Data Collectable Using Electronic Monitoring Systems Compared to At-Sea Observers in the Hawai‘i Longline Fisheries

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PIFSC Data Report DR-24-02.
Issued 2024 February 20
https://doi.org/10.25923/eewf-gz02

Overview

Previous work in the Pacific Islands indicates that electronic monitoring (EM) can be used to detect retained fish and protected species (Stahl & Carnes, 2020; Carnes et al., 2019) and to assess the likely post-release condition for sea turtles and cetaceans following fishing interactions in the Hawai‘i longline fisheries (Stahl et al., 2023). This document describes the data which can be collected using EM systems (NOAA, 2023) and the degree of accuracy to which it can be collected compared to at-sea observers. Data fields are compared by each data collection form used by the Pacific Islands Region Observer Program (PIROP). In addition, it is noted whether data can be collected by other sources, such as Vessel Monitoring Systems (VMS), dealer data, or electronic logbooks (referred to as elogs hereafter). Notes elaborating on the accuracy of EM or other data collection methods for each data field are included in the following tables.

The pelagic longline fishing gear that is used by the Hawai‘i longline fisheries consists of a mainline, branchlines with baited hooks, and floats that suspend gear in the water column. The PIROP observers watch the first hour of setting for each set of fishing gear that is deployed and the entire hauling of fishing gear; EM cameras are currently configured to only record during gear hauling. The observers record information on the forms included in this document during setting for location, date and time, gear configuration, and seabird mitigation; during hauling, they record location, date and time, and retained or discarded catch, including protected species and elasmobranchs. In addition, they record data collected during fisher interviews, including information on vessel, crew, and economics.

At-sea observers can perform some tasks that EM systems cannot, such as collect specimens, conduct interviews, and tag animals. Specimen and tagging forms are not included in this document, nor is the sketch form which is used by observers to draw gear or protected species that interact with a vessel. In addition, this document does not compare EM and observer data collection outside the scope of the observer data collection forms, such as providing near real-time reporting on protected species interactions. These data may be used to meet regulatory requirements, such as monitoring trip and annual interaction limits for sea turtles and area closures for false killer whales (*Pseudorca crassidens*).

Trip specifications form

At-sea observers record information for each Hawai‘i longline fisheries trip. Most of these data can be collected from EM or other sources such as elogs or VMS.

Table 1. Trip specifications form comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Trip start/end date and time	Yes	High	VMS; elogs	● High accuracy as collectable from EM sensor data.
Departure/arrival port	Yes	High	Elogs	● High accuracy from EM GPS sensors.
Intermediate port stops	Yes	High	VMS	● High accuracy from EM GPS sensors.
Observer identification number	N/A	N/A	No	-
Observer trip number	N/A	N/A	No	-
Declared trip type (shallow- or deep-set)	No	N/A	Elogs	-
Vessel documentation number	No	N/A	Elogs	-
Vessel name	Yes	High	Elogs	-
Operator name	No	N/A	Elogs	-
Any high-grading during the trip?	Yes	Low	No	● Low accuracy—only determined if discards occur during hauling and within camera views.

Set and haul form

At-sea observers record information on setting and hauling for the Hawai‘i longline fisheries. Most of this information can be derived from EM systems through video or sensors (hydraulic pressure, reel rotation, or GPS). Cameras do not need to be recording to collect data on date, time, and location. Elogs provide an alternate source of date, time, and location information for setting and hauling that is derived from the vessel’s VMS system.

Table 2. Set and haul comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Fishing logbook page number	No	N/A	Elogs	-
Set number	Yes	High	Elogs	● High accuracy as collectable from EM sensor data.
Begin/end set date and time	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM sensor data.
Begin/end set latitude	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM GPS sensor data.
Begin/end set longitude	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM GPS sensor data.
Begin/end set weather code	No	N/A	No	● Cameras are not configured to record during setting but can be depending on priorities.

Table 2: Set and haul form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Begin/end set Beaufort scale	No	N/A	No	● Cameras are not configured to record during setting but can be depending on priorities.
Begin/end set sea surface temperature	No	N/A	Satellite	● Satellites provide a more comprehensive source of sea surface temperature data.
Begin/end haul date and time	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM sensor data.
Begin/end haul latitude	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM GPS sensor data.
Begin/end haul longitude	Yes	High	Elogs derived from VMS	● High accuracy as collectable from EM GPS sensor data.
Begin/end haul weather code	Yes	High	No	-
Begin/end haul Beaufort scale	Yes	Moderate	No	-
Begin/end haul sea surface temperature	No	N/A	Satellite	● Satellites provides a more comprehensive source of sea surface temperature data.
Haulback direction	Yes	High	Elogs	● High accuracy as collectable from EM GPS sensor data.

