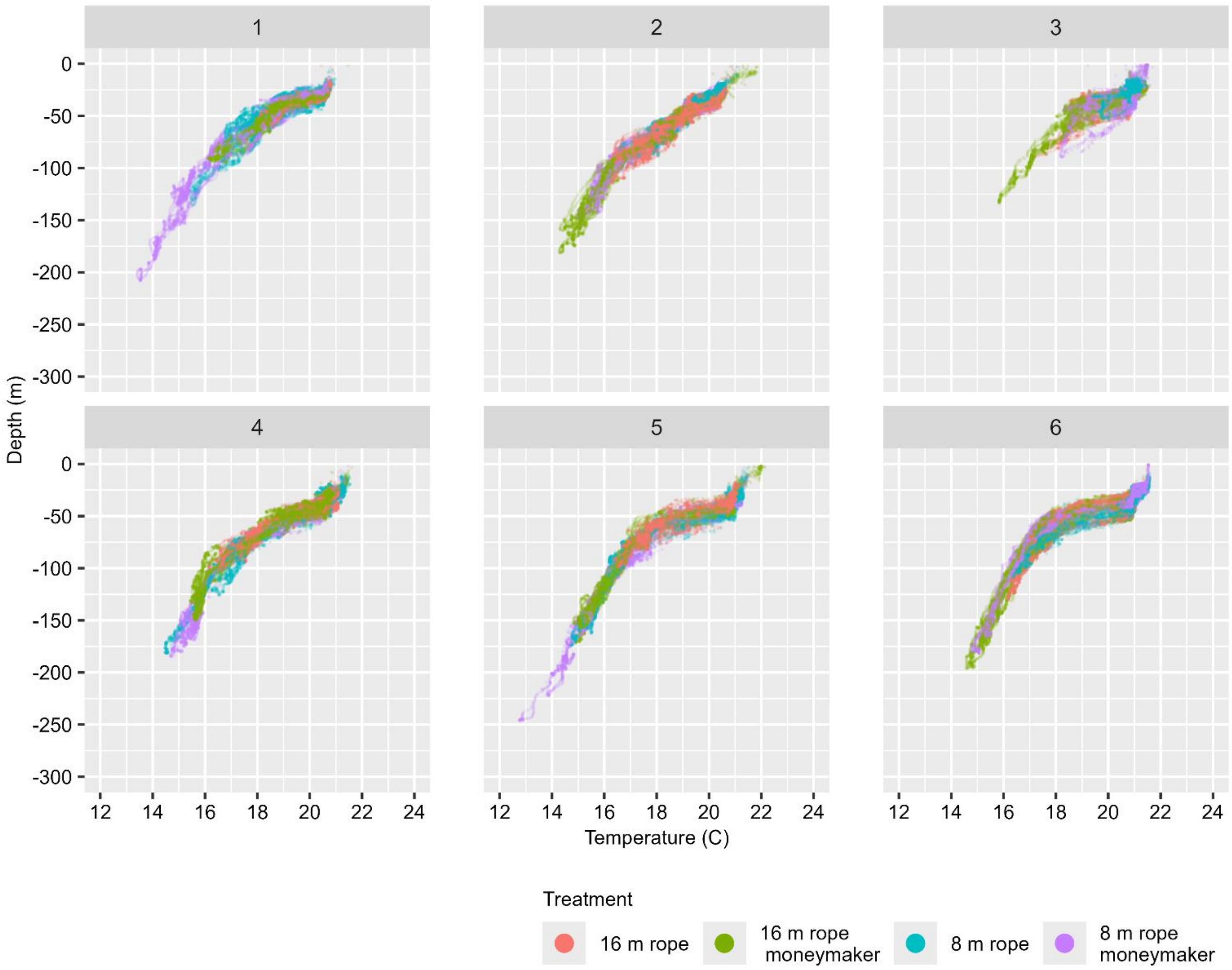

Figure A12. Temperature-depth plots, by set. Colour indicates the float rope length.

Trip C1, Vessel C targeting swordfish, March 420m2025

Results

The trip comprised eight longline sets over twelve days, and fishing commenced six days before, and finished two days after, the full moon. Lines were set reasonably shallow, west of Onehunga, targeting swordfish (*Xiphias gladius*), and three other boats were fishing in the same area, slightly to the north. Mitigation measures employed by the vessel included Hookpods and weight on all branchlines, bait retention, and a hauling 'curtain'. The typical fishing pattern involved setting lines between 1630 and 2130, and hauling between 0700 and 1500.

Bird abundance and behaviour were reasonably consistent throughout the trip with birds following the vessel in relatively low numbers and rarely attacking baited hooks. Dives during the set were very occasional, with one or two successful bait steals observed. During hauling, birds would typically follow well astern and wait for offal dumps rather than attacking baited hooks as they were hauled. Typical maximum bird abundance within 100 m of the vessel, per haul, was five great albatross (*Diomedea spp.)*, five white-capped albatross (*Thalassarche cauta*), and ten procellaria petrels. White-chinned petrels (*Procellaria aequinoctialis)* were present for the first half of the trip and black petrels (*Procellaria parkinsoni*) were present throughout. Black-browed albatross (*Thalassarche melanophris*), Buller's albatross (*Thalassarche bulleri*), and grey-faced petrels *(Pterodroma gouldi)* were seen occasionally.

A single white-capped albatross was caught dead and waterlogged beside a moneymaker float on a non-experimental section of the gear. A striped marlin *(Tetrapturus audax)* was caught on the other hook adjacent to the moneymaker. The marlin was alive and on the surface as the vessel approached, and the whole basket was relatively shallow.

Two leatherback turtles (*Dermochelys coriacea*) were caught on non-experimental sections of gear, on separate sets. The first was between approximately 1.8 and 2.0 m curved carapace length. It was tangled in the mainline and a branchline on hook number 7 or 8 in a 10-hook basket, with the hook in the neck. It was slowly brought alongside and the mainline was removed. It then swam strongly and dived briefly. Despite attempts to get the turtle alongside the branchline was cut with approximately four metres of monofilament, a Hookpod and a sliding lead attached. The second leatherback was smaller, approximately 1.6 m curved carapace length and was caught on a snood next to a float which was tangled with the float rope. An open wound, approximately 10 cm long was visible on the right shoulder and the hook was at the base of the right front flipper. The turtle was slowly brought alongside and the hook was cut off with about 10 cm of monofilament attached.

A total of 275 valid TDR records were collected. Six TDRs were lost to sharks, marlin, and tangles.

Catch rates of fish were not particularly satisfactory, and the skipper moved between most sets. In a similar manner to previous trips, catch and depth was highly variable between sets and baskets. Catch influenced soak depth for a number of TDR branchlies resulting in several 'hook hours shallower than 10 m' (Figure A16), though this occurred more often on the branchlines set deeper.

