Ministry for Primary Industries
Manatū Ahu Matua

A trial of video observation in the SNA 1 bottom trawl fishery

New Zealand Fisheries Assessment Report 2016/56

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ISSN 1179-5352 (online)
ISBN 978-1-77665-409-3 (online)

October 2016

New Zealand Government

Growing and Protecting New Zealand

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***New Zealand Fisheries Assessment Report 2016/56*. 58 p.**

A trial of video observation in the snapper 1 (SNA 1) bottom trawl fishery was carried out on six vessels during the period 1 April to 1 October 2014. The key objective of the trial was to validate the recently introduced reporting of the quantities of snapper returned to the sea because they are below the minimum legal size.

Footage comprising video imagery and GPS position data was collected from two cameras onboard each vessel near continuously during the period they participated in the trial. The electrical systems on one vessel required that the cameras were turned off during port calls. Processes for the automated retrieval of the footage during port calls were implemented and refined during the trial, and overall the equipment performed well during the trial.

Review of the footage ashore was carried out according to a standardised protocol. This generates observational data in much the same way that onboard observers provide standardised observations, although the video observations have the advantage of being checkable in retrospect by a further review of the footage. A single review was carried out of all footage collected during the trial while the vessels were operating within the SNA 1 quota management area and not engaged in research trips.

There was a high level of concordance between the patterns of fishing effort recorded in the statutory data and those observed from the video footage. Analyses detected some errors (missed events in the footage; missing records and transcription errors in the statutory returns) in both data sets. An independent source of verification is beneficial as transcription errors in the statutory data can sometimes produce large, and potentially influential, outliers.

Volumetric estimates of the quantity of sub-MLS snapper returned to the sea were facilitated by a change in fish handling practices that required crews to batch fish prior to their return. Previous practice involved the rapid return of individual fish, the observation of which would have been far more complex. Overall the change in practice was reasonably successful, allowing the video observation process to make independent estimates of sub-MLS snapper weight from bin volumes recorded in 0.25 bin increments and a standardised bin weight. The resulting estimates showed a high level of concordance with the statutory catch estimates reported by the participating vessels under the new SNX reporting code. The video observation trial is considered to have been successful and provides a new and rich source of information for use in management of the SNA 1 fishery.

1. INTRODUCTION

Following consultation on sustainability measures for New Zealand's north-eastern snapper (*Pagrus auratus*) fishery (SNA 1; Figure 1) in mid-2013, a number of measures and initiatives were put in place in the 2013/14 year. Many of the initiatives resulted from proposals put forward by "SNA 1 Commercial", the group representing owners of SNA 1 quota and the wider commercial fishing interests in SNA 1. This included the introduction of reporting by commercial fishers of the quantity of snapper below the minimum legal size (MLS) which were caught and returned to the sea.

Fisheries regulations require that any fish caught which are below the MLS ("sub-MLS fish") are returned to the sea. Furthermore the quantity of sub-MLS fish caught and returned has historically not been recorded via the statutory catch, effort and landings returns that all commercial fishers are required to complete. For the SNA 1 fishery, reporting of the quantity of sub-MLS snapper returned to the sea was introduced with effect from 1 March 2014. The new reporting was implemented under section 190 of the Fisheries Act 1996, and applies to fishing by trawl, Danish seine, or bottom long lining within the SNA 1 quota management area (QMA).

The estimated greenweight (kg) of sub-MLS snapper is reported under the new reporting code SNX, via the estimated catch section of the appropriate catch and effort return. In addition, and unusually, fishers are required to record a SNX catch of 0 if they caught no undersized snapper.

The series of returns completed by commercial fishers and Licensed Fish Receivers provide a means of validating catches. In particular, while fishers are only required to provide an estimated weight in the catch and effort part of the form, actual weights are subsequently provided when the fish are landed.

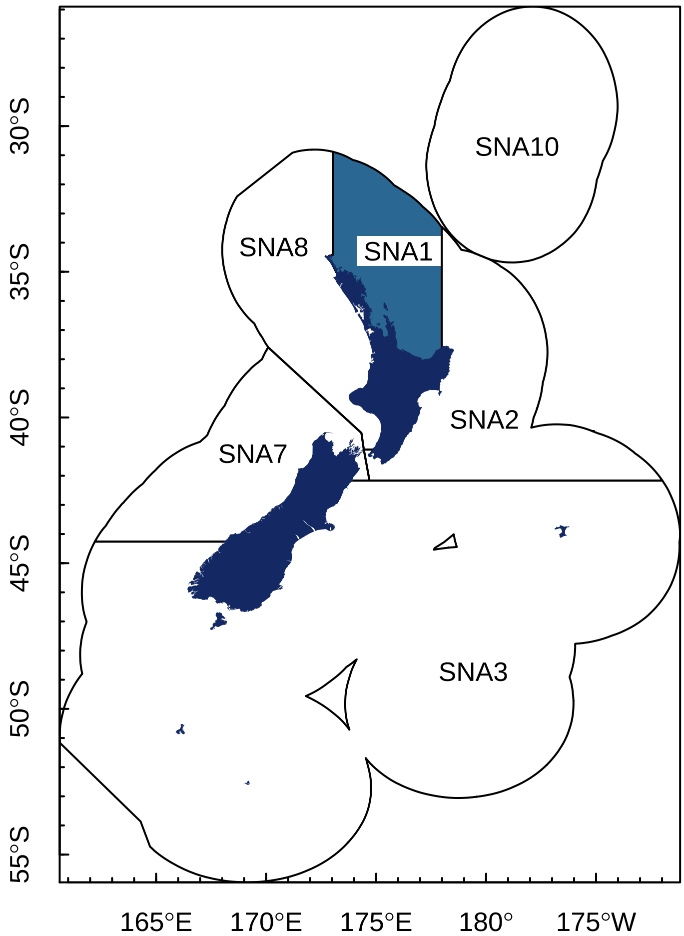

Figure 1: Quota Management Areas (QMAs) for snapper *Pagrus auratus*, with the SNA 1 QMA highlighted.

Clearly, for fish returned to the sea weighing of the fish on landing is not possible.

In order to validate the quantities of sub-MLS snapper declared under the new reporting regime, the Ministry for Primary Industries (MPI) put in place an independent monitoring programme, focussing on the SNA 1 bottom trawl (BT) fishery. Since 1989/90 SNA target bottom trawl catches have accounted for 16% of the SNA 1 catch, and snapper is also taken as a bycatch in trawls targeting other species including john dory, tarakihi, trevally and gurnard (Bentley et al. 2014). Although information is relatively sparse, bottom trawling is thought to catch more undersized fish than bottom longlining, and returned fish caught by trawling are expected to suffer higher levels of mortality.

The MPI monitoring programme comprised both human observers, and a trial of video observation (also known as electronic monitoring). Video observation uses cameras on vessels to collect footage which is reviewed ashore. The review process involves a reviewer watching the video footage and providing observational data which is similar to that provided by observers making direct observations at sea.

The video observation component of the SNA 1 monitoring programme represents the largest scale trial of video observation in New Zealand to date. Although various trials of video observation have been carried out in New Zealand since a pilot trial in the Canterbury set net fishery in 2003 (McElderry et al. 2007), it has not yet been adopted as a mainstream data collection tool in New Zealand's fisheries due to a number of technical and regulatory constraints. However, there is ongoing interest in assessing its use and overcoming these constraints.

This report details the part of the video observation trial carried out by Trident Systems under contract to the Ministry for Primary Industries. A parallel trial was carried out by Archipelago Marine Research (Pria et al. 2016).

1.1 Objectives

The contracted objectives of the trial were to use video observation on participating vessels in the snapper 1 fishery to:

1. verify reported quantities of sub-MLS snapper;
2. identify the occurrence of illegal discarding during fishing trips;
3. report compliance with the SNA 1 move on rule.

The trial also aimed to:

4. assess the general efficacy of electronic monitoring (EM) including cameras, data collection, data storage, viewer software, and reporting for observation of inshore fishing activity; and
5. contribute to the development of standards and protocols for the use of EM by MPI.

1.2 Background to the trial

In addition to proposing the recording of sub-MLS snapper returned to the sea, SNA 1 Commercial's August 2013 submission on the SNA 1 sustainability measures proposed that trials should be conducted of the use of cameras to monitor fishing activity.

In his decisions on SNA 1 sustainability measures for 1 October 2013, the Minister for Primary Industries indicated that trials of electronic monitoring on fishing vessels would be fast-tracked. The increased monitoring of the fishery required observer or electronic monitoring coverage of 25% of the SNA 1 trawl fleet by 1 December 2013, increasing to 50% by 2014 and 100% by the end of 2015.

In November 2013 Snapper 1 Commercial finalised an agreement of SNA 1 quota owners, licensed fish receivers and fishers which included "a suite of measures to safeguard and enhance the snapper stocks as part of their commitment to sustainable utilisation". Part of this agreement (rule five) encouraged vessels to carry video cameras if requested by the Ministry for Primary Industries as part of their electronic monitoring programme. The agreement noted that one of the aims of EM is to provide a cost efficient way to verify catch, including the volume of sub-MLS snapper returned to the sea, and the application of a move-on rule designed to avoid fishing in areas with predominantly small, sub-MLS snapper.

The SNA 1 agreement recognised that the introduction of electronic monitoring cameras on vessels may not be desired by all vessel operators and noted that human observers could be carried as an alternative method of achieving the requirements of the monitoring programme. To enable video observation trials to proceed in an environment that gave both parties confidence in the use of the resulting data, SNA 1 Commercial and the Ministry for Primary Industries agreed a Memorandum of Understanding governing the voluntary participation of vessels in the trial.

1.3 The SNA 1 MOU

The Memorandum of Understanding between SNA 1 Commercial, participating vessel operators, and the Ministry for Primary Industries formalised arrangements for managing the installation and use of cameras on vessels in the trial, and the collection, review and storage of the resulting footage.

The MOU explicitly distinguishes between *footage* (the raw video imagery and associated GPS data) and observational *data* resulting from the review of the footage, and defines ownership and access rights for both. It also recognised that an iterative approach may be necessary to the trial methodology, and established both Policy and Technical steering groups for the trial for industry, MPI and research providers to work together to resolve any issues arising in or from the implementation of the trial.

Part of the MOU was the specification of a "fleet plan" which established the basic operational parameters of the trial:

1. Filming is encrypted;
2. Filming is port to port, 24 hours per day, seven days a week;
3. Deployment of at least two cameras (general overview and detailed);
4. No more than two fish discard points on each vessel within the unobstructed view of a camera;
5. Discarded fish are to be batched so as to allow quantification to the tow level;
6. Filming is to capture all sorting and return to the sea events;
7. The reporting unit of measure is always kilograms of fish.

Vessel by vessel implementation of this fleet plan was specified via individual vessel plans, with an ability to incorporate any vessel specific deviations from the plan that did not compromise the objectives of the trial.

The process of establishing the MOU required significant work by SNA 1 Commercial prior to the trial getting underway. As a result of this preparation, all vessel operators allocated to Trident Systems for the trial were aware of the trial objectives and the MOU framework in which it was undertaken, and worked collaboratively with Trident to facilitate the trial.

2. METHODS

2.1 Trial logistics

The Ministry for Primary Industries selected 10 SNA 1 bottom trawl vessels for participation in the video observation trial, and allocated five to each of two research providers selected to implement the trial (see Pria et al. 2016 for details of the vessels allocated to the parallel trial). Vessels were chosen on the basis that they were a core part of the snapper 1 trawl fishery, with the expectation that the proportion of SNA 1 trawl effort observed would be greater than the proportion of the fleet observed.

To simplify logistics providers were allocated vessels that, to the greatest extent possible, operated from the same home port. As a result, most of the vessels that Trident was requested to monitor were based in Tauranga (Table 1).

Table 1: The vessels participating with Trident in the trial. All vessels were single trawl bottom trawlers active in the SNA 1 fishery.

Vessel	Base port	Registered length (m)
Vessel A	Tauranga	22.2
Vessel B	Tauranga	15.4
Vessel C	Tauranga	17.1
Vessel D	Auckland	14.4
Vessel E	Tauranga	13.8
Vessel F	Tauranga	18.4

One of the original five vessels monitored by Trident (Vessel B) was withdrawn from the fishery during the trial and its catch plan transferred to a new vessel operated by the same company. As a result, the video observation equipment was transferred to this new vessel (Vessel F), with the agreement of MPI and the vessel operator.

Initial camera installations on the five original vessels were completed in February 2014; however, the formal start of the trial was postponed until the finalisation of the MOU in mid-March. The MOU provided the basis for the individual vessel plans, which were completed in late March. As a result, 1 April 2014 is adopted in this report as a standardised starting date for the trial.

Building on the fleet plan and the other terms of the MOU, the individual vessel observation agreements detailed the equipment installed and the catch handling procedures required for quantification of the catch, with a focus on the quantification of sub-MLS snapper being returned to the sea. Vessels were provided with standardised 20kg iki bins with the intention that these were used to batch all sub-MLS snapper before these were returned to the sea.

An idealised representation of the vessel procedures in support of sub-MLS snapper monitoring by video is shown in Figure 2. It envisages a single sorting period per tow, completed before any further tows are completed, and the batching of all fish returned to the sea via containers visible on the video footage.

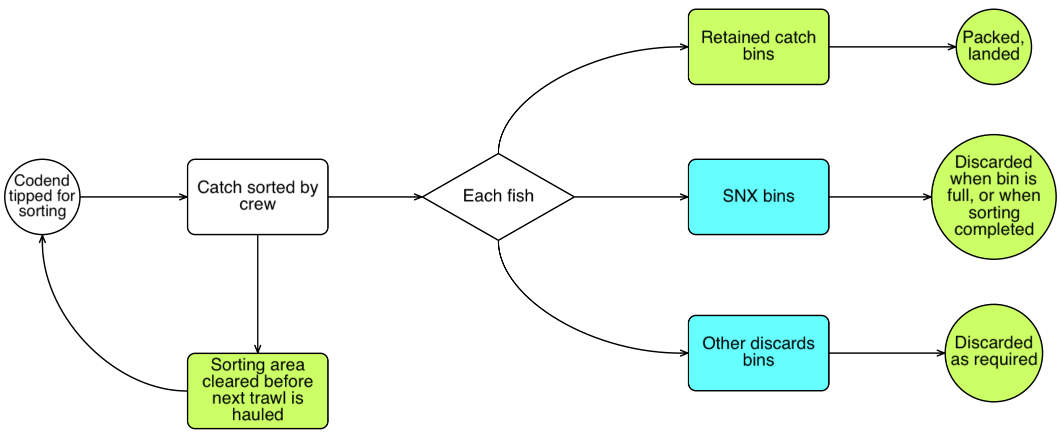

Figure 2: Idealised process for catch sorting on vessels to allow batch based quantification of sub-MLS snapper returns to the sea.

2.1.1 Vessel equipment

Two cameras were installed on each vessel. In general, one camera provided a broad overview of deck operations while the other provided a more detailed view of the catch sorting areas. Camera lens angles and mounting points varied according to vessel size and layout. Not all areas of the vessels' decks were in view of a camera (for example, the foredeck on those vessels with forward wheelhouses) and the vessel plans required that fish were not taken into those areas, as this would be out of view of the cameras.

Cameras were cabled to a wheelhouse unit which housed an appropriate power supply, and provided the facilities required for transfer of the footage ashore. Each camera was equipped with independent GPS and cellular communication.

All cameras stored footage internally in an encrypted format. Live viewing of the footage was available to the vessel crew via a laptop in the wheelhouse; however, most crews reported that they did not find it necessary to monitor the live views on an ongoing basis.

2.1.2 Camera monitoring

The cellular facility of the cameras allowed regular monitoring of camera status. Cameras were monitored hourly when in cellular range, sending both position data and a still image. Daily reports for each vessel were compiled from this information and emailed to the respective vessel operators.

2.1.3 Retrieval of footage

In the early stages of the trial footage was manually downloaded from all vessels during port calls. For the Tauranga based vessels, automated transfer of the footage to shore by wireless networking was put in place. Footage was transferred from the vessels to a port server, and was then transferred on to the footage storage facility using appropriately secure internet connections. Unfortunately, delays in the supply of fibre broadband connections meant that this transfer facility did not become fully operational until the latter part of the trial.

The electrical systems of one vessel in the trial were entirely powered down during port calls, and shore power available was not available at its berth. In this case footage was retrieved by site visits and the use of removable hard drives.

2.2 Review of footage

2.2.1 Trip definition and data integrity checks

To facilitate comparisons with the catch-effort data, and provide a meaningful unit for reviewing, footage downloaded from a vessel was first divided into trips. Non-overlapping trips were defined continuously throughout the period that a vessel was monitored in the trial. Trips were defined by a start and end time, and represented the period from port call to port call. As a result, trip definitions were based primarily on the GPS footage. Ports used in defining trip start and end points were restricted to the major ports where a vessel was likely to unload its catch. Trips did not have to start and end in the same port.

The trial was restricted to the SNA 1 quota management area. If vessels moved during a trip to a different area (i.e. the adjacent QMAs, SNA 2 or SNA 8) these periods were excluded from the trial footage. One vessel also took part in a number of research fishing trips during the course of the trial, and these were similarly treated as exclusions from the trial.

Footage integrity reports were prepared on a trip by trip basis; these enabled assessment of the extent to which footage (imagery and GPS, on a camera by camera basis) was complete. Any technical issues with the cameras were typically identified by the routine monitoring, but the integrity reports provided a clear picture of the impacts in terms of lost footage.

Vessels often spent a number of days in port between fishing trips. For all but one vessel footage was normally collected continuously whilst in port. Trips were typically arbitrarily divided approximately half way through a port call. In the case of short port calls, care was taken to ensure that the period a vessel spent unloading was associated with the preceding trip.

Our definition of a trip differs from the definition implemented in MPI's `warehou` reporting database (Ministry for Fisheries 2010), which builds on the definition in the Fisheries (Reporting) Regulations 2001. The concept of a trip in `warehou` is a mechanism for associating landings data with the processing, estimated catch, effort and environment data collected during the preceding fishing trip, i.e. the period since the previous landing. A `warehou` trip does not typically include periods in port; it begins when the vessel leaves port and may be terminated by either landing or transshipping. The general expectation, therefore, is that `warehou` trips would be a subset of the time period within a trip defined from the footage. Exceptions would arise if a vessel called in at a major port, but did not land catch. In this case a `warehou` trip could span two (or more) trips defined from the footage.

2.3 Manual review

Once separated into trips, footage from the trial was reviewed by a human reviewer who manually created observational data records, analogous to the data collected by observers at sea.

The broad approach to review of the video footage is illustrated in Figure 3. It required that vessel and crew activity were continuously categorised through a trip. Detailed review focussed on the periods where fish were sorted or packed.

Vessel activity was grouped into five categories (Table 2), and crew activity into four categories (Table 3). Additional events could be defined at any point in a trip. Pre-defined event types are listed in Table 4. In addition to having a defined event type, the event data created included the start/end time of the event and a number of fields specific to the event type. For discard batch events, used for recording when sub-MLS snapper were returned to the sea, the additional standard data fields are listed in Table 5. If no

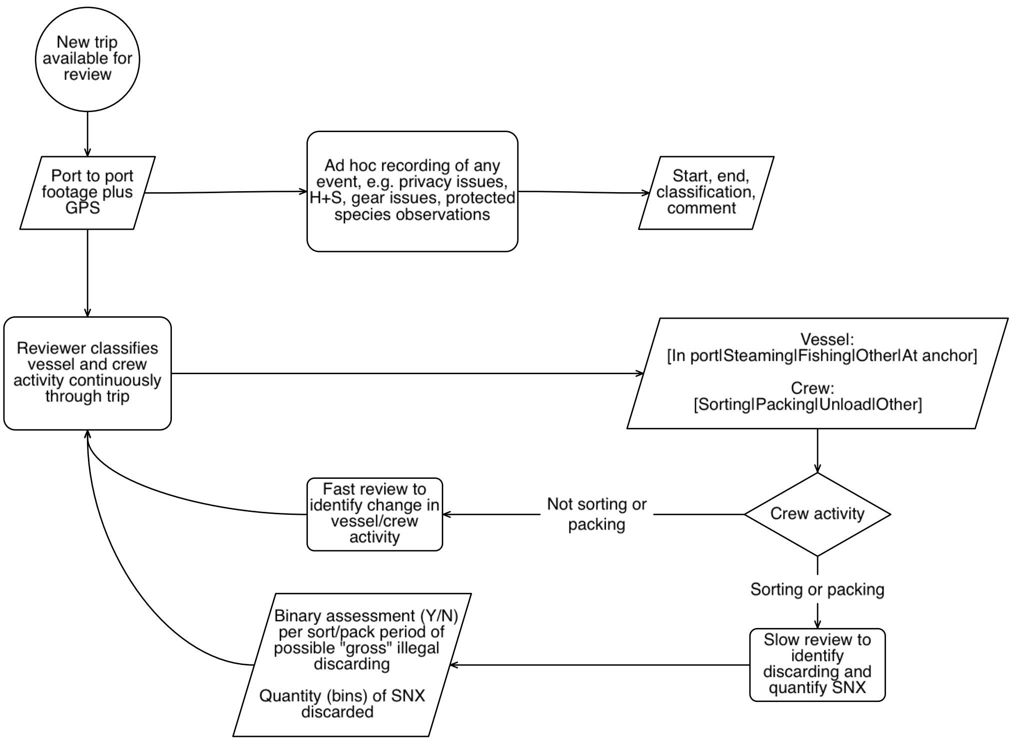

Figure 3: Outline of the manual video review process.

sub-MLS snapper were observed during a sort event, a discard event with a volume of 0 was created to specifically record this observation.

All reviewing was carried out "blind", i.e. with no knowledge of the statutory reporting data provided by the vessel.

Table 2: Categories of vessel activity defined for the review of video footage. At any point in a trip a vessel had to be assessed as undertaking one, and only one, of these activities.

Activity	Interpretation
In Port	Vessel is moored in port, or moving within the port environs. Activities such as unloading fish or loading ice may take place. Vessel is stationary or moving only at low speeds over short distances.
Steaming	Vessel is in transit from one area to another. Typically maintaining a consistent heading and speed. Speeds may vary from 2 to 10+ knots.
Fishing	Vessel is trawling. Defined as the period from the net entering the water to the cod end being retrieved on deck. Finer resolution of fishing activity (e.g. shooting/hauling) was considered unnecessary for this trial.
At anchor	Vessel is not in port, but is at anchor.
Other	Any other vessel activity. May include manoeuvring between trawls, hove to in bad weather etc.

Table 3: Categories of crew activity defined for the review of video footage. At any point in a trip the crew had to be assessed as undertaking one, and only one, of these activities.

Activity	Interpretation
Sorting	Sorting fish after tipping the cod end; fish to be packed are either in bins, in slurry tanks or bulked direct to hold.
Packing	Packing fish into the hold after sorting. Includes packing from slurry tanks into cases (which may involve some re-sorting/grading). Packing periods may occur at times that are separate from a particular tow, e.g. taking fish accumulated in slurry and packing these into the hold. The transition from sorting to packing may be somewhat arbitrary in some cases, but sorting and packing periods are both scrutinised for discards.
Unload	Fish are unloaded from the vessel in port (or via transshipment).
Other	Any other crew activity. Includes periods where crew are not visible on deck.

Table 4: Predefined event types used to categorise events (i.e. other than vessel and crew activity events) that could potentially occur at any point in a trip.

Event type	Description
Discard batch	Used to identify the discarding of a batch of fish in accordance with the Vessel Management Plan.
Non-compliant discard	Used to identify the discarding of fish in a manner that is inconsistent with the Vessel Management Plan.
Protected species capture	A seabird, marine mammal, or protected fish species is observed to be captured. The event should start when the protected species is first seen in the footage, and end when it is released, returned to the sea.
Gear event	Used to record any fishing gear problems, or unusual gear issues for further review.
Privacy concern	Allows the reviewer to flag any segments of footage where crew privacy may be compromised, and where - as a consequence - the footage should be restricted from normal viewing.
Health and safety concern	Segments of footage which the reviewer considers illustrate a health and safety concern.
Ad hoc event	Used to record an event which does not fall in any other category, but which the reviewer considers should be noted.

Table 5: Data fields collected (in addition to event start/end time) for discard batch events.

Field	Description
Species	The species of fish discarded. For the purposes of this trial only SNX (sub-MLS snapper) or OTH (other species) should be identified.
Volume	Size of the batch. Five numerical values: fullness of iki bin (0, 0.25, 0.5, 0.75, 1) or piece which indicates an individual fish.
Status	Two values: either good, in which case all fish discarded are judged to be legal discards, or flagged in which case the reviewer has doubts about the discard in which case a comment should be given.
Gear event	Used to record any fishing gear problems, or unusual gear issues for further review.
Comment	Primarily used if status is flagged, and used to describe the reviewers concerns about the discard.

3. RESULTS

3.1 Deployments and footage

A high level summary of footage collected during the trial illustrates the different camera deployments on each vessel (Figure 4). A number of vessels had camera changeovers during the trial. For example, on Vessel A, the largest vessel in the trial, a narrower angle camera was substituted (C-3 for C-1) in order to provide better resolution images of the fish sorting areas from the only practical camera mounting position. The gap in footage from camera C-2 on Vessel A, however, resulted from maintenance to address a failed hard drive.

Failed hard drives also required a change of camera on Vessels D and E; subsequent deployments used solid state storage devices to avoid this problem. Another camera on Vessel D suffered accidental physical damage to the lens and required repair.

On Vessel D, the lack of continuity in the footage is due to the vessel's electrical systems, including the camera power supply, being powered down while in port.

Camera software updates, and updates to the download software, were deployed during the trial to resolve a number of issues, some of which resulted in some patchiness in footage from some cameras during the early part of the trial. By the latter part of the trial cameras on all vessels were stable and reliably providing continuous footage.

MPI Observers were present on five of the trial vessels during the course of the trial, as indicated in Figure 4. However, the resulting Observer data is not considered in this report.

3.2 Summary comparisons between video and statutory data

With the exception of a small number of trips where technical problems caused footage loss, all trips between 1 April and mid-late September were reviewed. Summary comparisons of fishing effort recorded from the video footage with the statutory catch effort data are shown for each vessel in Appendix A. Black areas on these plots indicate either where a vessel was not in the SNA 1 quota management area, or where it was taking part in a research fishing trip. Only Vessels D and E fished exclusively in SNA 1 throughout the trial.

By eye comparisons indicate a high degree of concordance between the fishing activity identified in the video footage and that reported by fishers via the statutory catch-effort reporting. Also evident in these plots is the fact that the `warehou` trip definitions do not always contain strictly sequential fishing events, resulting in overlapping trips. This is especially evident for Vessel C in April and May (Figure 15).

In order to facilitate comparisons of video observations and the CEL data at a trip level, a set of 73 matching trips was defined where a single `warehou` trip was matched with one (or occasionally two) trips defined in the video data (Table 6). Trips were included on the basis that (i) they were exclusively SNA 1 trips, and (ii) both the `warehou` trip and the associated video trips identified a discrete period of fishing activity. The first condition meant that for one vessel no trips were included as all trips for the time observed included periods spent outside SNA 1. The second condition meant that some `warehou` trips which overlapped adjacent trips were excluded. Overall, 65.7% of reviewed SNA 1 tows were included in the matched trips.

3.2.1 Fishing and sorting activity

For the set of matched trips, a comparison of the number of tows identified in the video footage relative to those in the statutory data showed a good, but not perfect, correspondence (Figure 5). Reasons for the discrepancies can be assessed from the trip by trip comparisons of video and statutory data in Appendix B.

The largest positive discrepancies (Vessel E, trip 33 - see page 53; Vessel D, trip 46 - see page 46) relate

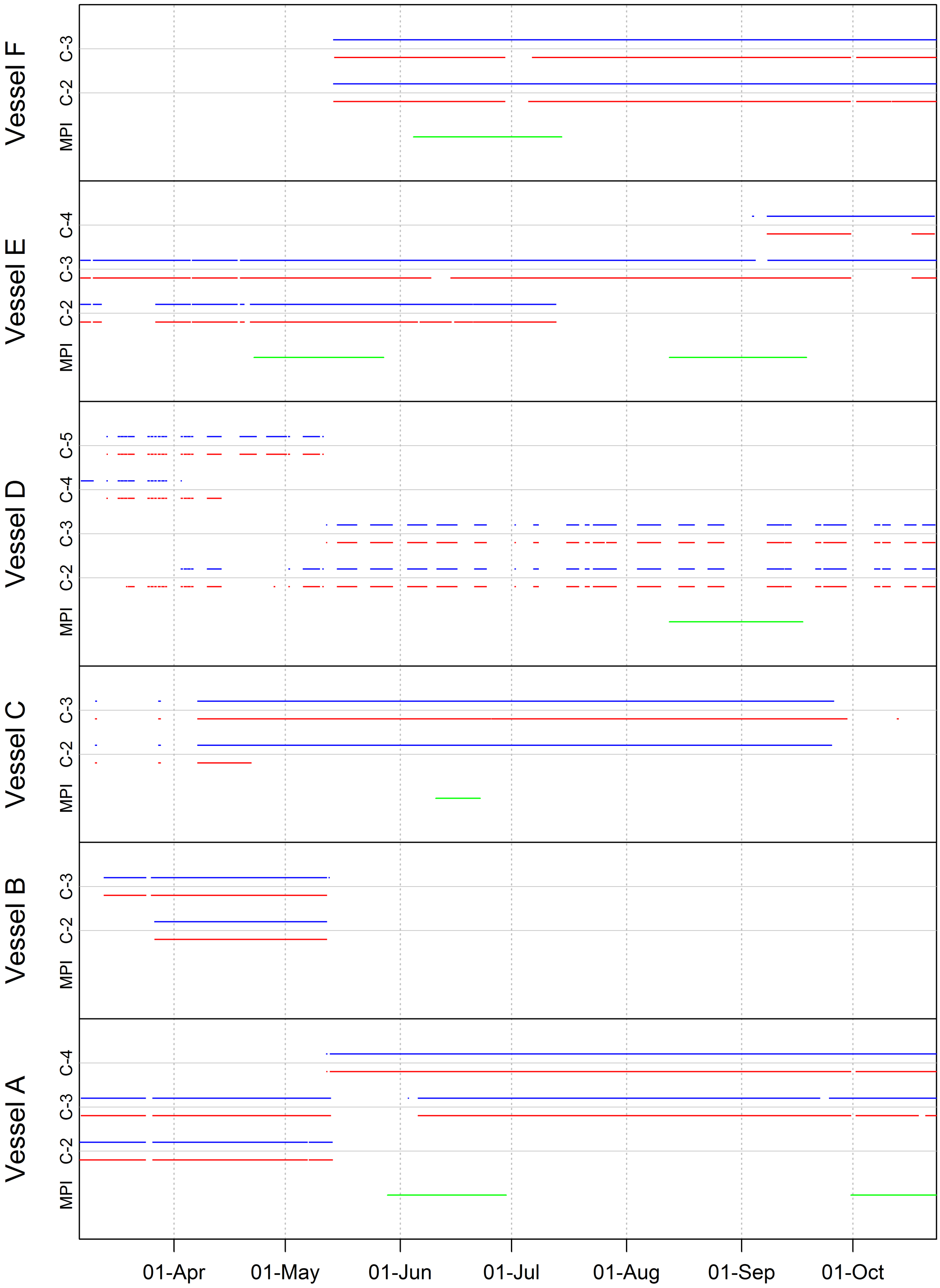

Figure 4: High level summary of footage by camera by vessel for the trial. For each camera, the red line indicates GPS footage and the blue line indicates video imagery. Periods when an MPI Observer was onboard a vessel during the trial are indicated by the green lines.