Table 2: Set and haul form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Mainline parted?	Yes	High	No	● High accuracy from EM video.
Number sections of mainline retrieved	Yes	High	No	● High accuracy from EM video.
Protected species interactions during setting	No	N/A	No	● Cameras are not configured to record during setting but can be depending on priorities. Camera views may need to be adjusted with view of stern to collect protected species data during setting.
Protected species interactions during haul	Yes	High	No	● High accuracy from EM video.

Gear configuration

At-sea observers collect information on the gear configuration form for the Hawai‘i longline fisheries. Measurements of gear nor detailed information on hook size cannot be collected from EM at this time.

Table 3. Gear configuration form comparison between fields collected by observers and with EM

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Hook type code	No	N/A	No	-
Hook sizes	No	N/A	No	-
Hook diameter	No	N/A	No	-
Hook percentage by type	No	N/A	No	-
Number of floats	Yes	High	No	● High accuracy if doing a full video review. ● High accuracy if using artificial intelligence (AI) to detect buoys but will need to develop models.

Table 3: Gear configuration form comparison continued.

Hooks per float[4]	Yes	Low/ moderate/ high	Elogs	● Moderate accuracy if reviewing the number of hooks between successive floats for a subset of a haul and calculating an average for the entire haul. ● Low accuracy if an AI model is developed to detect hooks with current camera setup as many hooks are coiled at bait boxes close to stern and may be hard to see or out of camera views. ● Moderate to high accuracy may be possible if an AI model is developed to detect snaps as a proxy for hooks. ● Moderate accuracy from elogs as minimum and maximum hooks per float are generally recorded with the same value—the number of hooks typically set per float.
Number hooks set	Yes	Low/ moderate	Elogs	● Cameras are not configured to record during setting so hook counts cannot be collected at that time with current configurations, but number of hooks can be collected during hauling. ● Moderate accuracy if reviewing the number of hooks between successive floats for a subset of a haul and expanding to a total number of hooks for the entire set, similar to current at sea observer protocols. ● Low accuracy if an AI model is developed to detect hooks hauled with current camera configurations as many hooks are coiled at bait boxes close to stern and may be hard to see or out of view.

[4] Hooks per float is the number of hooks between successive floats.

Table 3: Gear configuration form comparison continued.

				● Moderate to high accuracy may be possible if an AI model is developed to detect snaps as a proxy for hooks. ● Moderate accuracy for elogs as fishers may round.
Target species	Yes	High	Elogs	● High accuracy as could be determined from most frequently encountered species as seen in EM video. ● High accuracy if derived from the number of hooks between floats from either elogs or EM video as less than 15 hooks per float correlates to shallow-set trips targeting swordfish and 15 or more hooks correlates to deep-set trips targeting bigeye tuna. ● High accuracy from elogs as declared by fisher.
Bait code	Yes	High	Elogs	● High accuracy as different bait species can be discerned from EM video. ● Moderate accuracy for elogs as bait type(s) are recorded by set but composition of each bait type is not recorded for sets with multiple bait types.
Light type code	Yes	High	No	-
Light number of devices	Yes	High	Elogs	● High accuracy if calculated similarly to the method by observers (number of lights between successive floats expanded to the entire set). ● Moderate accuracy for elogs as captains estimate this number.
Light color code	Yes	High	No	-
Mainline material code	Yes	High	No	-

Table 3: Gear configuration form comparison continued.

Mainline diameter	No	N/A	No	-
Mainline color code	Yes	High	No	-
Float line material code	Yes	High	No	-
Float line diameter code	No	N/A	No	-
Float line measured length	No	N/A	No	-
Branchline material code	Yes	High	No	• High accuracy, almost always monofilament but should be able to discern if using multifilament.
Branchline diameter	No	N/A	No	-
Branchline measured length	No	N/A	No	-
Branchline color code	Yes	High	No	-
Leader material code	Yes	Low/high	No	• Low accuracy unless close to cameras as it is challenging to tell the difference between monofilament and wire leaders. • High accuracy if crew holds branchline to camera to verify leader material but would be assuming they do not switch leader types throughout trip.
Leader diameter	No	N/A	No	-

Table 3: Gear configuration form comparison continued.

