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The pāua data-logger system

New Zealand Fisheries Assessment Report 2017/54

P. Neubauer

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EXECUTIVE SUMMARY

Neubauer, P. (2017). The pāua data-logger system: present state and future direction. ***New Zealand Fisheries Assessment Report 2017/54.*** **12 p.**

The pāua data-logger system was conceived to provide high-resolution information on spatial resource use and catch-per-unit-effort in the pāua fisheries around New Zealand. The system consists of two hardware components, the boat unit and the turtle loggers, which together record catch (boat unit) and effort (recorded by the turtle logger, worn by free-diving fishers), and a database system. The database system manages uploads from the units and processes the data into a set of tables for analysis and visualisation. A web-based frontend tool allows users and administrators to assess the data quality and correct errors. Since its inception, the system has provided valuable information about pāua fishing activity, especially spatial trends in some of the quota management areas. This report presents a stocktake of the current state of the programme, discusses areas for improvement, and makes recommendations for the programme to transition successfully to the new Integrated Electronic Monitoring and Reporting System, mandated by the Ministry for Primary Industries from 1 October 2017.

1. INTRODUCTION

Catch-per-unit-effort (CPUE) is routinely used as the sole index of abundance in pāua (*Haliotis iris*) stock assessments in New Zealand (Breen et al. 2003, Fu 2012). This assessment approach contrasts with other abalone fisheries around the world, where CPUE has been regarded as an unreliable indicator of abundance (e.g., Tasmania; Prince & Hilborn 1998). Given the importance of CPUE time-series for managing pāua stocks, it is vital to ensure that CPUE in New Zealand's pāua fisheries reflects abundance over relevant spatial scales.

Many of the features that make abalone CPUE unreliable as an index of abundance relate to the spatial nature of the fisheries (see Neubauer 2015, for a more detailed discussion). Abalone stocks are thought to be vulnerable to serial depletion, where a fishery shifts to new areas after areas of high abundance are fished out (Prince & Guzmán del Próo 1993, Orensanz et al. 1998, Karpov et al. 2000, Prince 2005). In addition, the aggregating behaviour of abalone makes them prone to overestimating abundance from CPUE, as abalone densities typically do not decline steadily as they are fished; it is thought that catch rates remain high and fishing remains economical even when overall abundance is low (Prince 1989). Conversely, for target species that are predominantly found in many low-density and few high-density patches, fishing down of high-density patches may lead to hyper-depleted CPUE: catch rates decline faster than the actual biomass (because low-density patches are not fished; Hilborn & Walters 1992). Similarly, when a fishery contracts into a smaller area (i.e., covers less of the stock area) or reserves are established, CPUE can depict a hyper-depleted status of the biomass (Walters 2003, Maunder et al. 2006, Ono et al. 2015, Neubauer 2015).

Given the potential biases of CPUE for fisheries with a strong inherent spatial component, the Pāua Industry Council Limited (PICL) introduced a new automatic data-logging system, hereafter called pāua dive-loggers, to the fishery. These units record fishing effort at an unprecedented high spatial resolution, in an attempt to log fishing and abundance at the spatial scales of the resource. The usefulness of CPUE from the dive loggers as an index of local abundance was confirmed in a fish-down experiment (Abraham & Neubauer 2015), and the logging system has proven practical in a range of situations (Neubauer & Abraham 2014, Neubauer 2017).

This report details the current state of the pāua dive-logger system, and discusses potential avenues for future development. Both past and current developments are discussed in view of the key objective of obtaining reliable CPUE for pāua fisheries. This report needs to be considered in the wider context of expected changes to the Integrated Electronic Monitoring and Reporting System (IEMRS), set to be implemented by the Ministry for Primary Industries (MPI) on 1 October 2017. The new framework will make electronic reporting mandatory, and will potentially lead to the fishery-wide requirement to use the dive-logging technology (or equivalent). In this context, it is important to evaluate past and current technical developments, and to highlight some outstanding challenges that need to be resolved to ensure accurate statutory monitoring and reporting.

2. THE DIVE-LOGGER SYSTEM

The high-level objective of the dive-logger system is to provide high-resolution effort and catch data to provide

- (near) real time self-management,
- spatial resource use and status information,
- an improved CPUE index.

The development and deployment of the loggers is being managed by the fishing industry, through the PICL, and has been supported by Seafood Innovations Limited (SIL) and MPI. To date, the system has proven particularly valuable in providing spatial resource use information (Neubauer & Abraham 2014, Neubauer 2017). Nevertheless, although the accuracy and potential utility of logger-derived CPUE has been highlighted (Abraham & Neubauer 2015), use of logger-derived CPUE is currently limited by variable data quality and uptake across quota-management areas.

2.1 Hardware

Pāua dive-logger hardware (Figure 1) was developed by Zebra-Tech (Nelson, New Zealand) and introduced into the New Zealand commercial pāua fishery in October 2010. The units have remained largely unchanged in their functionality since then. The description of the units is detailed by Neubauer et al. (2014), and included here for completeness.

