NIWA
Taihoro Nukurangi

Orange roughy trawl survey and plume search, west coast South Island, ORH 7B

Prepared for Talleys Group Limited

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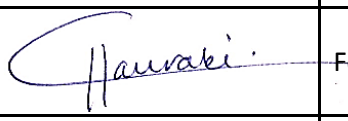	Formatting checked by:	Chloe Hauraki
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Executive summary

Research work on orange roughy on the West Coast South Island (WCSI) in management area ORH 7B was conducted using the fishing vessel *Cook Canyon* from 8 to 11 July 2016. This was the first step in the process to review the status of the fishery in the area, as the fishery was effectively closed in 2007–08 when the TACC was reduced to 1 t. This work was restricted to an area around the Cook Canyon, where most of the historical catch was caught. There were two parts to the work: a search for spawning aggregations (plumes); and a trawl survey to estimate relative abundance. Contingencies were in place to acoustically survey any large plumes found, but this did not eventuate.

One main spawning plume was found on two consecutive nights, but it dispersed during daylight hours which is its historical behaviour. Some other potential orange roughy marks were found in the area around the main plume, but the species composition of these marks is uncertain. The main plume was between 50 and 200 m high, depending on time, and in one instance it was about 100 m high, 650 m wide, and 1.8 km long. These were mapped using the FV *Cook Canyon*'s Furuno echosounder, i.e., an industry rather than a scientific echosounder (such as a Simrad ES60), so it was not possible to perform acoustic integration and, hence, no acoustic abundance estimate was made. The Furuno has a wider beam width than scientific echosounders used in other acoustic surveys and so the observed plume dimensions cannot be directly compared to aggregations surveyed in other areas. One short tow on the main plume produced about 18 t of orange roughy with little bycatch. The fish were mainly running ripe, i.e., actively spawning. Past experience from a fisher who has fished extensively in this area is that the fish come into the Cook Canyon area in waves over a period broadly between mid to late June and mid to late July.

The trawl survey used a randomised single phase design with two strata. A core stratum covered the main densities during the historic fishery, and the second stratum surrounded the core stratum. Twenty-two survey tows were successfully completed. The trawl survey abundance estimate was calculated using the swept area between the trawl doors (100 m) and gave an estimate of 190 t with a CV of 43%. This estimate is a relative one, i.e., not absolute, and excludes the plume. The skipper, an experienced orange roughy fisher, was certain that the separate plume had far more than 190 t of fish. Most survey orange roughy catches were small (median 19 kg) with a wide range of lengths (15 to 40 cm, mode at 22 cm), but there was one larger survey catch (600 kg) nearby the plume location which was composed of mainly spent (post-spawning) fish.

1 Introduction

Fishing for orange roughy on the West Coast South Island (WCSI) in management area ORH 7B (Figure 1) was first reported in the winter of 1985, and thereafter there was a sequence of quotas that started at 1,558 t for 3 years which then increased to 1,708 t. However, from 1995–96, quotas were reduced in steps to 430 t and then to 110 t before the fishery was essentially closed in 2007–08 (quota of 1 t). The last accepted stock assessment was in 2004 when the stock was estimated to be at 17% B_0 (using CPUE as the abundance index series). A stock assessment update in 2007 was rejected because the model had poor fits to the CPUE — it predicted a rebuild when none was evident in the CPUE (MPI 2015a).

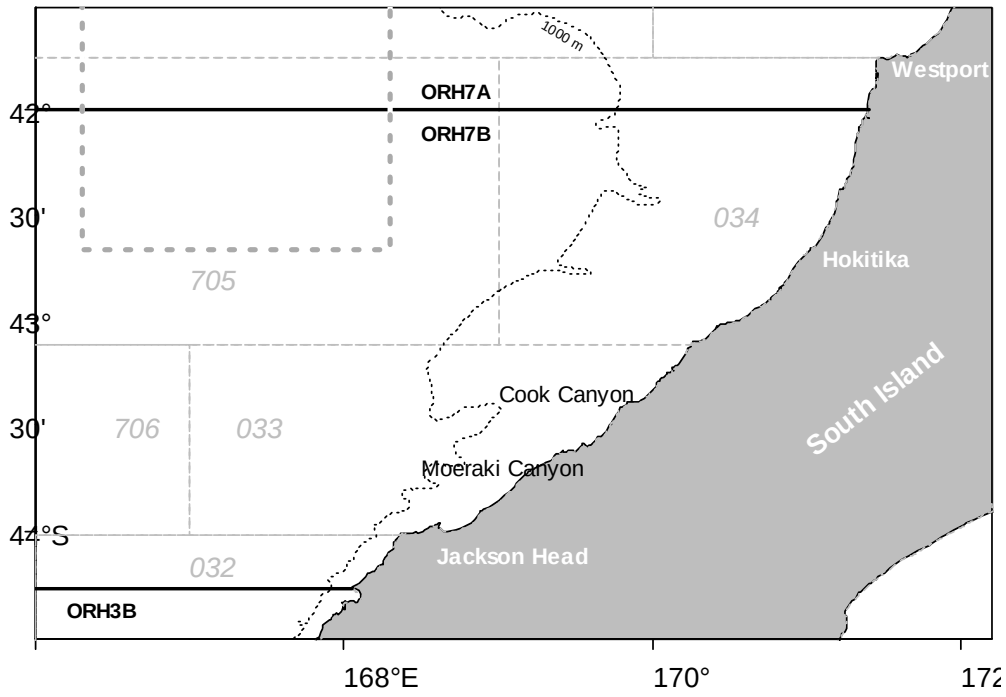

Figure 1: Location of the west coast South Island orange roughy fishery showing domestic fishing return statistical areas. The thick dashed grey line marks the perimeter of Benthic Protection Area "Challenger South" closed to bottom trawling (*from* Anderson & Dunn, 2012).