Leader measured length	No	N/A	No	-
Weight size	No	N/A	No	-
Gear configuration comments	No	N/A	No	-

Catch event log

At-sea observers record information about each catch event by species on the Catch event log for the Hawai‘i longline fisheries. Species catch composition was compared for 238 hauls for EM and at-sea observer data (Carnes et al., 2019) and indicated EM was able to detect 98% of retained catch and 89% of all catch. Here we compare which fields are collectable for catch events, including associated biological data, between EM and at-sea observer data.

Table 4. Catch event log comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Species code	Yes	High	Dealer; elogs	• High accuracy with EM video for most species. • Moderate accuracy from elogs for retained species. • Moderate accuracy from elogs for discarded sharks and low accuracy for other discarded species. • High accuracy from dealer data for retained species.
Float number	Yes	High	No	• High accuracy if doing a full video review. • High accuracy if an AI model is developed to detect buoys.

Table 4: Catch event log comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Hook number	Yes	Low/moderate/ high	No	● Low accuracy when reviewing video as it is hard to keep track and would be tedious and time intensive. ● Low accuracy if an AI model is developed to detect with current camera setup as many hooks are coiled at bait boxes close to stern and may be hard to see or out of view. ● Moderate to high accuracy may be possible if an AI model is developed to detect snaps as a proxy for hooks.
Caught condition code	Yes	High	No	● High accuracy for most species.
Kept/return code	Yes	Moderate	Dealer; elogs	● Moderate accuracy for EM as some catch may be discarded out of the camera's view, such as bycatch species or smaller fish. It may also be difficult to tell the condition of some species especially if not boarded. ● High accuracy from dealer data for retained species. ● High accuracy from elogs for retained species. ● Moderate accuracy from elogs for sharks and low accuracy for other discarded species.

Table 4: Catch event log comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Damaged code	Yes	Low/moderate	No	● Low accuracy if damage is on the side of the animal not presented to cameras. ● Moderate accuracy if damage is in camera view, but may be difficult to discern between shark, marine mammal damage, and other damage such as bird or squid. This area needs more research. Images could be collected and provided to experts to review damage.
Gender code	Yes (only in special cases)	Low/high	No	● Low accuracy for elasmobranch species. If the shark/ray ventral side is in camera views, then may be able to tell the presence or absence of claspers. However, this would be more difficult for juveniles. ● High accuracy for sexually mature dolphinfish (mahimahi, *Coryphaena hippurus*). ● Gender identification would be possible for other non-elasmobranch species with modifications in crew handling that would require holding the gonads up to cameras. This would likely lead to moderate accuracy as it may still be difficult to discern in

Table 4: Catch event log comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				cameras for fish with small and/or undeveloped gonads.
Length measurements	Yes	Low	Dealer	● Low accuracy with approximate length estimates possible using objects (e.g., floats, fishers) of known length for comparison. ● In the future, more precise length measurements may be possible through EM system modifications (e.g., stereo cameras, cameras calibrated to measuring boards) and fisher handling requirements or through development of AI algorithms. ● Dealer data processed weights can be converted to round weight and then length for retained species using conversion keys.

Sea turtle biological data form

EM video footage of 37 sea turtle interactions was examined to determine if data could be collected to assign a percent likelihood of post-interaction mortality in the Hawai‘i longline fisheries (Stahl et al., 2023). The data examined are normally collected by the at-sea observer on the sea turtle biological data form. Observer data, including imagery and the information from the sea turtle biological form, are reviewed by protected species experts to determine the injury and release condition and species to select the percent likelihood of post-interaction mortality from Table 1 in Ryder et al. (2006). If the sea turtle is a leatherback, then a higher percent (5–10% greater) likelihood of mortality is assigned for the same injury and release condition as a hardback. An injury category is assigned (I-VI) based on the hooking or entanglement location and whether the sea turtle is comatose or resuscitated. The release condition is based on the amount of attached fishing gear at release.

Table 5. Sea turtle biological form comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Set	Yes	High	Elogs	● Low accuracy for elogs as sea turtles are usually not recorded and may be misidentified. If recorded, can obtain the set number.
Species code	Yes	High	Elogs	● Low accuracy for elogs as sea turtles are usually not recorded and may be misidentified.
Captured date and time	Yes	High	Elogs	● Low accuracy for elogs as sea turtles are usually not recorded and may be misidentified. If recorded, can obtain haul start and end date and time.
Captured latitude and longitude	Yes	High	Elogs	● Low accuracy for elogs as sea turtles are usually not recorded and may be misidentified. If recorded, can obtain haul start and end latitude