Table 6: Trips per vessel in the set of matched `warehou` and video observation trips.

Vessel	Matched trips
Vessel A	24
Vessel B	0
Vessel C	21
Vessel D	13
Vessel E	30
Vessel F	4

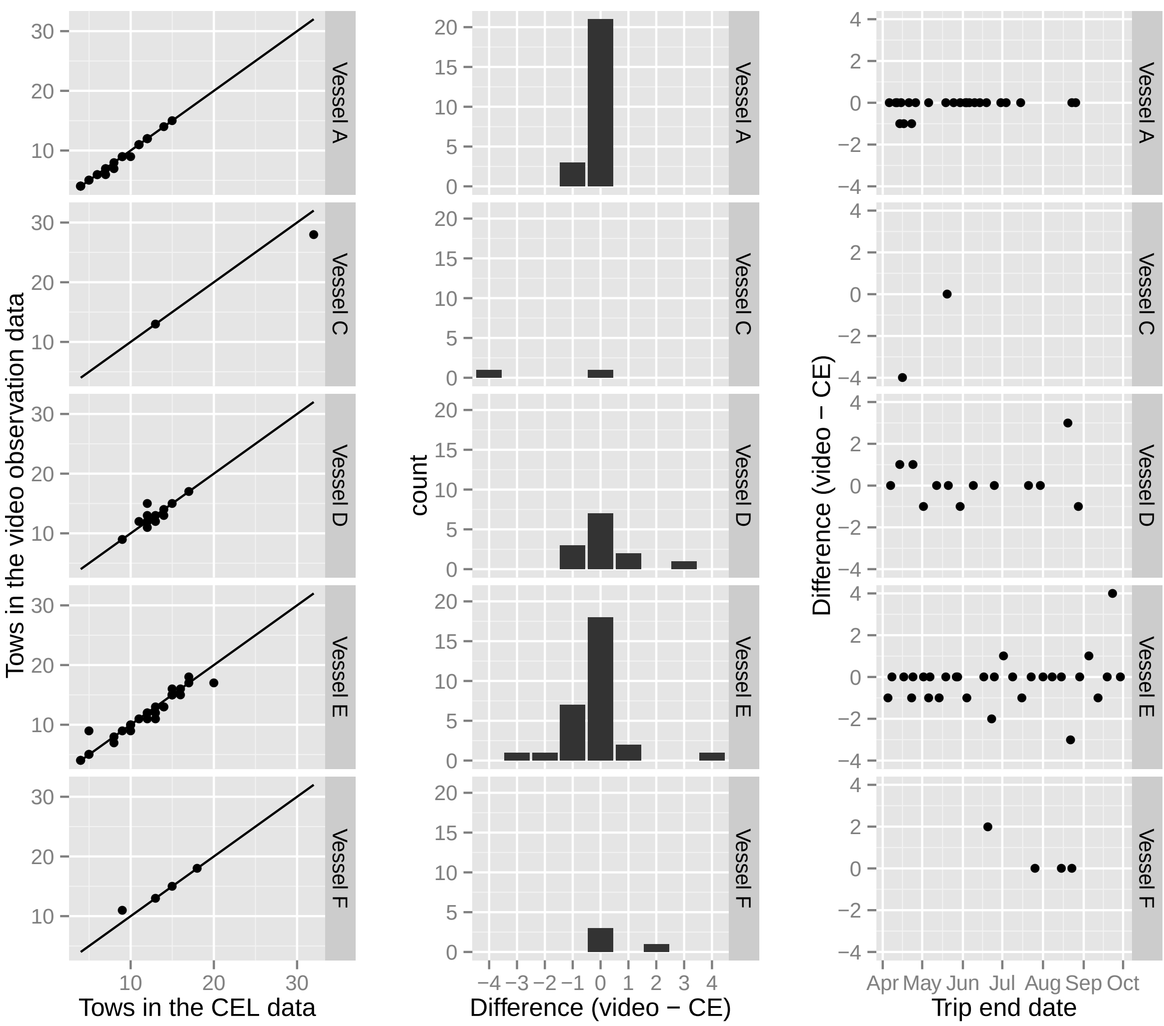

Figure 5: Comparison of the number of tows identified in the video observation data with tows present in the statutory data for matched trips.

to periods where fishing was recorded in the video footage but is not in the extract of statutory data. Verifying the completeness of the statutory data is required to resolve these discrepancies; for example, if forms have been returned for correction they may not have been available in the `warehou` database at the time the extract was made. Both these large positive discrepancies arose in the later part of the trial and so it is realistic that these statutory data may not yet have been finalised.

While other positive discrepancies also relate to apparently missing statutory data, such discrepancies can also arise due to differences in the definition of a fishing event. For example, extra fishing events recorded by the reviewer for Vessel D trips 36 and 37 (see page 43) are related to net cleaning and repairs at the end of the trip.

Negative discrepancies arise when tows are recorded in the statutory data but are not identified in the video footage. The largest negative discrepancy (Vessel C, trip 48, page 46) suggests that the reviewer missed four tows. Re-examination of this trip in the light of the statutory data indicates that the first discrepancy arose due to a haul (and initial sort) that was missed by the reviewer but that, while the vessel activity was miscoded for a period of three tows, the associated sort events were identified and reviewed.

The next largest negative discrepancy (Vessel E, trip 28, page 56) arose on a trip when only one camera was operational. Three missed haul/sorts can be identified from the statutory data. The statutory data from this trip also shows evidence of data errors with two incorrect tow end times, one leading to an erroneously short event whilst the other results in overlapping tows (probably due to midnight being entered as noon).

Examining a selection of the trips where a single tow was missing indicates that on some occasions a haul and sort event was missed by the reviewer, but that on other occasions the sort events were identified despite the fact that consecutive tows were lumped to a single event.

Discrepancies between the number of sorting events and the number of tows in the video observation data (Figure 6) should assist in identifying occasional lumping of fishing events by the reviewer (where the sort is recorded), while examination of patterns in the length of fishing events would assist in identifying cases where the haul and the sort are both missed.

The differing relationships between packing events and tows on a trip observed for the different vessels in the trial are likely to relate to between-vessel differences in catch handling. For Vessel E the relationship between the number of packing events and tows may indicate two different patterns of fishing activity by the vessel.

3.2.2 Sub-MLS snapper

Trip level comparisons between the estimated quantity of sub-MLS snapper reported via the statutory catch-effort forms, and the quantity estimated from video observations, show a strong positive relationship (Figure 7). Video based estimates assumed the consistent use of the intended discard batching bin, deemed to contain 20 kg of sub-MLS fish. In reality, a variety of bins were used, often larger than the small iki bins supplied. The dashed line in Figure 7 therefore illustrates the expected relationship if a 40 kg discard bin weight is assumed.

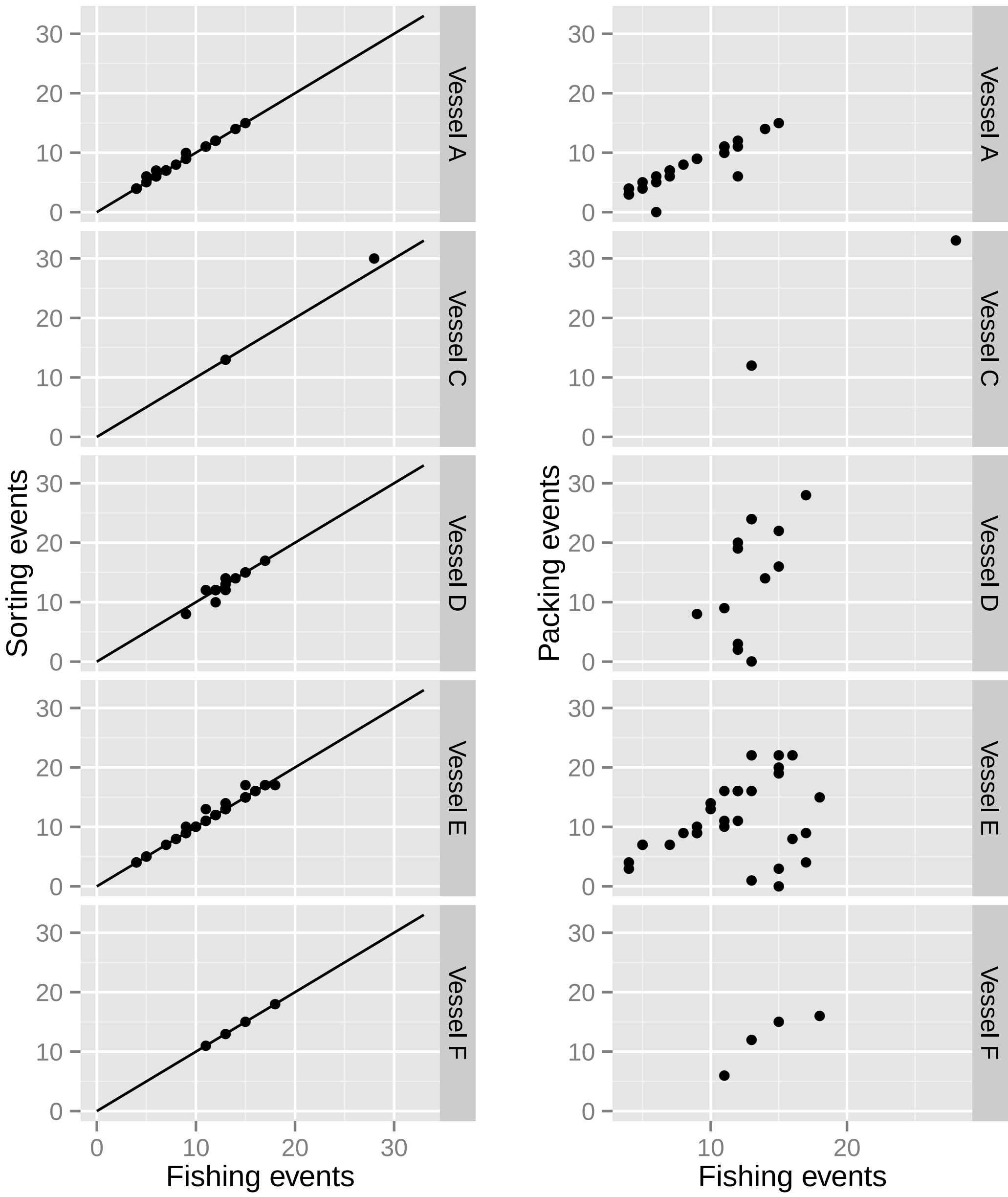

Figure 6: Trip by trip comparison of number of sorting (left column) and packing (right column) and fishing events in the video observation data.

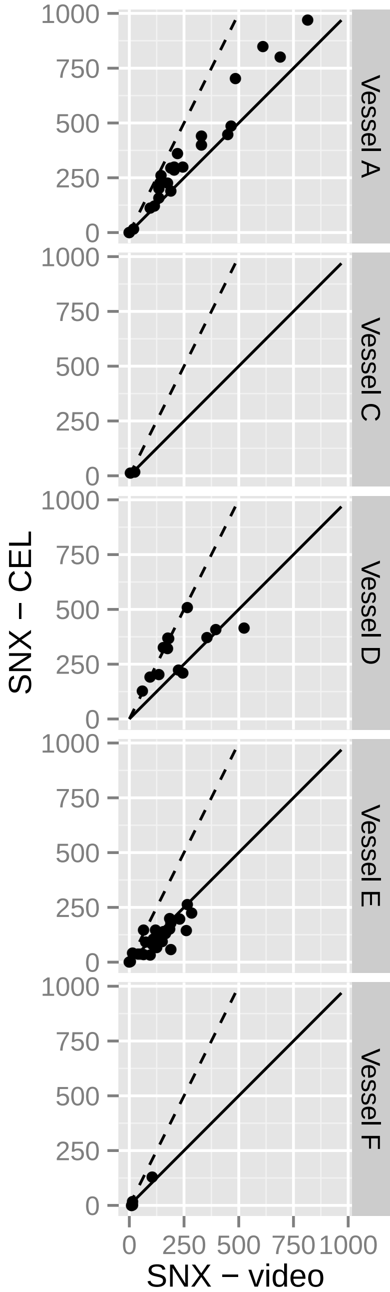

Figure 7: Comparison of the estimated catches of sub-MLS reported via the SNX species code and the quantity estimated from video observations, calculated assuming the use of the 20 kg iki bins, for matched trips. Any single returns of sub-MLS snapper recorded from the video were converted to a weight assuming a 24 cm fish and the standard length-weight relationship for snapper (Ministry for Primary Industries 2014). In addition to a 1:1 line (solid line) a 1:2 line (dashed) indicates the potential expected relationship if 40 kg discard batch bins are assumed.

3.3 Tow level comparisons

Tow level comparisons between the statutory and video observation data require matching the fishing events observed with the shots recorded on the Trawl Catch Effort Return (TCER) or Trawl, Catch, Effort and Processing Return (TCEPR) forms used by the vessels in the trial for their statutory reporting of fishing events. The explanatory notes for TCER and TCEPR forms define a trawl shot as follows:

> A shot is a particular part of a fishing operation. The start and end time of a shot are not the same as when fishing (including trawling) begins and ends.
>
> - The start of a shot is:
>   - when the trawl net first reaches the depth and position at which you intend to catch fish
>
>   or
>   - when fish are caught, whichever happens first.
> - The end of a shot is:
>   - when the trawl net leaves the depth and position at which you intend to catch fish
>
>   or
>   - when fish are last caught, whichever happens last.

In contrast, fishing events in the video observation data were defined by the net entering and exiting the water. As a result, a statutory "shot" is wholly contained within a video observation fishing event and tows can be matched by identifying the statutory fishing event contained within the time window defined by a video observation fishing event.

Tow matching was not restricted to the matched trips used in the trip level analyses. Tows were excluded if the start position of the video observation fishing event was outside the SNA 1 QMA, or if the tows were undertaken on a research fishing trip. In the event that more than one statutory shot was matched to a fishing event (for example, if the video observation fishing event had failed to separate two tows) the first statutory shot was taken as the matched shot for the purposes of the analyses reported here.

The matching process yields a set of 1104 matched tows (Table 7). Reasons for unmatched tows include statutory data that appears to be missing from the `warehou` extract, and errors in the start and end time of tows in the statutory data.

Table 7: Video observation fishing events (tows) per vessel matched or not matched to statutory shots.

Vessel	Matched tows	Unmatched tows
Vessel A	250	42
Vessel B	34	1
Vessel C	189	11
Vessel D	130	53
Vessel E	377	21
Vessel F	124	6

3.3.1 Tow position recording

The statutory data provides either a start position per tow (TCER form) or a start and end position (TCEPR form). The video data has continuous GPS recording. Although the definitions of the start of tow differ in the statutory and video observation data, a comparison of the difference between the truncated (to 0.1 of a degree) shot start positions from the statutory data with the position at the start of the matching video observation fishing event provides a basic check on the comparability of the position data from the two data sets (Figure 8). The small number of positions where the absolute difference is greater than 0.1° are likely to represent errors in the statutory data.

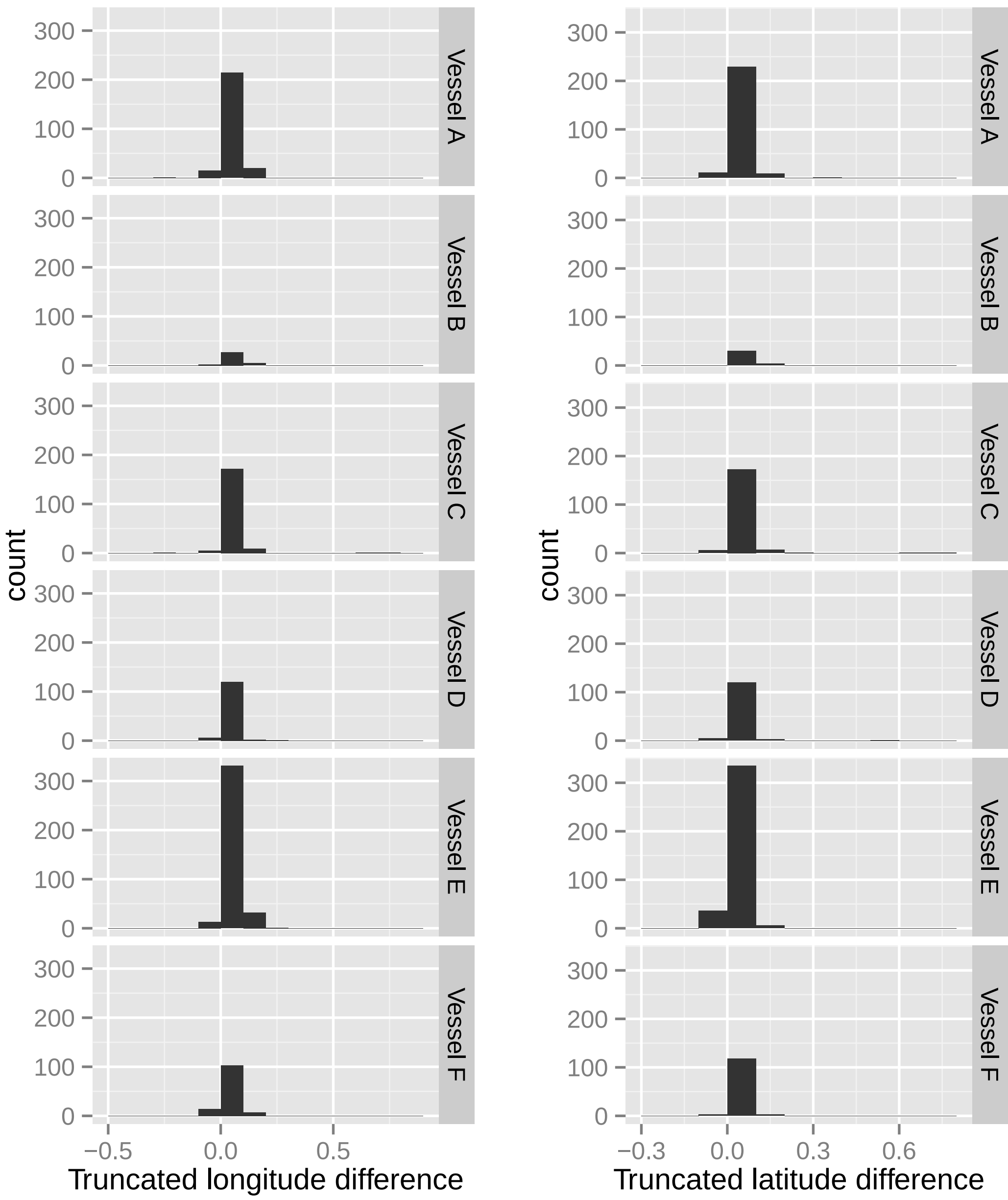

Figure 8: Differences between the truncated tow start positions from the statutory data and the truncated position for the start of the video observation fishing event, for matched tows.

3.3.2 Vessel sorting behaviour

The timing of fish returns to the sea (for both sub-MLS snapper and other non-retained species; Figure 9) varies between vessels as a result of variations in catch handling practices, which are in turn related to vessel size, configuration, number of crew etc. On some vessels most sub-MLS snapper are returned during the initial sort, while on other vessels most SNX are identified and returned as the fish are packed. For other species most discard events occur during the initial sort of the catch.

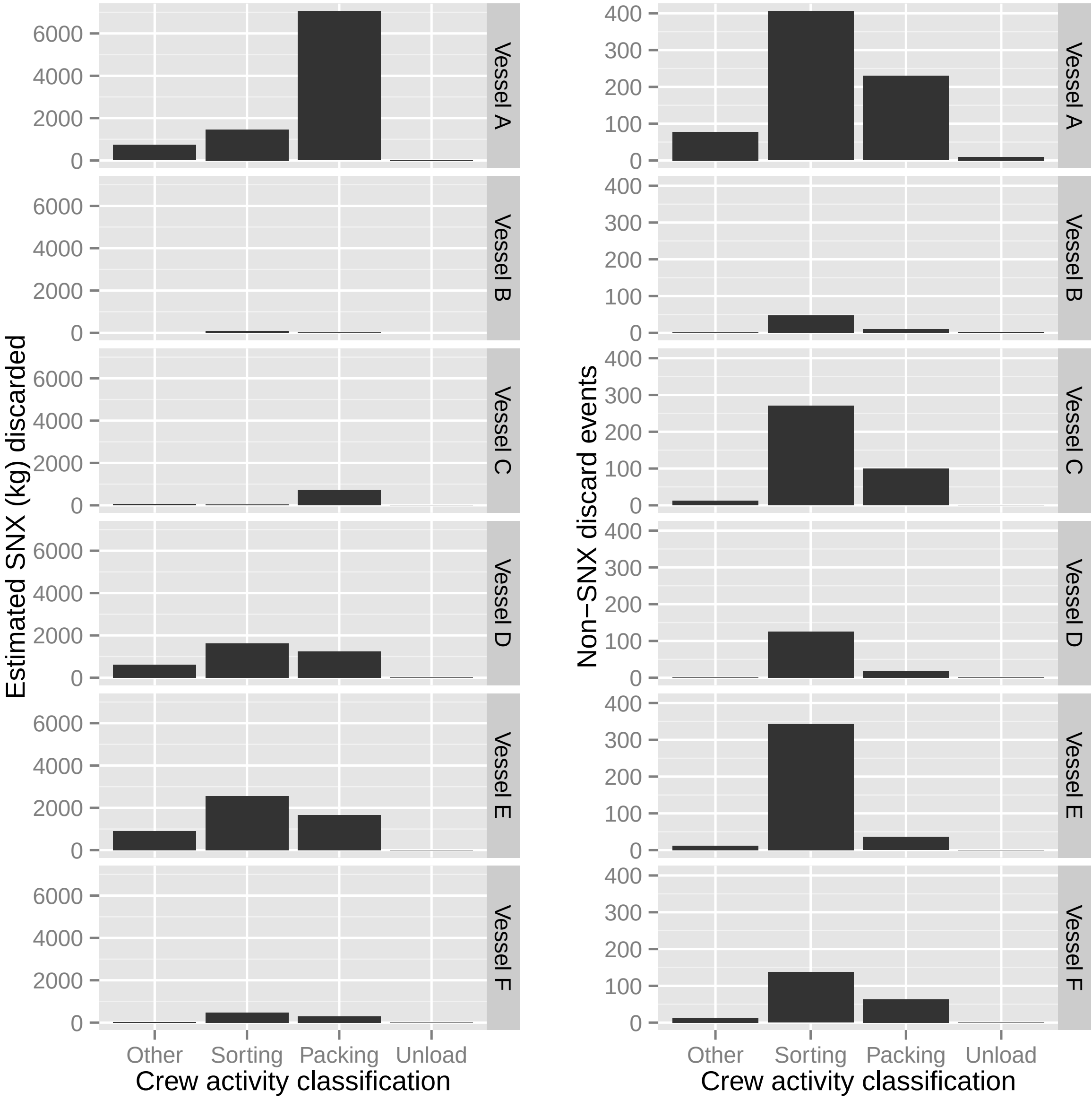

Figure 9: The occurrence of discarding events for sub-MLS snapper (left column) and other species (right column) by crew activity classification. For sub-MLS snapper the estimated quantity returned to the sea is given in kilograms, assuming a 20 kg bin and a 24 cm fork length for any single fish returns.

3.3.3 Tow-based comparisons of sub-MLS snapper

Tow-based comparisons of the quantity of sub-MLS snapper returned to the sea require that individual discard events are assigned to a particular tow. This is straightforward when the returns occur in the initial sort of a catch immediately after the codend is tipped on deck, but is less reliable for discards during a packing phase if fish have been accumulated in slurry. Final checks of fish size may also occur during unload, at which point assigning fish to a particular tow may be speculative if this relates to fish that have been packed in the hold prior to unload. For the purposes of this report, discards were assigned to the most recently completed fishing event.

As with the trip based comparisons, there is a strong positive relationship between the statutory and video based estimates of sub-MLS snapper although - unsurprisingly given the lower level of aggregation - the relationship is more noisy (Figure 10). While there are a number of outliers, the histograms of differences demonstrate that for the majority of tows there is close agreement between the two estimates.

Some of the larger outliers in Figure 10 prompt further consideration. For Vessel A, a prominent outlier is when the statutory returns indicate a discard of 80 kg of sub-MLS snapper, but there are no discards recorded in the video observations. However, on this occasion the reviewer noted “suspect multiple bins snx discard but footage gaps repeated so unable to trace bins”. A retrospective review indicated that while one camera shows a short gap in the footage, the sub-MLS returns are, in fact, visible on the second camera.

Vessels D, E and F all have an outlier tow where the video observation recorded greater quantities of sub-MLS snapper returns than are present in the statutory data (and which are likely to be influential in the regression lines). In all cases a check of the video confirms that the correct number of bins was observed. For the Vessel E and F outliers there is a possibility of a single digit transcription error in the statutory data, whereas for the Vessel D outlier the fact that much of the observed sub-MLS returns happened during packing from slurry means that fish from multiple tows may have been recorded against a single tow in the video observation data but split in the statutory data.

3.3.4 Differences between matched and unmatched tows

Because not all of the tows identified by video observation were readily matched in the extract of statutory catch and effort data, it is helpful to consider whether there are significant differences between the matched and unmatched tows. Distributions of the quantity of SNX estimated by video observation in the two sets of tows (Figure 11) suggest that the unmatched tows tend to have larger estimates of SNX (Welch two sample t-test, $t = -2.67$, p-value $= 0.008$), but there is no consistent pattern among vessels (Table 8) and none of the individual vessel differences are significant at the 5% level. The numbers of tows in this comparison is important (Table 7). The greatest discrepancy is for Vessel B where the single unmatched tow had a much greater SNX estimate than the mean quantity of SNX in the matched tows. However, most matched tows from this vessel caught no SNX, whilst a small number of tows had larger quantities (although the 35 kg estimate was the highest estimated quantity of SNX in any tow from that vessel).

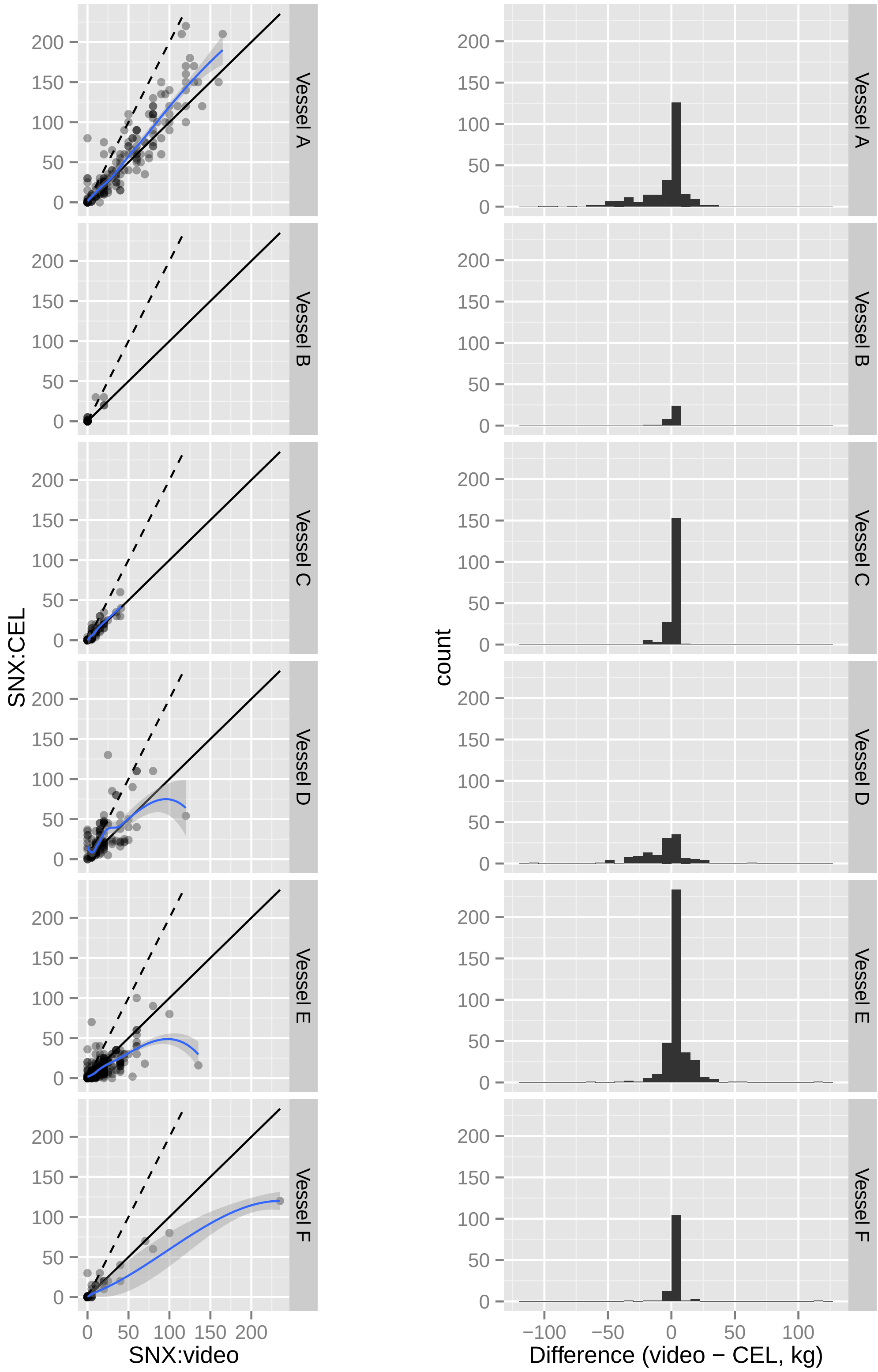

Figure 10: (Left column) Comparison of the estimated catches of sub-MLS reported via the SNX species code and the quantity estimated from video observations, calculated assuming the use of the 20 kg iki bins, for matched tows with all discard events assigned to the most recently completed tow. Any single returns of sub-MLS snapper recorded from the video were converted to a weight assuming a 24 cm fish and the standard length-weight relationship for snapper (Ministry for Primary Industries 2014). In addition to a 1:1 line (solid line) a 1:2 line (dashed) indicates the potential expected relationship if 40 kg discard batch bins are assumed. A local polynomial regression (loess) has also been added for reference (blue line), and points plotted with semi-transparency. (Right column) Histograms of tow by tow differences in the video and CEL estimates of sub-MLS snapper.