There were three random trawl surveys on the WCSI: two used the FV *Arrow* (October 1983, and in late July-early August 1986); and another by the RV *Tangaroa* in October 1991 (Tracey et al. 1990, Armstrong & Tracey 1987, Clark 1991). All three used different stratification, but they broadly covered the same total area.

The 2016 WCSI survey was carried out when orange roughy were probably spawning, known to be late June and early July. Adult orange roughy at that time of year are presumed to aggregate to spawn and therefore offer the chance of a higher overall catchability, and less survey vessel time. A 7 day survey was proposed to cover Cook Canyon, historically the largest of the ORH 7B fisheries. Cook Canyon produced about 80% of the past cumulative commercial catch (based on TCEPR records).

The current distribution of orange roughy in the Cook Canyon area is unknown, but in the winter of 2015, FV *Amaltal Explorer* did not observe any aggregations over 2 to 3 days of searching before catching 19 t from one tow that did not show on the echosounder. The latter is typical of hard-down layers or isolated schools of orange roughy. Later, they observed a typical spawning plume in the area, but time constraints meant that no further work was carried out on it. The location of the large catch

and plume were in a similar position to the spawning plume that occurred in the past fishery (Craig Jones, pers. comm.).

Locating a spawning aggregation and confirming it to be spawning orange roughy was a key objective of the 2016 survey since this signals a return of the stock to higher abundance levels and to significant spawning activity. In case no spawning aggregations were found, we planned a random trawl survey since marks may not have been obvious or numerous. Another key management requirement was obtaining an age composition of the 2016 fish population, i.e., are they recent young recruits or are they from another older population that has moved into this space? Otoliths were collected, but no age estimates were made under this project.

The motivation for embarking on this work was to determine if the fishery can be reopened or not, with the work proposed as a first step in this process. It was envisaged that the results of this work would guide future research, e.g., plan and design a scientific acoustic survey to be carried out in the winter 2017 for use in a stock assessment.

The catch of orange roughy during the survey was covered by Special Permit 626, held by Talleys Group Management Ltd.

1.1 Project objectives

The research work was carried out under a contract to Talleys Group Management Ltd. The specific objectives for the project were:

1. To locate one or more spawning aggregations.
2. To measure the spawning aggregation(s), and either map it on SeaPlot or, preferably, use a nearby vessel with a scientific echosounder (ES60 or better) in an acoustic survey.
3. To collect catch composition and other biological data (length, sex, & gonad stage) from the spawning aggregation(s), including otoliths.
4. To complete the trawl survey using Phase I stations only.
5. To collect data on orange roughy from the trawl survey (length, sex, gonad stage & otoliths).
6. To collect data on deepwater sharks caught as bycatch (and other vulnerable species).

The overall objectives of this work was:

1. To inform management on orange roughy (*Hoplostethus atlanticus*) in ORH 7B.

2 Methods

2.1 Survey area and design

The survey was planned to be 7 days in duration and carried two NIWA staff.

The design was a standard single phase stratified random survey (Francis 1984) of the Cook Canyon area (Figure 2), i.e., there were no phase 2 tows. Craig Jones, an experienced orange roughy fisher in ORH 7B, provided two survey strata: one the “core” area that had good catch rates during the fisheries

history, and the second, a wider area where fish may be concentrated. The second stratum acted as a guard stratum in case spawning layers had moved from past distribution.