Table 5: Sea turtle biological form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				and longitude.
Release date and time	Yes	Moderate	No	● Fishers sometimes wait to release sea turtles after the haul, so appropriate thresholds need to be set for sensors to trigger cameras to record.
Release latitude and longitude	Yes	Moderate	No	● Fishers sometimes wait to release sea turtles after the haul, so appropriate thresholds need to be set for sensors to trigger cameras to record.
Disposition	Yes	High	No	-
Hooked (Y/N/U)	Yes	High	No	-
Entangled (Y/N/U)	Yes	High	No	● High accuracy but may be hard to discern the number of wraps in line but can usually deduce entanglement location from how the turtle is swimming.
Hooked location code	Yes	Moderate/high	No	● High accuracy when boarded and hooked in the body. ● Moderate accuracy when released in water and/or when boarded and hooked in mouth as more challenging to obtain specific location which could lead to a more conservative mortality estimate and necessary to assume “worst case scenario.” ● May need to use “mouth unknown” code more often than observer data. However, this code does not include beak, so a new code may need to be developed of “beak/mouth unknown”.

Table 5: Sea turtle biological form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Gear removal type code	Yes	High	No	● High accuracy for boarded sea turtles when fishing gear removal is in camera views and does not occur in bait shed or blocked by fisher. ● High accuracy when fishing gear is removed when the animal is in the water and is in camera views and not behind the vessel or blocked by crew.
Gear attached code/ gear attached description	Yes	Moderate/high	No	● High accuracy for the amount of gear attached for boarded turtles. ● Moderate accuracy for sea turtles released in water if handling (release from gear and/or coiling of line) is in camera views then likely able to determine if trailing line is greater than ½ or less than ½ the body length for mortality estimates. Otherwise, a more conservative "worst case" estimate is necessary to assume. ● Cannot determine hook type/leader material from EM cameras.
Light device color	Yes	High	No	-
Light device proximity code	Yes	High	No	-
Measurements	Yes	Low	No	● Low accuracy with approximate length estimates possible using objects (e.g., floats, fishers) of known length for comparison. ● In the future, more precise length measurements may be possible through system modifications (e.g., stereo cameras, cameras calibrated to

Table 5: Sea turtle biological form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				measuring boards) and fisher handling requirements or through development of AI algorithms.
Tags present	Yes	Low/high	No	● High accuracy for observation of satellite tags. ● Low accuracy for observation of flipper tags.
Injuries (Y/N), description	Yes	Low/high	No	● High accuracy for large or major injuries that may result in mortality if in camera views. ● Low accuracy for small or minor injuries in camera views. ● Not possible for injuries out of camera views unless modifications to crew handling and the injury is presented to the camera.
Turtle board method	Yes	High	No	-

Marine mammal biological data form

EM video footage of eight cetacean interactions was examined to discern if determinations of injury severity (mortality, non-serious injury, or serious injury) could be made that likely result following an interaction in the Hawai‘i longline fisheries (Stahl et al., 2023). The data that were examined are normally collected by the at-sea observer on the marine mammal biological data form. Observer data, including imagery and information collected on the marine mammal biological data form, are reviewed by protected species experts to make determinations based on criteria defined for small cetaceans (odontocetes except sperm whales) from NMFS 2023. If data are insufficient to establish injury severity, then the interaction injury is recorded as “cannot be determined” (NMFS, 2023). The accuracy level was determined for instances where the interaction occurred within the view of the cameras. The likelihood that cetacean interactions occur out of the view of the cameras has not yet been determined.

Table 6. Marine mammal biological form comparison between fields collected by observers and EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Set number	Yes	High	Elogs	● Low accuracy for elogs as marine mammals are usually not recorded and may be misidentified. If recorded, can obtain the set number.
Species code/ identification characteristics (color, shape, pattern, dorsal fin)	Yes	Low/moderate/ high	Elogs	● High accuracy when brought next to the vessel. ● Moderate accuracy if not brought next to the vessel but within 20 ft, then may be able to identify to group but not species (e.g., dolphin or “blackfish”). ● Low accuracy if released at distance. ● Low accuracy for elogs as marine mammals are usually not recorded.