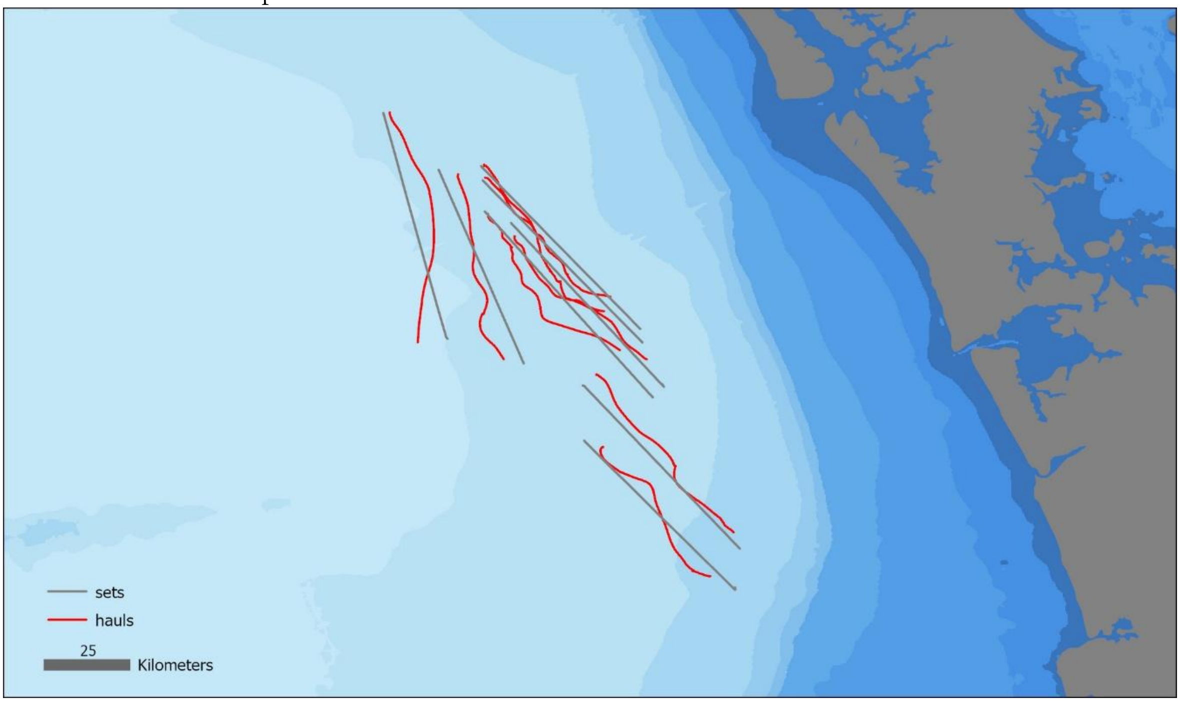

Figure A13. Set and haul locations for trip C1 Vessel C.

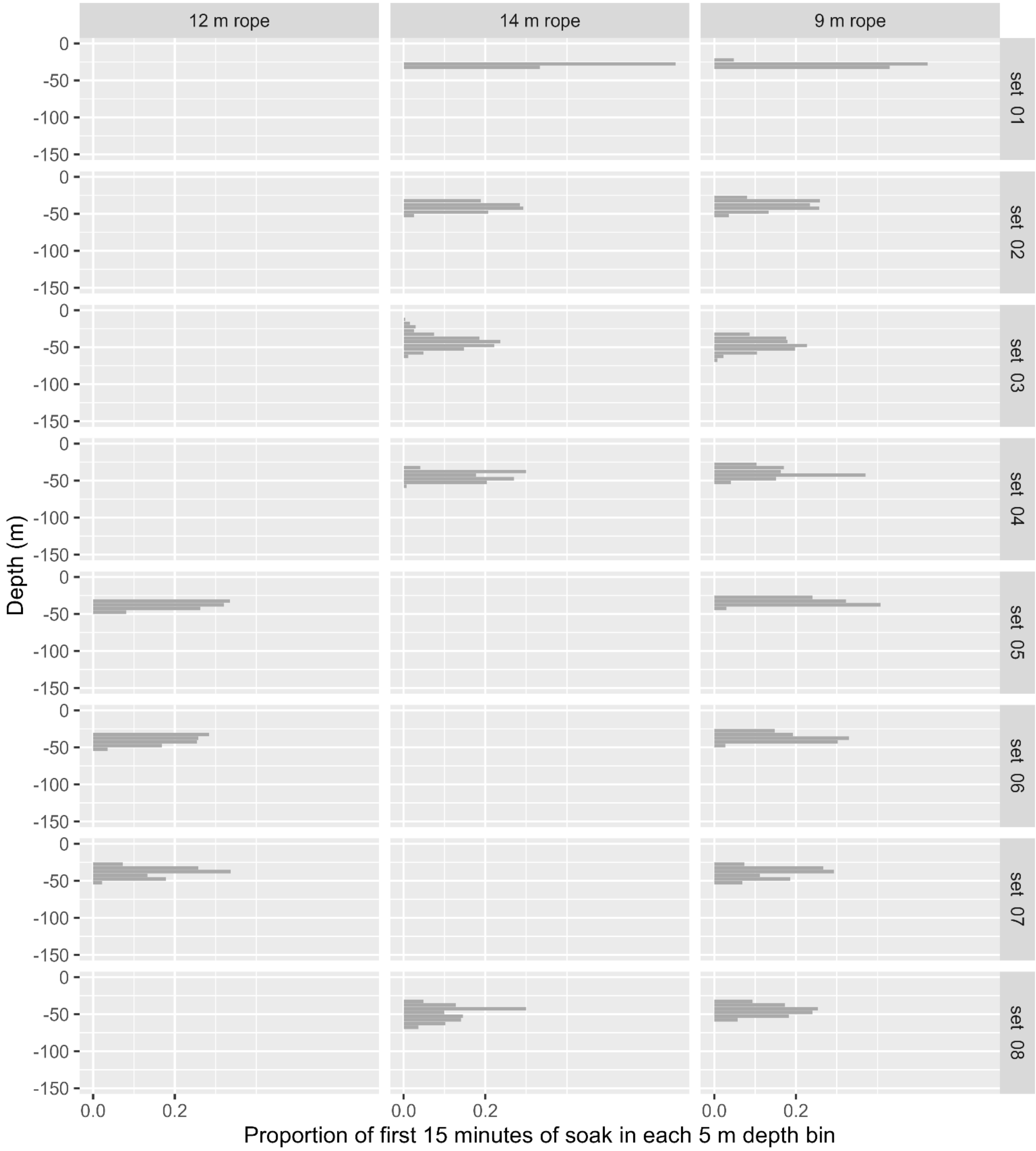

Figure A14. Histograms of TDR depth during the first fifteen minutes of the soak, by set and treatment