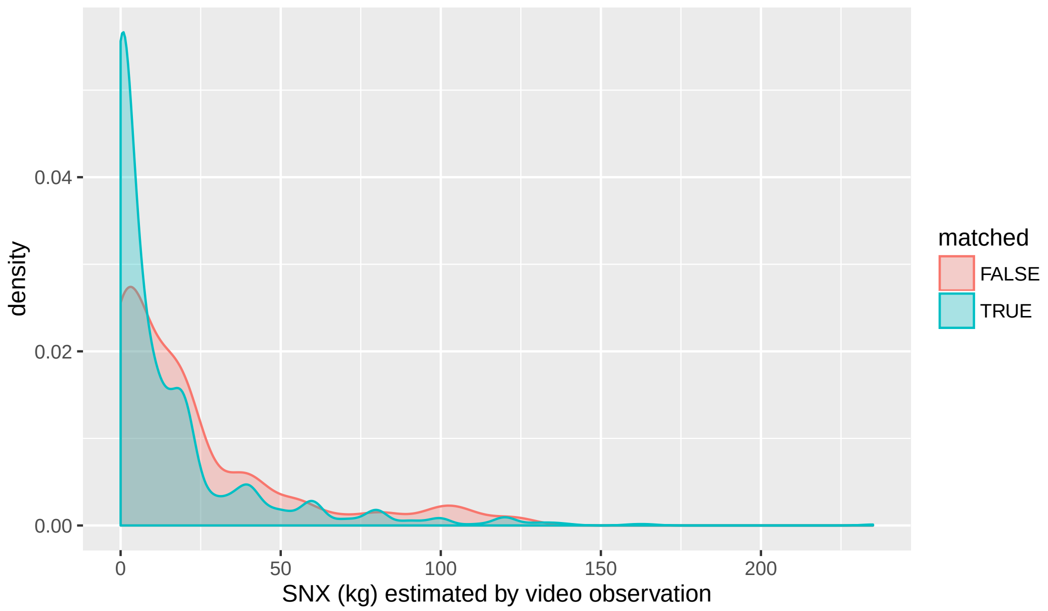

Figure 11: Distributions of the quantity of sub-MLS snapper estimated by video observation for tows that were subsequently either matched to tows in an extract of statutory catch and effort data from MPI's `warehou` database, or not matched.

Table 8: Mean estimates of SNX in tows that were matched, or not matched, to tows in an extract of statutory catch and effort data.

Vessel	Mean SNX in matched tows (kg)	Mean SNX in unmatched tows (kg)
Vessel A	31.0	35.6
Vessel B	2.1	35.0
Vessel C	4.1	3.2
Vessel D	18.0	21.3
Vessel E	13.0	11.2
Vessel F	6.5	2.0

4. DISCUSSION

4.1 Monitoring technology

In general the FishEye monitoring technology used in the trial performed very well. As this is undergoing active development a number of issues were identified and overcome. For this particular video observation task, two cameras were necessary on all vessels. Their locations varied with vessel layout but, in general, one camera provided an overview of the deck area whilst the second provided a closer, higher image resolution, view of the sorting area. All cameras used were version 1 of the FishEye smart cameras, developed by Trident's technology partner Snap Information Technologies. The retrospective pan and zoom facility provided by these cameras provides flexibility for the reviewer to choose appropriate views during the review process, which can be adapted as fishing activity on the vessel varies. For example, catches of different sizes occupy different parts of the deck area and may involve sorting activity by differing numbers of crew.

The maximum frame rates of the v1 cameras of 2 - 3 frames per second was considered adequate for the majority of the reviewing, although any individual fish discards were extremely rapid and the frame rates would not have been adequate for detailed examination (e.g. definitive species identification) of all such events. Short gaps in the digital imagery footage (of up to 30 s) occurred on all cameras due to peaks in processor use. Where these gaps occurred during sorting operations it required diligence by the reviewer, and use of the alternative views provided by the second camera, to keep track of all sorting activity. Both the frame rate and camera processing power of the v2 FishEye cameras will be higher.

Glare from direct or reflected sunlight impacts image quality although typically did not render footage unviewable from any camera. Having separated camera locations mitigates the impact of glare on the review process. Ongoing experimentation with video processing filters has demonstrated that the imagery can often be improved by their use.

Deck lighting on the vessels was generally adequate for monitoring sorting or packing activity that occurred after dusk. However, on Vessel A the metal halide (or similar) lights exhibited frequent drop-outs and took approximately 15 minutes to cool, re-ignite, and regain full brightness.

Deck lights were extinguished at night when there was no activity on deck. Ambient light generally allowed the reviewer to confirm this lack of activity, although independent infra-red illumination, and appropriate camera sensors, would probably be required for absolute verification of activity during the hours of darkness.

Processes for managing the retrieval of footage, integrity checking and the definition of trips for review were developed during the trial. The volume of footage involved is large and ensuring that this process is rigorous with robust checks and good oversight is critical, especially as video observation moves from trial implementations to routine operation.

Delays in the provision of fibre broadband connections for the trial delayed the full evaluation of the potential of using New Zealand's developing "ultra-fast broadband" infrastructure to support video observation. However, wireless transfer of footage to the Tauranga shore station and onward to the data centre was fully operational by the end of the trial, and has good potential for use in a routine video observation programme. Likewise, the distributed review of footage over secure internet links from a central data centre has proved practical. This provides the opportunity to minimise the need to ship copies of the data on physical disks. However, while remote and automated retrieval of footage at port calls clearly has many benefits the need for ongoing engagement with vessel operators should not be neglected.

Cellular connectivity to the cameras also proved effective during the trial. While moving large quantities of data by cellular networks would be cost-prohibitive for routine use, the connections allowed for invaluable routine monitoring of the camera operation, including the regular retrieval of snapshots which were used in daily reporting to vessel operators.

Electronic monitoring initiatives have often made use of sensors on vessel equipment (e.g. winches) to trigger the collection of imagery. With reducing prices and increasing capacities of storage the need to limit the collection of imagery for technical reasons is now much reduced. In the case of the current trial, sorting of fish and the return of sub-MLS snapper could not be assumed to be tightly integrated with the deployment of fishing gear as sorting and packing may take place some time after hauling. As a result continuous footage was required in this trial. The availability of continuous footage also removes doubt in the review process about what might have occurred pre- or post- recording, while removing the need to switch recording on and off removes a technical failure point. For the vessel in the trial that was unable to provide power to the cameras in port there were often delays in restarting the system at the beginning of a trip. While this generally did not compromise the monitoring of fishing activity, it is nevertheless undesirable, and we therefore consider that "always on" recording is highly desirable for future video observation programmes.

Continuous on-board video recording, while highly desirable from an observational viewpoint, requires that privacy issues are appropriately addressed through both on-board procedures and robust data management controls; the SNA 1 MOU provided a good foundation for these processes that can be built on in future programmes.

A number of camera hard drive failures occurred in the trial; these were mitigated by the adoption of solid state storage devices as the replacements. The cameras did not suffer greatly from moisture on the lenses, although clearly the choice of installation location, both to avoid spray where possible and facilitate wiping of the lens where necessary, is important.

4.2 Vessel practices

Validating the quantity of sub-MLS snapper returned to the sea through video observation required a change in typical fish handling practice on all vessels in the trial. Whereas undersized snapper were previously discarded individually and very rapidly, practical quantification of the returns required that crews binned up the fish to allow volumetric estimates.

In general this process was successfully adopted for sub-MLS snapper on all vessels. Occasional individual fish discards still occurred during the trial, but these comprised less than 5% of the observed sub-MLS snapper discard events and a smaller still proportion of the total weight discarded.

As illustrated in Figure 2 the ideal catch handling process would have seen all discards sorted into bins prior to discards. However, while vessel crews successfully adapted to binning sub-MLS snapper, batched discarding was not generally adopted for other species. While part of this is due to the difficulty in making changes to long-standing practice, there are also logistical challenges. For example skates and rays, returned under schedule 6, are less suited to binning.

Vessels were provided with standard 20 kg iki bins, in distinctive colours, to use for sub-MLS snapper. While uptake of these bins was reasonable, their use diminished later in the trial as they appeared to become "just another fish bin" onboard. As a consequence, batching of sub-MLS snapper took place via a variety of bins and it is likely that volumes varied, with 40 kg bins in use on occasions. The dimensions of the larger bins, other than their depth, were similar to the 20 kg bins and use of larger bins may therefore not have been readily identified in the review process.

Crew often assisted the review process by clearly holding up bins to the camera prior to discard. Changes in crew typically resulted in a change of behaviour on the vessel, particularly when the senior deck crew changed, requiring the reviewer to adapt to different customs. The sorting and discard areas differed at times from those defined in the Vessel Management Plans. However, it is also apparent that the logistics of sorting and packing on small vessels show some inherent variation due to differing catch volumes and compositions, and in response to gear events.

Overall, vessel practices changed successfully to facilitate quantification of sub-MLS snapper returns and it is likely that further iterative changes in practice could be introduced successfully in future to facilitate further video observation initiatives.

The ease and accuracy of fish species identification by the reviewers varies for a range of technical reasons (camera fixed zoom level, lighting, contrast) and for reasons related to on board practice such as how fish are presented. Modifications to vessels could also be contemplated to facilitate routine video observation; discard via a chute could be done if individual fish discarding was required for either operational or observational reasons.

The necessity for such changes must be assessed in light of programme goals. For this trial it was accepted from an early stage that the video observation was not intended to visualise, identify and measure every last fish. Not unlike onboard observers, the video reviewer in this trial was primarily making a general and overall judgement about whether sorting of fish by species, measurement of those species with a minimum legal size, and returns to the sea were in accordance with the regulations.

Although MPI's SNA 1 monitoring plan called for human observer coverage in addition to the video observation trial, dual coverage by observers on vessels with cameras was not explicitly planned. However, as indicated in Figure 4, seven observer deployments of up to a month duration occurred on vessels participating in the video observation trial. These observer deployments had an unintended impact on the trial as observer duties onboard could change the mode of operation, including how and where SNA/SNX were measured and discarded. Observers often took a bin of fish for measurement and discarded these individually after measuring rather than in a batch, and also discarded in areas non-compliant with the Vessel Monitoring Plan and camera visibility.

In future video observation programmes, observers need to be more clearly briefed on cameras on board and catch handling procedures including sort/discard areas.

4.3 Reviewing

The review process during the trial proved quite efficient, with the proportion of footage reviewed exceeding expectations and yielding a large set of observations. Both the raw footage, and the resulting observational data, are rich sources of information and would be amenable to further detailed review and analyses.

Comparisons with the statutory data did reveal that the reviewer had missed a small number of sorting events, and had also sometimes lumped tows into a single event while nevertheless identifying and reviewing the intervening sort. Quantifying the error rate relative to the statutory data is not straightforward as a number of errors (i.e. apparently missing forms, and clear transcription errors or mistakes on the original forms) are evident in our `warehou` extract. To date, trips in the trial have been subject to only a single review. Undertaking a selection of multiple reviews would allow between or within reviewer error to be quantified.

Additionally a number of data checks on event numbers, durations and sequencing could be devised that could be used to prompt a closer look at particular trips or events.

4.4 Sensitivity of SNX estimates to sources of error

In assessing the likely scale of errors in estimates of SNX made through video observation it should be noted that some errors are additive, whilst others are multiplicative. Over the 73 matched trips, the average number of tows per trip was eleven, and the average estimate of SNX was approximately 200 kg per trip. Failing to identify a tow would therefore typically impact the trip estimate of SNX by less than 10% (or less than 20 kg). A missed bin would result in a similarly sized negative bias.

In contrast, and as illustrated in Figure 7 for example, misidentification of the size of bins used for sorting sub-MLS snapper has the potential to result in a twofold error (i.e. 50-100%) in estimates of SNX. Potentially such errors can result in a positive or negative bias, although in this study substitute bins would have typically been of equal or greater volume than the intended bins, resulting in a negative bias.

4.5 Verification of sub-MLS snapper discards

Comparisons at both the trip level (Figure 7), and for individual tows (Figure 10), indicated good overall correspondence between the statutory estimated catches of sub-MLS snapper (SNX) declared by the skippers, and the estimates made by video observation. The trial did not address the extent to which skippers' estimates of SNX may have been influenced by the change from individual to binned discards of sub-MLS snapper.

Reasons for some of the outlier discrepancies between the two estimates are discussed above, and both estimates could doubtless be improved. However, the extent to which this would be useful requires further specification of ongoing management information needs.

The correspondence between observer and statutory estimates of catches are not routinely reported at a fine scale. However, a comparison of observer and statutory catch estimates for matches tows was provided for the silver warehou west coast South Island (SWA1) fishery by Middleton (2007), and this is reproduced in Figure 12. While the scale of the catches in this middle depths fishery is very different from that of the SNA 1 trawl fishery, the overall correspondence between the statutory and video observation estimates of sub-MLS snapper is at least as good, if not better, than that found for SWA 1.

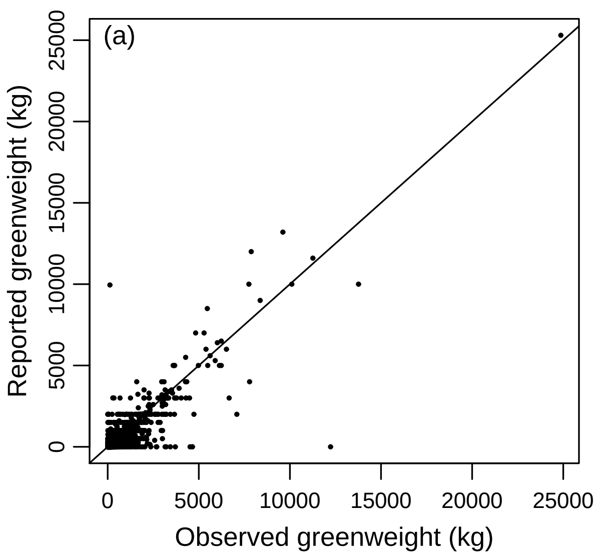

Figure 12: A comparison of observer and statutory estimates of silver warehou catches for matched tows in the SWA 1 fishery. Reproduced from figure 10 in Middleton (2007).

In conclusion, the video observation data shows good correspondence with the statutory estimates of sub-MLS snapper and therefore can be considered to validate the statutory reporting of SNX for the participating vessels during the trial. There is also good general correspondence in the time and location of fishing effort in the two data sets.

5. ACKNOWLEDGEMENTS

The successful implementation of this trial required considerable collaboration between the research providers, the seafood industry and the Ministry for Primary Industries. The groundwork for the trial relied on the efforts of SNA 1 Commercial, in particular the logistical efforts of Alison Undorf-Lay (Sanford Ltd) and the participating vessel operators and their skippers. The trial was part of the SNA 1 monitoring plan and members of MPI's inshore management team, in particular Mark Geytenbeek, Jacob Hore and Steve Halley, worked to ensure that the trial progressed. MPI data managers, Kimon George and Christopher Dick, facilitated our access to the statutory data. Archipelogo Marine Research, as the second research provider in the trial, participated in the technical working group processes that developed the fleet monitoring approach defined for the trial. Improvements to this report were made following review by an *ad hoc* workshop convened by the Ministry for Primary Industries to consider the results of the two EM trials carried out in the SNA 1 trawl fishery in 2014, and following detailed review by Martin Cryer and Marianne Vignaux.

Snap Information Technologies Ltd's development team continued work on the FishEye technical infrastructure through the project. Dragonfly Science Ltd provided the LaTeXtemplate used for this report. We made extensive use of the R software environment for statistical computing and graphics (R Core Team 2014).

This trial was funded by the Ministry for Primary Industries, with investment in developing the underlying technology by members of the Trident Systems Limited Partnership.

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A. SUMMARY COMPARISON PLOTS

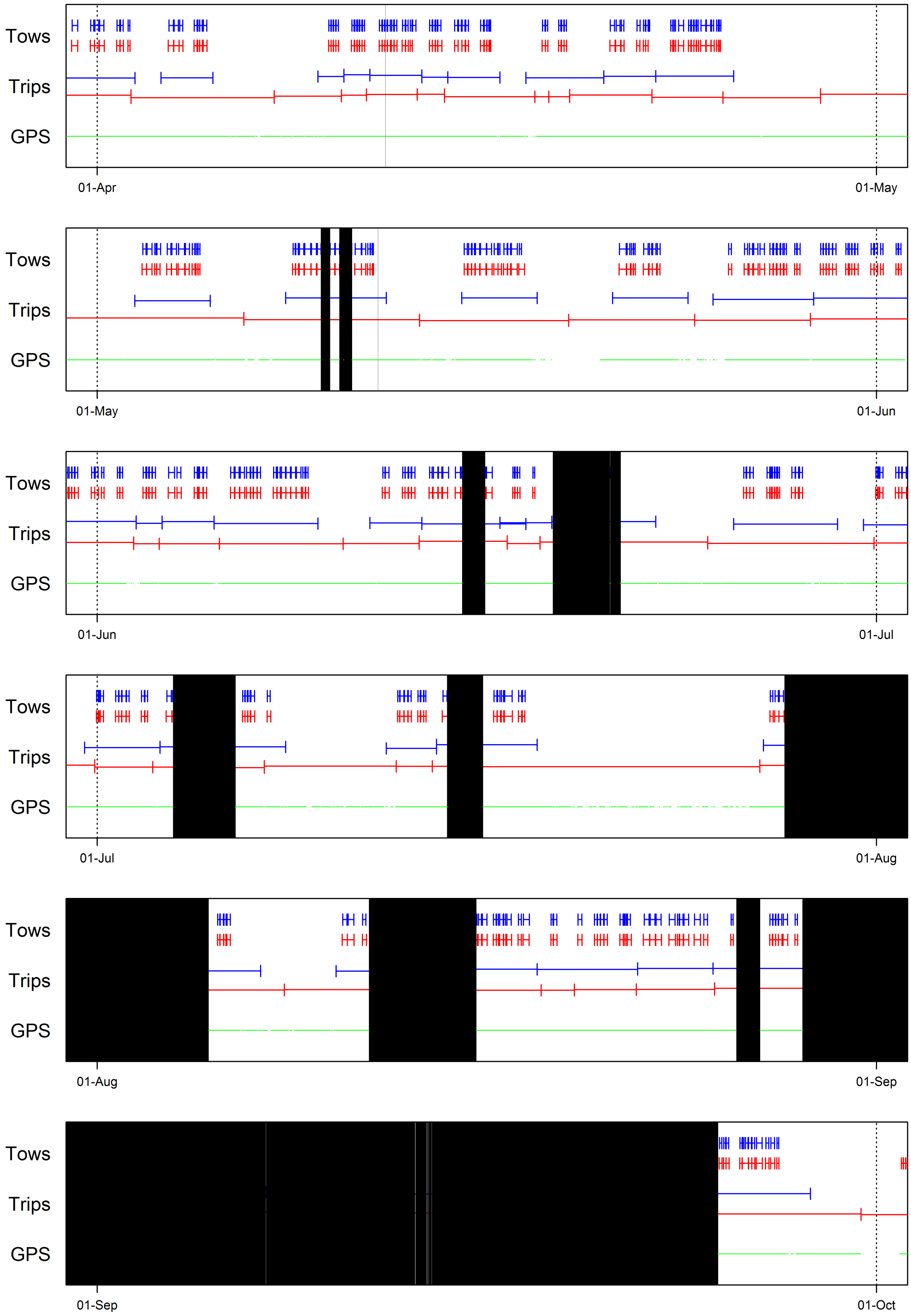


Figure 13: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel A. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

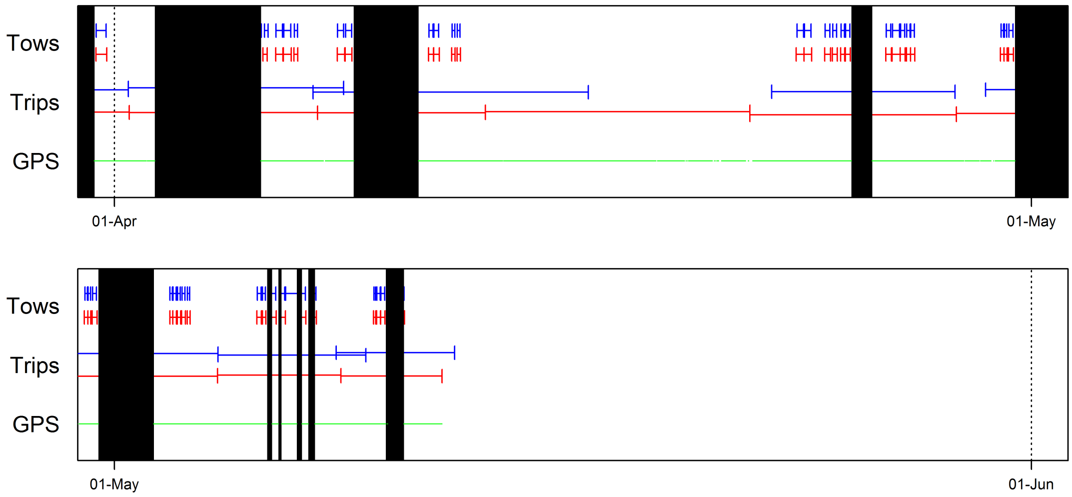


Figure 14: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel B. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

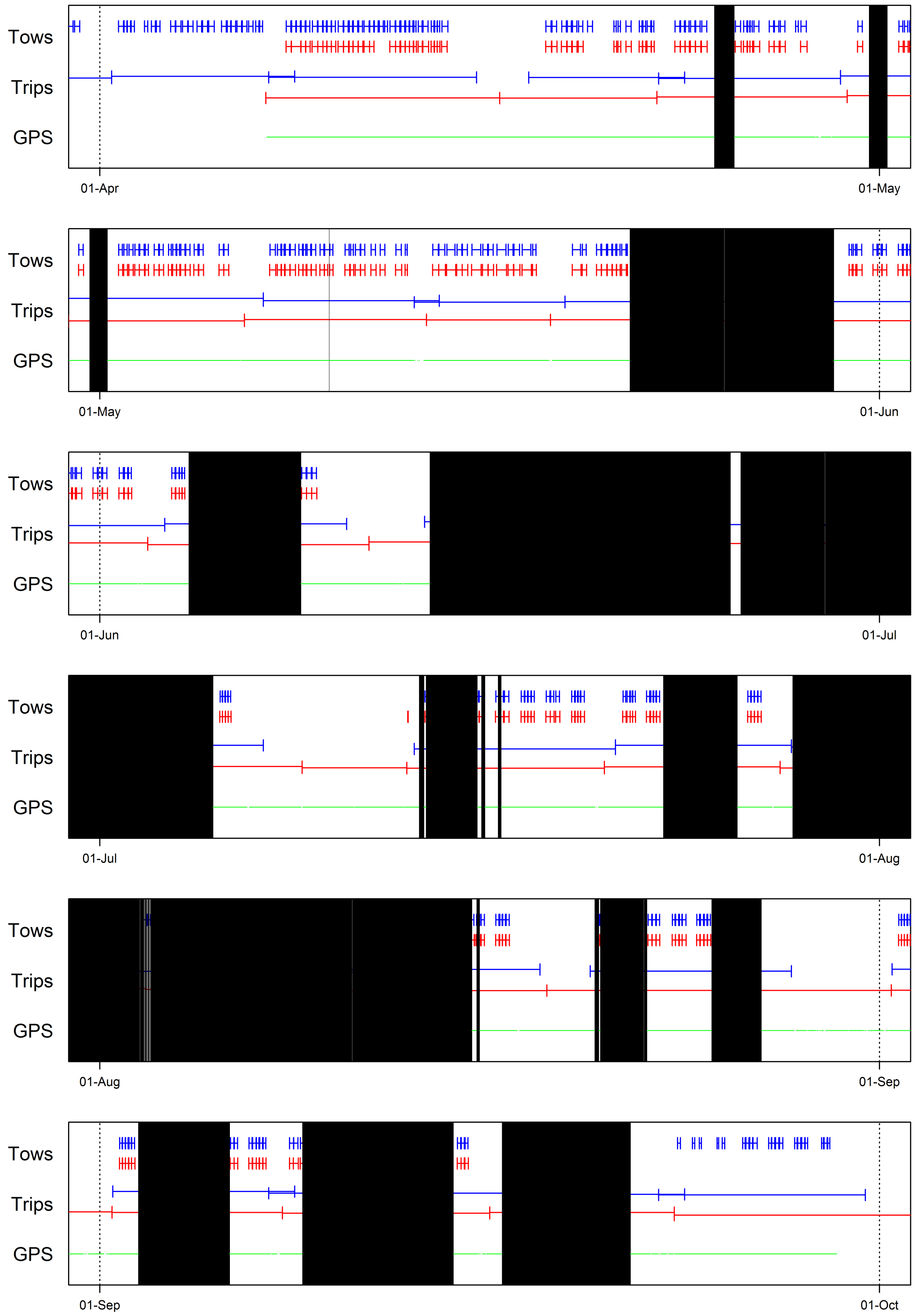


Figure 15: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel C. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

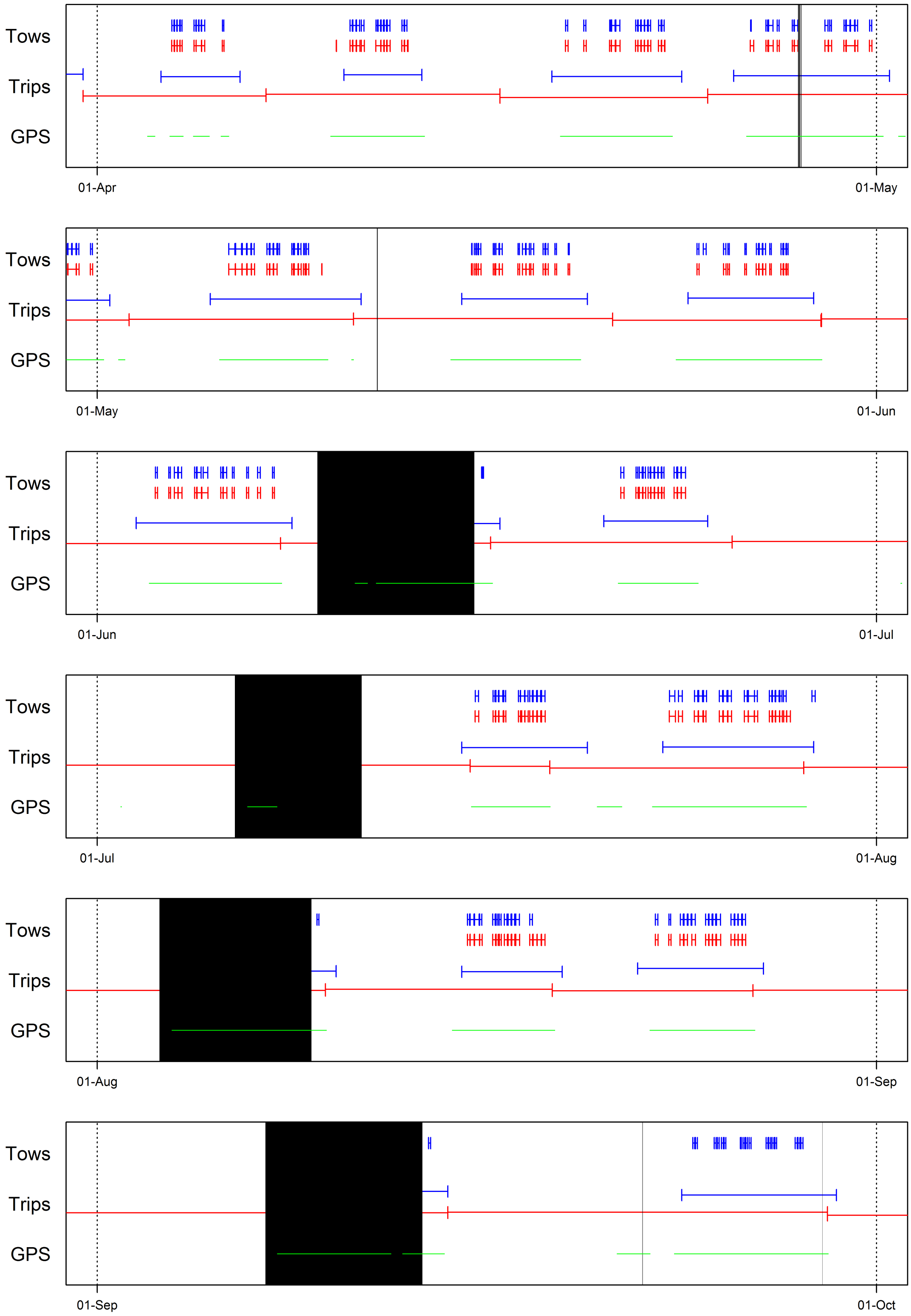


Figure 16: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel D. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