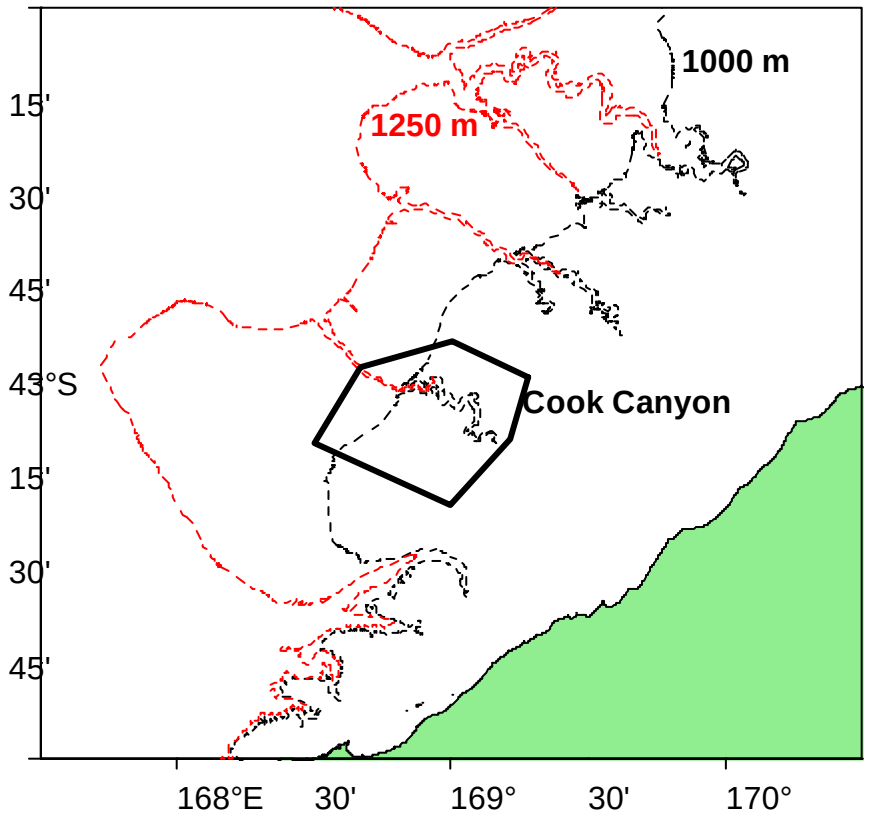

Figure 2: **The 2016 Cook Canyon survey area.**

To allow time for searching, tows were occupied in the most efficient manner. There were 15 stations in the core stratum, where most commercial catch was caught, and 10 in the wider area stratum to catch shifts in distribution since the fishery was closed. This allocation was arbitrary, but allowed for more sampling in the core stratum and enough sampling in the other stratum to find orange roughy if they were there. The strata and the proposed tow positions are shown in Figure 3.

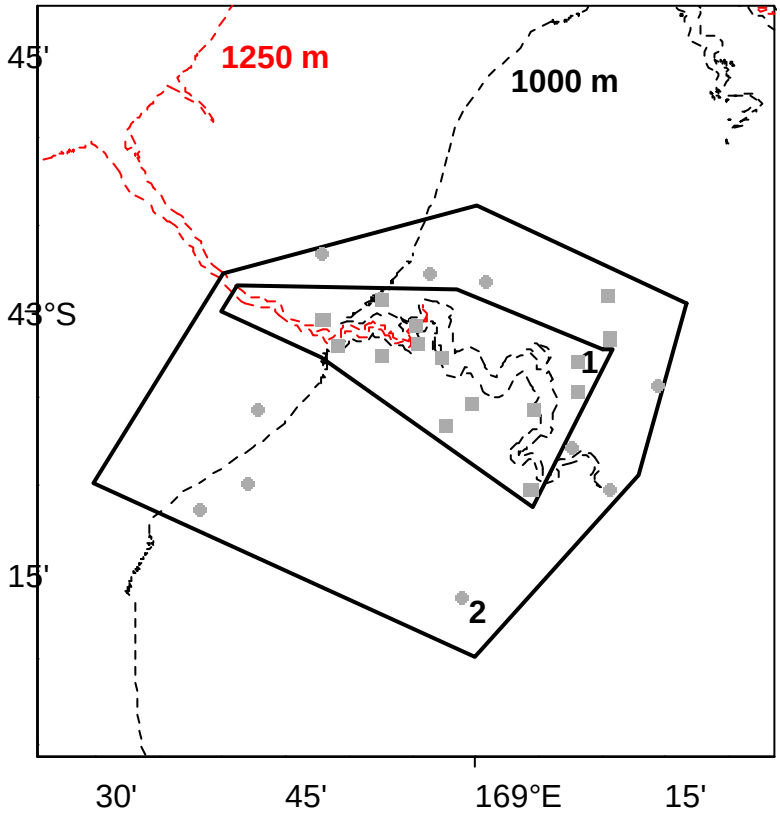

Figure 3: Cook Canyon 2016 random trawl survey area and strata (1 & 2). The planned phase 1 station positions are the grey circles and squares, and tows completed are the grey squares.

2.2 Vessel and trawl gear

The survey was conducted using the FV *Cook Canyon*, which is a steel-hull trawler built in 1971, with a gross tonnage of 113 t, an overall length of 27.10 m, and a maximum breadth of 6.13 m. The vessel had a hull mounted 38-kHz transducer interfaced with a Furuno FCV 1150 echosounder.

The net used was the Cook *Canyon*'s rough bottom net (net plan is in Appendix A). This net had a 110 mm mesh codend, 9 inch rock hopper bobbins with rubber spacers, 70 m sweeps, and 50 m bridles. The wingtip distance was about 15 m and the distance between the doors during fishing (door spread) was 100 m. Doors were Poly-Ice.

2.3 Locating a spawning aggregation

The vessel echosounder was on at all times to provide opportunistic searches between trawl survey tows. In addition, time was set aside for more systematic searches in areas not covered by the steaming between survey tows. The planned procedure on finding a spawning aggregation was to map it and call on a nearby vessel with a scientific transducer to complete an acoustic survey.

After the spawning aggregation survey (or the mapping if no other vessel is available), a non-survey tow was planned to provide species composition and biological data. The intention was to clip the

mark and catch 3–5 t. A target of at least 300 otoliths was planned since this would constitute the main data for an age frequency estimate.

CTD data were collected from a Seabird Microcat CTD (provided by NIWA) attached to the headline of the trawl net on the aggregation tow.

2.4 Trawling procedure

Station positions were selected randomly before the voyage using RandomStation, NIWA's station generating package. The minimum distance between specified positions was 1.5 n. miles. If a station was found to be on foul ground, a search was made for suitable ground within 3 n. miles of the station position. If no suitable ground could be found, the station was abandoned and another random position was substituted from a list of extra stations.

At each station, the net was towed for 1.5 n. miles at a speed over the ground of 3 knots. The tow started when the net was observed from the net monitor display to first touch and settle on the bottom, and finished when the net left the bottom. If foul ground was encountered the tow was considered valid for the abundance survey only if it was at least 1 n. miles long, otherwise it was replaced by the next tow on the spares list. Tow direction was usually parallel to the depth contour. The whole tow length should be within the stratum area. Trawling occurred during day and night.