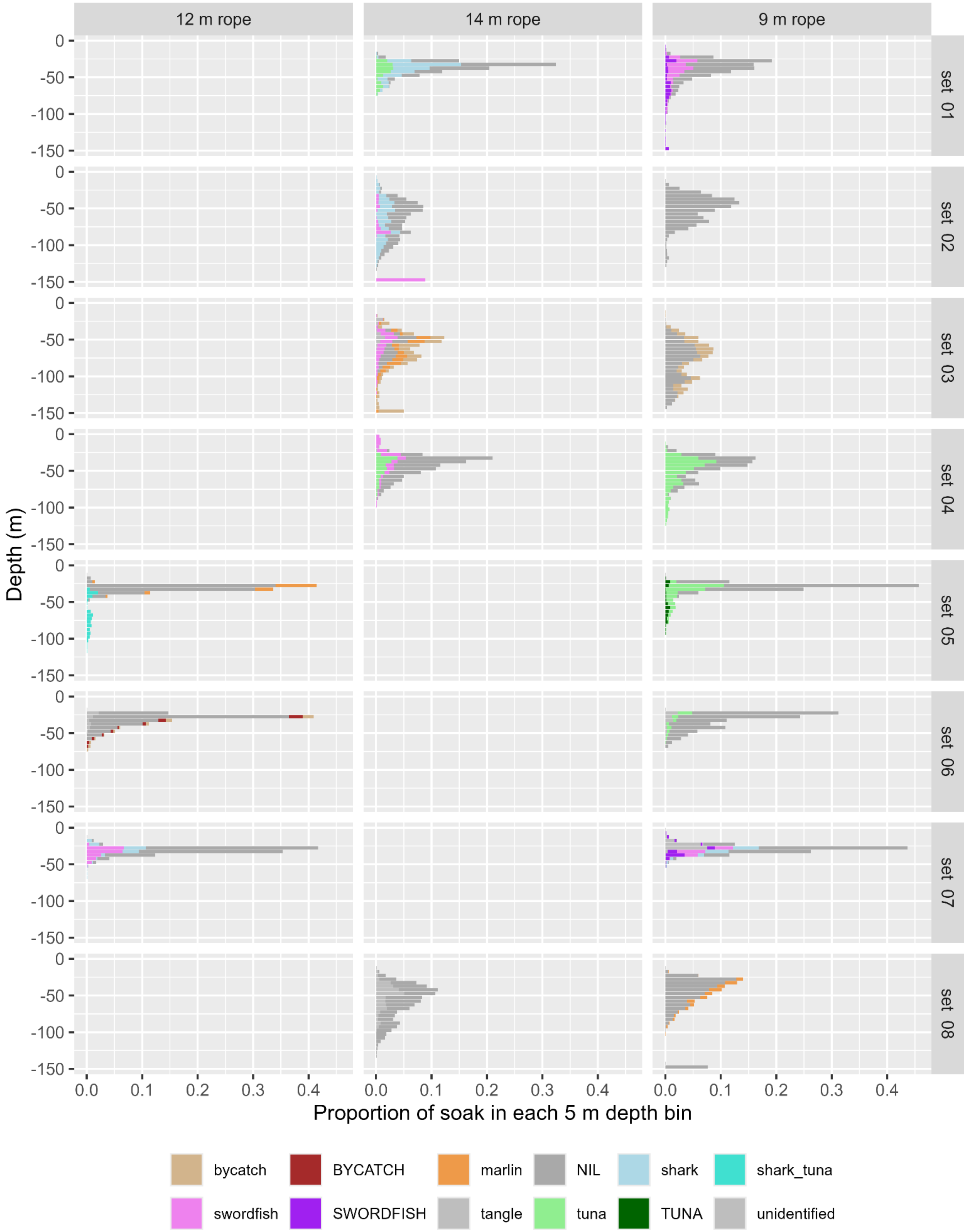

Figure A15. Histograms of TDR depth during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

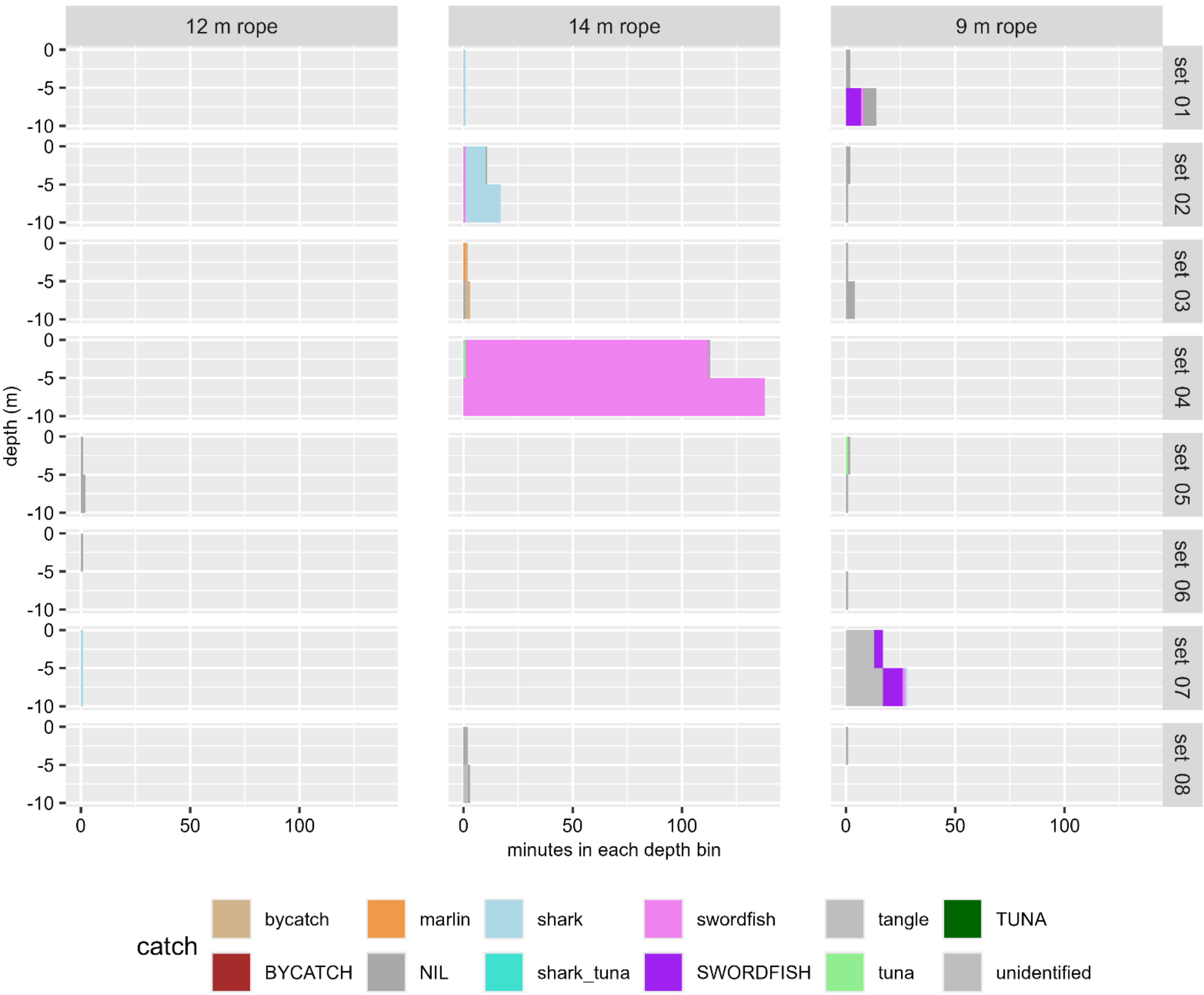

Figure A16. Histograms of time TDRs spent in the top 10 m during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket. Total number of TDR deployments = 234.