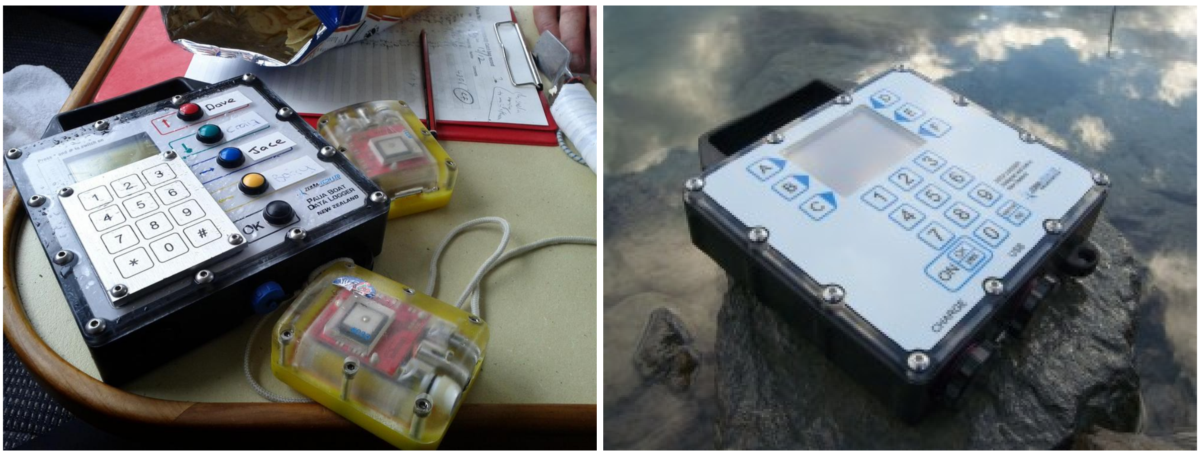

Figure 1: Pāua dive loggers consisting of a boat unit with buttons for recording catch bags and a key pad for entering catch weight and other data, and ”turtle loggers” carried by divers (left image). Newly developped deck-logger boat unit (right image; photo courtesy of Zebra-Tech, Nelson).

The dive loggers consist of two units, including a boat unit used to record catch, boat position and daily dive conditions, and a “turtle logger” worn by divers. The turtle loggers are compact units that fit in a pocket on the back of a diver’s wetsuit. When the diver is at the surface, the logger records depth and position, using a Global Position System (GPS; in 10 s intervals), whereas underwater, the logger records the diver's depth at 1 s intervals (Figure 2). The switch between recording modes is automated with a depth sensor that initiates surface and dive modes. At the end of the fishing day, a summary of turtle activity is sent via Bluetooth to the boat unit.