Towing speed and gear configuration were maintained as constant as possible during the survey.

2.5 Catch and biological sampling

At each station all items in the catch were sorted into species and weighed. Where possible, fish, squid, and crustaceans were identified to species and other benthic fauna to species or family. Unidentified organisms were collected and frozen at sea. Specimens were stored at NIWA for later identification.

The catch from each tow that was sampled were sorted by species. Large catches of fish were sub-sampled and the total catch estimated from processing figures. From each sampled tow, a random sample of up to 50 orange roughy were randomly selected from the catch to measure, length (standard length, SL) gonad stage, and sex. From the latter sample, up to 20 individuals of orange roughy were selected for more detailed biological analysis which included length (SL), sex, gonad stages and extracting otoliths.

For catches over 1 t, two or more 50 fish samples were processed from different parts of the catch as well as repeated biological sampling.

Potentially vulnerable species (e.g., deepwater sharks) were identified to species level and measured (length, sex).

2.6 Estimation of relative abundance and length frequencies

Doorspread abundance was estimated by the swept area method of Francis (1981, 1989) using NIWA's software package, SurvCalc (Francis & Fu 2012). We assumed that there were no orange roughy above the headline, that all fish are herded into the trawl path by the sweeps and bridles, and that all fish within the path of the trawl doors were caught. We ignored the fact that some fish are likely to escape between the bobbins and the bottom, i.e., go under the net, which would require specific experimental

work on this net to measure the proportion escaping. Consequently, the catchability coefficient was set to 1 for this analysis.

Scaled length frequencies were calculated for the orange roughy samples using SurvCalc.

3 Results

The *Cook Canyon* arrived at the survey area on 8 July at 1200 hr and began a search for spawning marks, before commencing the trawl survey work and other aggregation searches. The initial search area was where the *Amaltal Explorer* had seen a mark and caught a large catch of orange roughy in 2015. Twenty two trawl survey and one tow on the spawning plume were completed. Work was stopped on 11 July at 2400 h because of poor weather and the *Cook Canyon* then returned to port. Appendix B shows the trawl data and orange roughy catch.

3.1 Trawl survey

3.1.1 Catch composition

The main species caught are shown in Table 3-1.

Table 3-1: Catch composition and station occurrence of the top 15 species by weight.

Code	Fish Species	Common Name	Number of tows	Catch (kg)
ORH	*Hoplostethus atlanticus*	Orange roughy	23	19 198.2
HAK	*Merluccius australis*	Hake	22	628.5
WHX	*Trachyrincus aphyodes*	White rattail	23	477.0
HOK	*Macruronus novaezelandiae*	Hoki	21	414.5
CYO	*Centroscymnus owstoni*	Smooth skin dogfish	15	254.5
SND	*Deania calcea*	Shovelnose spiny dogfish	19	202.0
SSM	*Alepocephalus antipodianus*	Slickhead, smallscaled brown	16	107.8
OPO	*Octopoteuthidae Taningia* sp.	*Octopoteuthidae Taningia* sp.	1	100.0
RIB	*Mora moro*	Ribaldo	16	98.0
GSP	*Hydrolagus bemisi*	Pale ghost shark	10	63.0
PLS	*Centroscymnus plunketi*	Plunkets shark	2	54.0
CYP	*Centroscymnus crepidater*	*Centroscymnus crepidater*	10	49.1
SBI	*Alepocephalus australis*	Slickhead, bigscaled brown	8	47.3
RCH	*Rhinochimaera pacifica*	Widenosed chimaera	4	41.0
WSQ	*Onykia* spp.	Warty squid	2	40.0

3.1.2 Catch distribution

Figure 4 shows the catch rates from the trawl survey tows. Higher catch rates were obtained in the area close to where the spawning plume was found, with very low catch rates outside this area.