Although a reasonably strong thermocline was consistently present at approximately 50 m (Figure A18), variation in temperatures fished were greater between sets than between treatments within a set (Figure A17).

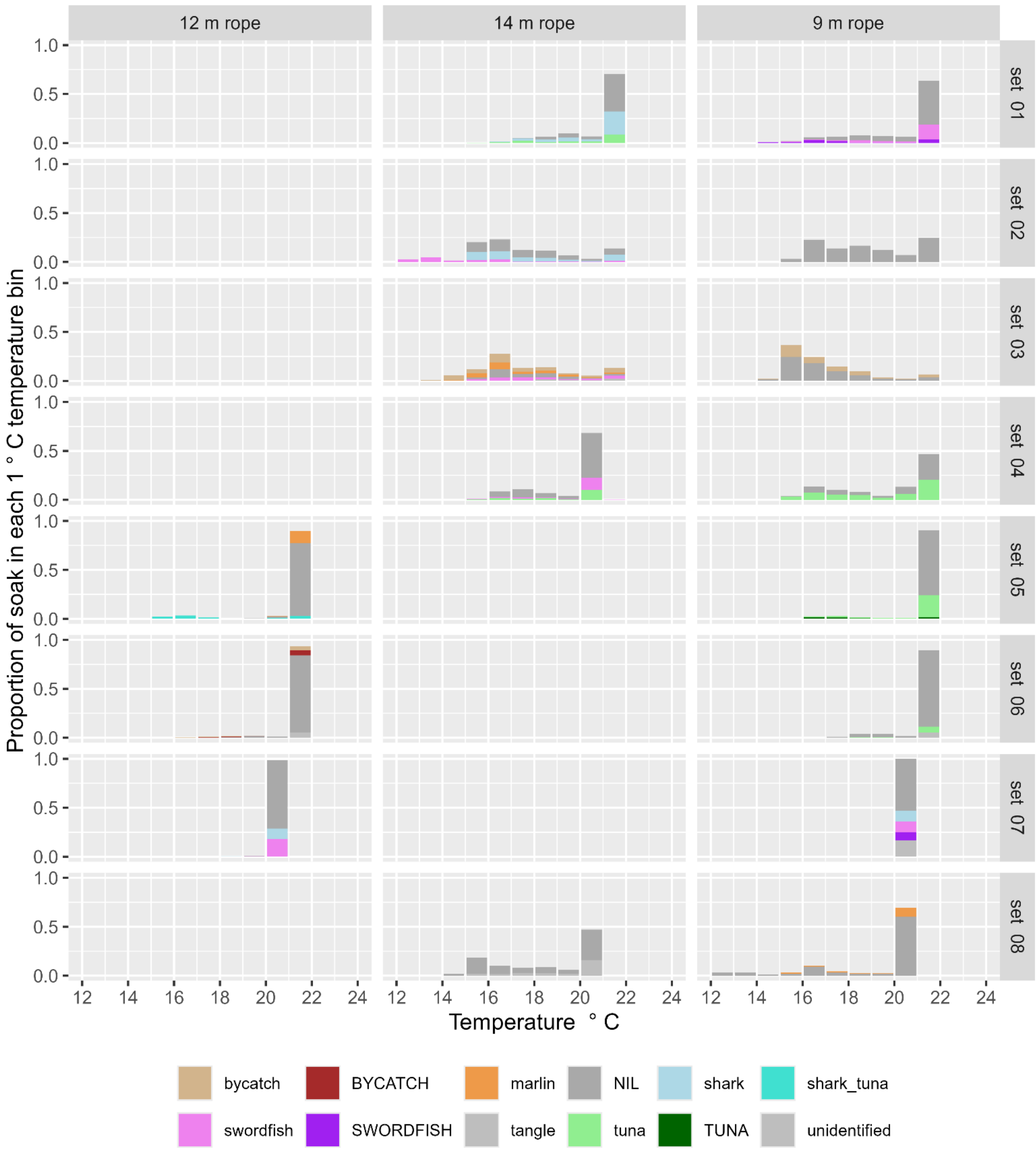

Figure A17. Histograms of TDR temperature during the whole soak, by set and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