Table 6: Marine mammal biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Captured date and time	Yes	High	Elogs	● Low accuracy for elogs as marine mammals are usually not recorded. If recorded, then could obtain haul start and end date and time.
Captured latitude and longitude	Yes	High	Elogs	● Low accuracy for elogs as marine mammals are usually not recorded. If recorded, then could get a haul start and end latitude and longitude.
Release date and time	Yes	High	No	-
Released latitude and longitude	Yes	High	No	-
Boarded Y/N	Yes	High	No	-
Disposition code	Yes	High	No	-
Hook type	No	N/A	No	-
Hook size	No	N/A	No	-
Hook diameter	No	N/A	No	-
Hooked Y/N	Yes	High	No	-
Entangled Y/N	Yes	Moderate	No	-
Hooked location ID	Yes	Low/moderate	No	● Moderate accuracy if animal is brought to the vessel—a general hooking location could

Table 6: Marine mammal biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				likely be determined. But if an animal is mouth-hooked, then may not be able to discern specific hook location from EM. ● Low accuracy or unknown hooking location when the animal is not brought to the vessel. ● If hooking location is unknown but trailing gear is known to be greater than body length, then serious injury determination could be made. ● If hooking location is unknown but trailing gear is less than a body length, then no injury determination could be made. Condition is considered serious if mouth-hooked and non-serious if in other body location and no other case specific factors indicate a serious injury.
Gear removal ID	Yes	High	No	● High accuracy when fishing gear is removed, and handling is in camera views and not behind the vessel or blocked by crew.
Entangled location ID	Yes	Moderate	No	-
Gear attached ID/ gear attached description	Yes	High	No	● High accuracy if handling (release from gear and/or coiling of line) is in camera views to determine if the amount of attached fishing gear at release is more likely to result in a serious or non-serious injury. ● If hooking location is unknown but trailing gear is known to be greater than the body length,

Table 6: Marine mammal biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				then serious injury determination could be made. ● If hooking location is unknown but trailing gear is less than a body length, then no determination can be made. Injury is considered serious if mouth-hooked and non-serious if hook is in another body location and no other case specific factors indicate a serious injury. ● Cannot determine hook type or leader material.
Gear comments	Yes	Low/moderate/ high	No	● High accuracy of release methods (e.g., dehooker, line cut) if handled in camera views. ● High accuracy for a determination of the animal breaking the line if the line is coiled in the camera views, then it can be discerned if a hook is attached. ● Moderate accuracy of hook straightening if the line is coiled in camera views and hook is attached. ● Cannot determine hook type/leader material. ● Difficult to determine hauled gear condition, missing, straightened, or broken hooks, or tangled and broken lines that are not part of interaction that may be associated with depredation. ● Cannot discern the diameter of mainline or monofilament.

Table 6: Marine mammal biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Light device color code	Yes	High	No	-
Light device proximity code	Yes	High	No	-
Tags present Y/N	Yes	Moderate	No	-
Capture behavior (struggling/ lethargic)	Yes	Low/high	No	● High accuracy if less than 20 ft from the vessel as cameras allow a good perspective to view behavior for the duration of the event. ● Low accuracy if at a distance or the interaction is short or animal has limited surface time.
Capture behavior (vocalizing)	No	N/A	No	● No audio for EM videos.
Injuries description (line wrap, handling, bleeding)	Yes	Low/moderate/ high	No	● High accuracy for larger or major injuries that may result in mortality if in camera views and animal is less than 20 ft from the vessel. ● Low accuracy for small or minor injuries in the camera views even if close to the vessel. ● Not possible to view injuries that are not presented to the cameras or remain underwater. ● Moderate accuracy to discern the extent of line wraps if entangled. ● High accuracy in determining if handling results in injuries if in camera views.

Table 6: Marine mammal biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				● Moderate accuracy for bleeding as can potentially see blood on cetaceans but may be difficult to see in water.
Comments (duration, distance, how interaction ended, other marine mammals present, depredation)	Yes	Low/moderate/ high	No	● High accuracy for interaction duration and distance to cetacean. ● High accuracy for how interaction ended when fisher handling and gear removal is in camera views. ● Low accuracy for other marine mammals as not likely to see other cetaceans in the area unless EM systems include a 360° camera. ● Moderate accuracy for depredation as possible to see depredated fish but difficult to discern from empty hooks (i.e., amount of hooks returned with no bait). Research is needed to determine if possible with an AI model.