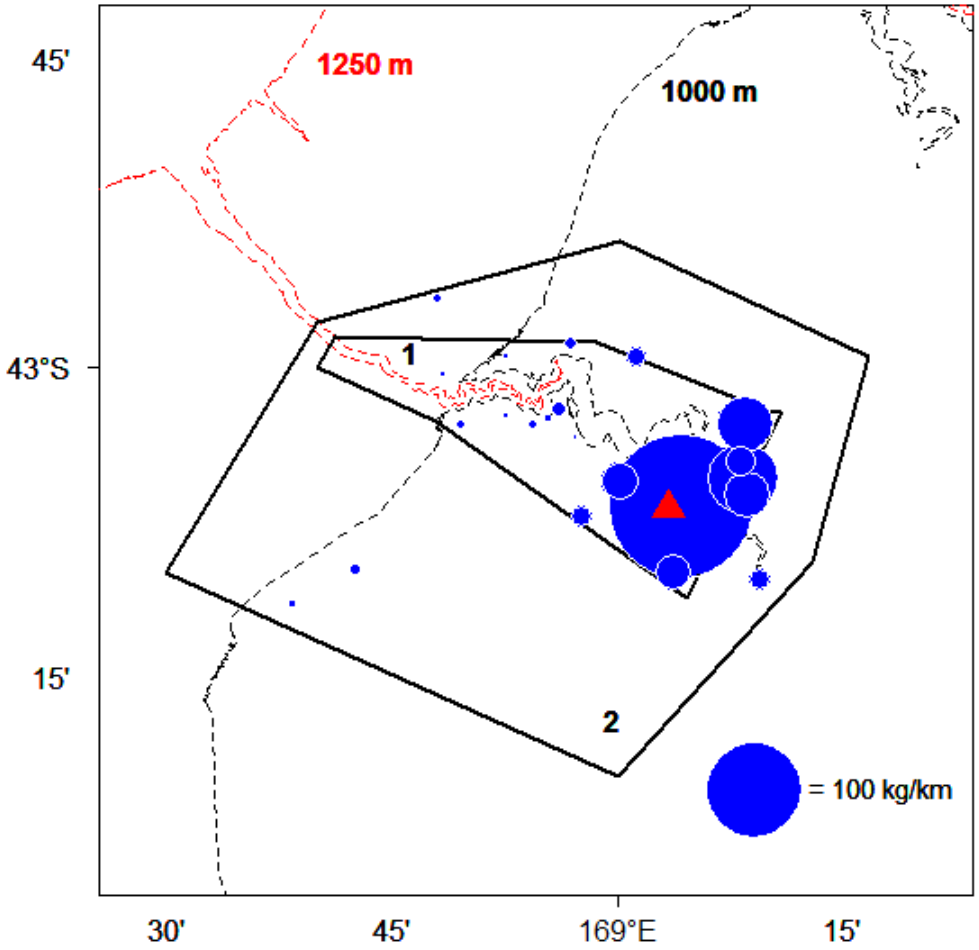

Figure 4: Catch rates (kg/km) of orange roughy from the 2016 ORH 7B trawl survey (blue circles) and the location of the main spawning plume (red triangle).

3.1.3 Trawl survey relative abundance estimates

The trawl survey abundance estimate was 190 t (Table 3-2) with a CV that higher than ideal (43%). This is a relative estimate, not an absolute one, and requires the application of a factor (catchability) to scale it to an absolute estimate obtained either from experimental data or within a stock assessment analysis. There were higher densities of orange roughy in stratum 1, where the spawning plume was located, compared to stratum 2.

Table 3-2: Trawl survey relative abundance door spread estimates of orange roughy on the WCSI.

Stratum	Area (km^2)	Number of tows	Number of tows with ORH	Density (kg/km^2)	Abundance (t)	CV abundance (%)
1	466	15	15	246	115	61
2	1412	7	7	54	76	55
Total	1879	22	22	102	190	43

3.1.4 Biological data

The length frequency distribution for the orange roughy sampled from the random trawl survey (excluded samples from the plume tow) is shown in Figure 5. It does not have a prominent mode for spawning fish size (greater than 30 cm SL) that is usually found in other spawning areas. The spawning fish size mode was present in stratum 1, but was almost absent in stratum 2 (Figure 6). Most of the spawning fish in the random trawl survey was from station 15, which was located nearby the spawning plume. Excluding data from station 15 showed a length frequency with equal proportions of spawning and pre-spawning fish sizes. Length data from the spawning plume showed larger sized fish that are expected for spawning plumes in other areas (Figure 6).

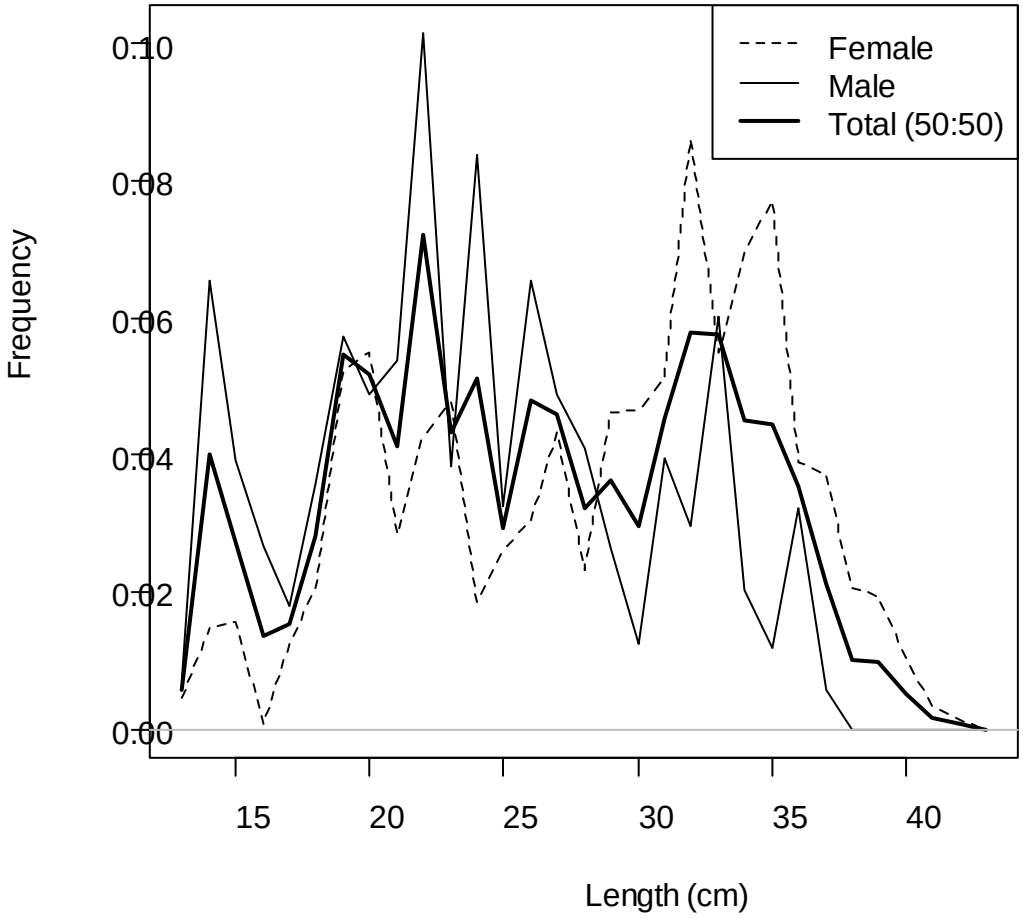

Figure 5: Orange roughy length frequency distribution for the 2016 random trawl survey (excluded plume sample fish) by sex. Overall sex ratio was 50 male:50 female.