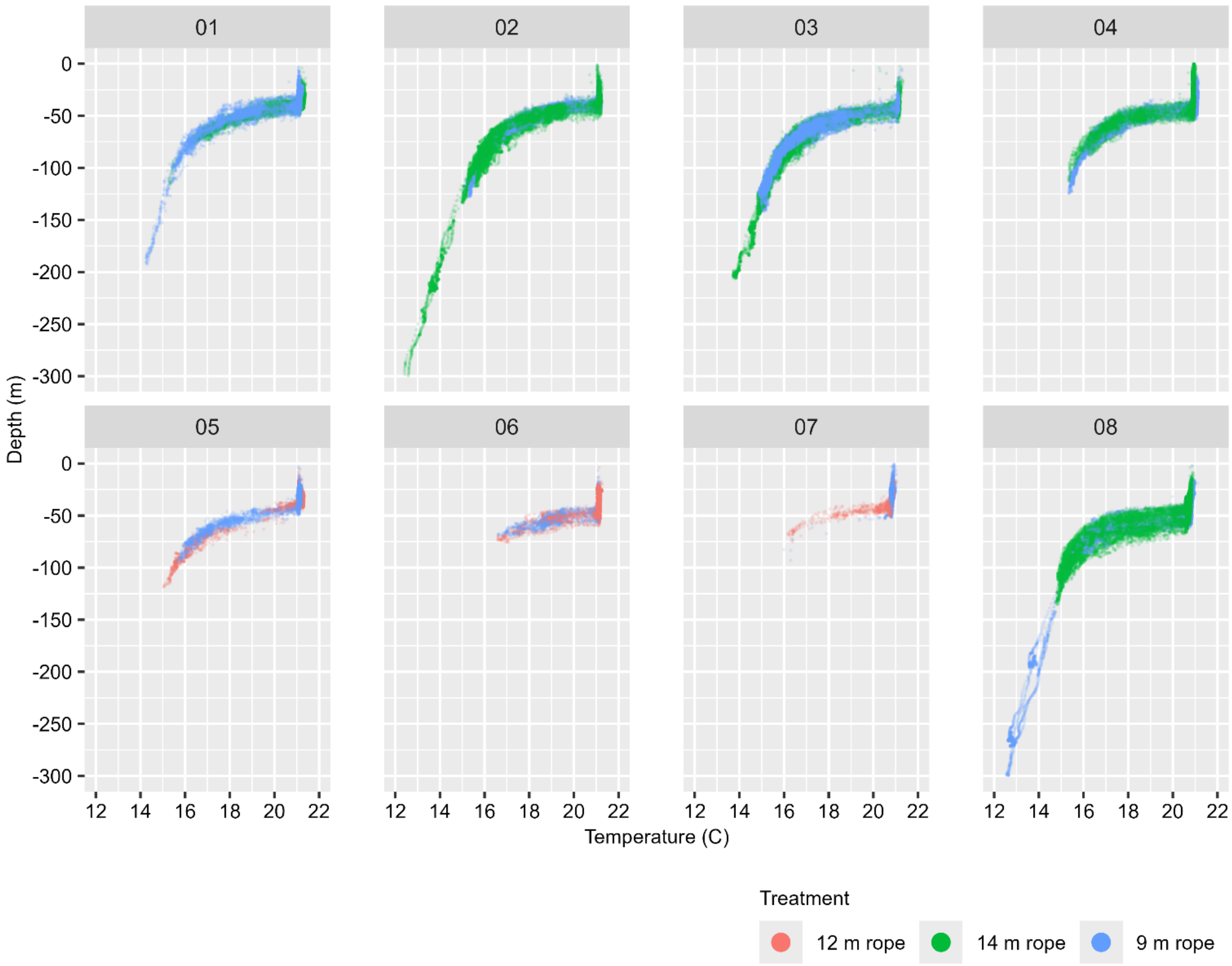

Figure A18. Temperature-depth plots, by set.

Trip C2, Vessel C, targeting bluefin tuna, April 2025.

Results

The trip comprised eight longline sets over ten days, and fishing commenced seven days after the full moon and finished on the new moon. Lines were set reasonably deep, east of Dunedin, targeting bluefin tuna (*Thunnus maccoyii, T. orientalis*), and two other boats were fishing in the same area. Lines were typically thirty miles long with 1200 hooks, though on the third set the line was cut short at 15 miles, due to poor weather conditions, and a single five-basket treatment section was deployed.

Mitigation measures employed by the vessel included a Hookpod and 60 g weight on all branchlines, bait and offal retention and batch discarding, and a hauling 'curtain'. The typical fishing pattern involved setting lines between 2300 and 0330, and hauling between 1400 and 2130.

Bird abundance and behaviour varied throughout the trip with birds following the vessel during the haul, and no birds visible during the set. During hauling, birds would typically follow astern and wait for offal dumps and baits lost during hauling, rather than attacking baited hooks as they were hauled. Typical daily maximum bird abundance within 100 m of the vessel, per haul, was two to six great (usually identified as royal) albatross (*Diomedea spp.)*, two to ten white-capped albatross (*Thalassarche cauta*), two to eight Buller's albatross (*Thalassarche bulleri*), one to four black-browed albatross (*Thalassarche melanophris*) 20 to 90 white-chinned petrels (*Procellaria aequinoctialis),* and five to 20 cape petrels *(Daption capense)*. Giant petrels *(Macronectes halli)* and prions (*Pachyptila spp.)* were also observed occasionally.

A total of 235 valid TDR records were collected. Typically three baskets were sampled per treatment section and either two or three baskets per control section. One TDRs was lost to a shark, one recorded spurious depths, and two ran flat.

Catch rates of fish were not particularly satisfactory, and the skipper moved between most sets in response to catches along the line, water temperature, and information from other vessels.

In a similar manner to previous trips, catch and TDR depth were variable between sets and baskets. However, relatively modest increases to float rope length consistently produced increased soak depths. Instances of TDRs above 10 m depth were almost all associated with fish caught on the branchline.

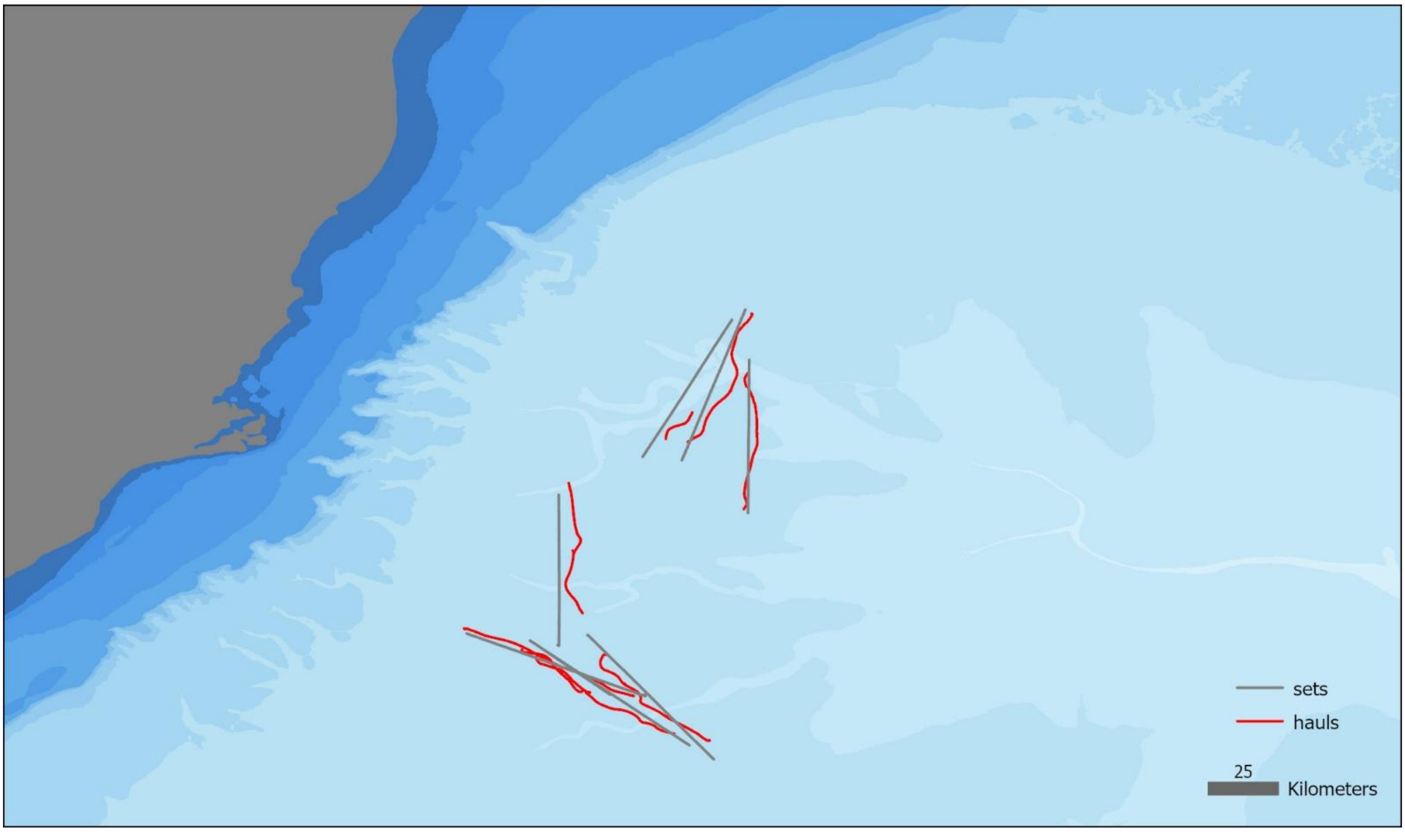

Figure A19. Set and haul locations for trip C1 Vessel C.