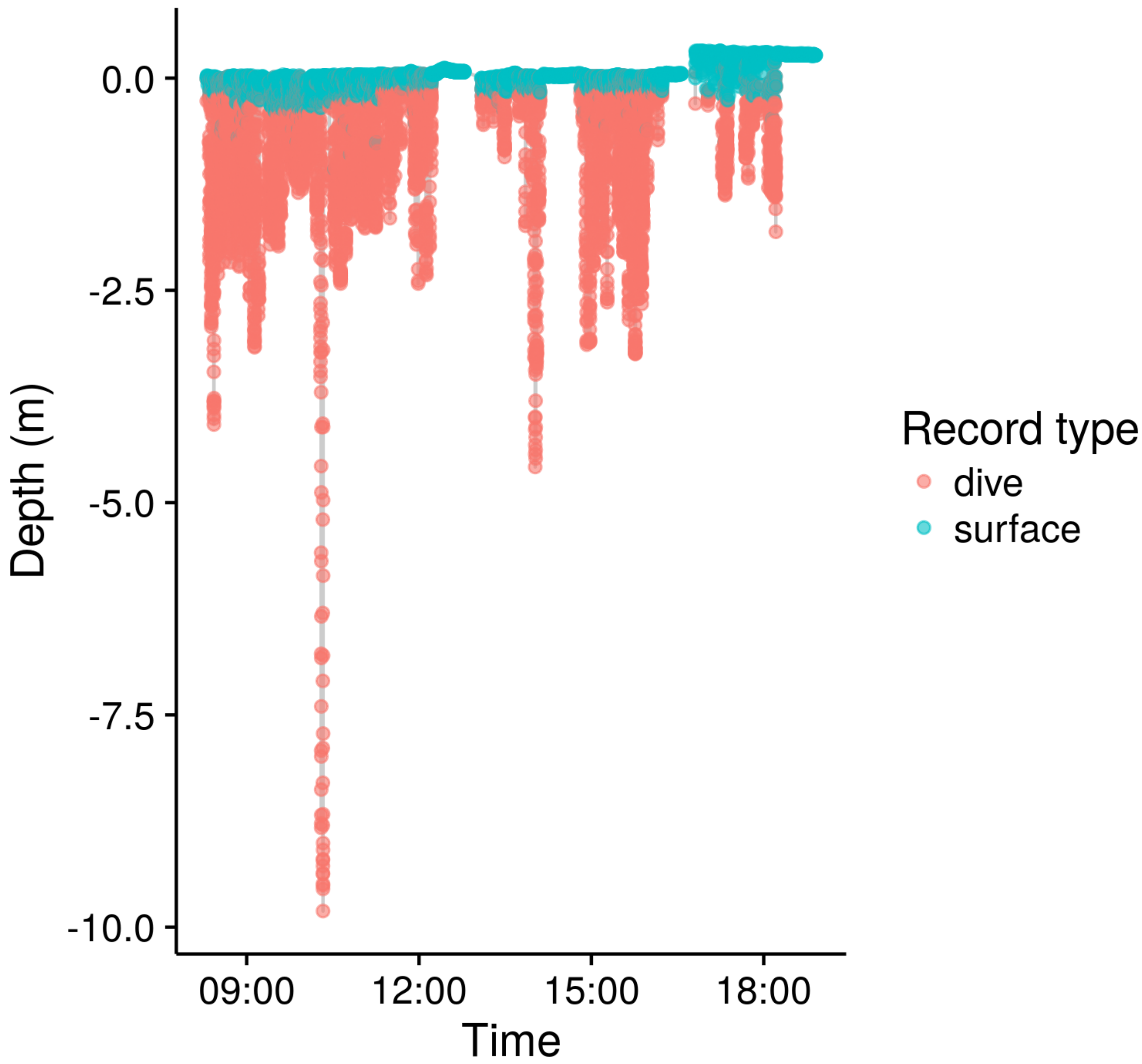

Figure 2: Example of data from a turtle logger worn by pāua divers. The logger records the depth and position of the diver at the surface (blue) and underwater (red).

The boat unit is used to record the location and time of catch bags being brought on-board (Figure 1). Two types of boat unit are currently in use, the original "boat-logger" and the more recently developped "deck-logger". (Note that both loggers are referred to as boat units as they serve the same purpose, while the terms boat-logger and deck-logger are used here to distinguish between the two types.) The deck-logger has a number of advantages over the original unit, including easier use through an improved interface, and streamlined data transfer via USB (Universal Serial Bus; see below). Following new requirements for electronic statutory reporting, the original boat units will need to be replaced by deck-loggers by the 2017–18 fishing year.

The boat units record GPS time and location at intervals of around a minute (depending on configuration). The button associated with a diver is pushed when they land a catch bag. The weight of each bag is not estimated. At the end of fishing, or when shifting between statistical areas, fishers close the boat-unit record. When the record is closed, the weight caught by each diver is entered.

Combined, the boat unit and turtle loggers are referred to as pāua dive-loggers, and records from both are needed to calculate CPUE. Divers enter their Seafood Industry Training Organisation number (SITO ID) in the boat unit with the number of their turtle logger (the turtle ID). Turtle units are assigned to individual divers, and fishers are able to reassign turtle loggers to other divers. The turtle ID links the turtle-logger data to the boat data, and the SITO ID links the boat and turtle data to the diver.

2.2 Data transfer and processing

The current system was designed to meet challenges discovered since the inception of the programme, especially for providing quality-controlled data suitable for science and management. Data are transferred from the three types of units into a cloud-based receiver database (Figure 3). The deck logger can be plugged into a computer via USB, and data can be downloaded as a text file. There is currently no automatic data upload from the deck loggers to the receiver. The lack of this automatic data upload means that deck-logger files are currently kept local until they are emailed for upload into the receiver database. This system is fragile, as data could easily be lost. With the anticipated switch to deck loggers across the fishery, a priority needs to be the upload facility for deck loggers to ensure complete coverage and complete CPUE.

For boat- and turtle-logger units, the data transfer to the receiver is facilitated through the application pāua Relay. The latter is a stand-alone application that communicates with the units and the database, and provides a direct link to upload the data from a device into the receiver database. It replaced the logger offload software provided by Zebra-Tech, which was restricted to Windows platforms. In addition, Relay provides access to the complete data stream, allowing post-hoc fixes, compared with data pre-processed by the offloader.

The receiver is a database that stores all incoming files, including metadata about the data packets that make up the transfer. Since units can potentially be uploaded through different pathways (e.g., relay and the legacy offloader), and fishing days can be uploaded multiple times, there was a clear need to separate incoming data from tables that describe actual fishing activity. The receiver manages these potentially overlapping uploads, and stores information related to the upload, such as the upload date, the person who uploaded them, and the type of firmware present on the units at the time of the upload.

The raw data held in the receiver database is parsed by the decoder application into tables used for frontend views and analyses. The decoder processes files from the different units and parses them into tables.

The decoder identifies dives from linear records of depth and time in the turtle units. This task is a considerable challenge given the amount of data (millions of lines) and the variability in the dive data; for example, surface depth has been frequently found to drift or jump between fishing bouts, or spurious data have been collected when the devices were turned on, but recorded data were clearly not fishing activity (Figure 4).

To identify dives, the decoder processes periods of dive activity separated by unit shutdowns or 10-minute breaks in the data. For each dive period, it identifies the surface from an upper 95% quantile of the depths, and it then assumes that data below a depth threshold of 50 cm correspond with dives. This procedure does not rely on the surface-dive switch on the turtle units themselves, as this was found to switch mode at different depths throughout individual fishing days (Figure 2). Since the switch may be influenced by the wearing gear (i.e., the logger pouch) through its influence on the wet-dry status of the unit, depth alone was used as an indicator of dive activity.