Elasmobranch biological data form

Elasmobranch interactions were reviewed to determine if similar biological data could be collected with EM systems as that collected by the at-sea observers in the Hawai‘i longline fisheries. Many shark events were not captured by EM in the past, because release occurred outside of camera views with most fishers cutting branchlines close to the snap (Carnes et al., 2019). However, more research is needed to determine detection of mobula rays and sharks with EM as fisher handling may shift with recent and upcoming changes in regulations. With a recent prohibition on wire leaders in the Hawai‘i longline fisheries some vessels may bring sharks into camera views to retrieve weights from branchlines, which was more difficult with wire leaders. However, fishers' behaviors will vary by boat, as there is a risk of injury from weights flying back unless fishers use a device designed to reduce this probability, an area of ongoing research. In addition, shifts in shark handling are expected with recent regulation changes in the Hawai‘i longline fisheries to remove trailing gear from oceanic whitetip sharks and with Western and Central Pacific Fisheries Commission (WCPFC) conservation and management measure 2022-04 that states by January 2024, sharks must be brought alongside vessels carrying EM or observers for identification and branchlines must be cut as close to the hook as possible for all shark species. It is likely regulations will be followed in the Hawai‘i longline fisheries in accordance with WCPFC CMM 2022-04.

Table 7. Elasmobranch biological form comparison between fields collected by observers and EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Set number	Yes	High	Elogs	● Moderate accuracy for elogs as sharks are often recorded but mobula rays are not. If recorded, can obtain the set number.
Species code	Yes	Low/high	Elogs	● High accuracy when elasmobranchs are in camera views and within 20 ft from the vessel or brought alongside the vessel. More fishers may now bring sharks to the boat to retrieve weights from branchlines in deep-set fishery after prohibition on wire leaders. ● Low accuracy when elasmobranchs are cut

Table 7: Elasmobranch biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				from line out of camera views or at distance. ● Moderate accuracy for elogs with fishers not distinguishing sharks within the same family (e.g., threshers, makos). Mobula rays are typically not recorded.
Disposition ID	Yes	Low/high	No	● High accuracy when elasmobranchs are in camera views and less than 20 ft from the vessel or brought alongside the vessel. More fishers may now bring sharks to the boat to retrieve weights from branchlines in deep-set fishery after prohibition on wire leaders. ● Low accuracy when elasmobranchs are cut from line out of camera views or at distance.
Hooked location ID	Yes	Moderate/high	No	● High accuracy for sharks hooked in fins or tail when in camera views. ● Moderate accuracy for mobula rays hooked in head, cephalic or pectoral fins when in camera views. ● Moderate accuracy for elasmobranchs hooked in mouth as it is difficult to discern whether the hook has been ingested or is external. However, the distance of the weight on the branchline to mouth can be used as an indicator if ingested or not, as weight can generally be seen (if less than 20 ft from the vessel). ● Need to add a new code of “mouth unknown” that includes both internal and external hooking.
Entangled location ID	Yes	High	No	-

Table 7: Elasmobranch biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Damage ID (handling)	Yes	Low/high	No	● High accuracy when fisher handling is done in view of cameras. ● Low accuracy when fisher handling is done out of view of cameras or blocked by other crew.
Gear remaining	Yes	Low/moderate	No	● Moderate accuracy for gear remaining if the crew removes elasmobranchs from gear in the view of the cameras or coils the remaining line in the camera views. Should be able to determine if the trailing line is greater than or less than a body length or if the line is cut below the weight on the branchline, which are useful metrics for assessing likely post-release condition. It is recommended to leave less than 1 m of line to improve shark survival by up to 40% for 360 days post-release (Hutchinson et al., 2021) ● Low accuracy for leader material, only possible to tell if close to camera.
Brought alongside the vessel	Yes	High	No	● High accuracy for determining if elasmobranchs are brought alongside vessels as long as in camera views.
Boarded	Yes	High	No	-
Line cut below the weighted branchline	Yes	Moderate	No	● Moderate accuracy as we can generally see the weight on the branchline if handling is

Table 7: Elasmobranch biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				performed in camera views and not blocked by other crew.
Comments	Yes	High	No	-

Seabird biological data form

A few seabird interactions were reviewed from EM video to determine if similar biological data could be collected with EM systems as that collected by the at-sea observers in the Hawai‘i longline fisheries.

Table 8. Seabird biological data comparison between fields collected by observers and EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Set number	Yes	High	Elogs	● Low accuracy for elogs as seabirds are usually not recorded but set number can be obtained if recorded.
Species code	Yes	High	Elogs	● Low accuracy for elogs as there may be misidentification if recorded.
Captured date and time	Yes	High	Elogs	● Low accuracy for elogs as seabirds are usually not recorded. If recorded, haul start and end date and time can be obtained.
Captured latitude and longitude	Yes	Moderate	Elogs	● Low accuracy for elogs as seabirds are usually not recorded. If recorded, could obtain set start and end latitude and longitude.
Release date and time	Yes	High	No	-
Released latitude and longitude	Yes	High	No	-
Boarded Yes/No	Yes	Low/high	No	● High accuracy if seabird is in the camera views when brought aboard or released from vessel or while on deck.