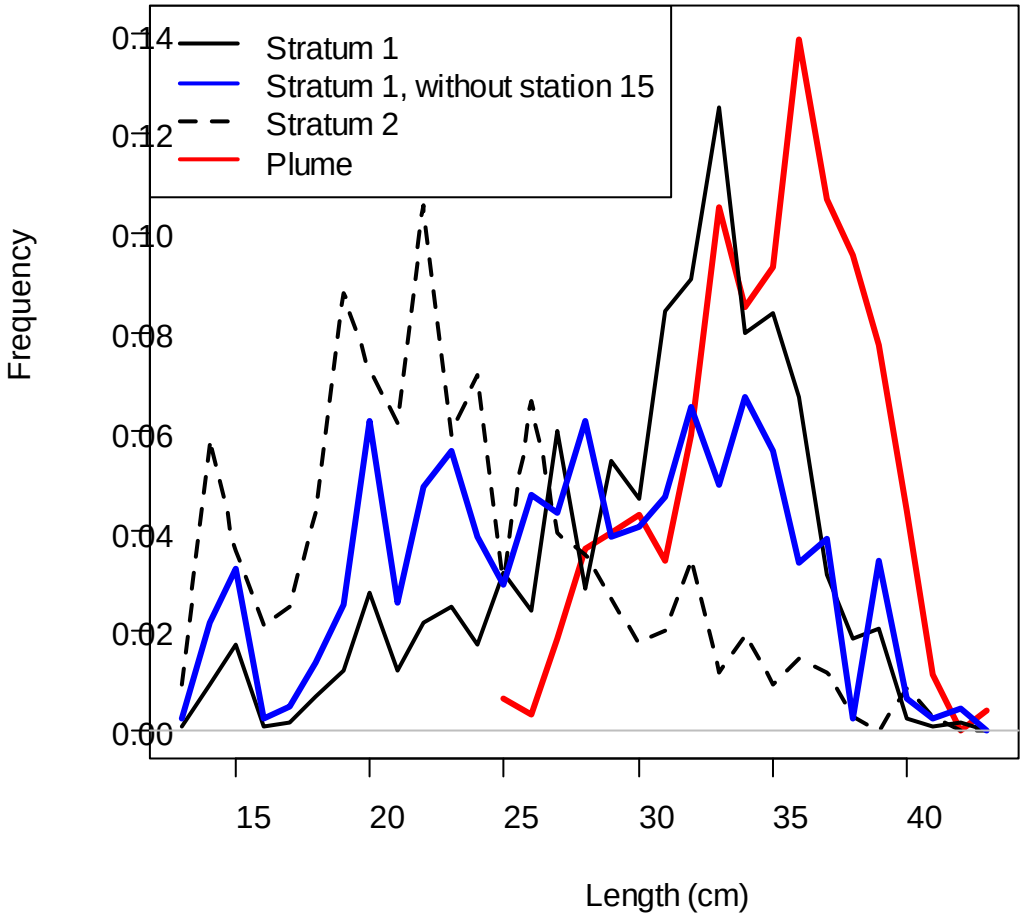

Figure 6: Orange roughy length frequency by stratum, for stratum 1 without station 15, and from the spawning plume.

Biological data were collected from 651 orange roughy. Table 3-3 shows the data collected on gonad stages by sex. For the random trawl survey, a large proportion of fish were immature, especially males, and spent. For the spawning plume (one tow), most females were ripe or running ripe, whilst males were mostly spent.

Table 3-3: Numbers (no.) sampled and percentage of orange roughy at each gonad stage by sex and area ("–", not applicable).

Gonad stage	Male no.	Male %	Female no.	Female %
Trawl survey				
Immature	155	38	99	21
Juvenile maturing	34	8	69	14
Mature resting	0	0	0	0
Maturing	16	4	3	1
Ripe	0	0	51	11
Running	27	7	70	15
Partially spent	38	9	13	3
Spent	142	34	174	36
Atretic	–	–	0	0
Spawning plume				
Immature	0	0	0	0
Juvenile maturing	0	0	0	0
Mature resting	0	0	0	0
Maturing	14	9	2	1
Ripe	0	0	40	29
Running	18	11	56	41
Partially spent	29	18	8	6
Spent	103	63	30	22
Atretic	–	–	0	0

Otoliths were collected from the spawning plume tow (n=299) and from the trawl survey (n=177).

The number of length measurements collected by species is shown in Table 3-4.

Table 3-4: Number of length measurements by species.