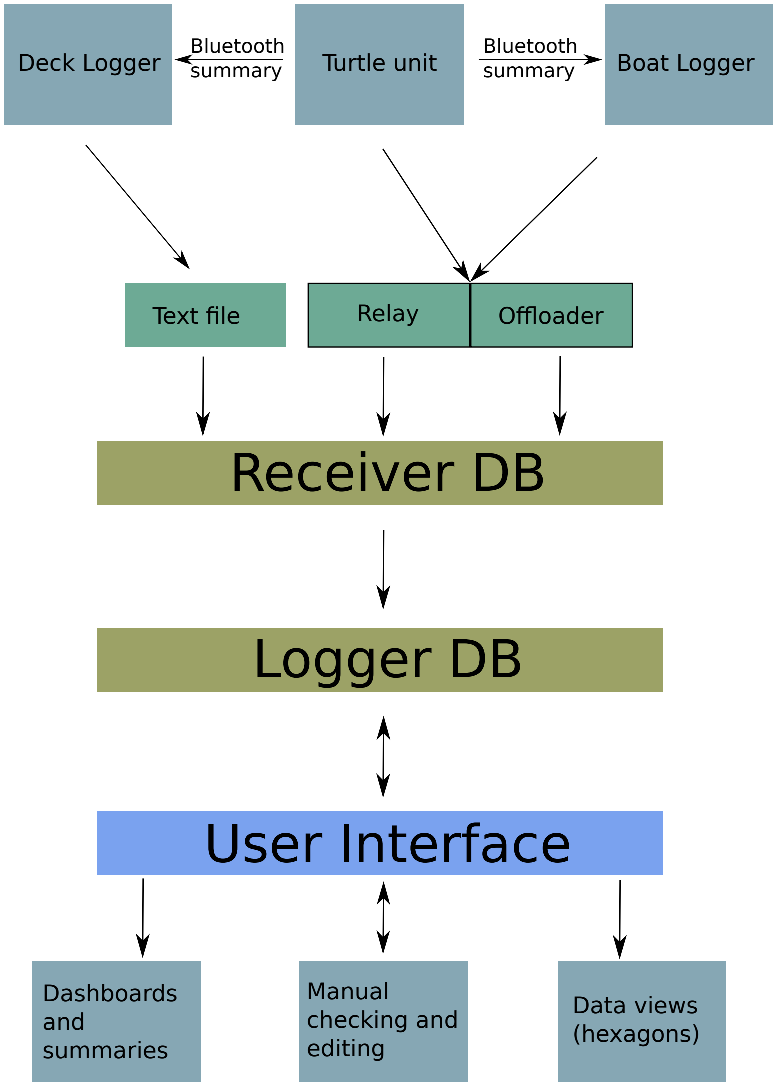

Figure 3: Flow chart of data transfer from the pāua dive-loggers, consisting of the turtle unit carried by divers and the deck or boat logger used on the fishing vessel to record the location and time of catch bags being landed.

2.3 Logger database

Turtle- and boat-unit data may be uploaded separately. The logger database pairs catch and effort data (boat- and turtle unit data), and produces a number of summaries for display and analysis. Pairing of