Table 8: Seabird biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				• Low accuracy if seabird is out of camera views as bird interactions often occur at the stern of the vessel and may be boarded or released without boarding.
Disposition code	Yes	High	No	-
Hooked Y/N/U/ hooking location code	Yes	Moderate/ high	No	• High accuracy if the bird is brought on the deck as the hook should be visible. • Moderate accuracy if the bird is not boarded as observations depend on camera views but can deduce the general area of hooking even if the hook cannot be seen. • May be difficult to tell if a hook is ingested but can use distance of weight on the branchline to mouth to deduce. Might need a new code of "mouth unknown."
Entangled Y/N/U/ entangled location code	Yes	Moderate/ high	No	• High accuracy as entanglement can be deduced from movements or behavior. • Moderate accuracy in determining location of entanglement as might be hard to see monofilament and the extent of wraps.
Gear removal type code	Yes	High	No	• High accuracy if handling is done in camera views and crew is not blocking.
Gear attached type/ gear attached description	Yes	Moderate/ high	No	• High accuracy if boarded before release as should be able to see the hook.

Table 8: Seabird biological data form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				● Moderate accuracy if not boarded and can see crew release from gear or coil remaining line, then can estimate trailing line.
Light device color code	Yes	High	No	-
Light device proximity code	Yes	High	No	-
Bill color ID	Yes	High	No	-
Mantle color ID	Yes	High	No	-
Head color ID	Yes	High	No	-
Bill tip different color	No	N/A	No	-
Tags present Y/N	No	N/A	No	● Bird bands too small to read.
Identification characteristics	Yes	High	No	-
Injuries description	Yes	Low/high	No	● High accuracy for large or major injuries in camera views. ● Low accuracy for small or minor injuries in camera views. ● Not possible for injuries out of camera views.
Comments	Yes	High	No	-

Seabird mitigation form

At-sea observers collect data related to seabird mitigation measures during both setting and hauling in the Hawai‘i longline fisheries. However, seabird mitigation measures are generally only documented and observed during the first hour of setting. The current EM cameras do not record during setting operations, as a result many of the seabird mitigation measures would not be collectable. Also, setting most often occurs off the stern of the vessel; however, current EM cameras have views of the deck and alongside the vessel that would likely miss many seabird mitigation measures that occur off the stern and out of the cameras' views.

Table 9. Seabird mitigation form comparison between fields collected by observers and with EM.

* Observer data collection is likely ending for these fields.
**Observer data collection is likely to be modified for these fields.

During setting

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Number of floats observed*	No	N/A	No	• Cameras do not record during setting.
Set at night Y/N	Yes	High	Elogs	• High accuracy as can be obtained from sensor data even if cameras are not recording.
Towed buoy Y/N*	No	N/A	No	• Cameras do not record during setting and would also need a stern-facing camera.
Tori line Y/N	No	N/A	No	• Cameras do not record during setting and would also need a stern-facing camera.
Line shooter used Y/N	No	N/A	No	• Cameras do not record during setting and would also need a stern-facing camera.

Table 9: Seabird mitigation form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Water sprayed on sea surface*	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.
Bird curtain	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.
Side setting	No	N/A	Elogs	● Cameras do not record during setting. ● High accuracy from elogs. ● High accuracy from shoreside observation as this can be determined based on location of line setter.
Bait blue dyed Y/N	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.
Weighted line*	Yes	High	No	● High accuracy as can see branchlines during hauling.
Strategic offal discard** Y/N	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.
Strategic bait discard**	No	N/A	No	● Cameras do not record-during setting and would also need a stern-facing camera.
Bait thawed Y/N	No	N/A	No	-
Bait set outside of wake Y/N	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.
Other deterrent used Y/N	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera.

Table 9: Seabird mitigation form comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Birds Present Y/N	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera to see all birds.
Comments	No	N/A	No	● Cameras do not record during setting and would also need a stern-facing camera to get all mitigation techniques.

During hauling

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Towed buoy Y/N*	No	N/A	No	● Would need a stern-facing camera.
Tori line Y/N	No	N/A	No	● Would need a stern-facing camera.
Water sprayed on sea surface*	No	N/A	No	● Would need a stern-facing camera.
Bait blue dyed Y/N	No	N/A	No	● Unlikely the coloration of residual blue dye in bait could be viewed in cameras during hauling.
Weighted line*	Yes	High	No	-
Strategic offal discard** Y/N	No	N/A	No	● Would need a stern-facing camera.
Strategic bait discard**	No	N/A	No	● Would need a stern-facing camera.
Other deterrent used Y/N	No	N/A	No	● Would need a stern-facing camera.