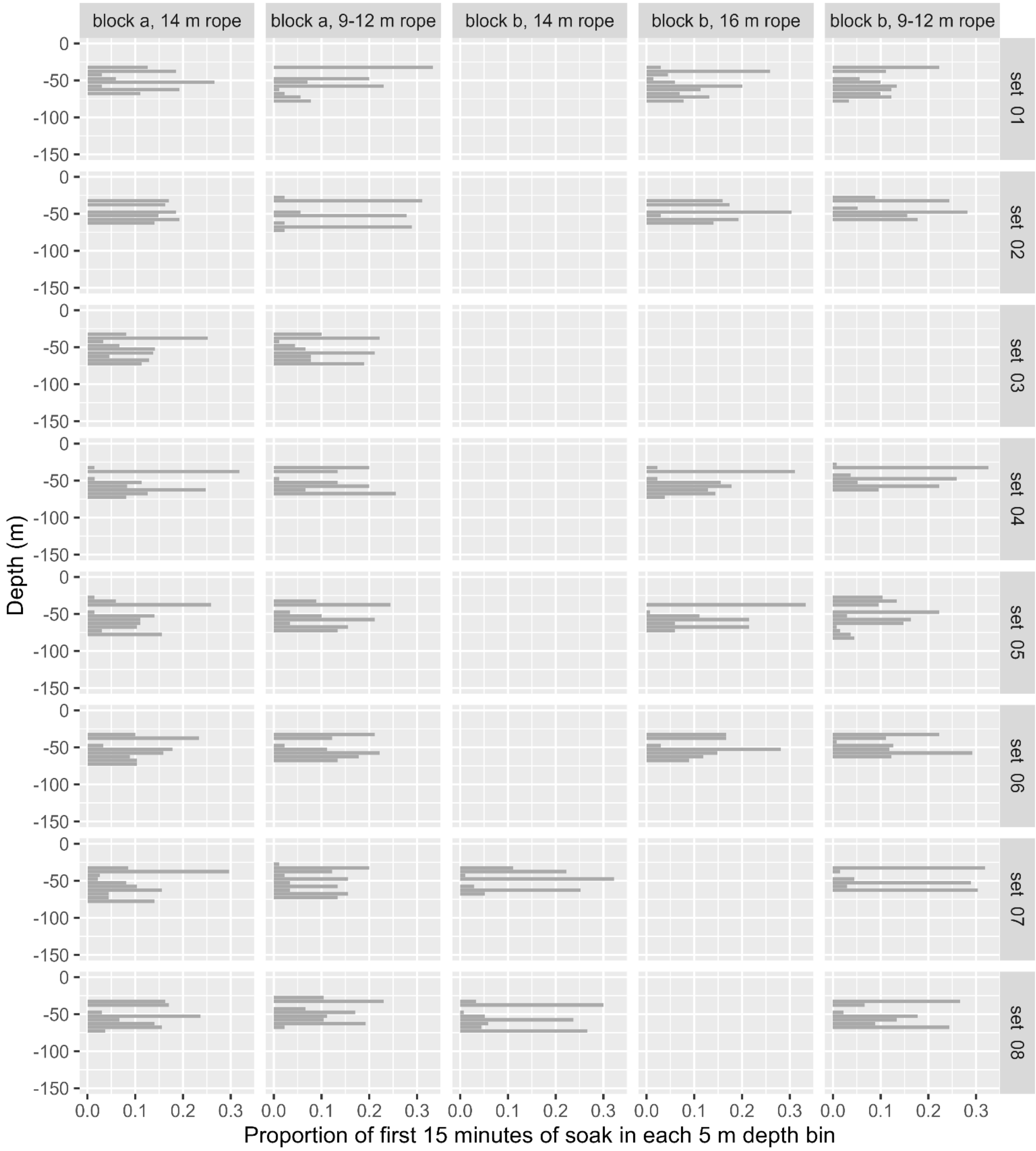

Figure A20. Histograms of TDR depth during the first fifteen minutes of the soak, by set and treatment