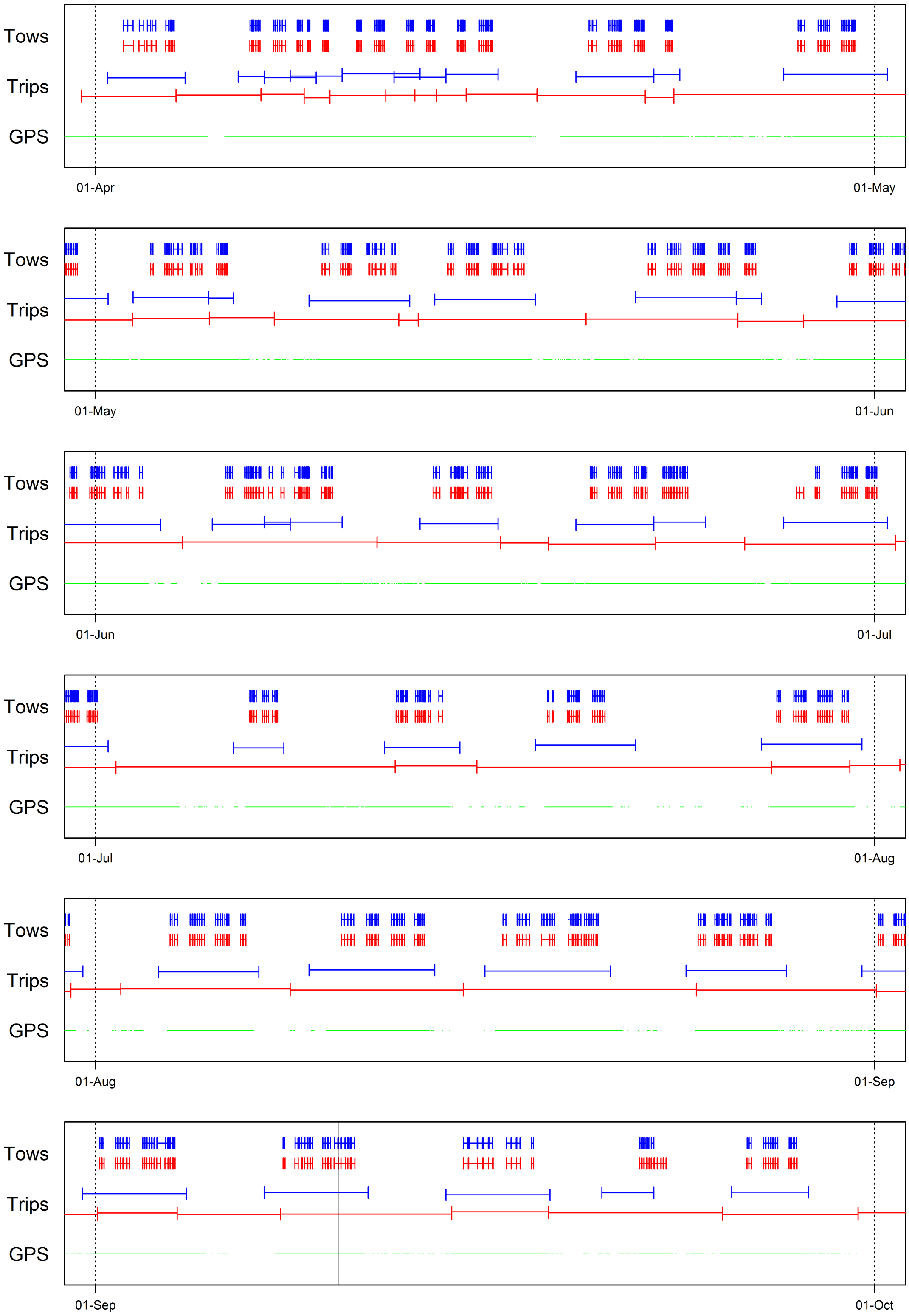


Figure 17: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel E. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

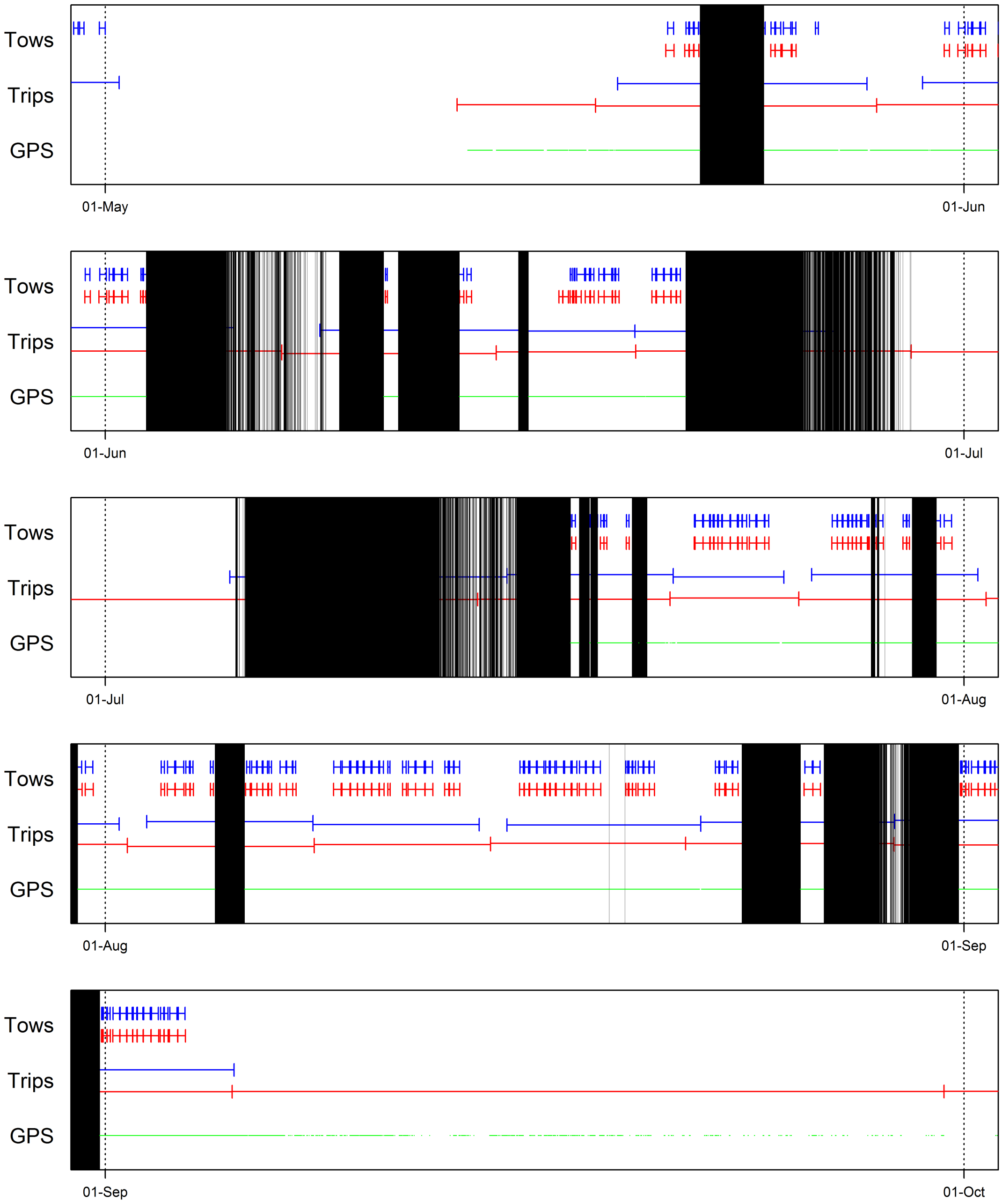
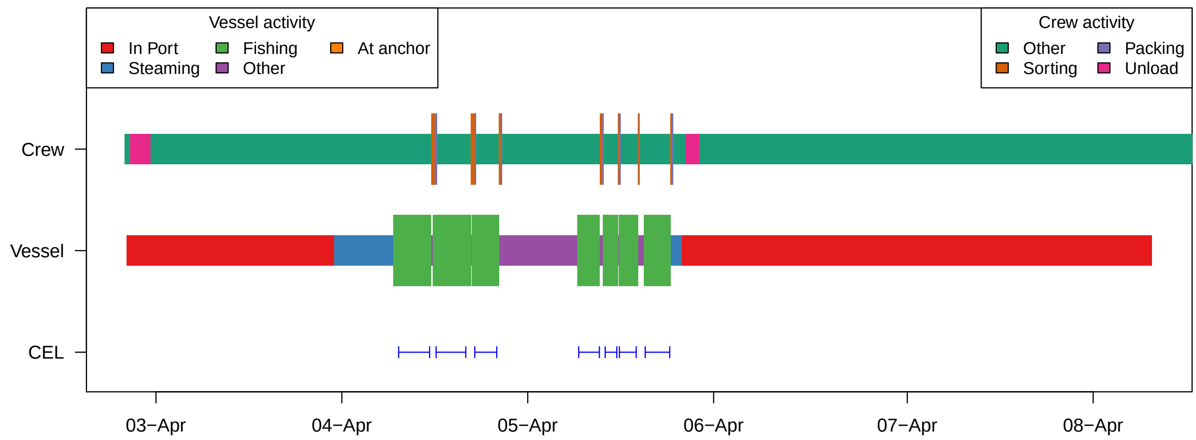


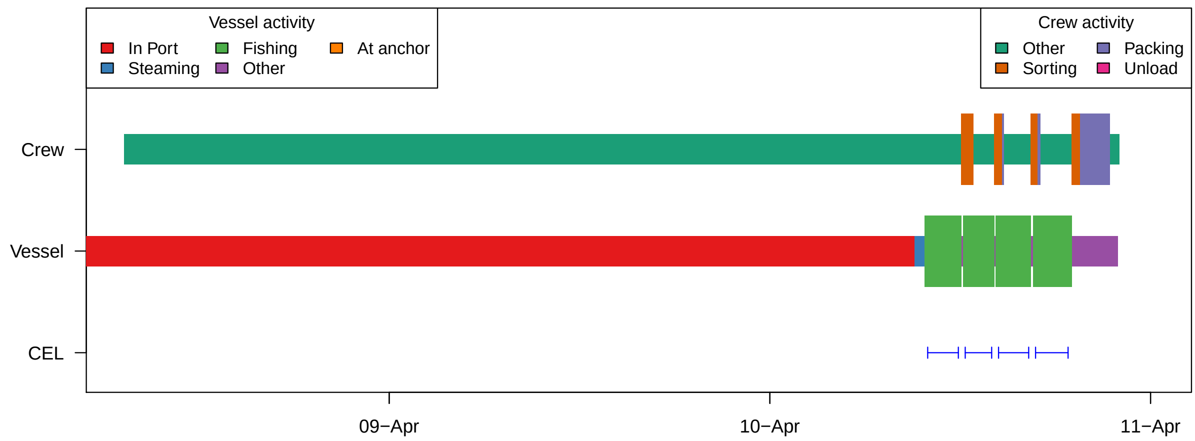
Figure 18: Month by month comparison of video observer and statutory (catch-effort-landings) data for Vessel F. Green points indicate the vessel was in the SNA 1 QMA; when the vessel was outside this area the plots are censored using vertical black lines. In the comparisons of trips and tows, red lines indicate video observer data while the CEL data is shown in blue.

B. TRIP COMPARISON PLOTS

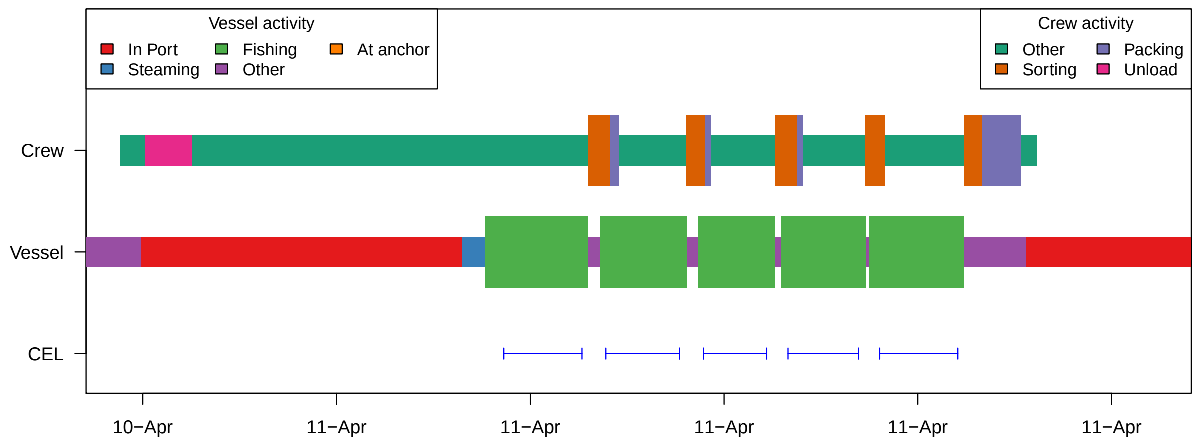
Vessel A, trip: 50
CE tows = 7, Video tows = 7

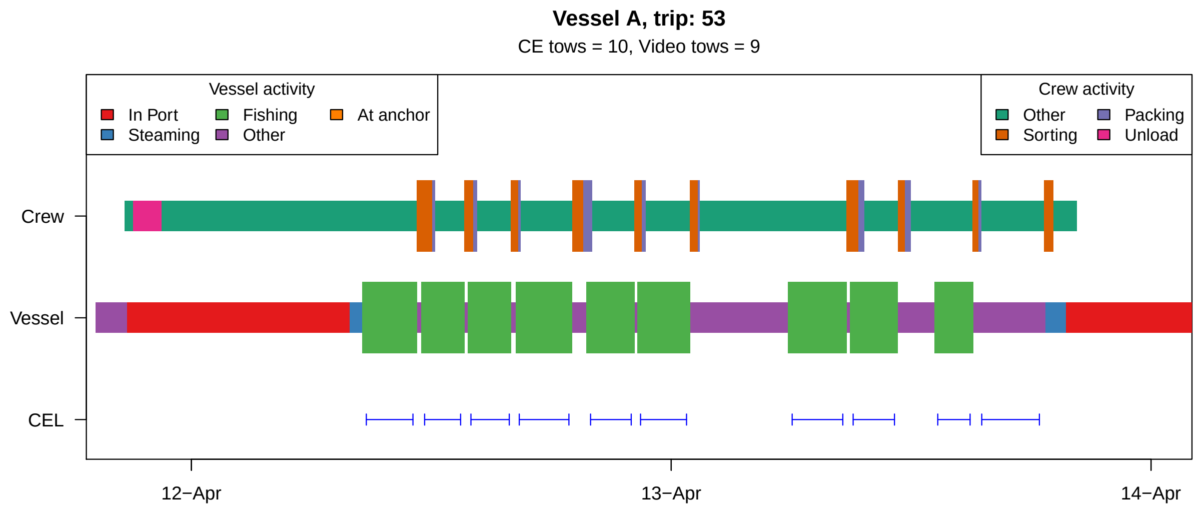


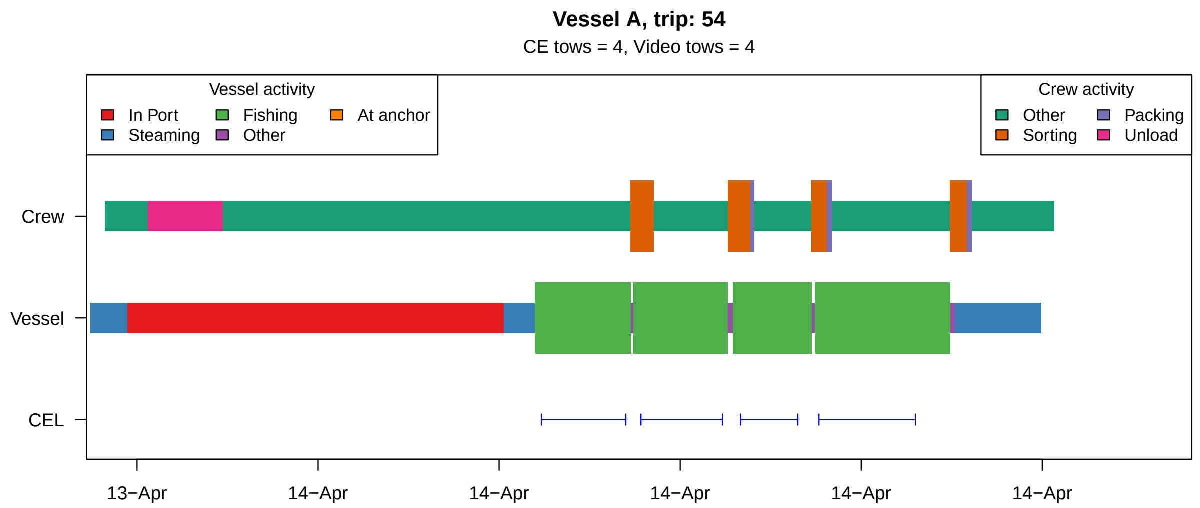
Vessel A, trip: 51
CE tows = 4, Video tows = 4

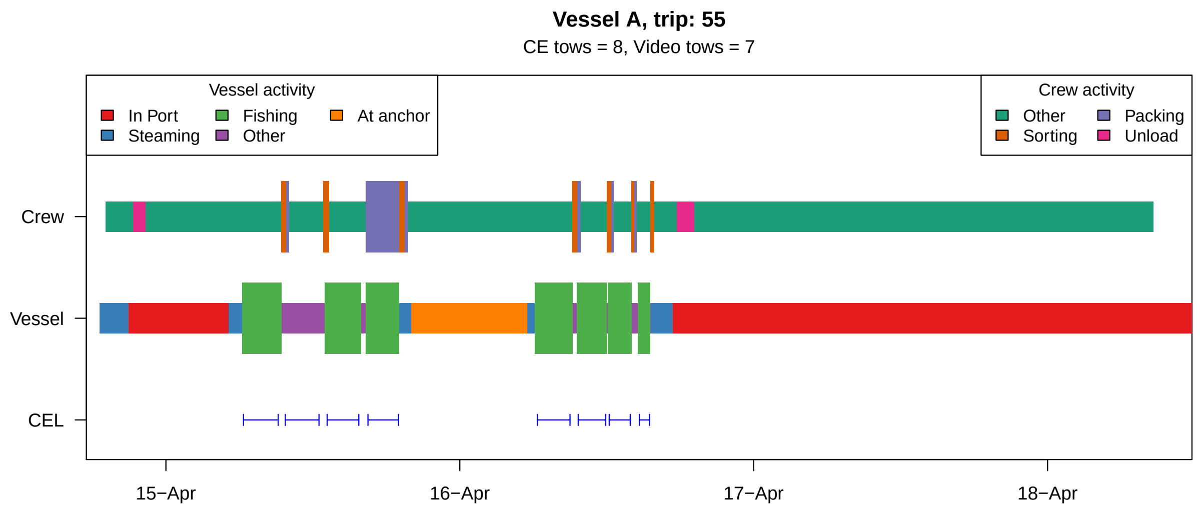


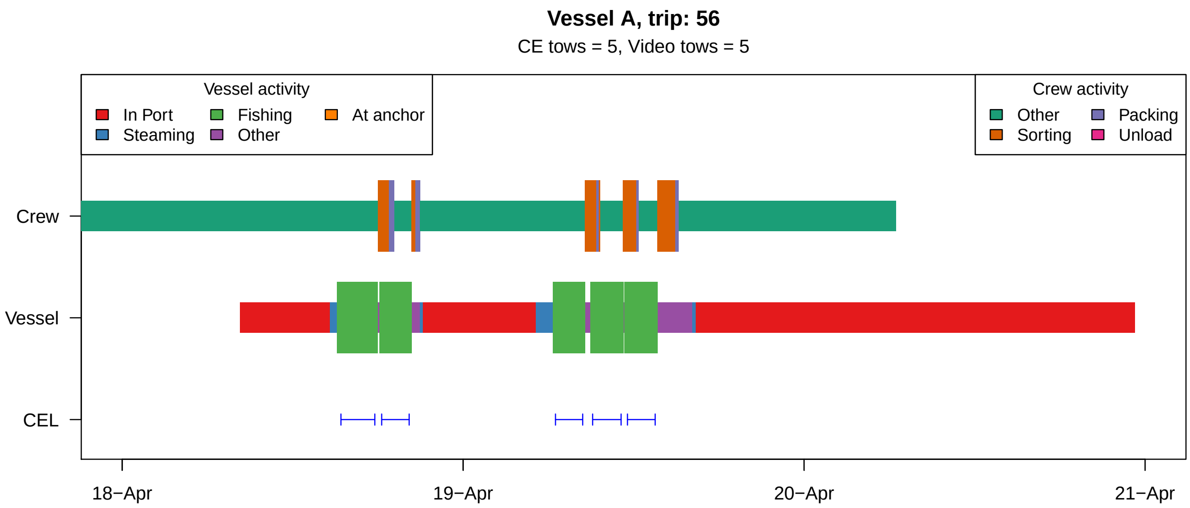
Vessel A, trip: 52
CE tows = 5, Video tows = 5

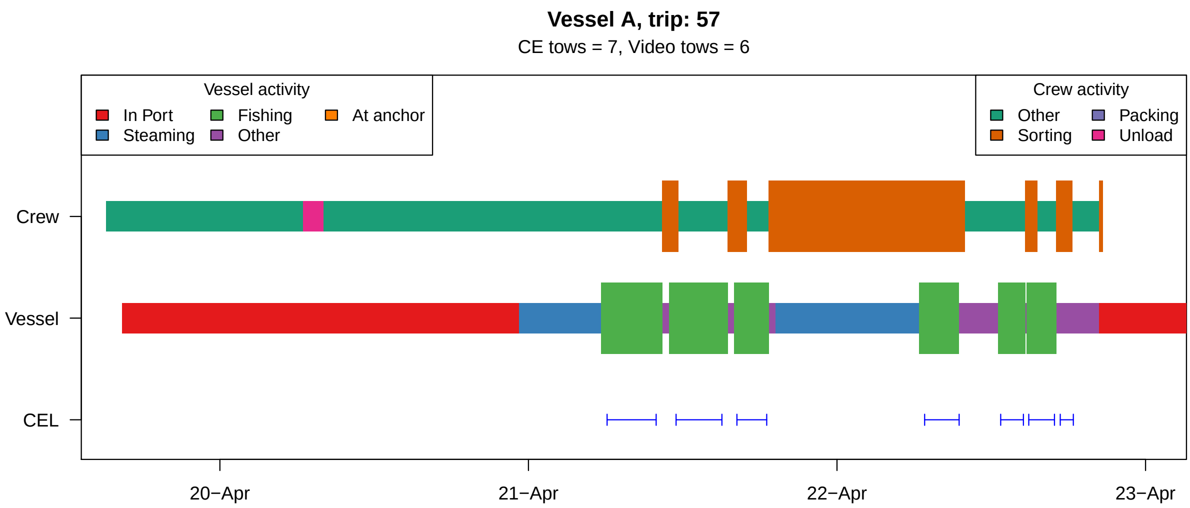


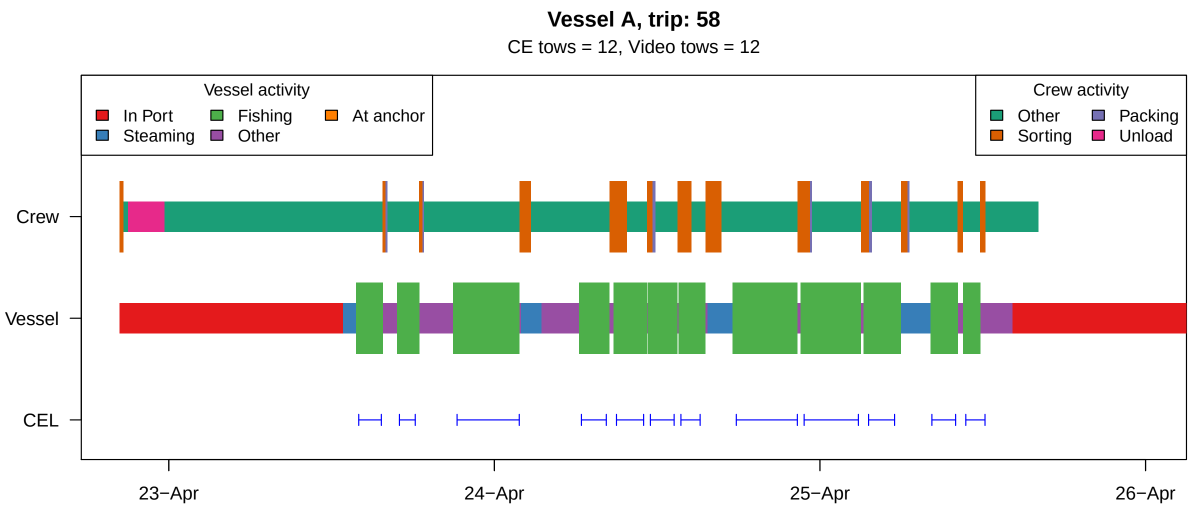

Vessel A, trip: 53
CE tows = 10, Video tows = 9
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
12−Apr
13−Apr
14−Apr


Vessel A, trip: 54
CE tows = 4, Video tows = 4
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
13−Apr
14−Apr
14−Apr
14−Apr
14−Apr
14−Apr


Vessel A, trip: 55
CE tows = 8, Video tows = 7
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
15−Apr
16−Apr
17−Apr
18−Apr

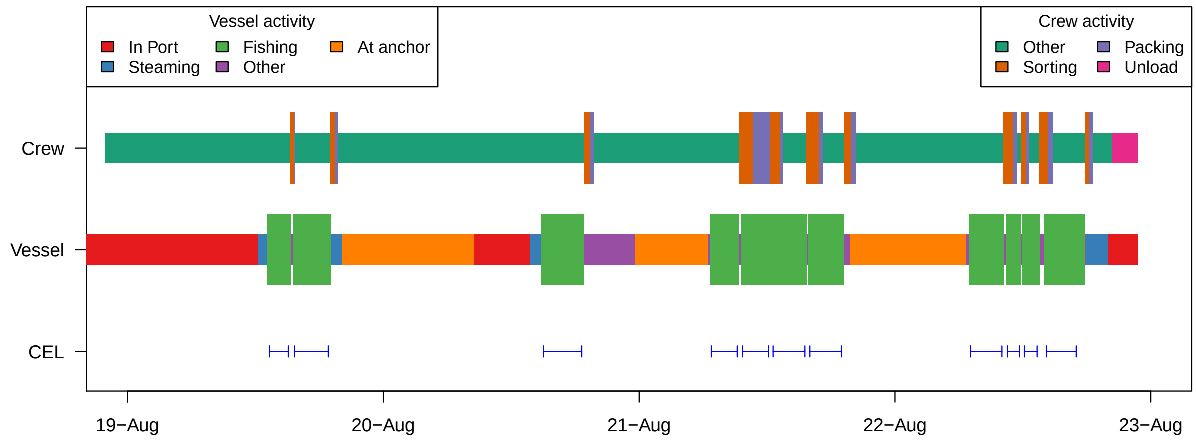

Vessel A, trip: 56
CE tows = 5, Video tows = 5
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
18−Apr
19−Apr
20−Apr
21−Apr


Vessel A, trip: 57
CE tows = 7, Video tows = 6
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
20−Apr
21−Apr
22−Apr
23−Apr


Vessel A, trip: 58
CE tows = 12, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
23−Apr
24−Apr
25−Apr
26−Apr