Scientific name	Common name	Code	Number of samples
Allocyttus niger	black oreo	BOE	1
Centrophorus squamosus	deepwater spiny dogfish	CSQ	2
Centroscymnus owstoni	smooth skin dogfish	CYO	9
C. crepidater	longnose velvet dogfish	CYP	6
Etmopterus baxteri	Baxter's dogfish	ETB	11
Merluccius australis	hake	HAK	241
Macruronus novaezelandiae	hoki	HOK	176
Hoplostethus atlanticus	orange roughy	ORH	6 807
Centrophorus plunketi	Plunket's shark	PLS	6
Deania calcea	shovelnose dogfish	SND	15
Zameus squamulosus	Velvet dogfish	ZAS	3

3.2 Spawning plume locations

A total of 45 hours was used searching for plumes and searches was also made during the steam between each random trawl survey station. Initial searching was around the area where the *Amaltal Explorer* saw marks in 2015 and included searching along the northwest edge of Cook Canyon and zig-zagging along its southern edge. One spawning mark was located close to that observed in 2015 and one tow was completed on this mark (Figures 4, 7). This general area was searched three more times over the course of the survey. Other searches were undertaken in Stratum 2 and over the "Arrow" tow. Only one clearly spawning plume was located, but other much smaller marks were found in the wider area around the plume. It is unclear whether these smaller marks were also orange roughy. The spawning aggregation was found on two consecutive night, but it dispersed during the day.

A mapping exercise showed that the plume was approximate 80 m high, 650 m wide, and 1.5 km long. These dimensions will be larger than those that would be obtained using an ES60 or equivalent scientific echosounder transducer since the ships Furuno echosounder beam width is greater than that for the Simrad ES60 (scientific echosonder usually used in other acoustic surveys of aggregations) and so comparison of plume dimensions with other spawning plumes is difficult. Other smaller marks seen had dimensions of about 450 m by 20 m high. Although there are too many factors involved to estimate an abundance relative to other assessed spawning plumes (using different beam angles), the volume seen on the aggregation looked smaller than that encountered during the 2009 Challenger Plateau (ORH 7A) acoustic survey on the main spawning plume (Doonan et al. 2009).

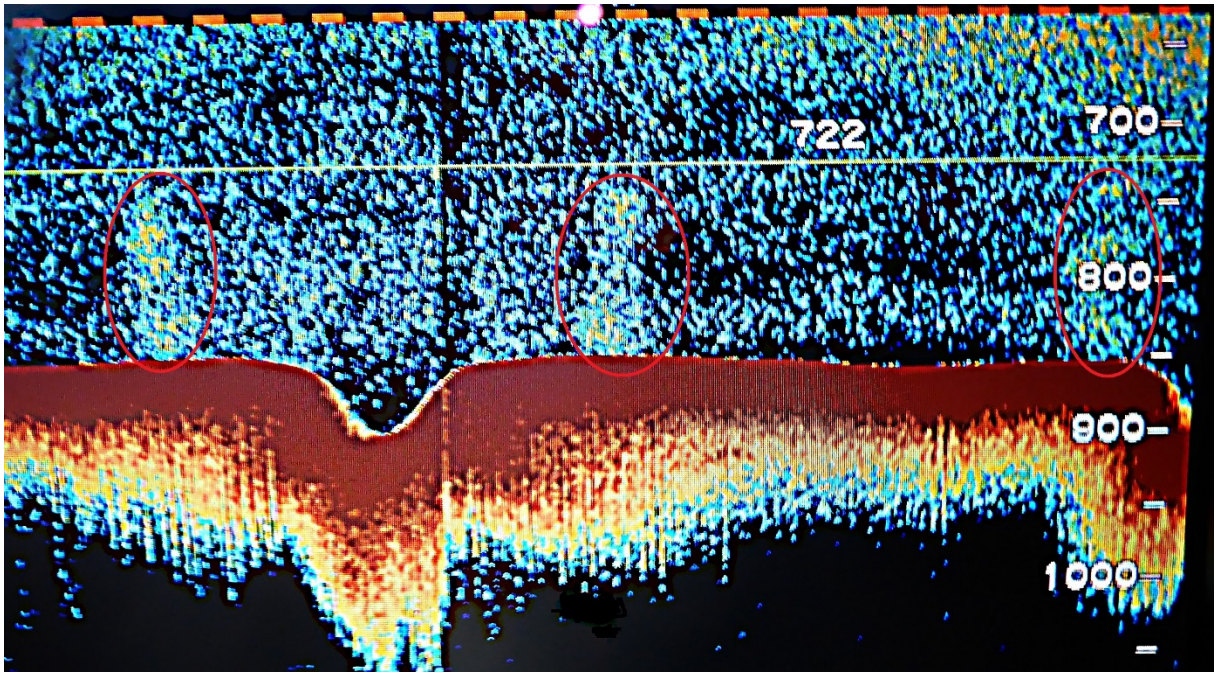

Figure 7: Screen image from the Furuno echosounder during three passes over the same part of the orange roughy spawning plume (delineated with red ovals), Cook Canyon, 9 July 2016. Width of each plume is about 650 m, and height about 80 m.

4 Discussion

4.1 Summary

In the Cook Canyon area, one main orange roughy spawning plume was clearly identified. A number of smaller marks t were also observed, but these could not be identified as orange roughy with confidence. The approximate extent of the largest observed aggregation was estimated, the species composition was determined by trawling, and biological data (length, sex, gonad stage, otoliths for age estimation) were collected. Away from the plume, the density of orange roughy was very low and in these areas the length distributions spanned a wide range, with numerous fish of about 22 cm (i.e., juveniles). In areas well away from the spawning plume, juvenile-sized fish dominated. This was a successful pilot survey for planning future abundance surveys in ORH 7B.