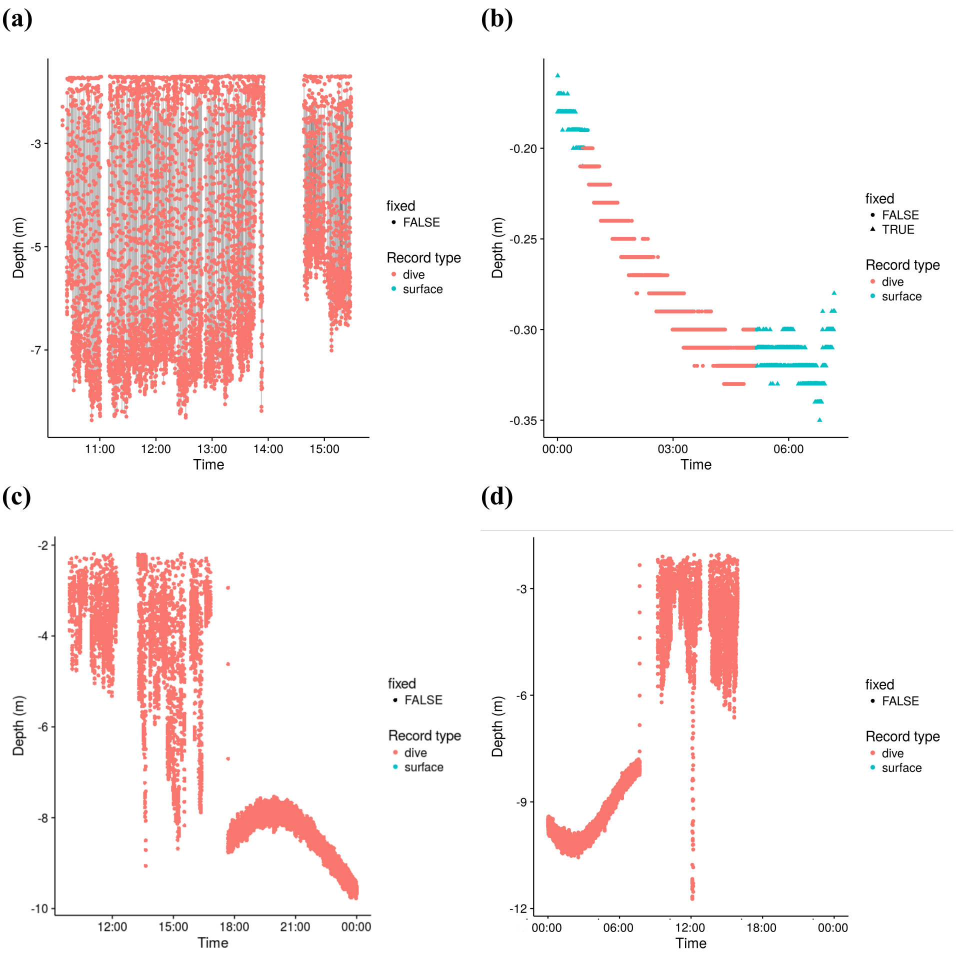

Figure 4: Examples of incorrect records in turtle-unit data (surface records indicated in blue and dive records in red). (a) Consistent dive activity, but surface depth recorded as below zero. As no points were recorded at the surface, no Global Position System points were aquired for the day. (b) Spurious data recorded by the unit, with no apparent dive activity. (c), (d): Dive data, with no recorded surface mode, and spurious data from a unit being lowered to 8-m depth overnight, to be retrieved the next day and used for diving.

catch and effort data is based on the link between turtle units and diver identifications entered on boat units. It is often necessary to include a temporal aspect in this link as catch weights (associated with unit shutdown events) are sometimes entered a day or multiple days after the fishing occurred. In this case, it is necessary to work backwards from the boat-unit shutdown event to link dive activity.

2.4 User interface—assuring data quality and confidentiality

The current logger database system was designed to meet requirements of a strict permissions system to ensure data confidentiality for individual operators. To ensure confidentiality, four distinct roles were designed — fishers, quota management area (QMA) administrators, partners, and system administrators (super users) — , each with a specific set of permissions to view and edit data. For example, divers can only view data from a unit that was assigned to them, and only for the period that the unit was assigned to them (Figure 5). This restriction means that someone obtaining a unit that was not assigned to them, or that houses data that are not theirs, will not be able to view those data on the website, unless an administrator assigns the unit to them for the relevant period. Fishers can delegate units to QMA administrators to manage their crew assignments and quality control. QMA administrators can view all fishing data from their QMA at a day level for quality-control and administration purposes, but cannot view detailed spatial fishing information.

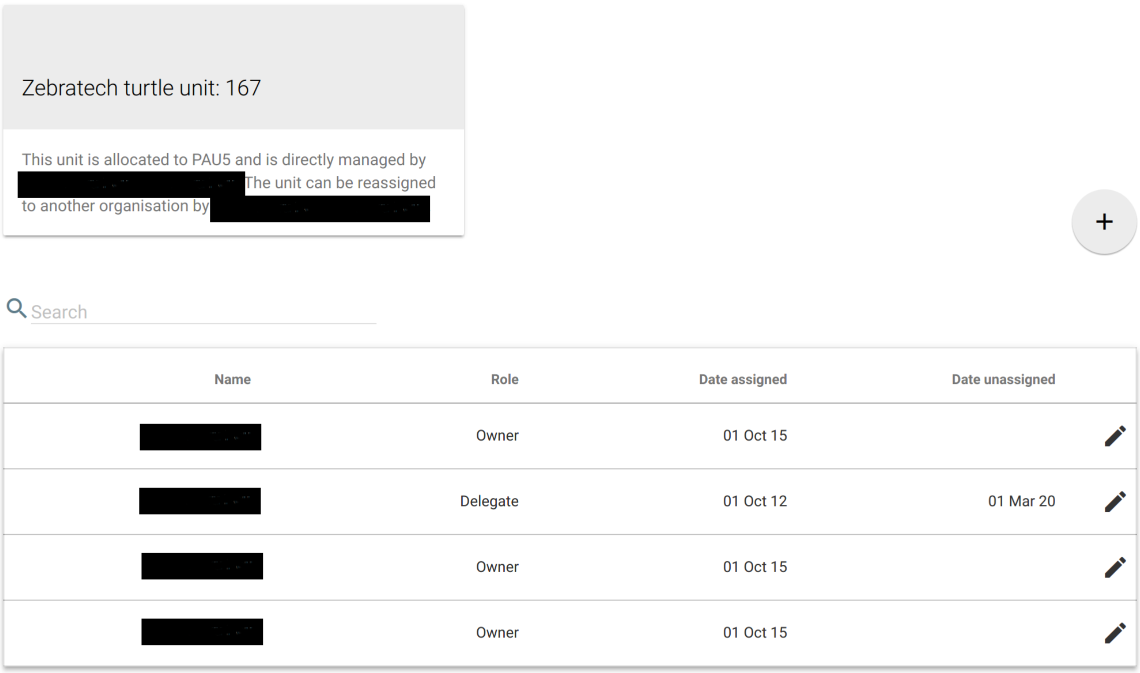

Figure 5: Example of a paua data-logger unit assignment. Each unit can be assigned to one or multiple divers, delegated by a quota management area administrator. All assignments have start and end dates to ensure data confidentiality when units are assigned to different fishers.

The logger database contains data of two stages: one stage reflects the original data, and the other stage reflects edited records that were identified as erroneous and corrected as part of the quality-control process. The quality-control process functions via a number of cues that divers and QMA administrators can view and edit (to the level of their respective permissions; Figure 6). The cues reflect records where unit assignments were either wrong or missing, or fishing days are incomplete (i.e., no turtle-logger or boat data). All data except for the turtle-logger dive effort can be edited by unit owners or delegated QMA administrators to correct errors. Records can also be deleted to remove spurious effort (such as illustrated in Figure 4).