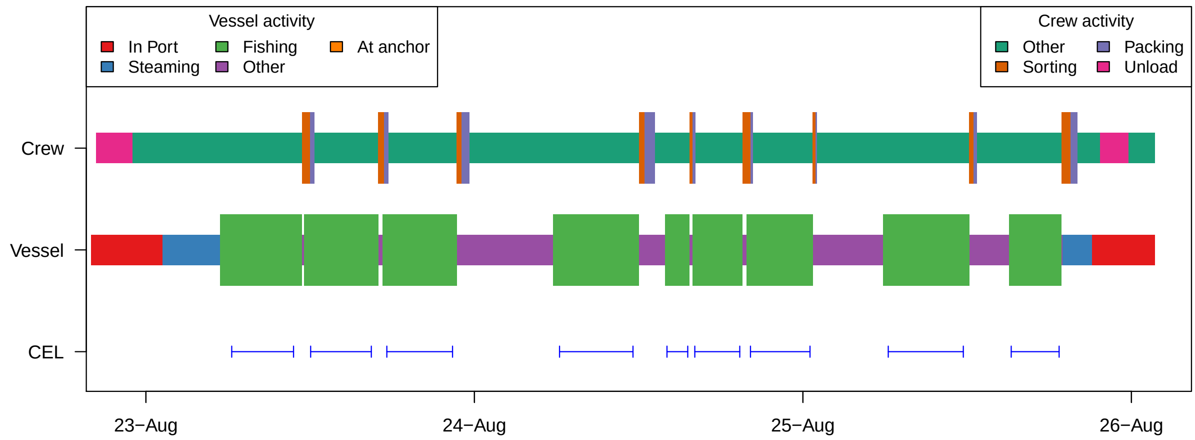
Vessel A, trip: 72

CE tows = 11, Video tows = 11



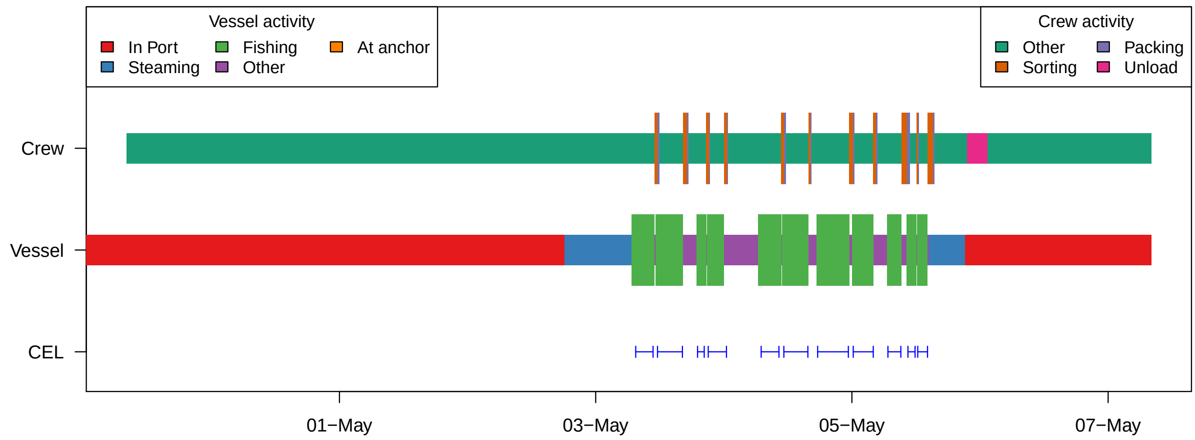
Vessel A, trip: 73

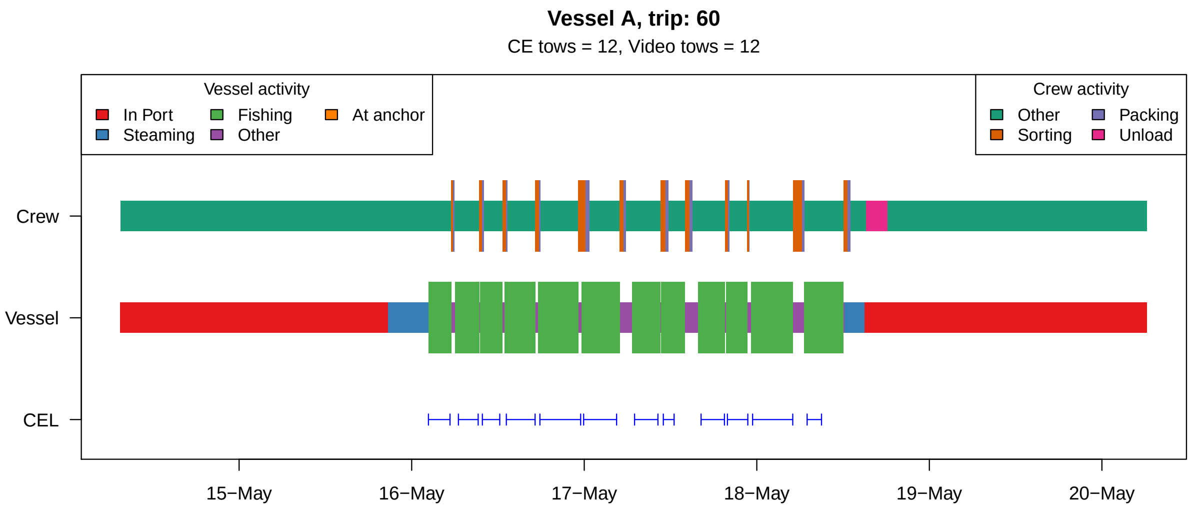
CE tows = 9, Video tows = 9

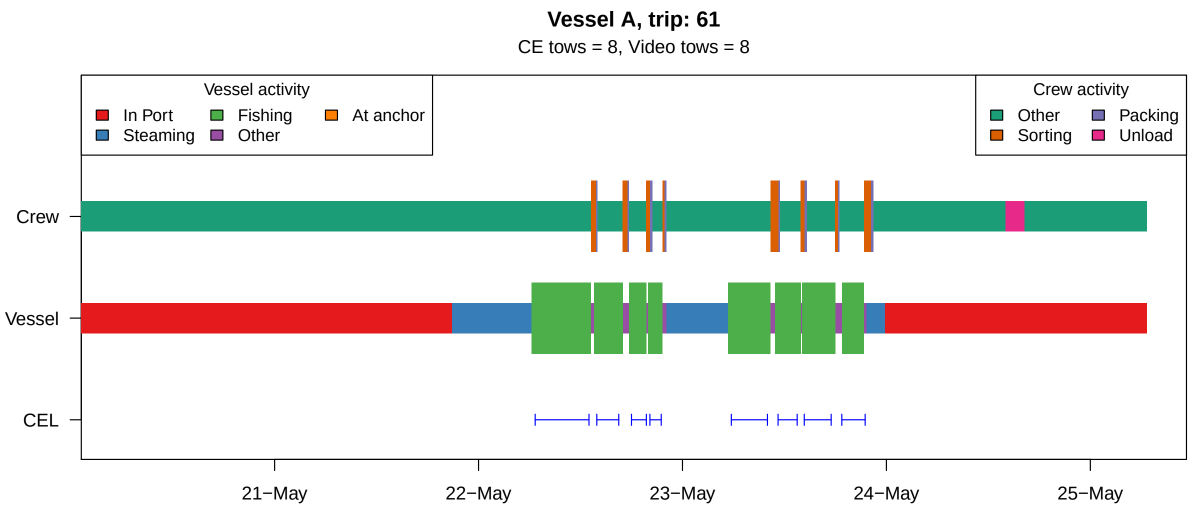


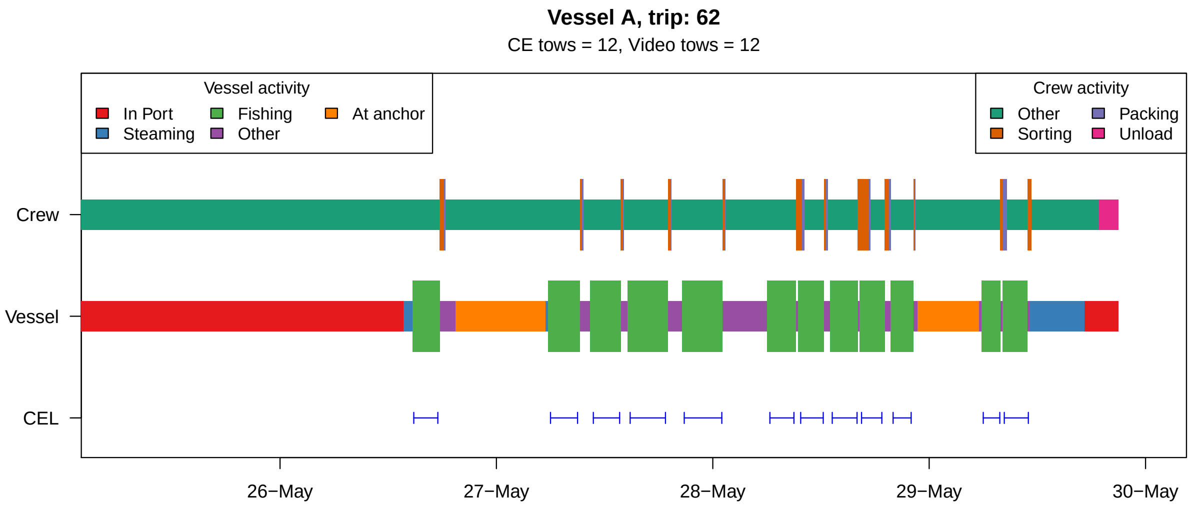
Vessel A, trip: 59

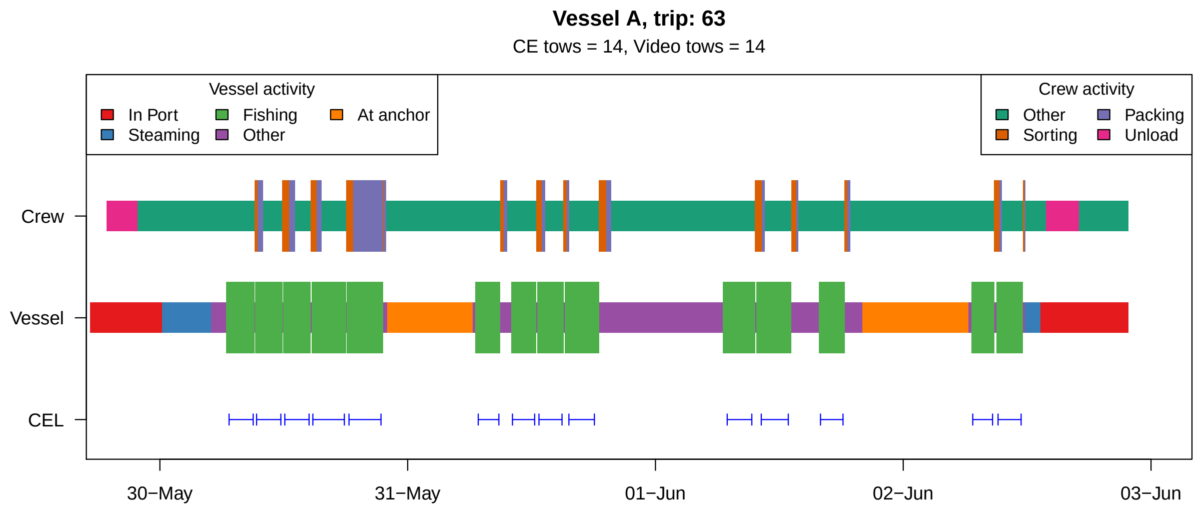
CE tows = 11, Video tows = 11

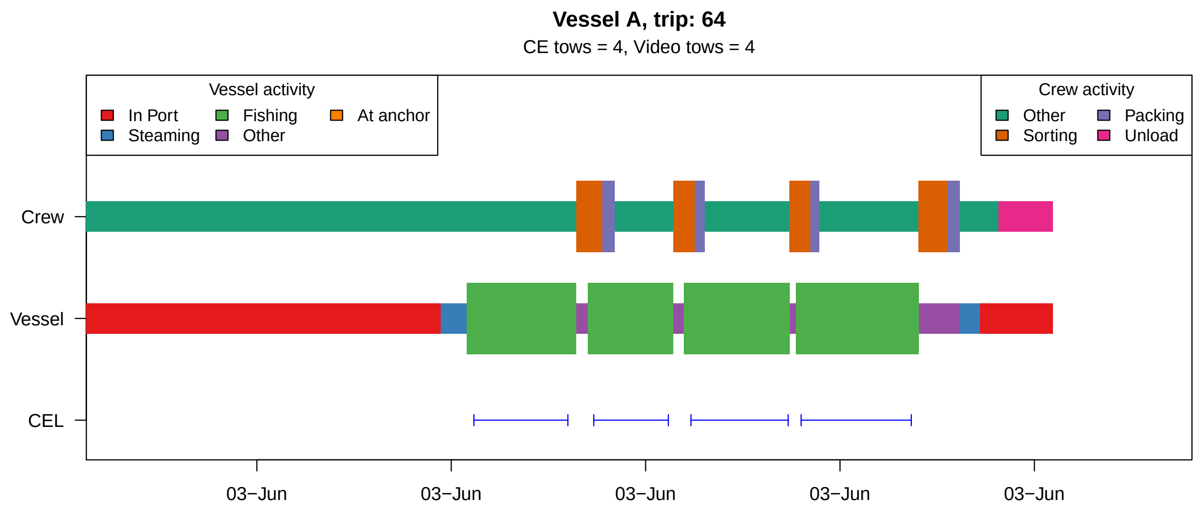


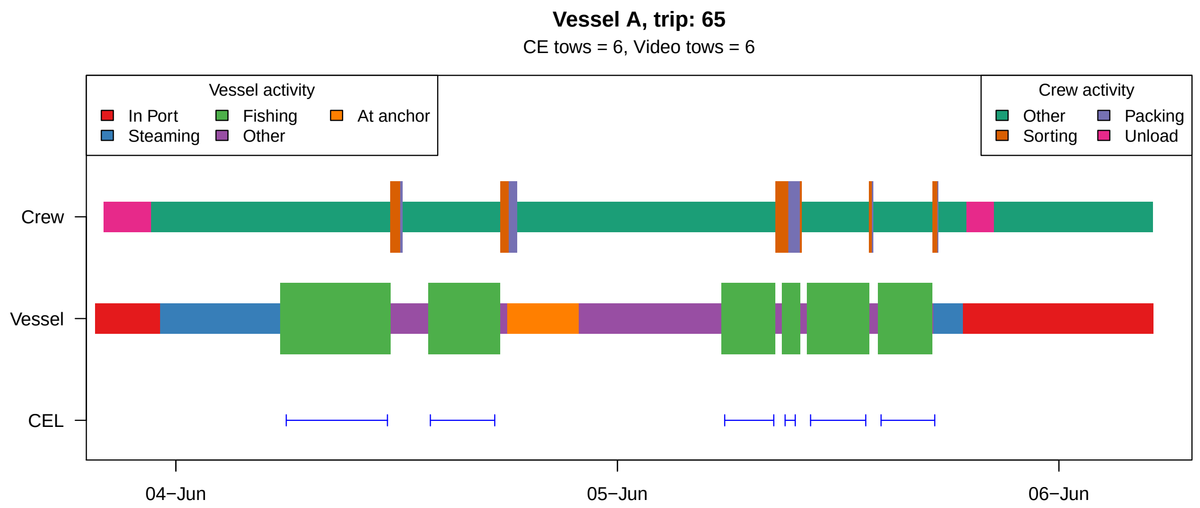

Vessel A, trip: 60
CE tows = 12, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
15−May
16−May
17−May
18−May
19−May
20−May

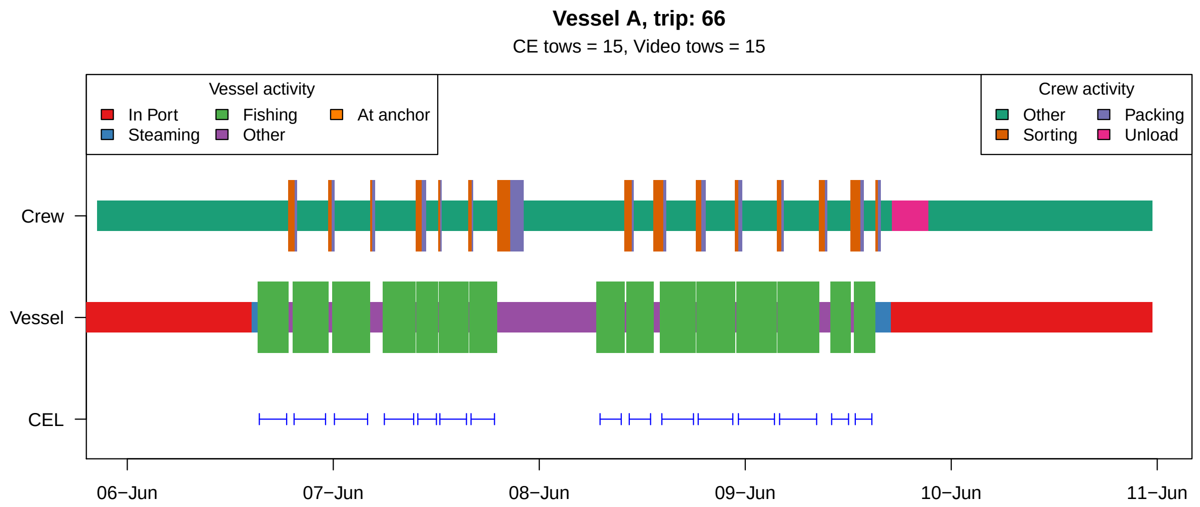

Vessel A, trip: 61
CE tows = 8, Video tows = 8
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
21−May
22−May
23−May
24−May
25−May

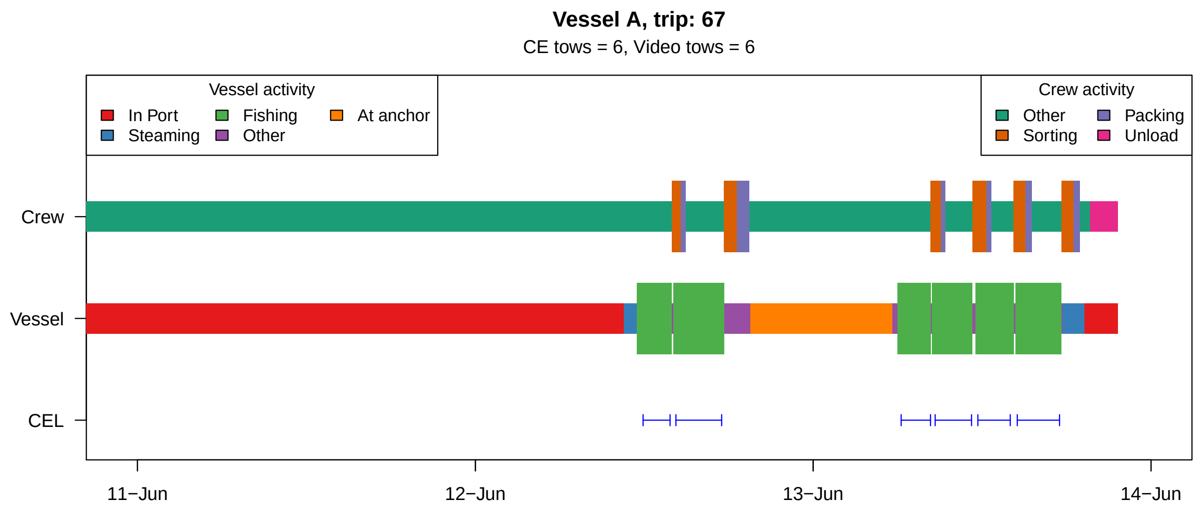

Vessel A, trip: 62
CE tows = 12, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
26−May
27−May
28−May
29−May
30−May

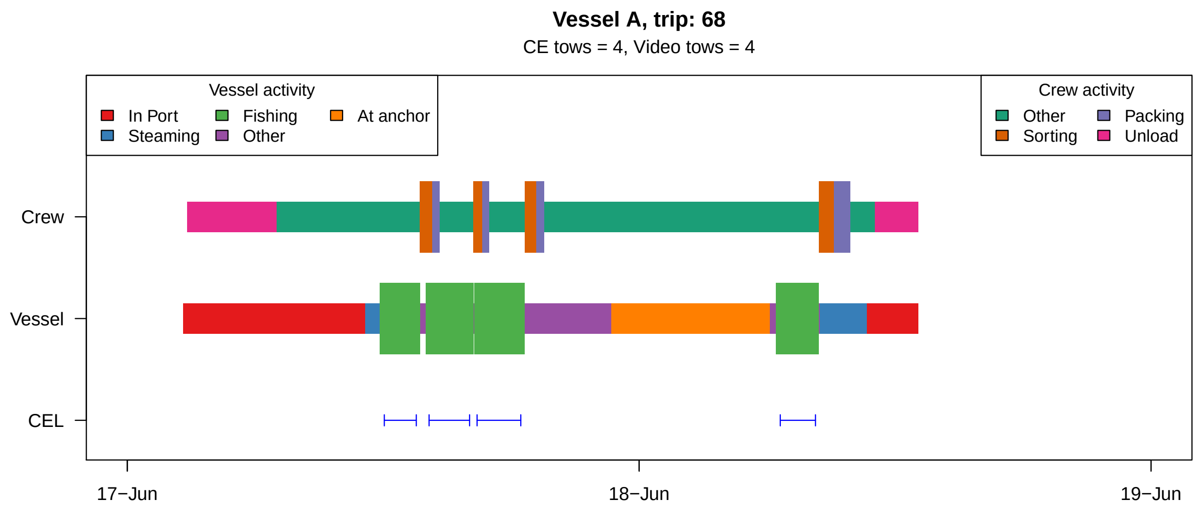

Vessel A, trip: 63
CE tows = 14, Video tows = 14
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
30−May
31−May
01−Jun
02−Jun
03−Jun

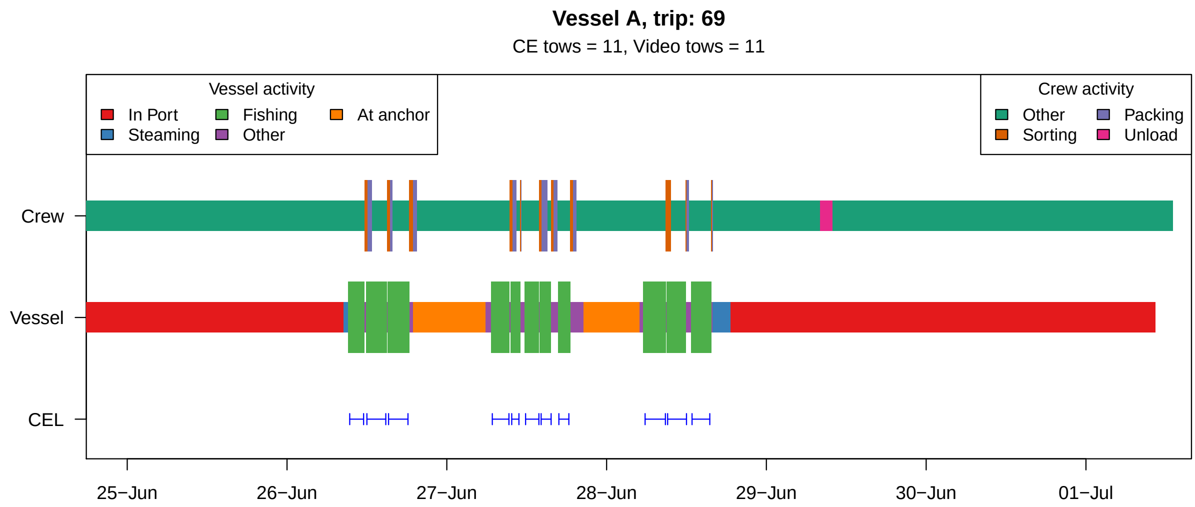

Vessel A, trip: 64
CE tows = 4, Video tows = 4
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
03−Jun
03−Jun
03−Jun
03−Jun
03−Jun

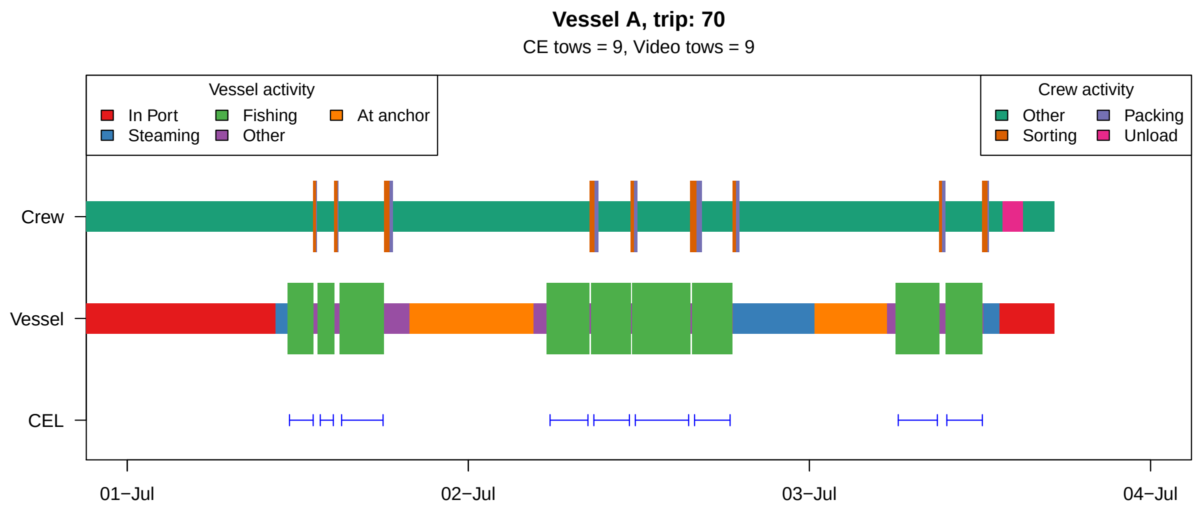

Vessel A, trip: 65
CE tows = 6, Video tows = 6
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
04−Jun
05−Jun
06−Jun

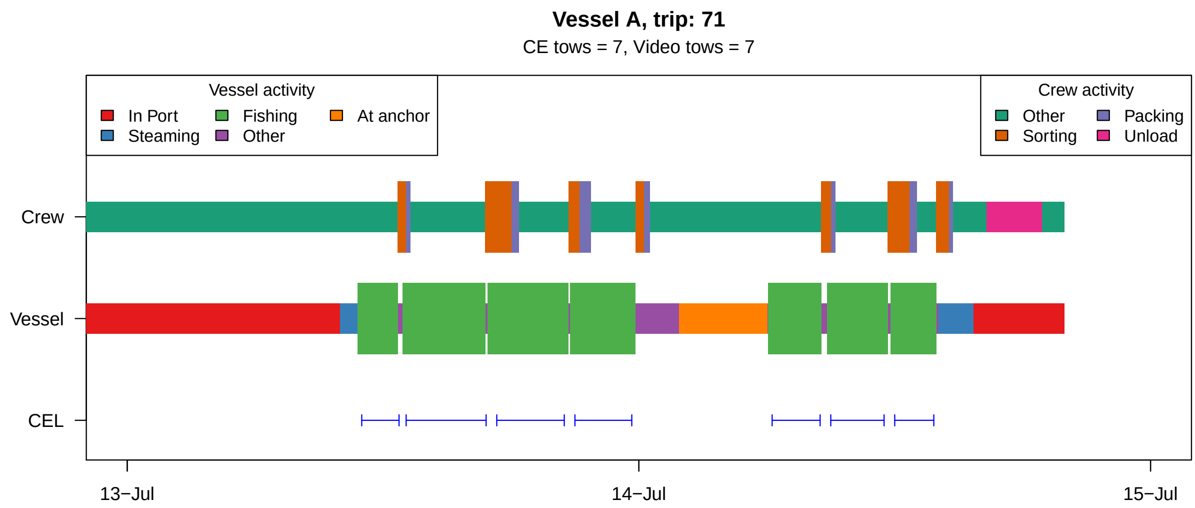

Vessel A, trip: 66
CE tows = 15, Video tows = 15
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
06−Jun
07−Jun
08−Jun
09−Jun
10−Jun
11−Jun

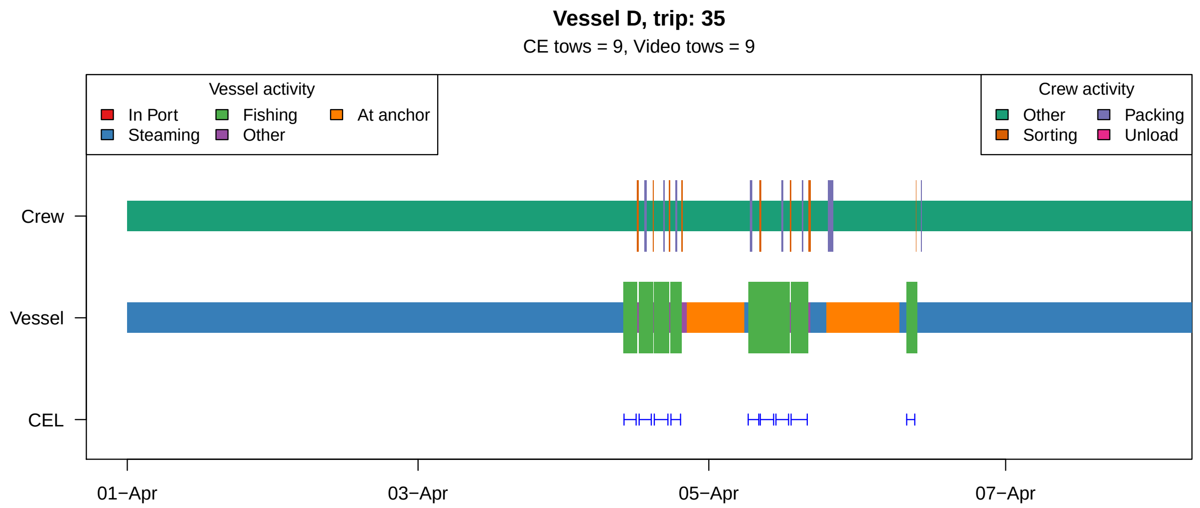

Vessel A, trip: 67
CE tows = 6, Video tows = 6
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
11−Jun
12−Jun
13−Jun
14−Jun

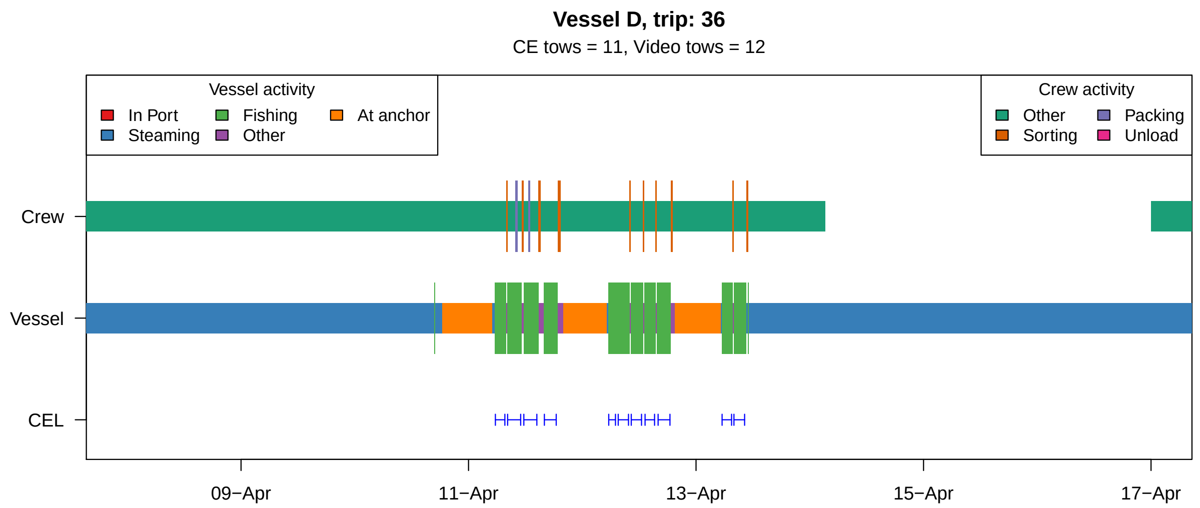

Vessel A, trip: 68
CE tows = 4, Video tows = 4
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
17−Jun
18−Jun
19−Jun

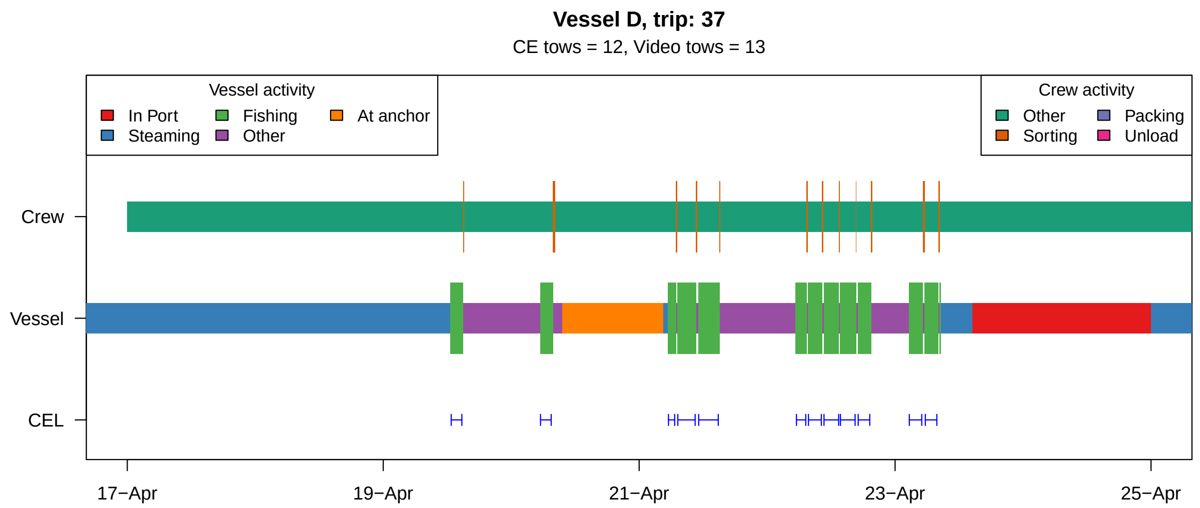

Vessel A, trip: 69
CE tows = 11, Video tows = 11
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
25−Jun
26−Jun
27−Jun
28−Jun
29−Jun
30−Jun
01−Jul