Table 9: Seabird mitigation form comparison continued.

Birds present Y/N	Yes	Low	No	• Low accuracy as could only observe birds in camera views but would miss most birds at stern where the majority are seen by observers.
Comments	Yes	Low	No	• Low accuracy as birds and mitigation techniques may be performed at stern out of camera views.

Seabird scan

Observers also identify and count the number of seabirds in the area around the vessel during setting of gear. If EM cameras are not set to trigger during setting, then this information cannot be collected. If cameras are configured to record during setting, then data on seabirds during setting would still be limited with the deck and rail cameras used in the Hawai‘i longline program as the majority of birds are recorded by observers at a vessel’s stern.

Marine debris log

At-sea observers collect data on marine debris that occurs in the Hawai‘i longline fisheries. Marine debris has been observed in EM cameras. However, marine debris data collection is limited to when cameras are recording during hauling and to the camera views of the deck and side of the vessel.

Table 10. Marine debris form comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Trip number	Yes	High	No	-
Latitude and longitude	Yes	High	No	-
Date and time	Yes	High	No	-
Incident type (gear interaction, vessel interaction, entangled species caught, unusual debris sightings, other)	Yes	Moderate	No	• Moderate accuracy as entangled species, unusual debris, and vessel interactions may be out of camera views (for example, if marine debris gets wrapped in the propeller).
Debris type	Yes	High	No	-
Biota types associated with marine debris	Yes	Low	No	• Low accuracy as may be able to see larger associated fish but would be hard to see crustaceans and encrusting organisms.
Estimated total weight	Yes	Low	No	• Low accuracy but may be best estimated by a marine debris expert.

Table 10: Marine debris log comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Photos	Yes	High	No	● Can extract photos from video.
Debris brought on board?	Yes	Moderate	No	● Moderate accuracy as can only observe marine debris brought on board in camera views.
Length of time to recover marine debris	Yes	High	No	-
Description of downtime/ costs	No	N/A	No	● Would need to interview the captain or crew to get an estimate of total downtime and of any costs associated with damaged fishing gear.

Protected species event log

At-sea observers record protected species events that are not associated with a gear interaction during hauling in the Hawai‘i longline fisheries. Almost all of these types of protected species events would occur outside of the camera views or when the cameras are recording during hauling. Only animals that swim by the vessel during hauling and within 50 m or less of the vessel would be recorded in the cameras. Cetaceans that are bow riding would be missed by EM.

Table 11. Protected species event comparison between fields collected by observers and with EM.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
Start/end event date and time	Yes	Low	No	● Low accuracy if an event is recorded as would be difficult to determine when an event begins.
Event type (behavior or contact)	Yes	Moderate	No	● Moderate accuracy as would likely be able to determine if the event was due to a gear interaction.
Vessel activity (gear retrieval, gear set, gear drift/soak, other)	Yes	High	No	● High accuracy as an event would likely only be recorded during gear retrieval.
Set number	Yes	High	No	-
Latitude and longitude	Yes	High	No	-
Species	Yes	Low	No	● Low accuracy unless the animal is close to the vessel.
Behavior	Yes	Low	No	● Low accuracy as would only be able to record the behaviors recorded within the camera

Table 11: Protected species event log comparison continued.

Data field	Collectible with EM	Accuracy	Other source(s)	Notes
				views.
Species count	No	N/A	No	• If an event was recorded, then it would not be possible to determine a full estimate of animals around the vessel with the current camera views.

Photo log

Observers take photos of protected species and other catch events of interest and record associated metadata on a photo log. Similarly, metadata can be recorded for any photos extracted from EM video on a photo log.

WCPFC mandatory data elements

Observers collect information requested by the WCPFC for longline fishing trips. This includes data on crew, vessel attributes (e.g., vessel gross tonnage, engine power, cruising speed) and the presence and frequency of usage of vessel electronics (including presence of VMS and if security seals are intact). This information is currently collected through interviews and visual inspection by the observer while on board the vessel, but these data could be collected by other staff. This information is not collectable from EM.

Trip expenditure form

Observers also collect economic information related to trip expenditures. This includes the cost of fuel, engine oil, freon for freezers, bait, fishing gear, communications, provisions, and any transport costs of fish to the market or canneries. In addition, the price for each species of fish is recorded. This information is collected through interviews by the observers but could be collected through other staff after a fishing trip. This information is not collectable with EM.

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