2.5 Ensuring complete data coverage

Currently, the only way to assess completeness of the logger-programme data is to compare records with the Paua Catch Effort and Landing Return (PCELR) statutory reporting. Nevertheless, incoming IEMRS requirements to use vessel monitoring systems, and electronic reporting at the end of each fishing day mean that it will be possible to track data completeness via recorded fishing activity from 1 October 2017. This update also means that users can be prompted to complete their records (e.g., by uploading turtle-logger data of their fishing activity). To this end, a "boat stub" (i.e., a pre-populated boat record) is initiated from electronic-reporting data (Figure 7). The stub includes details about the boat unit and day, and (if created from electronic-reporting data) fisher identifications and catch. The stub can then be completed by uploading turtle-logger data.

2.6 User interface—data products

The user interface contains two main data products: the hexagon view and the QMA dashboards. The hexagon view allows divers and analysts to inspect spatial fishing patterns for strategic planning and analyses (Figure 8). It displays catch per hectare hexagon, and a summary of all fishing activity in a

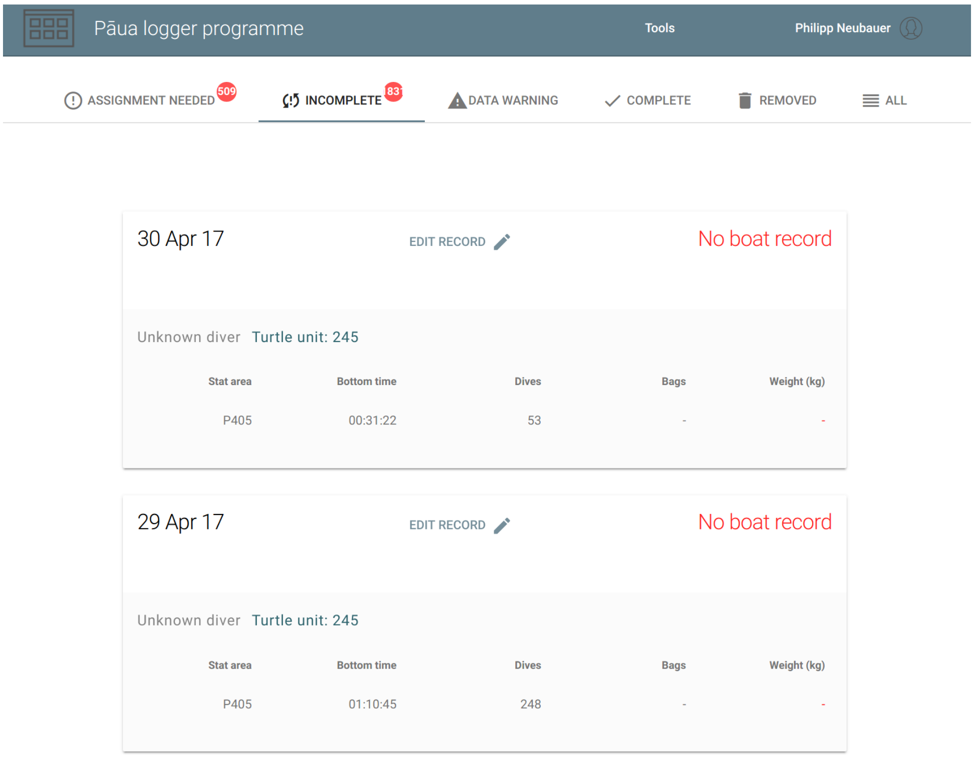

Figure 6: Example of the quality-control cues for assessing pāua data-logger records. Multiple cues highlight records that either need assignments, are incomplete (i.e., lack turtle- or boat-unit data), or result in unrealistic CPUE (Data warning). All removed and completed records can be viewed and searched.

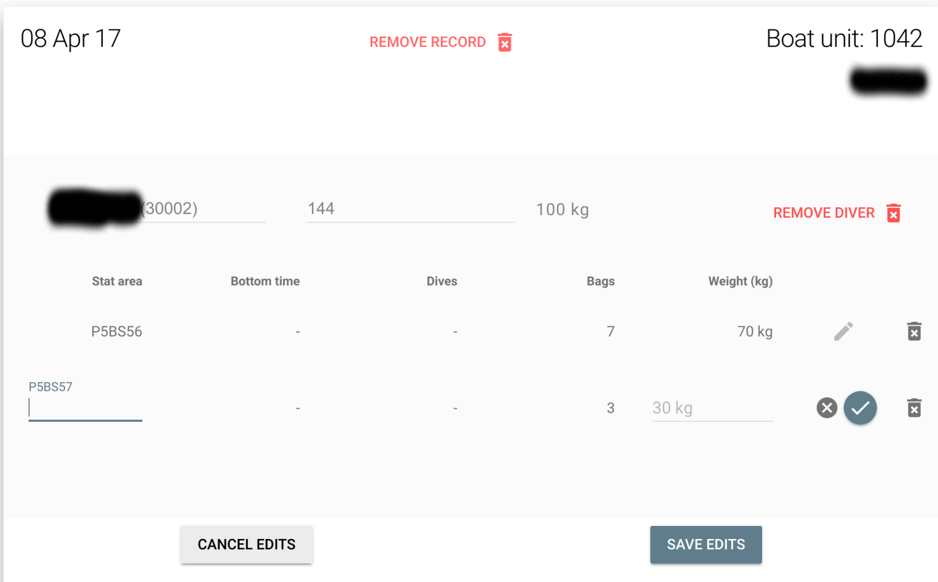

Figure 7: Example of the "boat stub", which is an incomplete record created from submitted fishing activity data. Fields can be edited manually (under "Stat area") and completed by uploading boat- and turtle-unit data. Diver identification blacked out for confidentiality.