Vessel A, trip: 70
CE tows = 9, Video tows = 9
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
01−Jul
02−Jul
03−Jul
04−Jul

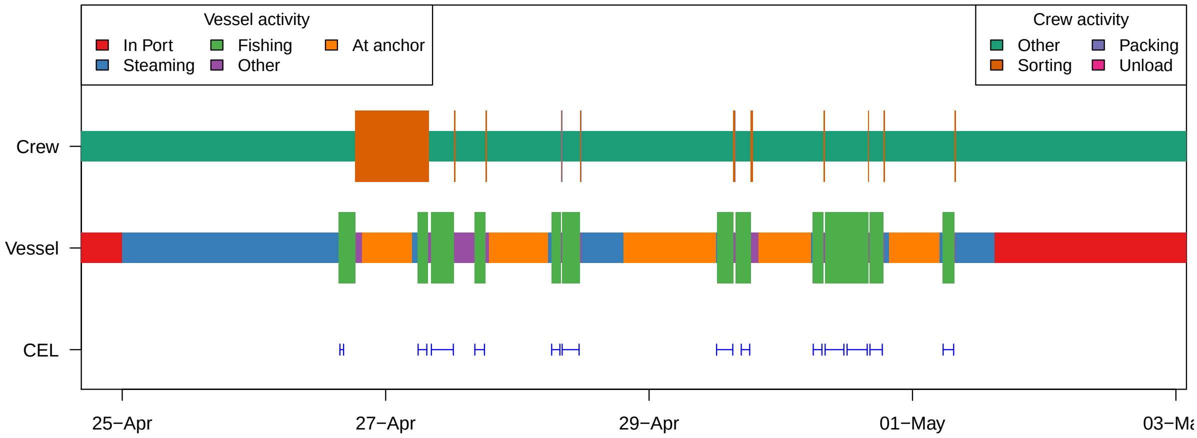

Vessel A, trip: 71
CE tows = 7, Video tows = 7
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
13−Jul
14−Jul
15−Jul


Vessel D, trip: 35
CE tows = 9, Video tows = 9
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
01−Apr
03−Apr
05−Apr
07−Apr

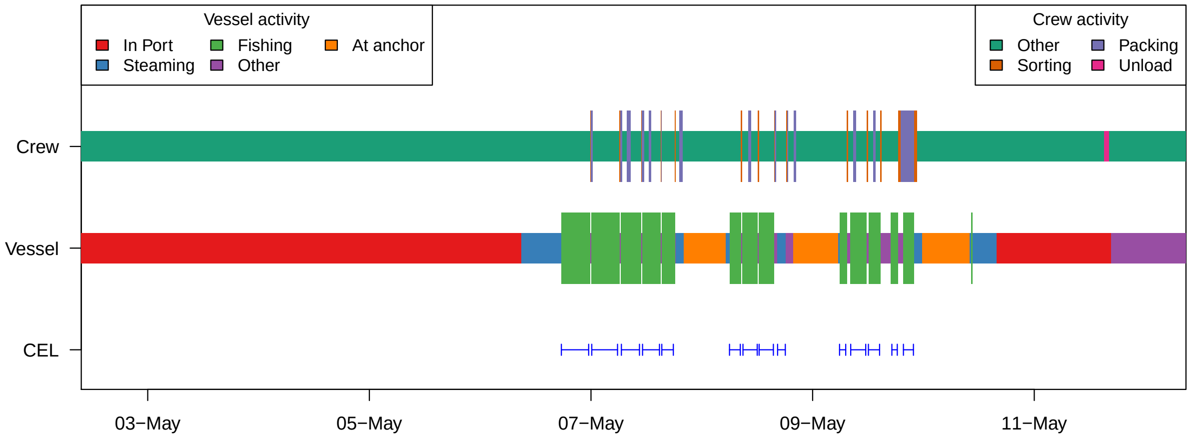

Vessel D, trip: 36
CE tows = 11, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
09−Apr
11−Apr
13−Apr
15−Apr
17−Apr


Vessel D, trip: 37
CE tows = 12, Video tows = 13
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
17−Apr
19−Apr
21−Apr
23−Apr
25−Apr

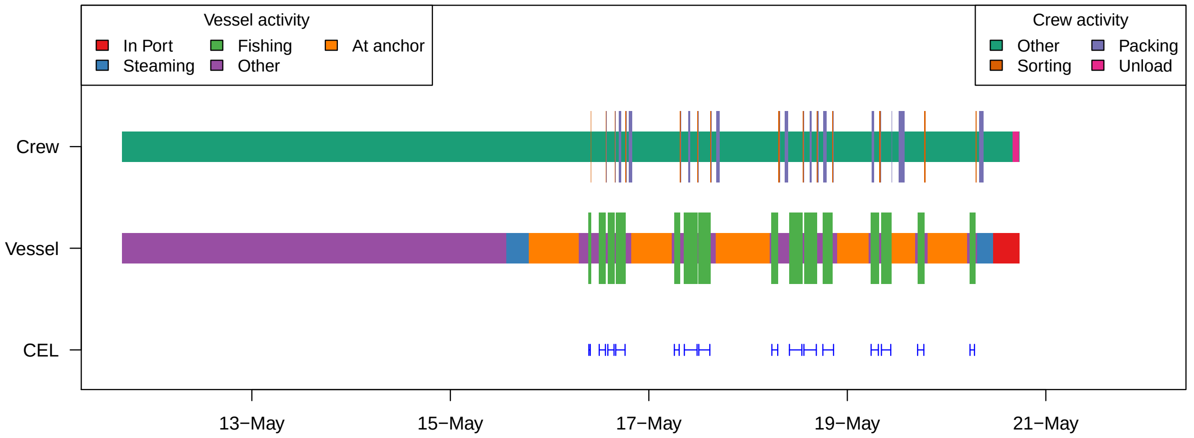
Vessel D, trip: 38
CE tows = 13, Video tows = 12

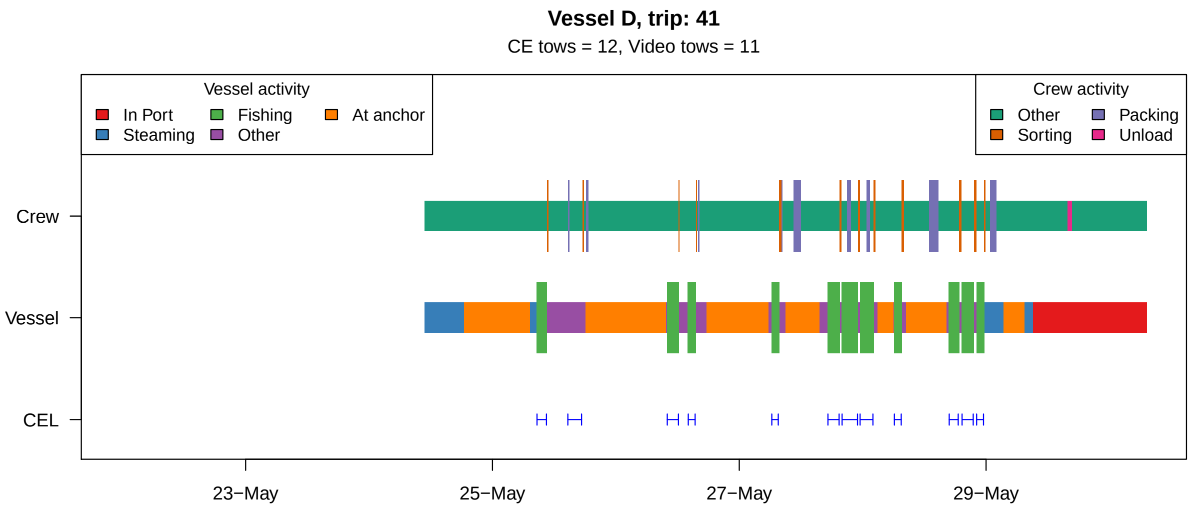


Vessel D, trip: 39
CE tows = 14, Video tows = 14

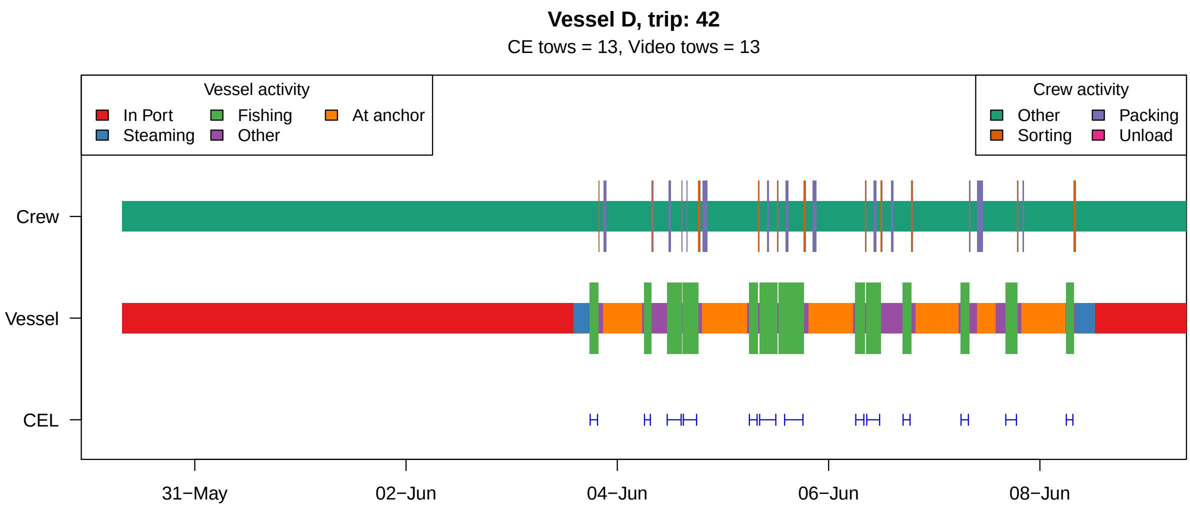


Vessel D, trip: 40
CE tows = 15, Video tows = 15

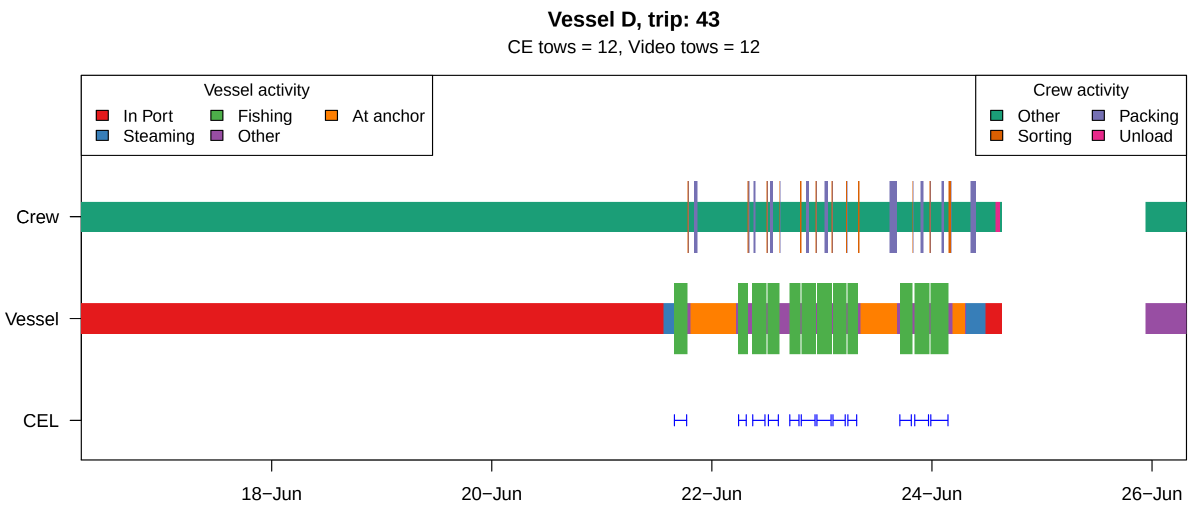




Vessel D, trip: 41
CE tows = 12, Video tows = 11
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
23−May
25−May
27−May
29−May

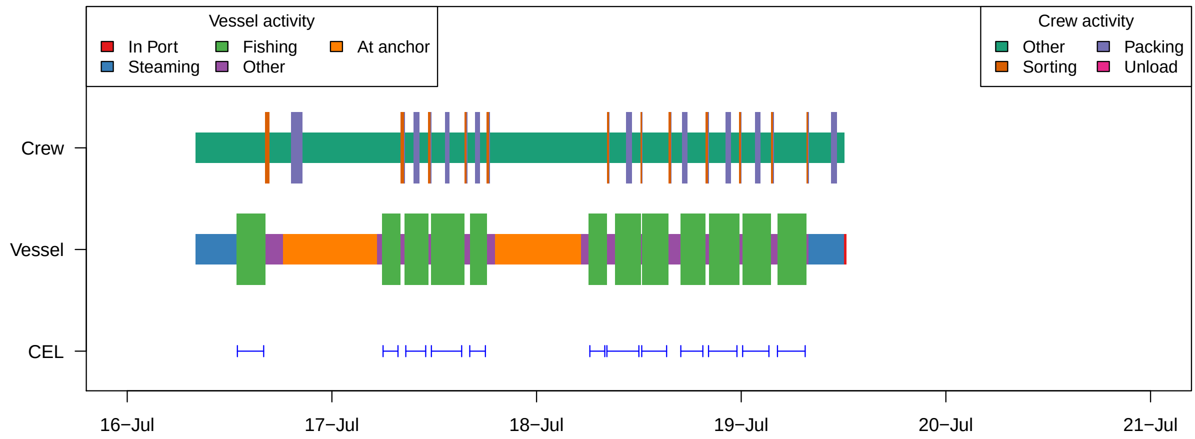


Vessel D, trip: 42
CE tows = 13, Video tows = 13
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
31−May
02−Jun
04−Jun
06−Jun
08−Jun

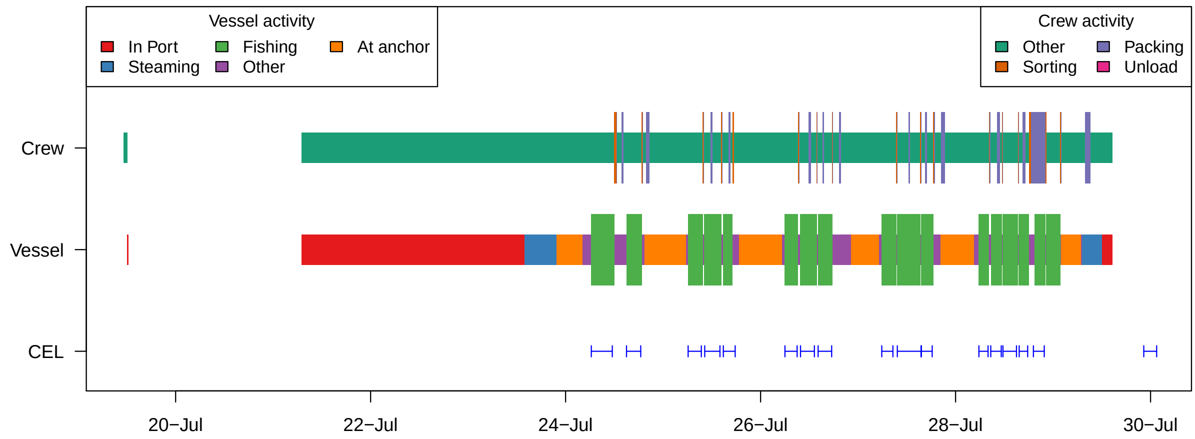


Vessel D, trip: 43
CE tows = 12, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
18−Jun
20−Jun
22−Jun
24−Jun
26−Jun

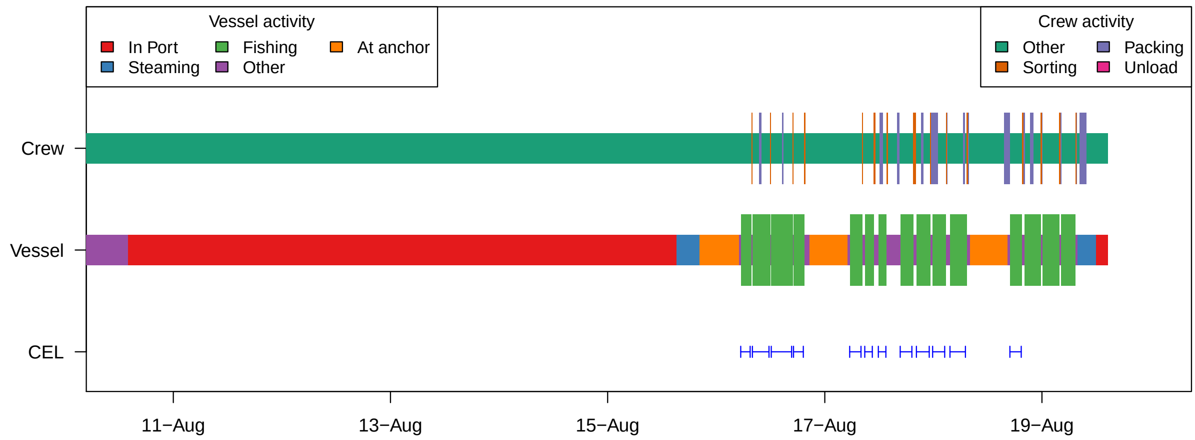
Vessel D, trip: 44
CE tows = 12, Video tows = 12



Vessel D, trip: 45
CE tows = 17, Video tows = 17

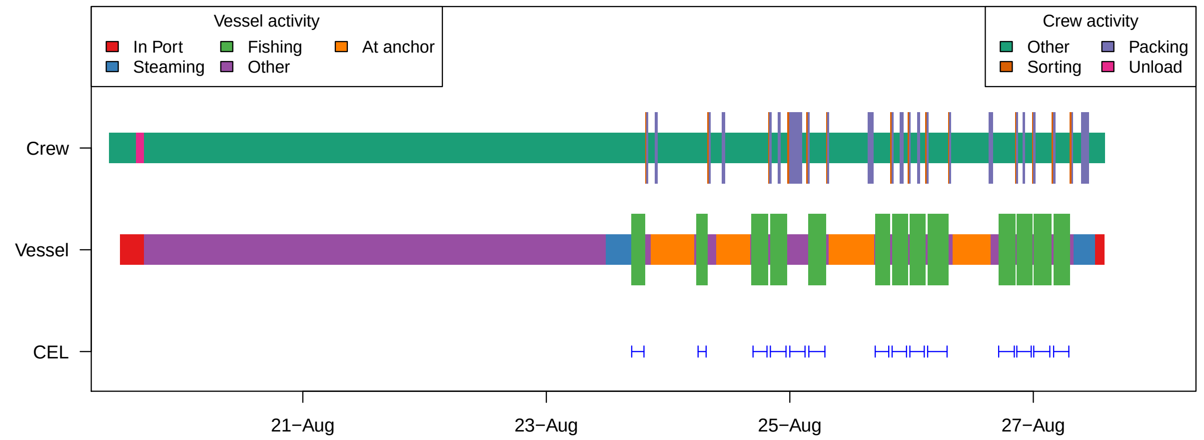


Vessel D, trip: 46
CE tows = 12, Video tows = 15



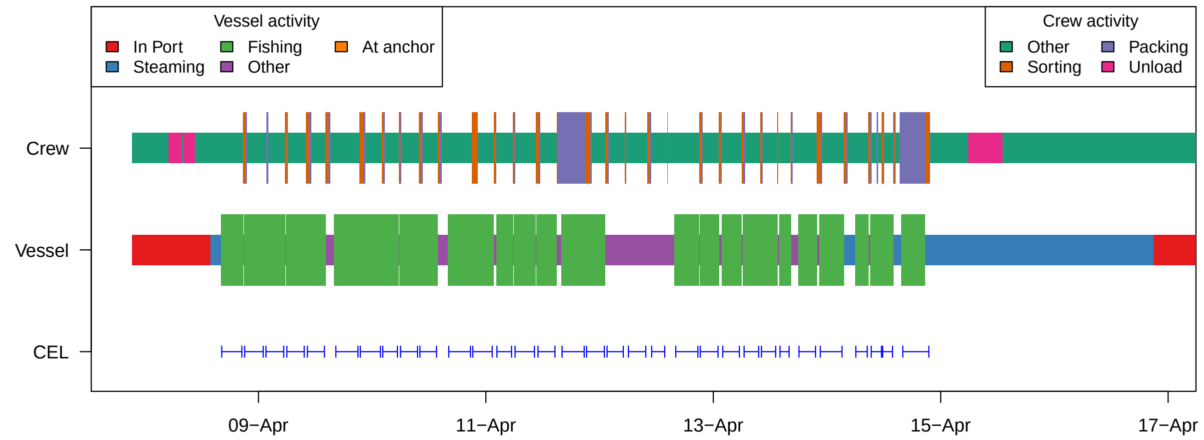
Vessel D, trip: 47

CE tows = 14, Video tows = 13



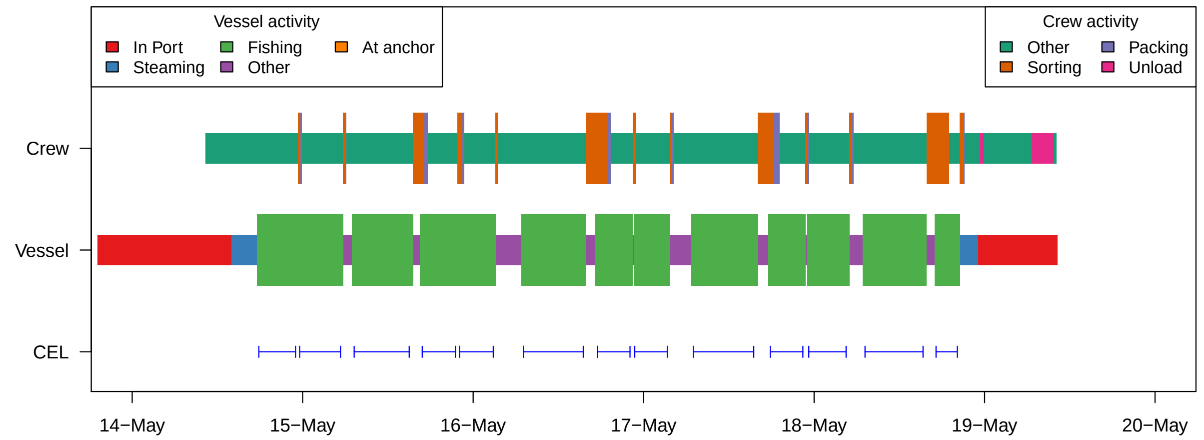
Vessel C, trip: 48

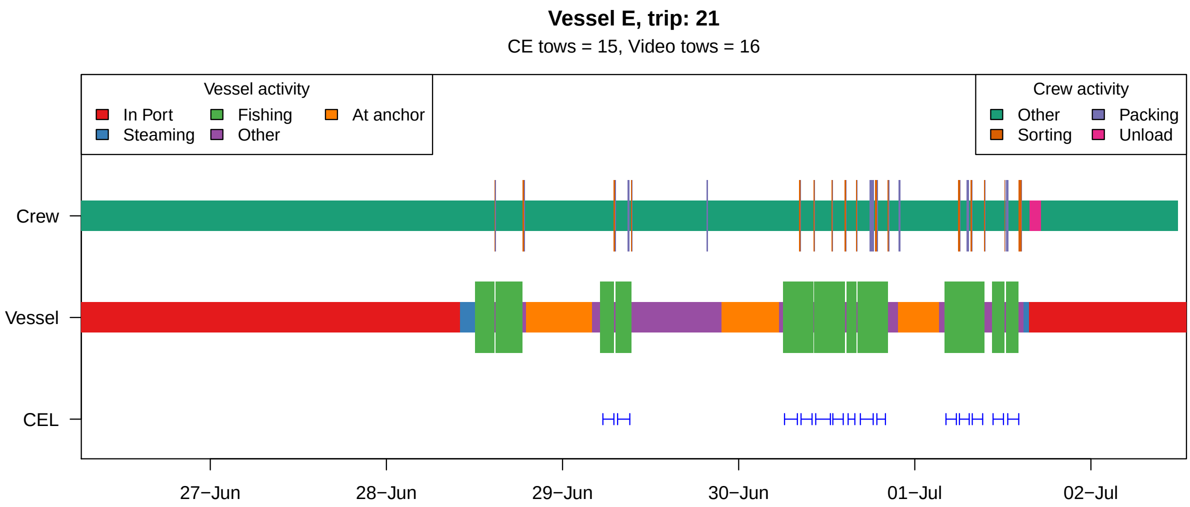
CE tows = 32, Video tows = 28

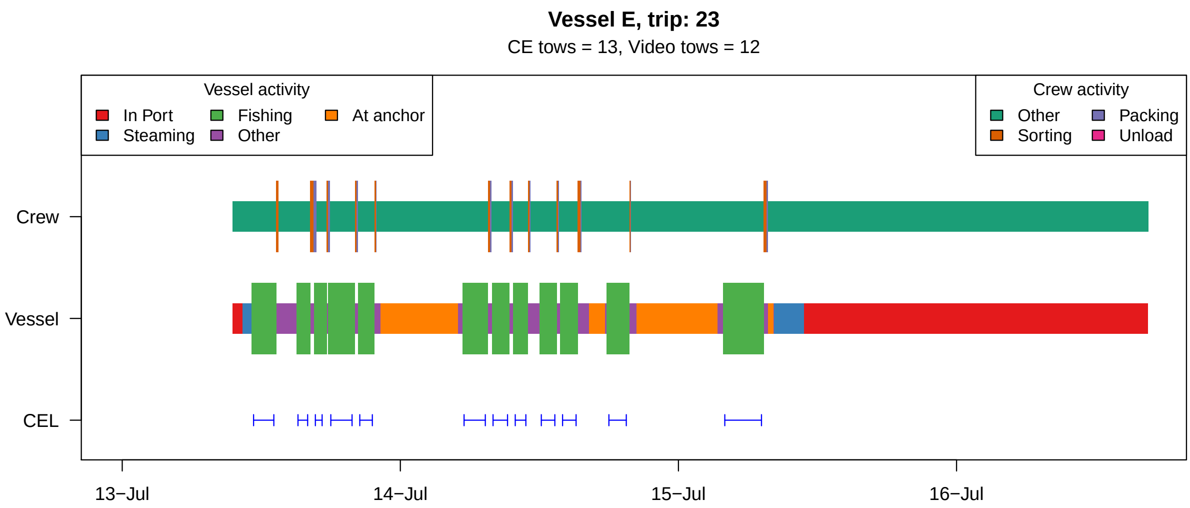


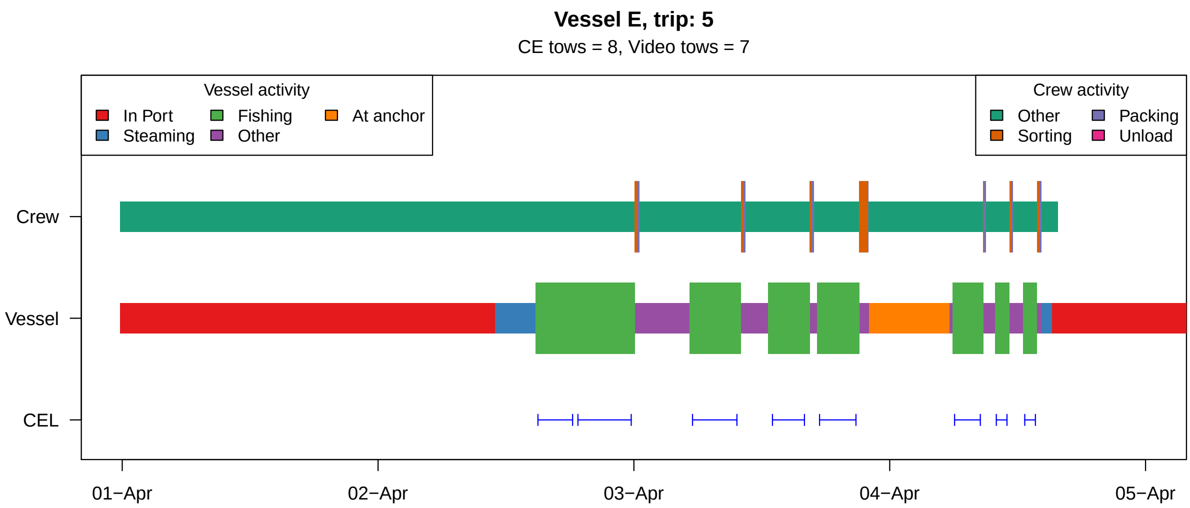
Vessel C, trip: 49

CE tows = 13, Video tows = 13

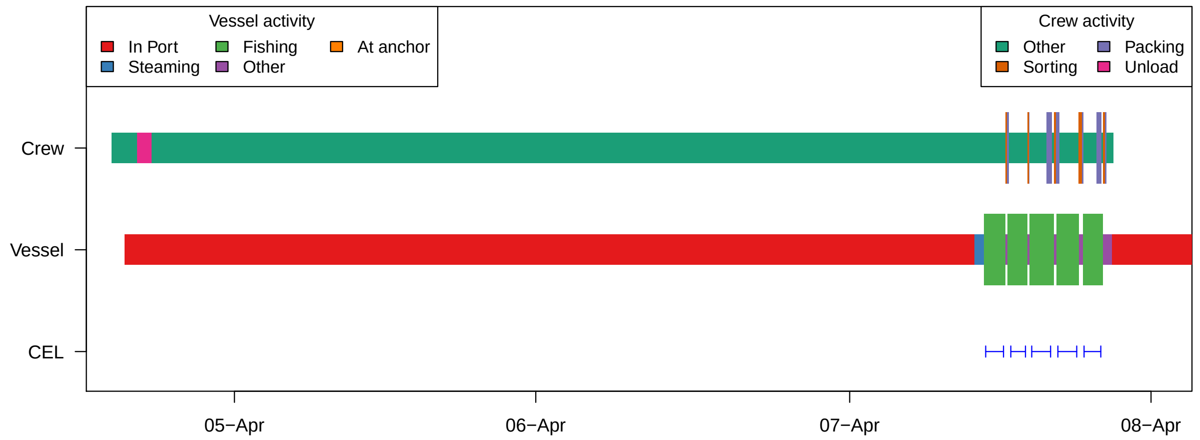



Vessel E, trip: 21
CE tows = 15, Video tows = 16
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
27−Jun
28−Jun
29−Jun
30−Jun
01−Jul
02−Jul