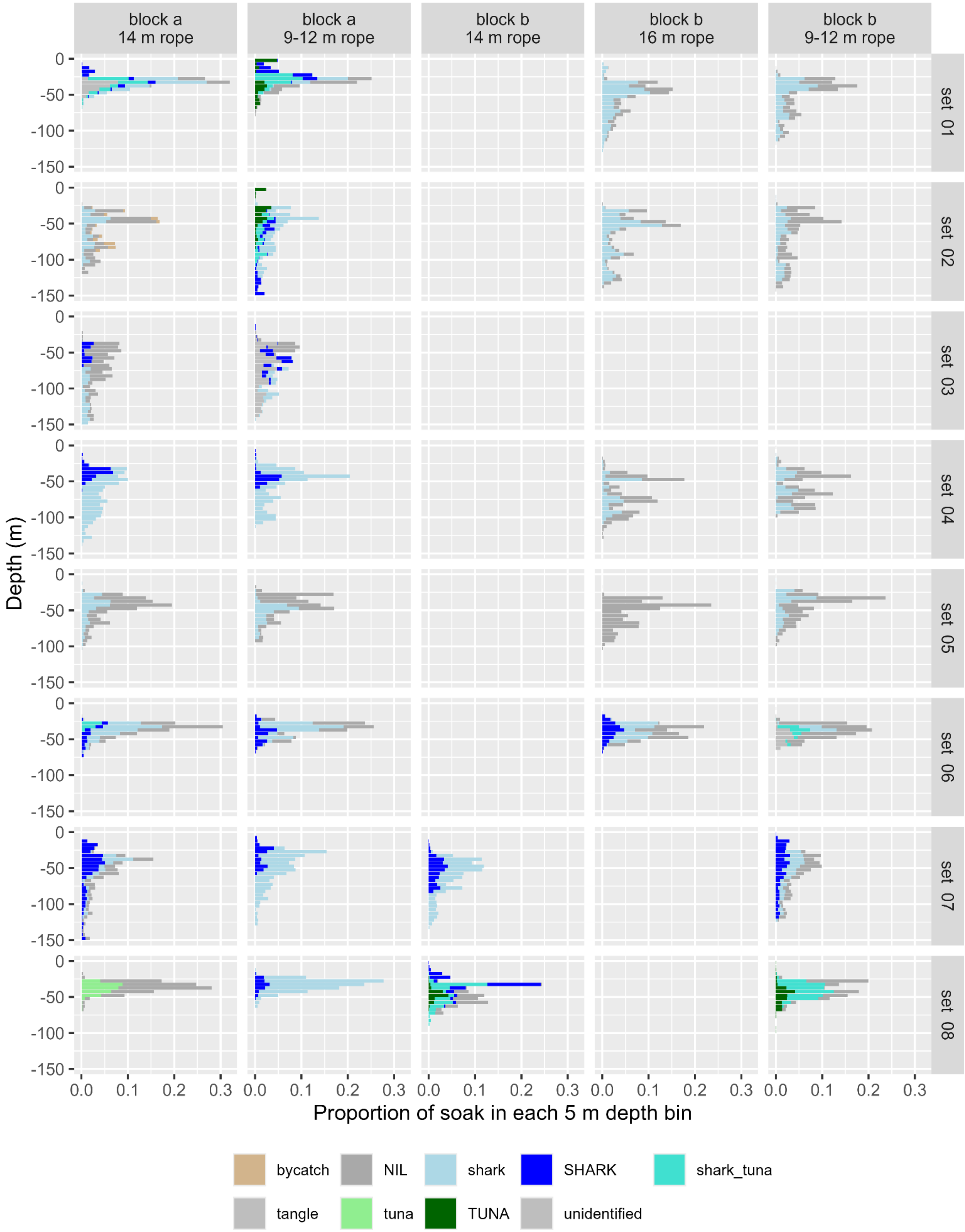

Figure A21. Histograms of TDR depth during the whole soak, by set, block, and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

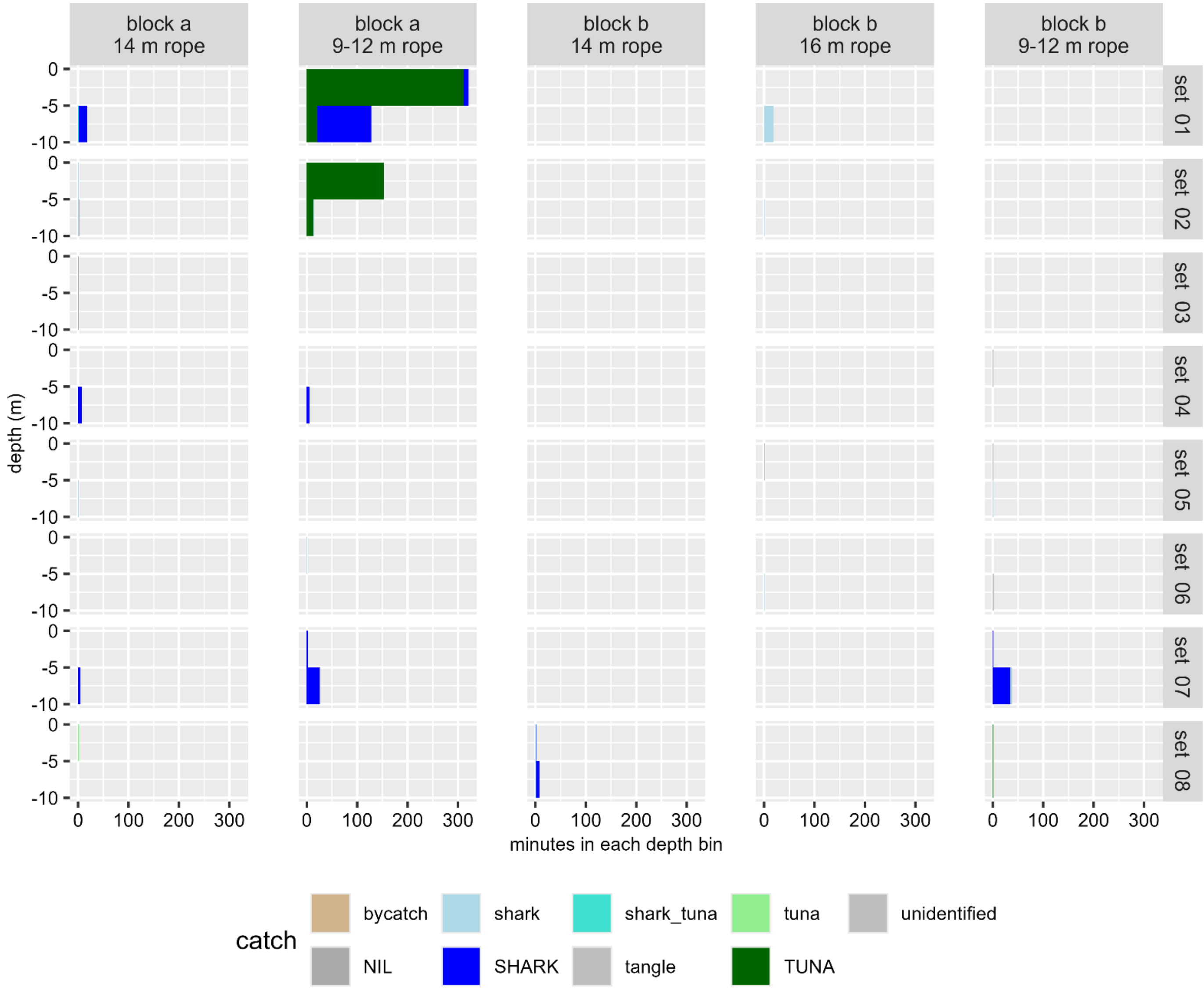

Figure A22. Histograms of time TDRs spent in the top 10 m during the whole soak, by set, block, and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket. Total number of TDR deployments = 234.

Thermocline depth and temperatures fished changed between sets with different blocks in sets 4 and 8 fishing in different water temperatures (Figure A24). Temperatures fished were similar between treatments (Figure A23).