selected hexagon or region (defined by a rectangle drawn around a series of hexagons). Divers can only view their own data, whereas system administrators can view all data on the maps.

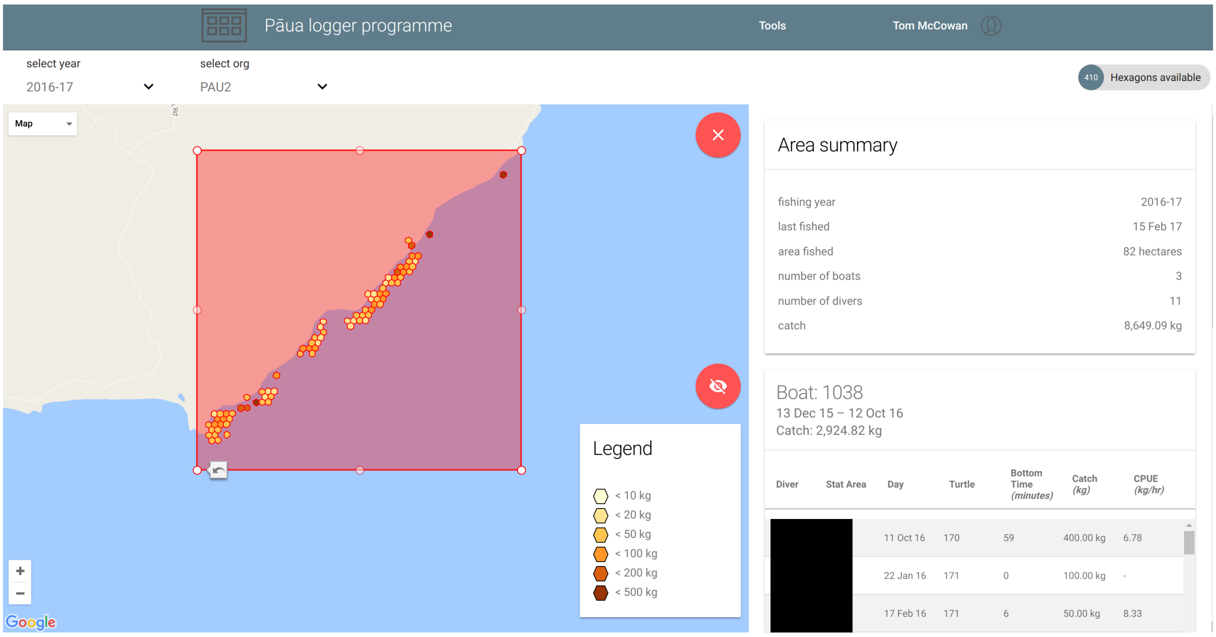

Figure 8: Example of the hexagon-level data view, with one-hectare hexagons coloured according to pāua catch in the selected year. Selecting hexagons or drawing a square around hexagons (by pressing shift and dragging a box) opens a summary tab on the right, with boat-level summaries of all individual dives in a hexagon or selected area. Diver names are blacked out in this example to ensure confidentiality.

The dashboard view reflects in-season changes in status of individual statistical (QMA) areas across the fisheries, with respect to self-imposed fishing limits in these areas (Figure 9).

3. IDENTIFYING AREAS OF IMPROVEMENT

Currently, some of the data produced by the system cannot be used for spatial resource-use and CPUE analyses, usually due to some missing information. For example, turtle-logger units sometimes do not acquire GPS positions for parts of a day, meaning no accurate spatial information was collected (Figure 4). This shortfall could be due to insufficient start-up time before the turtle-logger was used in the water, so that the unit could not acquire a satellite position. Another potential cause of data limiations may be the custom pouches that are used for turtle units by most divers. These pouches may not have sufficiently large holes to allow water to escape at the surface. In this case, the units do not switch to surface mode, and no GPS positions are recorded (see Figure 4, top left panel).

Another source of missing data is the lack of clear association between catch and effort data for a number of records. The association between turtle and boat units is currently created manually by entering a diver's SITO ID number and turtle unit number into the boat unit. This manual entering is a considerable limitation as the button association needs to be manually updated when units or divers change, and this task may be easily missed. Furthermore, this process allows for entry errors. For instance, a large number of SITO numbers are entered as dummy data, such as "00000", often because divers did not remember their SITO ID. This number is then sometimes not updated for long periods of time, creating a missing link between the turtle unit and the diver's name and catch.