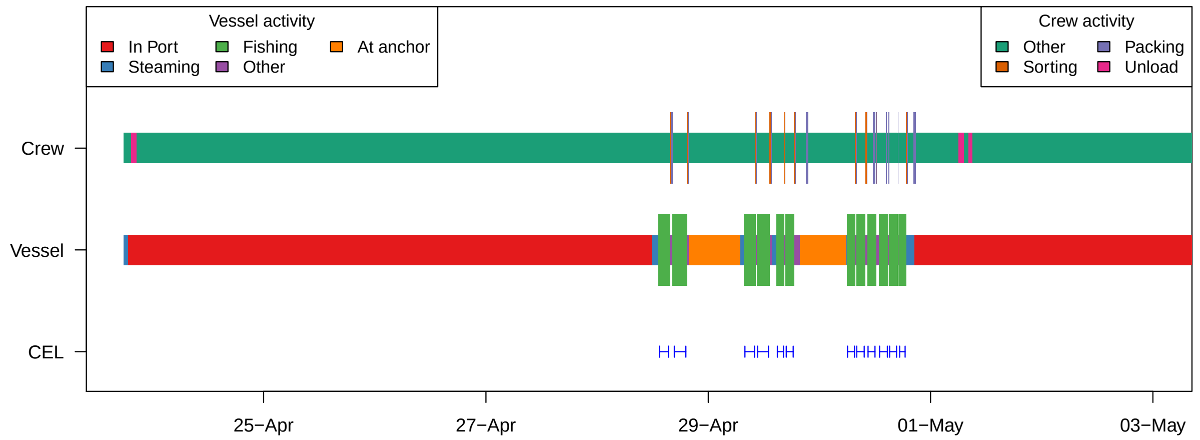

Vessel E, trip: 23
CE tows = 13, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
13−Jul
14−Jul
15−Jul
16−Jul


Vessel E, trip: 5
CE tows = 8, Video tows = 7
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
01−Apr
02−Apr
03−Apr
04−Apr
05−Apr

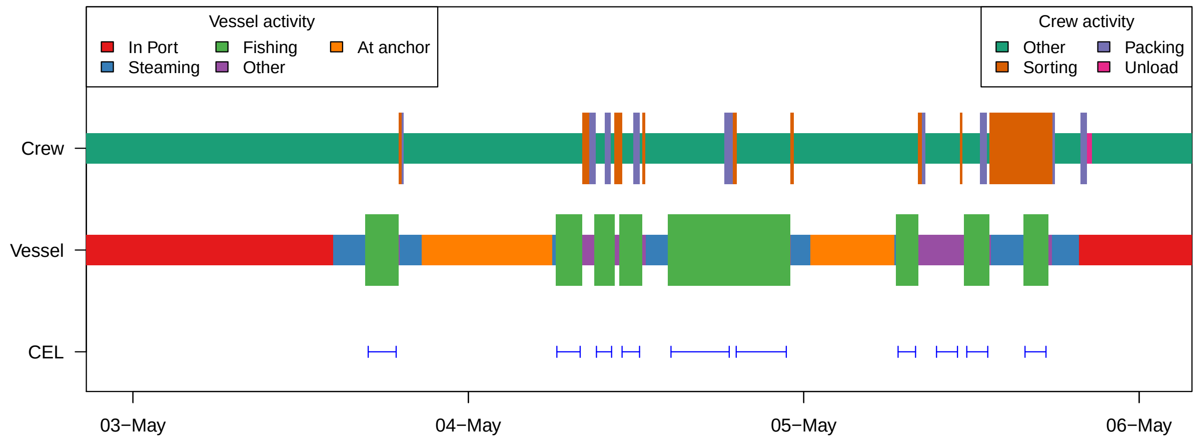
Vessel E, trip: 6
CE tows = 5, Video tows = 5

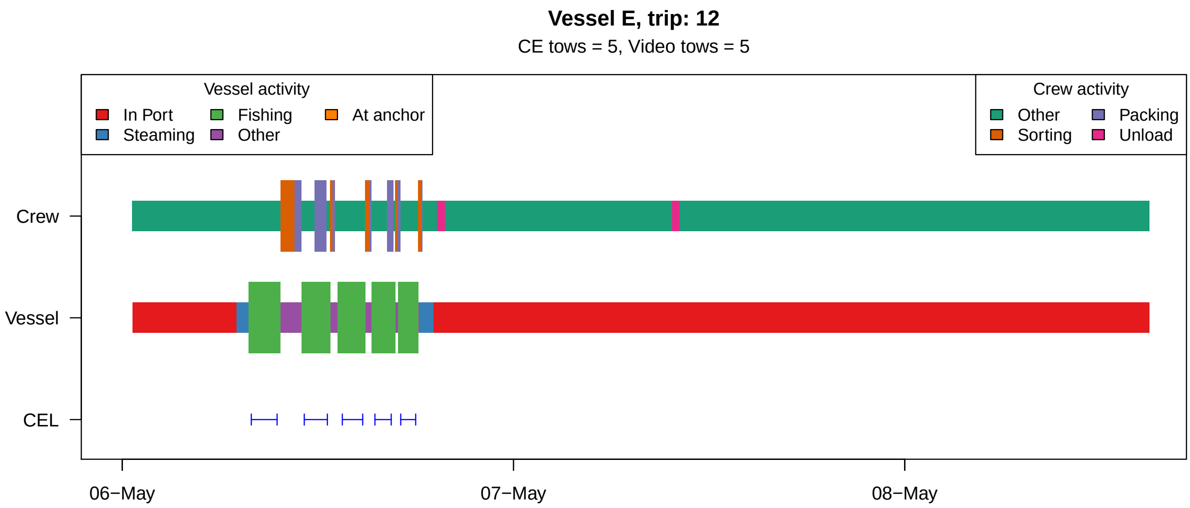


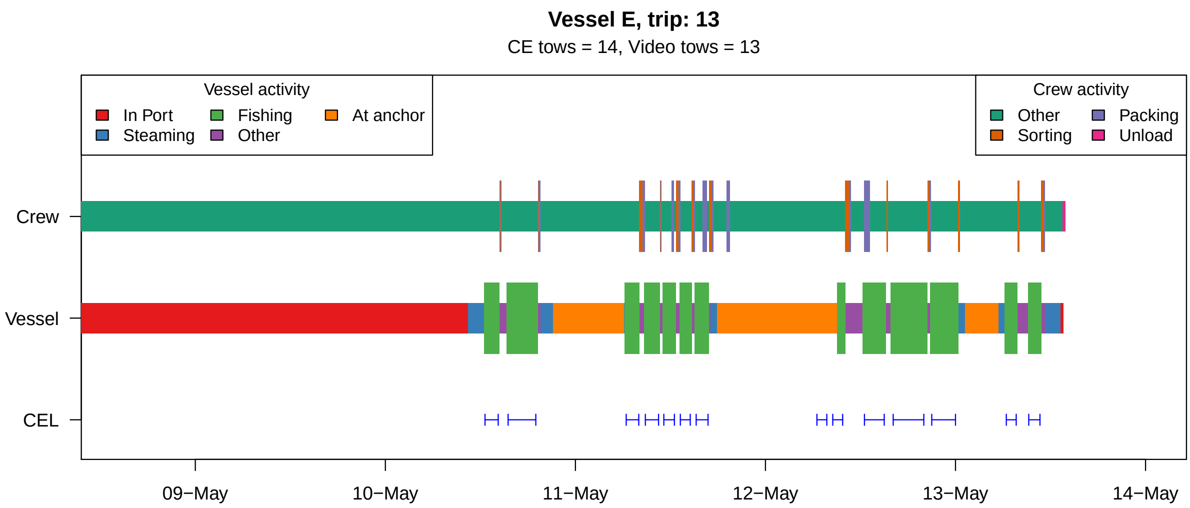
Vessel E, trip: 10
CE tows = 12, Video tows = 12

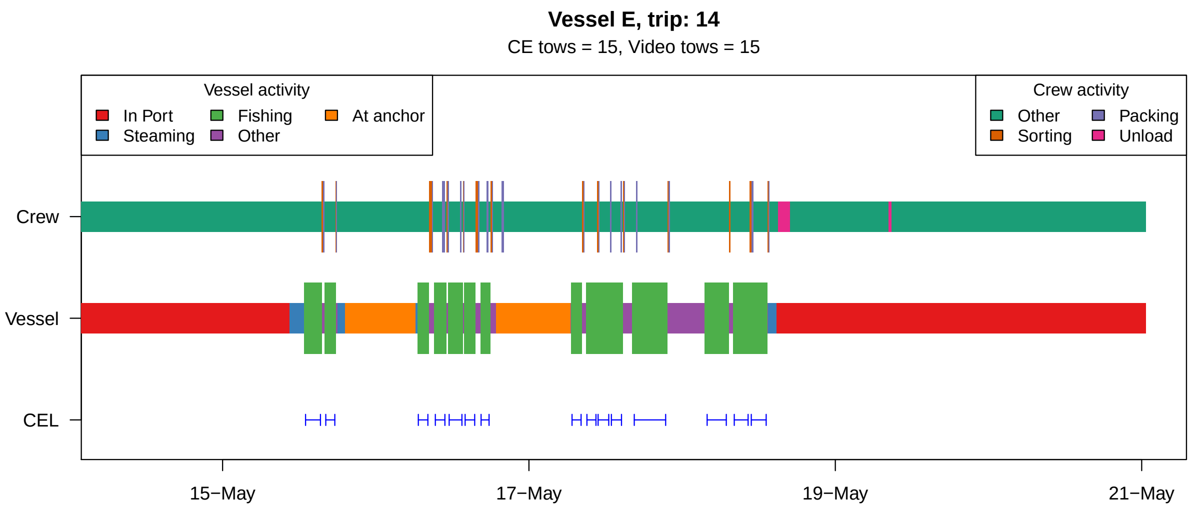


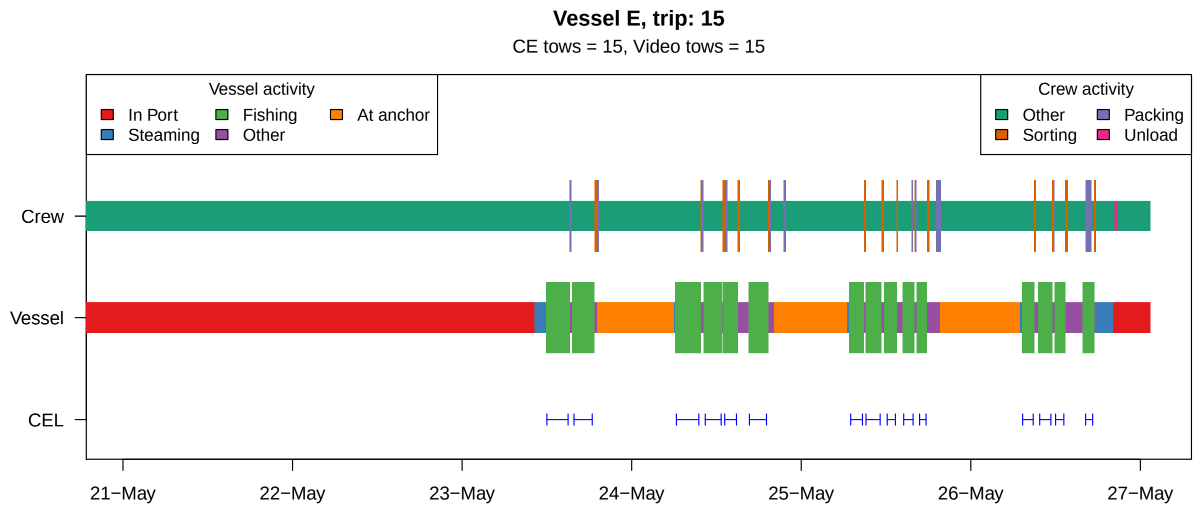
Vessel E, trip: 11
CE tows = 10, Video tows = 9

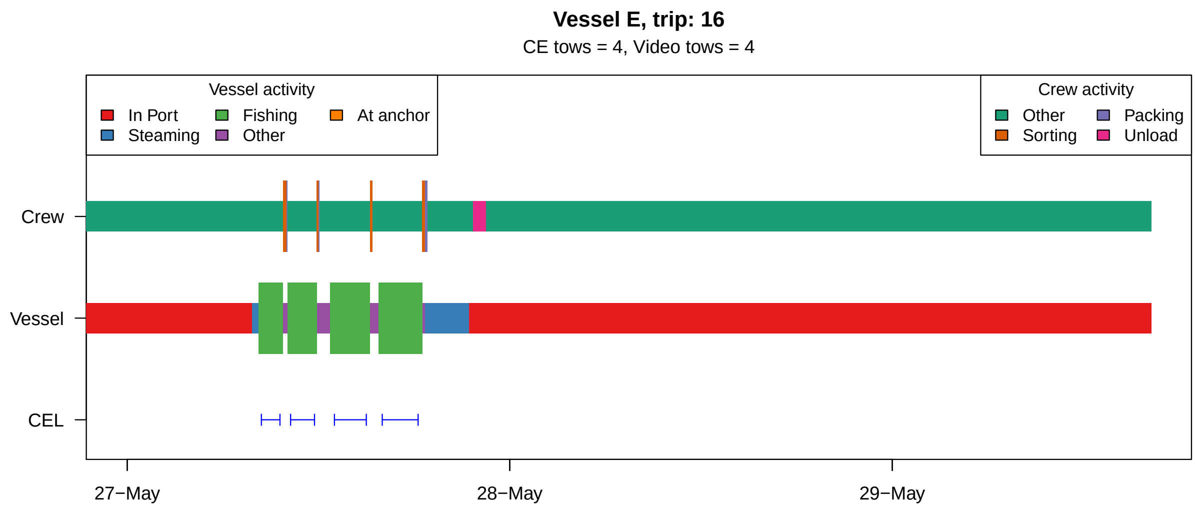


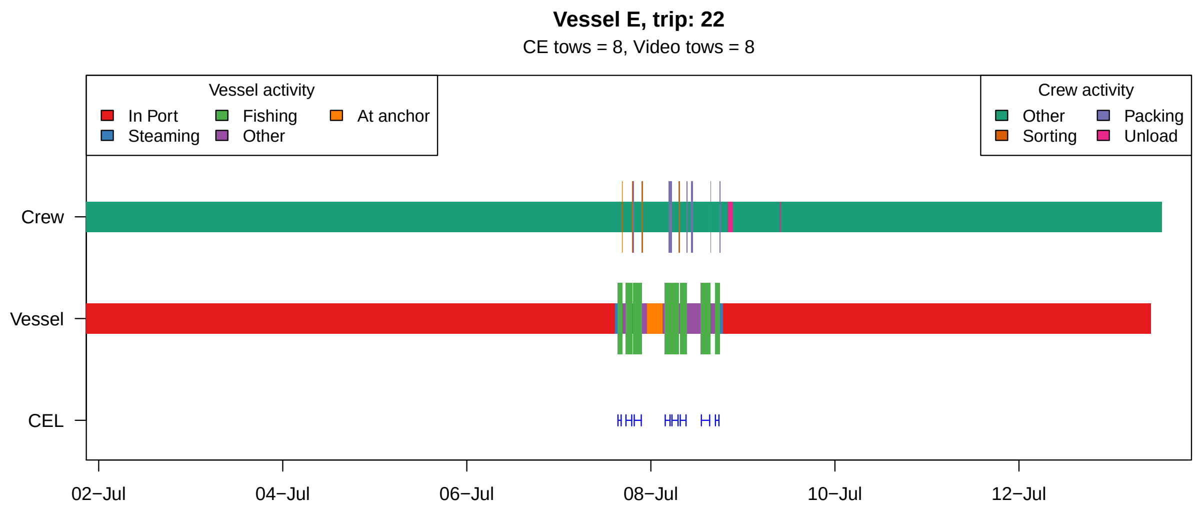

Vessel E, trip: 12
CE tows = 5, Video tows = 5
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
06−May
07−May
08−May

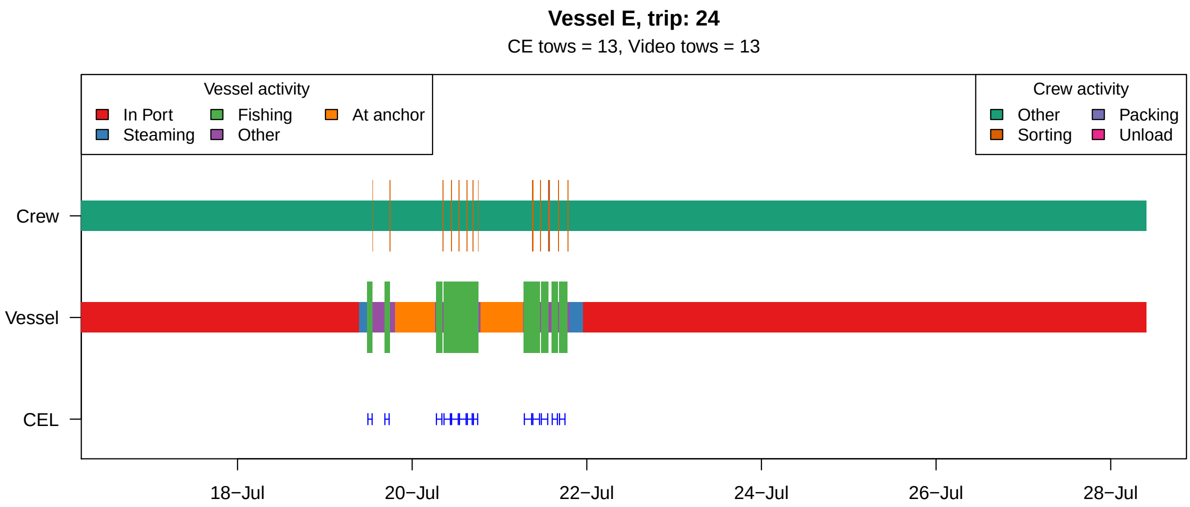

Vessel E, trip: 13
CE tows = 14, Video tows = 13
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
09−May
10−May
11−May
12−May
13−May
14−May

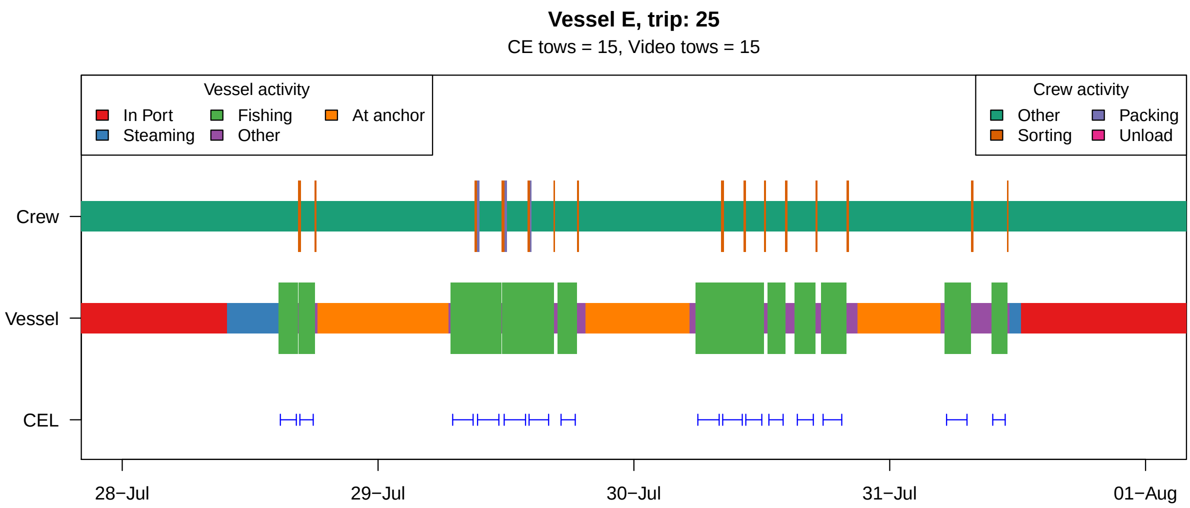

Vessel E, trip: 14
CE tows = 15, Video tows = 15
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
15−May
17−May
19−May
21−May

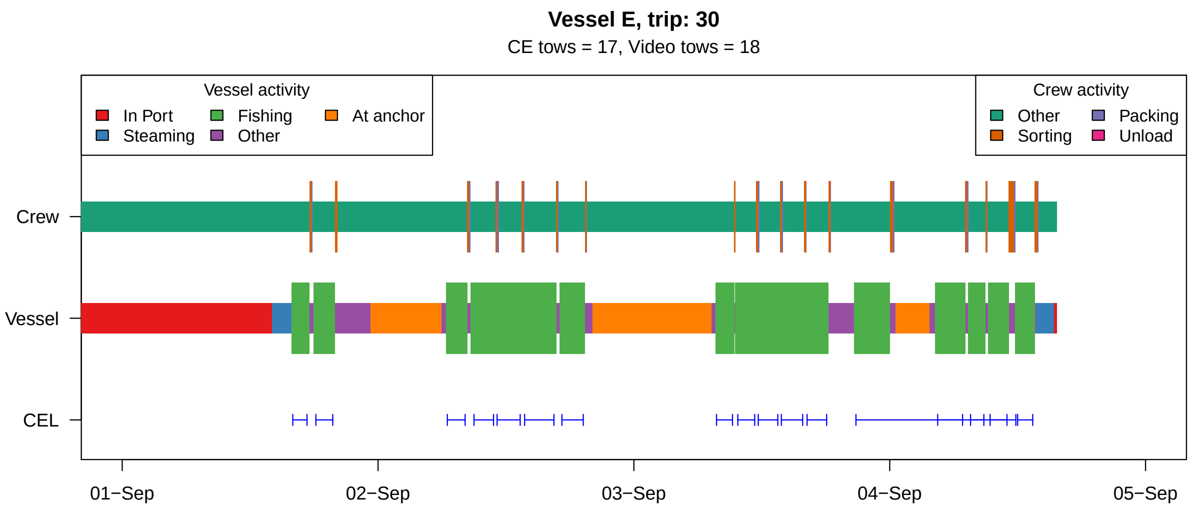

Vessel E, trip: 15
CE tows = 15, Video tows = 15
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
21−May
22−May
23−May
24−May
25−May
26−May
27−May

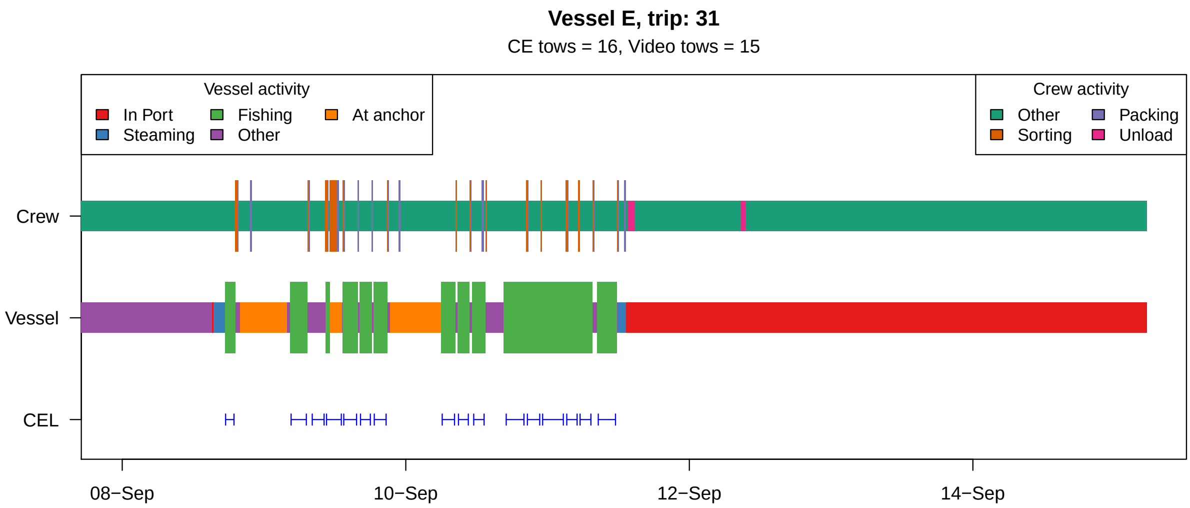

Vessel E, trip: 16
CE tows = 4, Video tows = 4
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
27−May
28−May
29−May

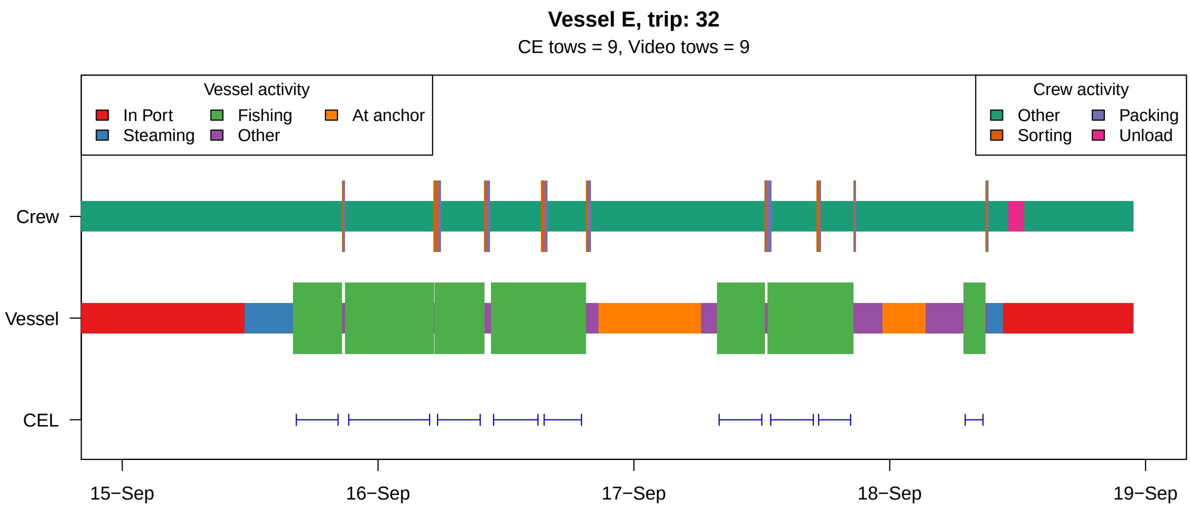

Vessel E, trip: 22
CE tows = 8, Video tows = 8
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
02−Jul
04−Jul
06−Jul
08−Jul
10−Jul
12−Jul

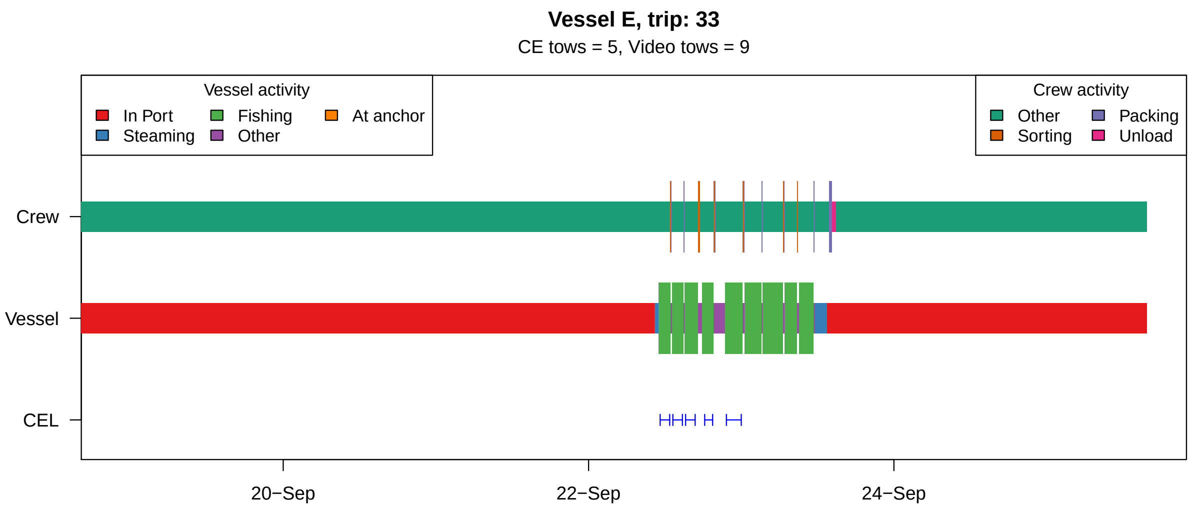

Vessel E, trip: 24
CE tows = 13, Video tows = 13
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
18−Jul
20−Jul
22−Jul
24−Jul
26−Jul
28−Jul


Vessel E, trip: 25
CE tows = 15, Video tows = 15
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
28−Jul
29−Jul
30−Jul
31−Jul
01−Aug

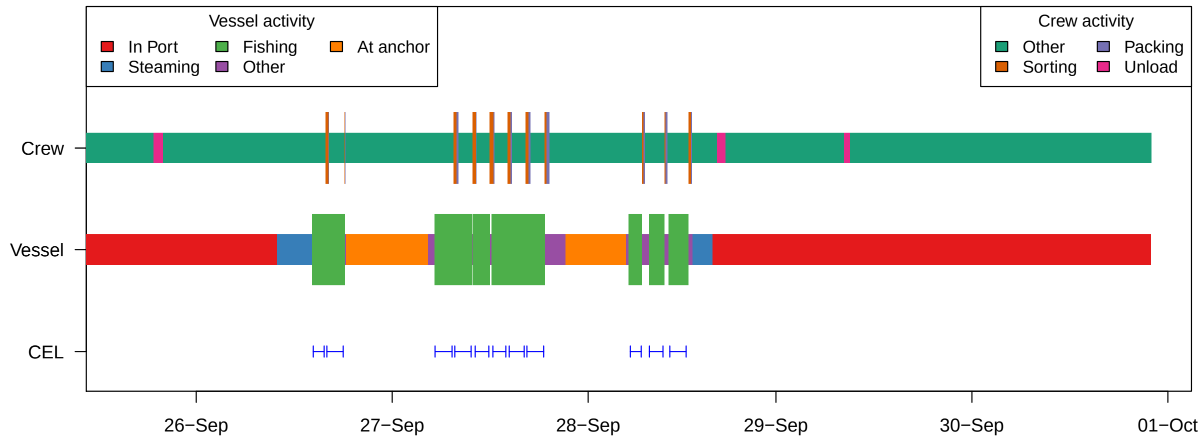

Vessel E, trip: 30
CE tows = 17, Video tows = 18
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
01−Sep
02−Sep
03−Sep
04−Sep
05−Sep


Vessel E, trip: 31
CE tows = 16, Video tows = 15
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
08−Sep
10−Sep
12−Sep
14−Sep