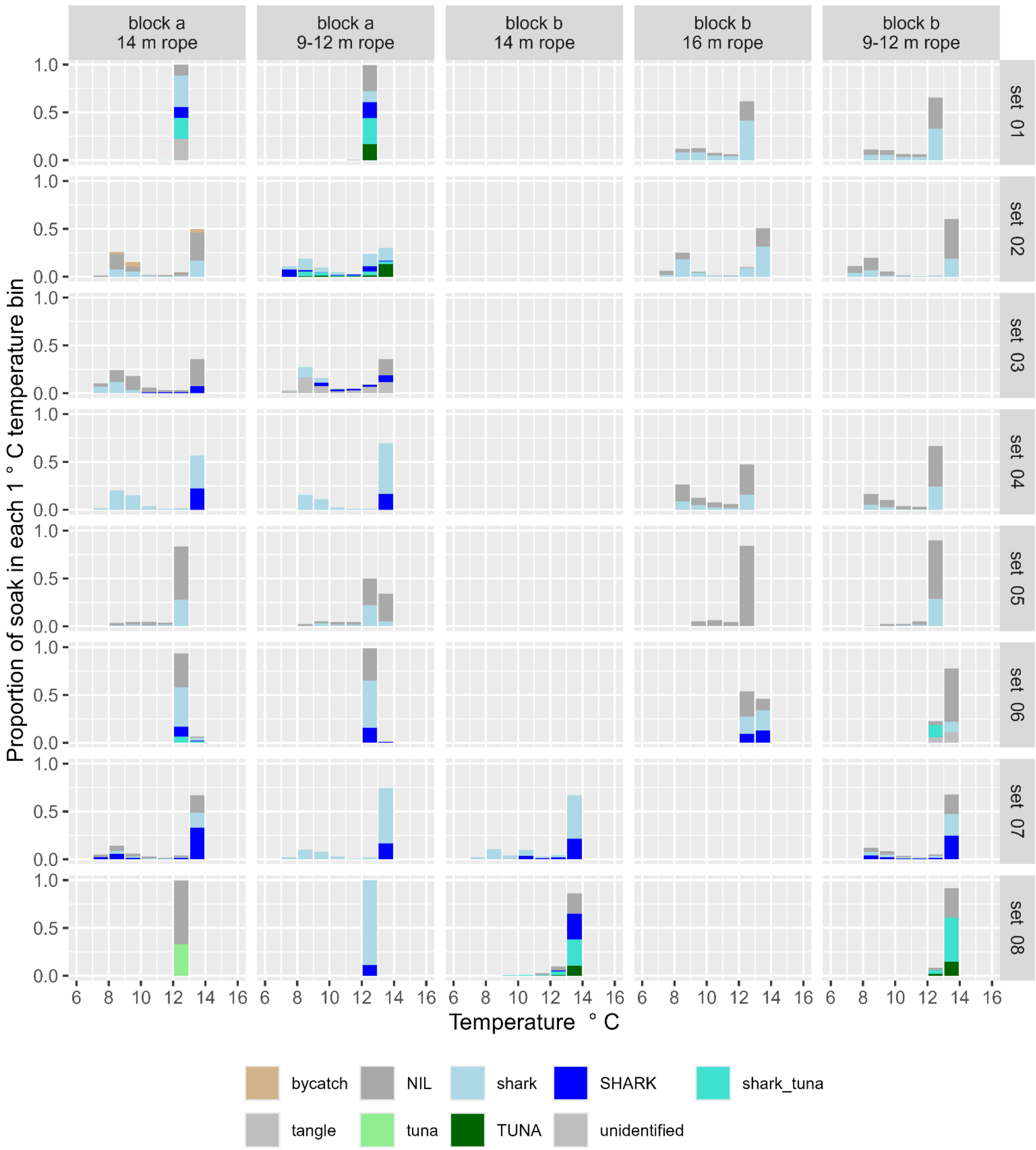

Figure A23. Histograms of TDR temperature during the whole soak, by set, block, and float rope length. Colours indicate catch with darker colours and capital letters indicating catch on the TDR snood, and weaker colours and lowercase letters indicating catch in the same basket, NIL = no catch in the TDR basket.

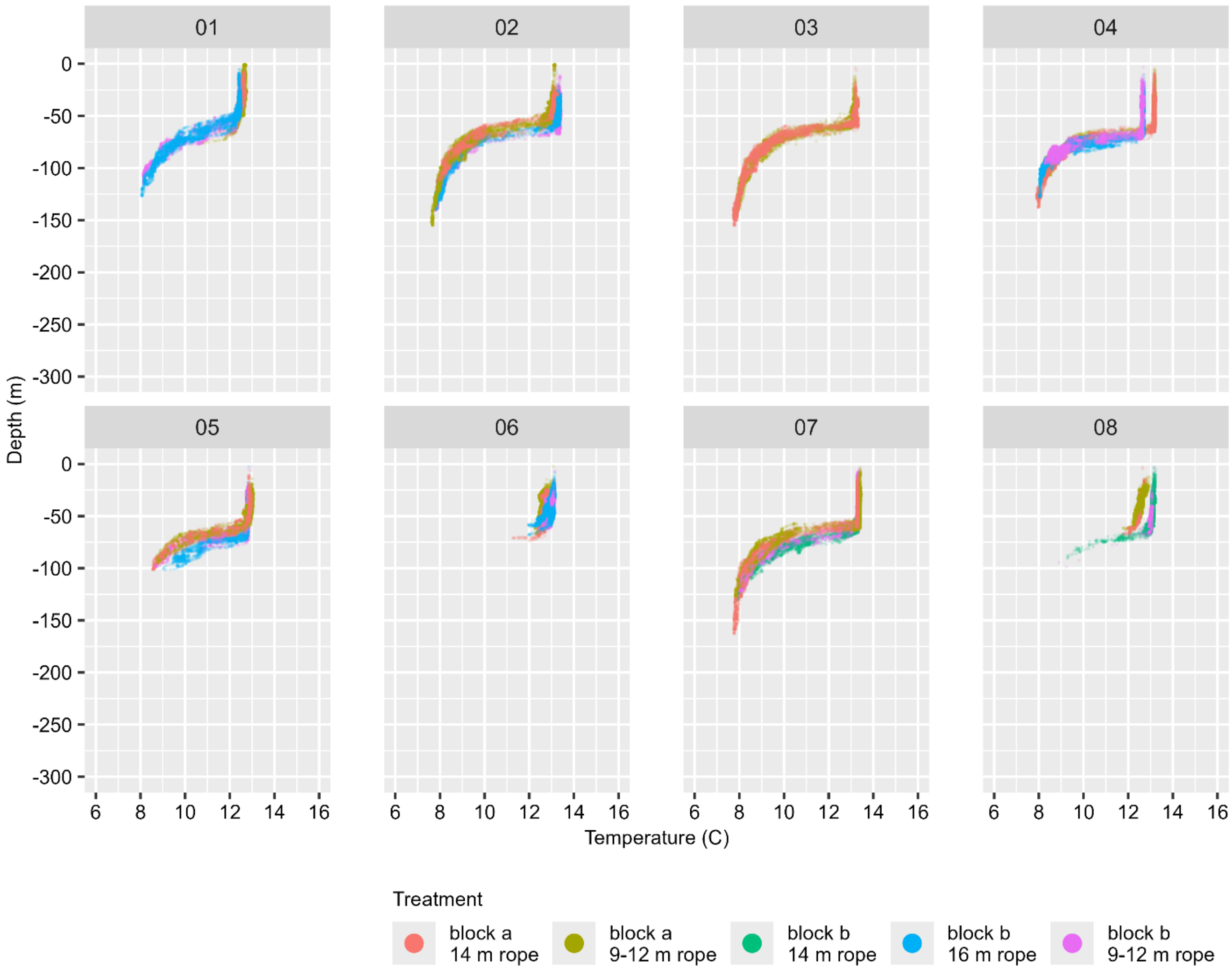

Figure A24. Temperature-depth plots, by set.