To record spatial CPUE, it is necessary to obtain catch information at a spatial scale that is comparable to the effort (e.g., at a statistical area scale or an even finer scale). Currently, catch is entered either at the end of the day or when changing statistical areas. Consistent practice is needed to ensure that subsequent analyses can rely on higher resolution data. Furthermore, catch-bag buttons are often pressed away from

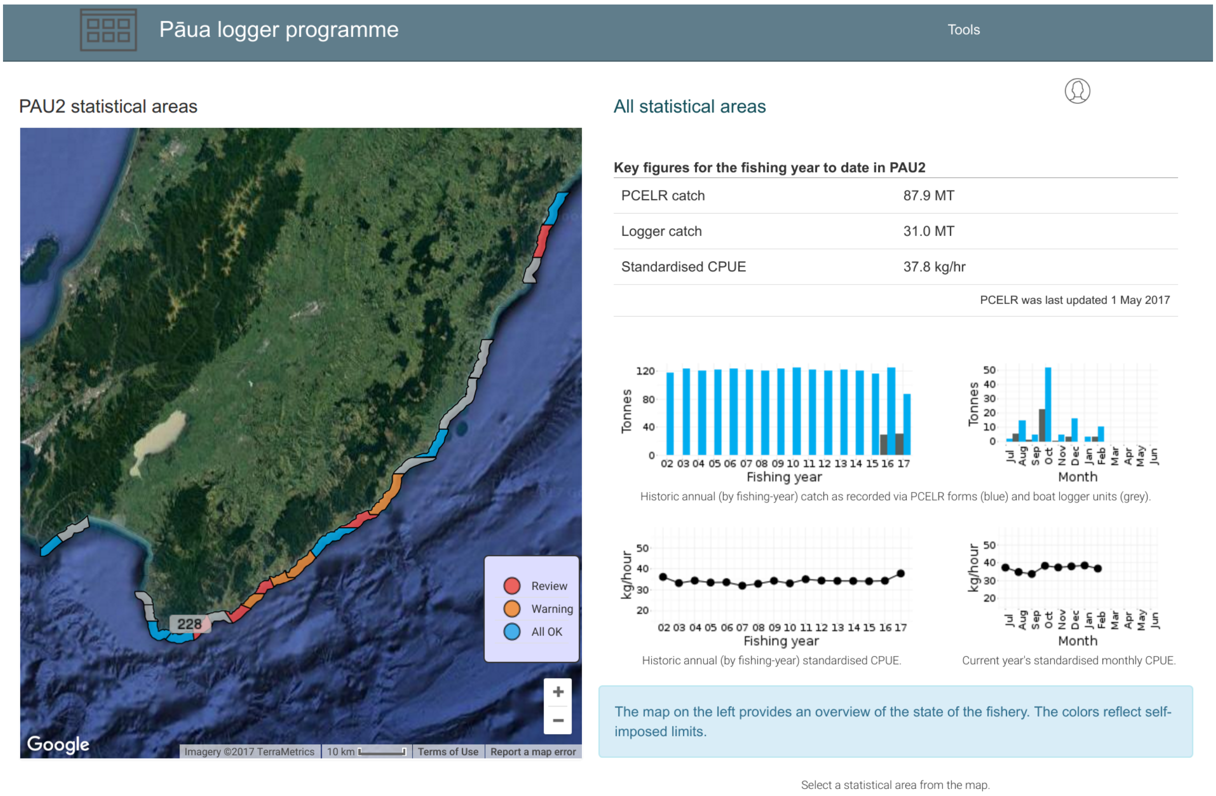

Figure 9: Example of the quota management area dashboard showing pāua catch data. On the map, statistical areas are coloured according to self-imposed limits for catch and catch-per-unit-effort (CPUE). Catch statistics and CPUE trends are displayed to provide context for the map. Individual statistical areas can be selected to show statistical area-level trends.

the fishing effort, sometimes in different statistical areas. This makes it difficult to obtain spatial CPUE from a subset of the data.

4. RECOMMENDATIONS AND FUTURE DIRECTIONS

The advent of IEMRS provides the opportunity to both address existing limitations outlined here, and to expand the pāua-logger programme to provide complete coverage. Key aspects that need to be addressed for accurate reporting, including spatial resource information and CPUE are:

- Ensuring a reliable link between turtle units and boat units. This link could potentially be achieved by prompting users to associate buttons to divers and turtle units at the beginning of each fishing day, with turtle-logger numbers pre-populated to avoid data entry errors.
- Repeated training to ensure devices are turned on sufficiently early before entering the water, and appropriate gear for wearing the units. These updates could lead to substantial improvements in the data quality from these devices. Field testing could be used to ascertain what the most crucial factors are in determining data quality. These improvements are essential to obtain high-quality CPUE and spatial effort data.
- In order to relate spatial effort to catch, button presses should occur at minimum within the same statistical area as the fishing activity, and ideally close by.
- Obtaining complete, timely records for fishing activity, via IERMS, so that completeness of logger data may be rapidly assessed, allowing closer monitoring of the programme.

In combination, these changes will provide significant improvements in data quality and completeness. More complete and accurate reporting would markedly increase the value of the data for in-season monitoring via dashboards, and for spatial analyses and simulation models, such as spatial assessment models and management procedure evaluation (and implementation). In summary, improved data quality from vital updates to the current system under IEMRS have the potential to significantly improve the value of real-time monitoring data and current data products. In addition, improved data quality would allow analyses and management decisions to be made at relevant temporal and spatial scales.

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