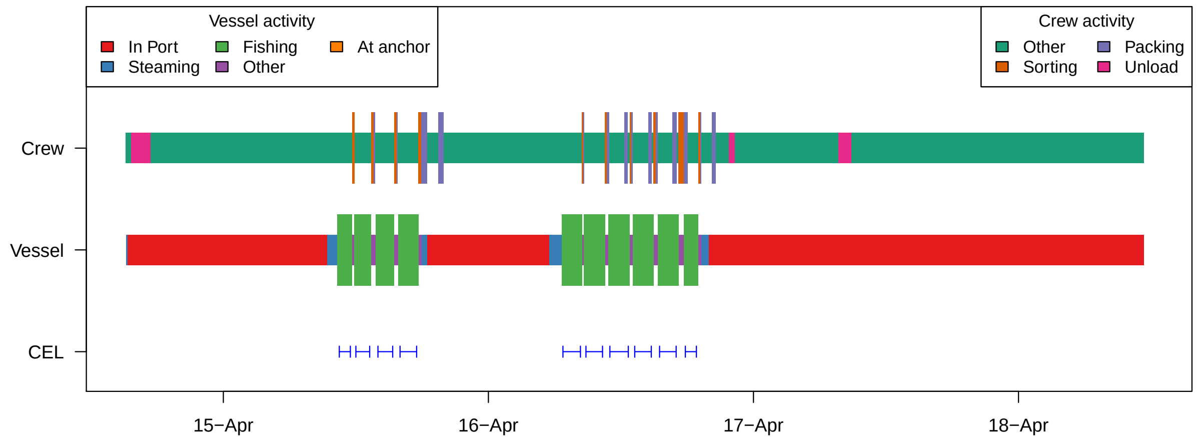

Vessel E, trip: 32
CE tows = 9, Video tows = 9
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
15−Sep
16−Sep
17−Sep
18−Sep
19−Sep


Vessel E, trip: 33
CE tows = 5, Video tows = 9
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
20−Sep
22−Sep
24−Sep

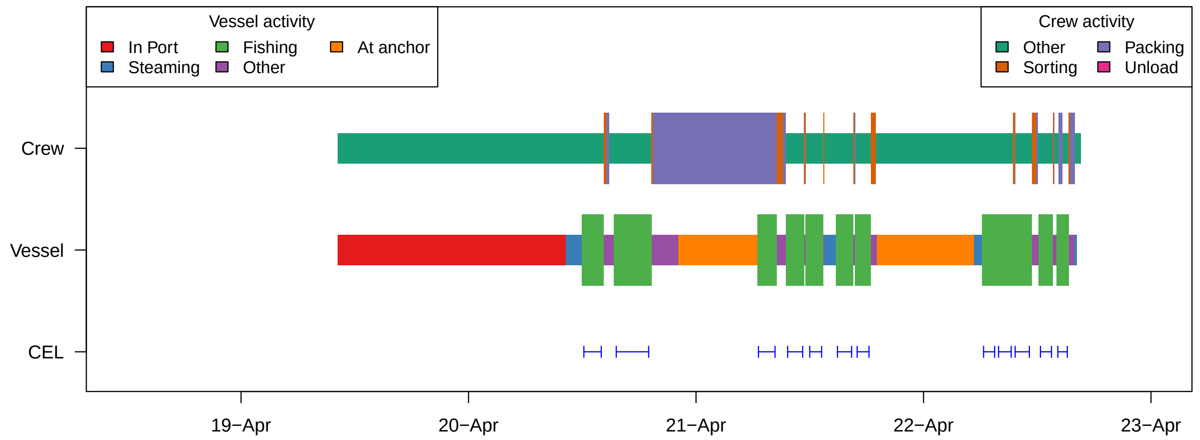
Vessel E, trip: 34
CE tows = 11, Video tows = 11

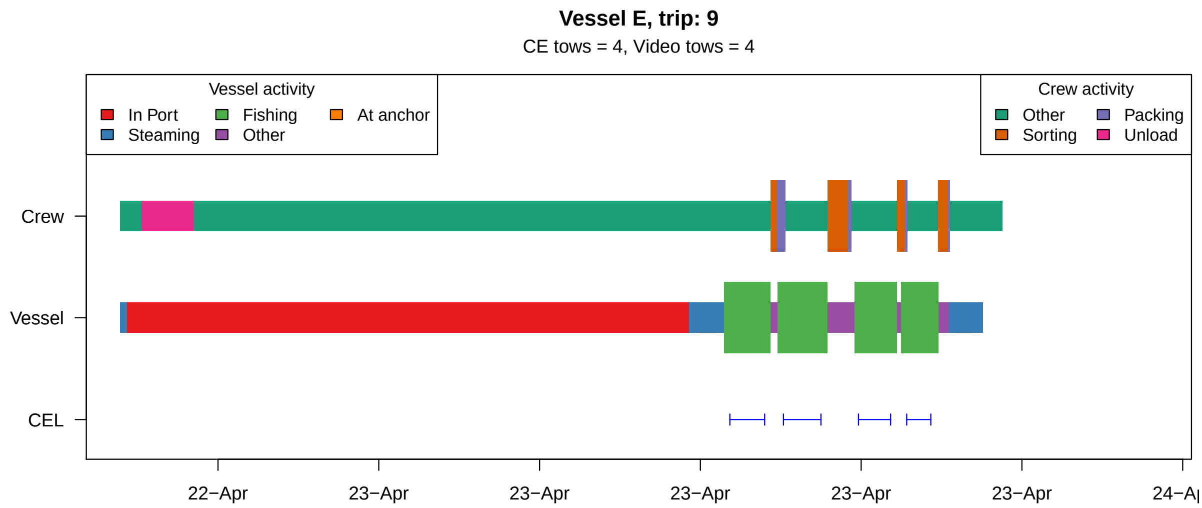


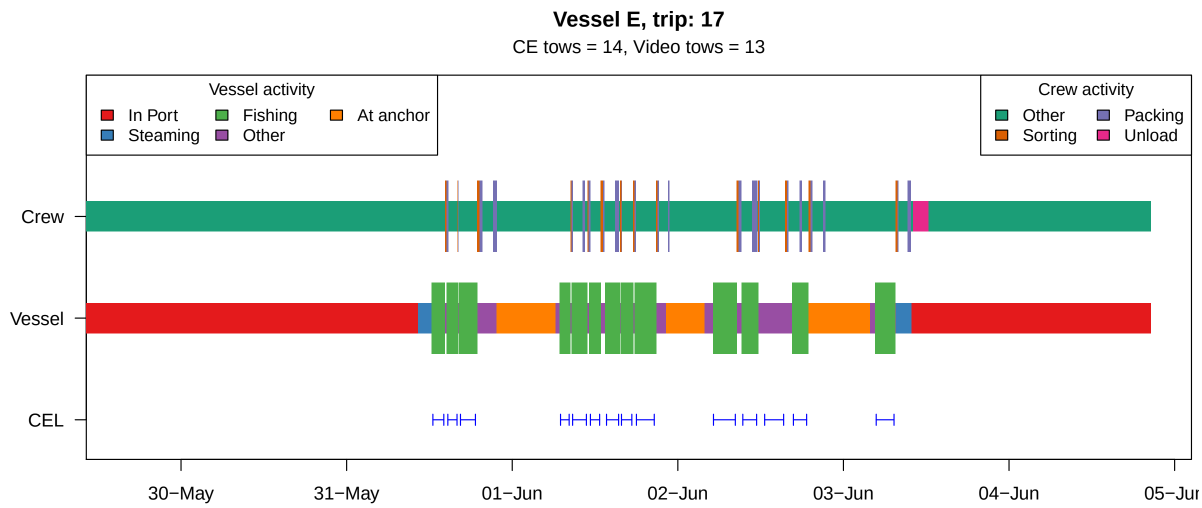
Vessel E, trip: 7
CE tows = 10, Video tows = 10

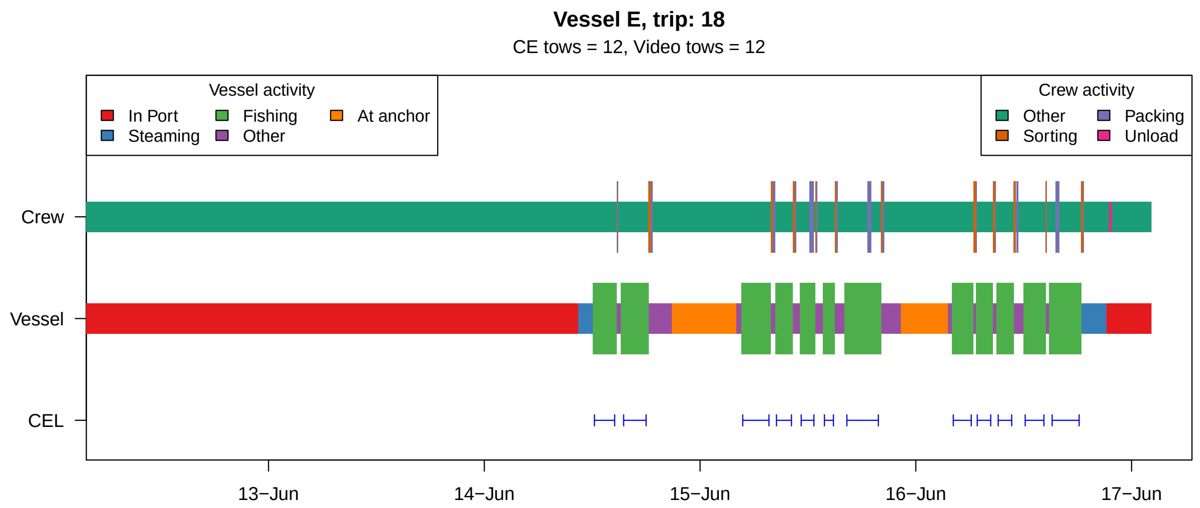


Vessel E, trip: 8
CE tows = 12, Video tows = 11



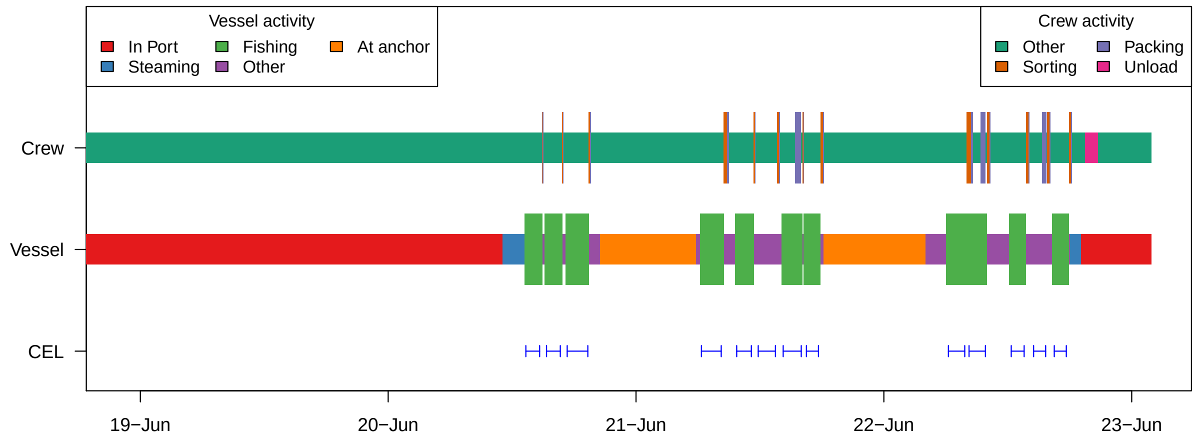

Vessel E, trip: 9
CE tows = 4, Video tows = 4
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
22–Apr
23–Apr
23–Apr
23–Apr
23–Apr
23–Apr
24–A


Vessel E, trip: 17
CE tows = 14, Video tows = 13
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
30–May
31–May
01–Jun
02–Jun
03–Jun
04–Jun
05–Jun


Vessel E, trip: 18
CE tows = 12, Video tows = 12
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
13–Jun
14–Jun
15–Jun
16–Jun
17–Jun

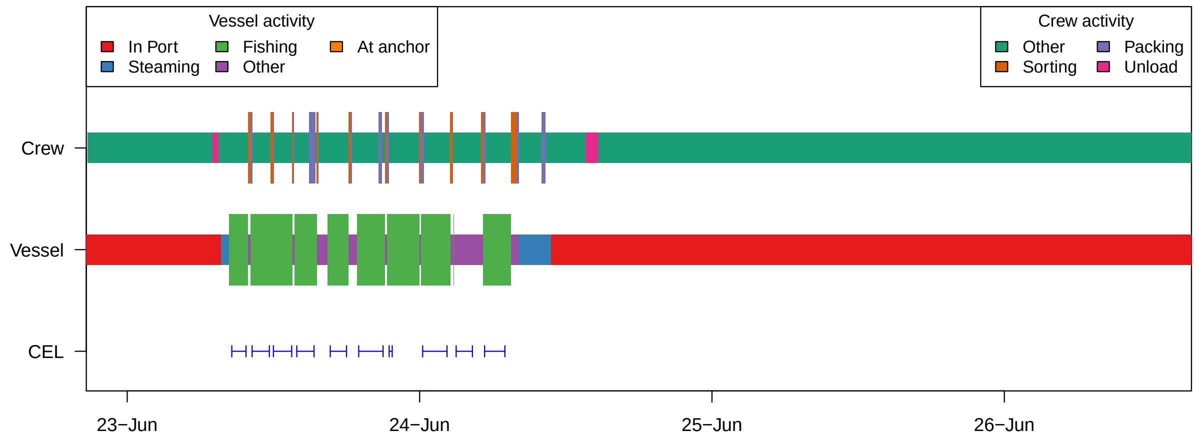
Vessel E, trip: 19

CE tows = 13, Video tows = 11



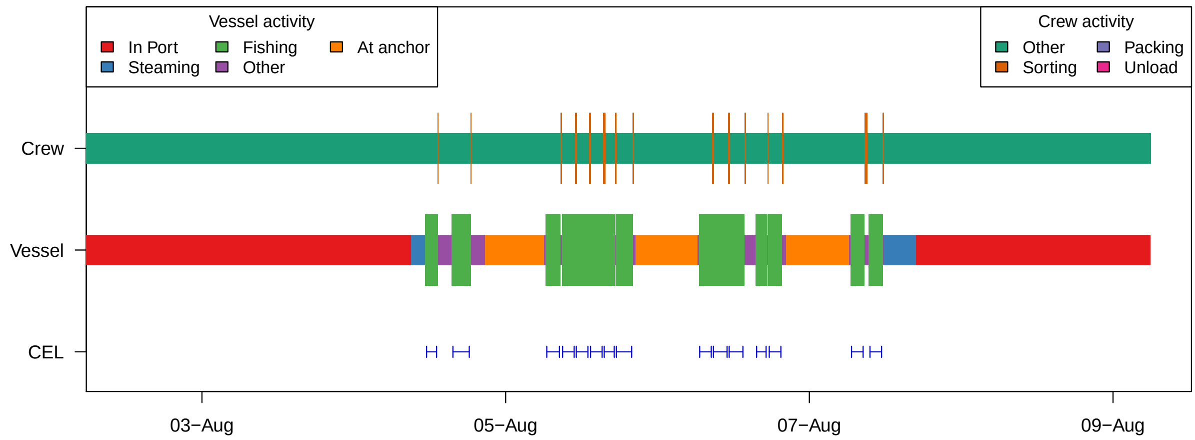
Vessel E, trip: 20

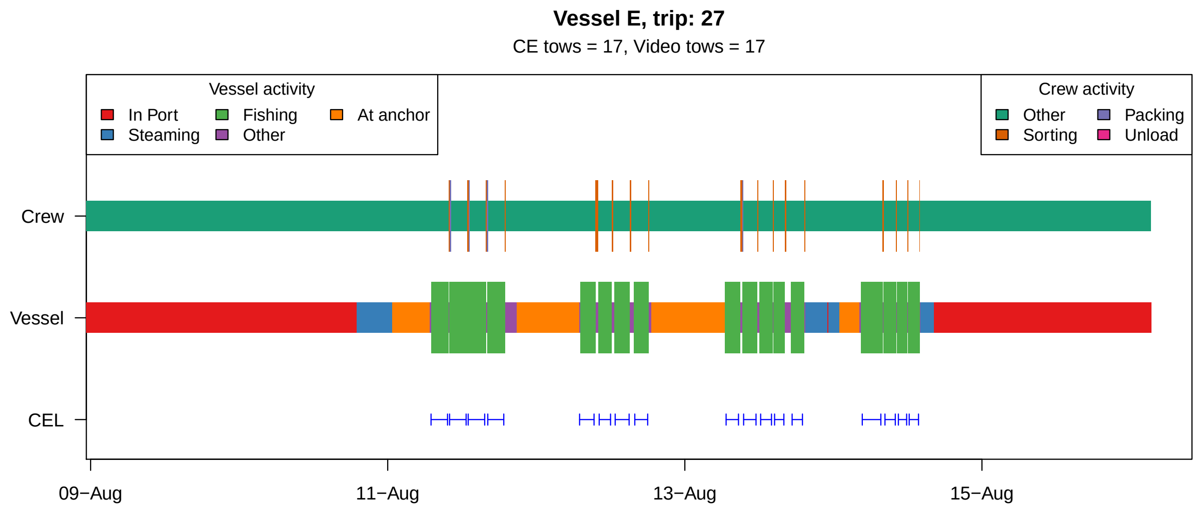
CE tows = 10, Video tows = 10

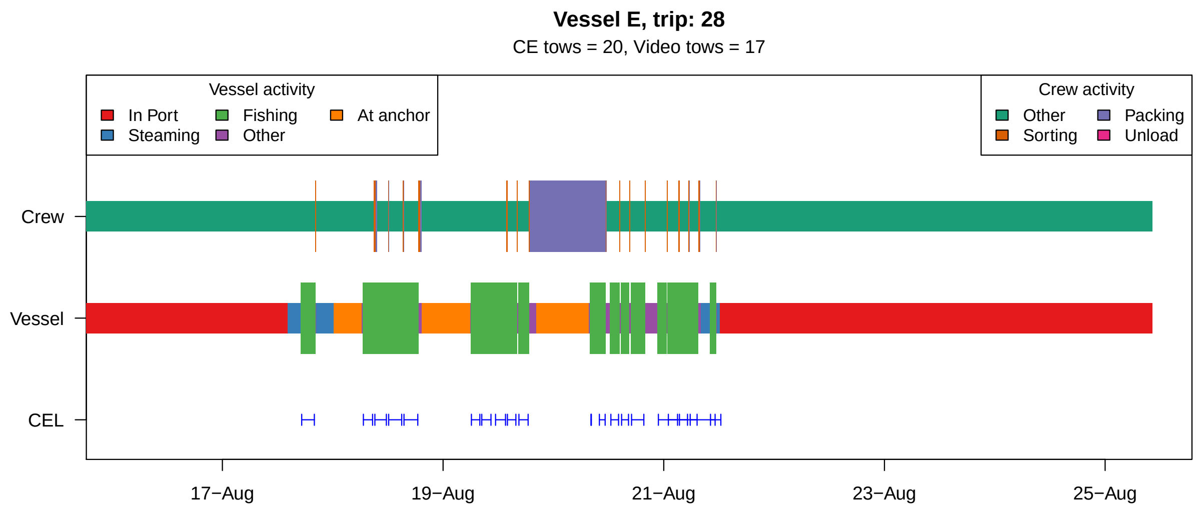


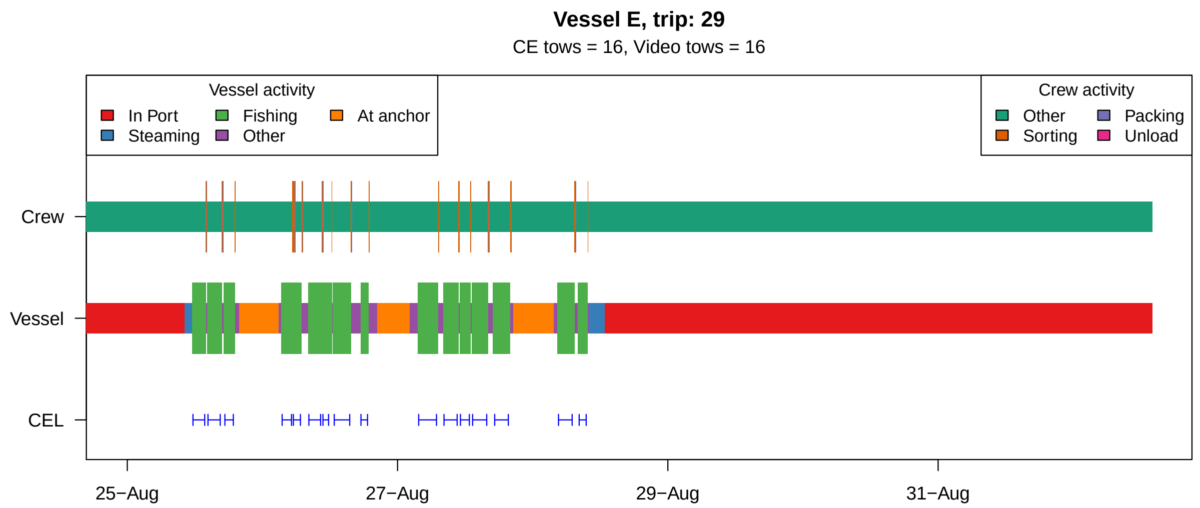
Vessel E, trip: 26

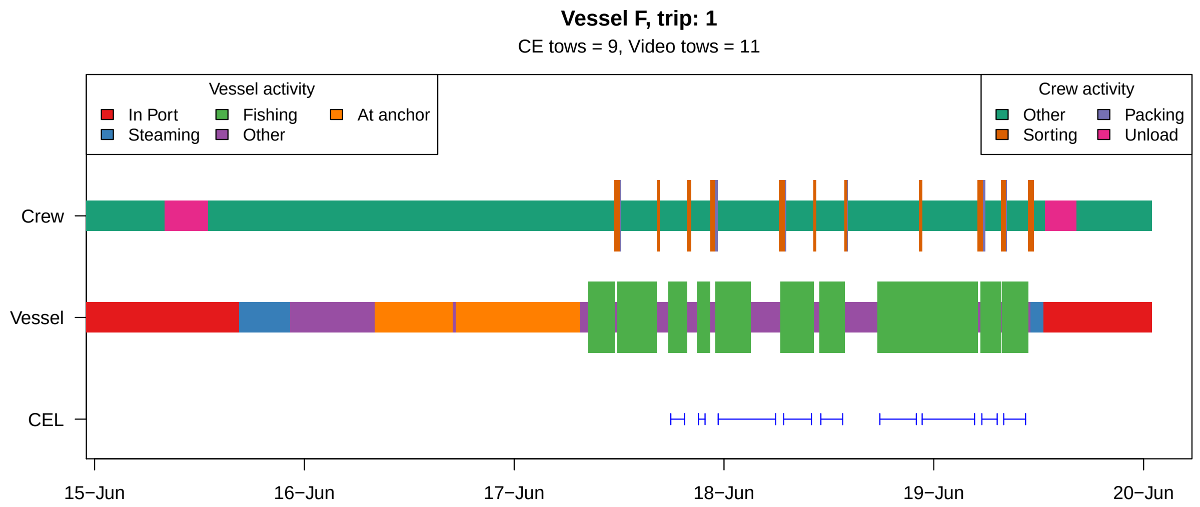
CE tows = 15, Video tows = 15

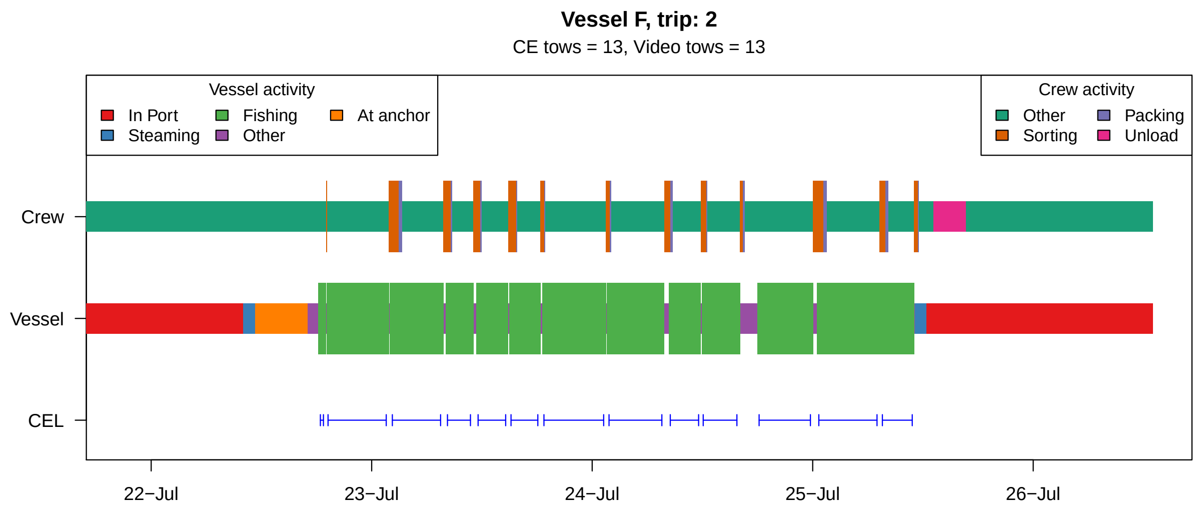


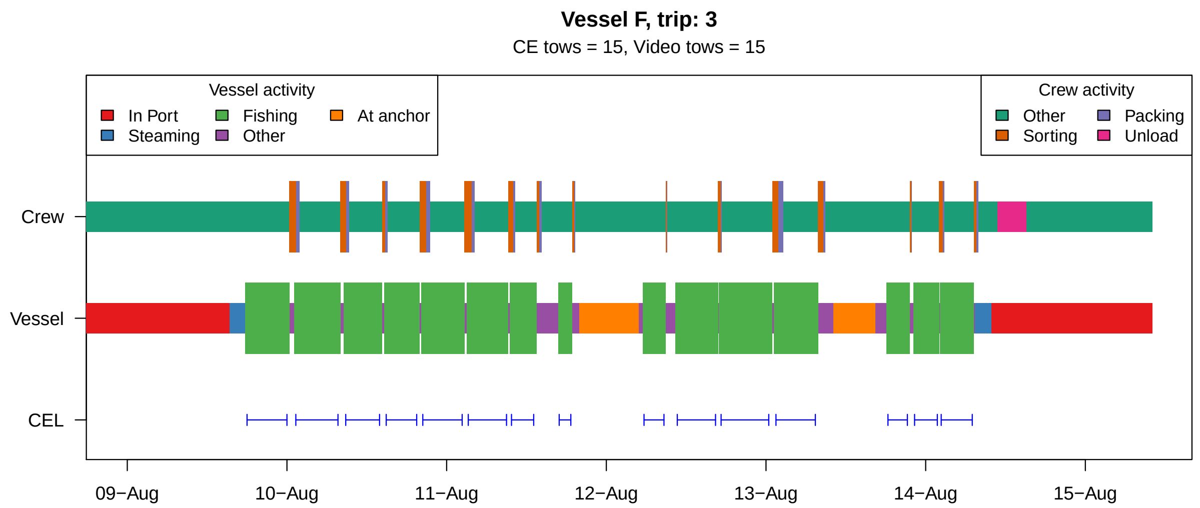

Vessel E, trip: 27
CE tows = 17, Video tows = 17
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
09−Aug
11−Aug
13−Aug
15−Aug

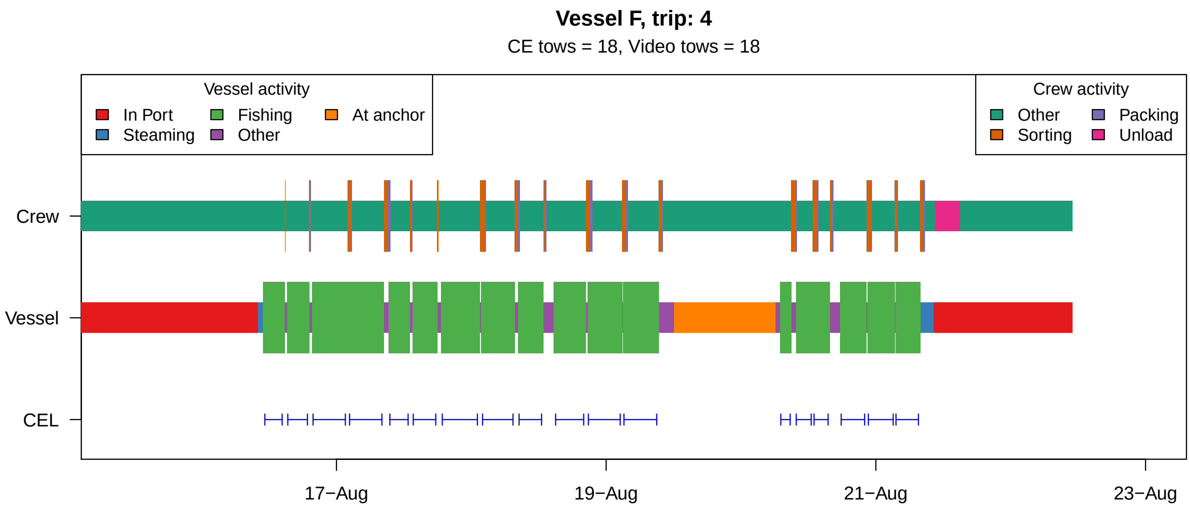

Vessel E, trip: 28
CE tows = 20, Video tows = 17
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
17−Aug
19−Aug
21−Aug
23−Aug
25−Aug


Vessel E, trip: 29
CE tows = 16, Video tows = 16
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
25−Aug
27−Aug
29−Aug
31−Aug


Vessel F, trip: 1
CE tows = 9, Video tows = 11
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
15−Jun
16−Jun
17−Jun
18−Jun
19−Jun
20−Jun


Vessel F, trip: 2
CE tows = 13, Video tows = 13
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
22−Jul
23−Jul
24−Jul
25−Jul
26−Jul


Vessel F, trip: 3
CE tows = 15, Video tows = 15
Vessel activity
In Port
Fishing
At anchor
Steaming
Other
Crew activity
Other
Packing
Sorting
Unload
Crew
Vessel
CEL
09−Aug
10−Aug
11−Aug
12−Aug
13−Aug
14−Aug
15−Aug



Vessel F, trip: 4
CE tows = 18, Video tows = 18
Vessel activity
In Port
Steaming
Fishing
Other
At anchor
Crew activity
Other
Sorting
Packing
Unload
Crew
Vessel
CEL
17−Aug
19−Aug
21−Aug
23−Aug