The estimated relative abundance from the trawl survey was 190 t (CV 43 %). If we substituted the plume tow (whose randomness is in dispute, tow 9) for the tow done later at that site (tow 15), the abundance increases substantially to 4,501 t, but it also a very high CV of 97%. In either event, trawl surveys of the wider area were not satisfactory because the high catch rate area is very small relative to the area of stratum 1, so the chance of a random tow there is also very small. Where a tow occurred in this small area, the associated large CV makes the results unusable (and the estimate is likely to be an over-estimate). If there are no random tows in this tiny area, the CV is lower, but the abundance is

also low likely to be an under-estimate. The bias would disappear if the number of tows planned ensured at least one tow in the high catch rate area, but this would make the survey prohibitively expensive.

4.2 Proposed future work

We believe that the results from this survey support future abundance survey work in ORH 7B, but that the work should focus on acoustic surveys which are able to provide an abundance estimate for a stock assessment. To fit the abundance in an assessment, five other data inputs are required. These are either available known or easily obtained. The information required are: the catch history (known); the acoustic and fishery selectivity (this can be estimated from otoliths collected already, but they would need to be prepared and aged); the maturity ogive for orange roughy (available from other orange roughy stock assessments); a prior on the orange roughy target strength to convert the abundance into an absolute abundance and which also accounts for errors in the target strength (available from other orange roughy stock assessments that use acoustic abundances); and a survey proportion prior to account for fish in other areas that were not surveyed but which are also in the management area (*see* Cordue 2014 for details). The survey proportion prior is partially subjective, but these have been used in past orange roughy assessments and have been accepted by the Deepwater Working Group. This would therefore not be a problem as the survey covered a large proportion of the stock (about 80% of the cumulated fishery catch). This areal proportion could be made larger if acoustic surveys were completed in other areas known to have had spawning aggregations in the past.

Other data that could be included are the CPUE series (currently not in favour by the Deepwater Working Group, so unlikely to be accepted in its current form), and an early age frequency distribution from otoliths collected in early trawl surveys. In the *Arrow* trawl surveys in 1985 and 1986, there are seven tows that targeted a spawning mark that had catches ranging from 1 t to 52 t (Tracey 1985; Armstrong & Tracey, 1987). Another four random tows (repeated at the same site) in 1986 caught 1 to 2 t each. The reports state that 20 otoliths per tow were collected, so there are potentially 220 otoliths, which is a relatively small sample. There are trawl survey data from the early part of the fishery, but these would require an experimental estimate of their catchability as in the timing of these surveys and the vessels used would preclude relative estimates of catch in a new stock assessment. Otoliths are also available for those surveys which could be used to estimate age frequency, e.g., the 1986 survey had about 79 random tows that caught 8 t in total, so enough otoliths should be available.

A scientifically conducted acoustic survey of the ORH 7B spawning plume of orange roughy is required to provide an acoustic abundance estimate of aggregated fish. This should be conducted using a calibrated echosounder, e.g., a Simrad ES70. For other smaller potential orange roughy marks, an Acoustic Optical System (AOS) may be more efficient because an AOS using dual transducers at different frequencies could be used to discriminate between swimbladder and non-swimbladder species, thereby reducing the need to trawl on each mark. Some trawling would always be needed during an acoustic survey to confirm species identification and collect biological data.

Talleys are investigating upgrading the echo sounder on Cook Canyon to a Furuno FCV 30 so that acoustic survey work can be undertaken. However, this is conditional on current NIWA work (project ENL16301) showing that the Furuno FCV 30 can be calibrated. This work is nearing completion and it is expected that the Furuno FCV 30 will be able to be calibrated (Yoann Ladroit, NIWA, pers. comm.).

Craig Jones has had extensive experience in this fishery from its inception. He relates that at the height of the fishery, spawning fish occurred in at least, two waves: once in late June, and another in July. Craig's notes on this phenomena should be analysed to see if this interpretation has credence. Whether these are the same or different fish probably cannot be determined without further data. The hypothesis is biologically plausible, but other spawning behaviours that give the appearance of two waves are also plausible, e.g., older fish arriving first then younger fish arriving, or batch spawning. One way to determine this is to survey in June and again in July. If we can do the survey in June (late in the spawning season), gonad stages should indicate the numbers of spent and active spawners. If the second survey in July is earlier in the spawning sequence, then the gonad staging will reflect this, i.e., maturing and ripening females will be present. Since gonad stage cannot go backwards the two waves are likely to be different fish.

For any proposed acoustic survey, a contingency is needed in the event that the spawning plume does not form up during a survey. Craig Jones' experience is that there are periods when no spawning plume is evident so there is a realistic possibility that time for acoustic work is confined to small temporal windows. Results from the 2016 survey show there is no point in completing a wide area trawl survey that will be on essentially detect only juvenile fish. An alternative is to complete a trawl survey in a restricted area assuming that fish are present, but that they are in layers that are not apparent to the echo sounder. For use in a stock assessment, catchability work would also be needed. An AOS would be perfect for this situation (assuming it had transducers with multiple frequencies) since it could differentiate orange roughy (strictly non-swimbladder species) from other species with swimbladders. However, the cost of this approach may preclude it.

Proposed research outline

- Upgrade the echosounder to the Furuno FCV 30
- Calibrate echosounder
- Plan and complete one or two acoustic surveys of the Cook Canyon spawning plume in the winter of 2017.
- Prepare and read otoliths from the 2016 survey and, if possible, otoliths from targeted tows in the 1985 & 1986 *Arrow* surveys.
- If the survey is successful, commission a stock assessment using the acoustic abundance, catches, and age data.

There is also a need to plan for monitoring of the stock in the event of the fishery being reopened such as a series of acoustic surveys, bycatch monitoring, and collection of otoliths at intervals so that the management information can meets MPI's standards.

5 Acknowledgements

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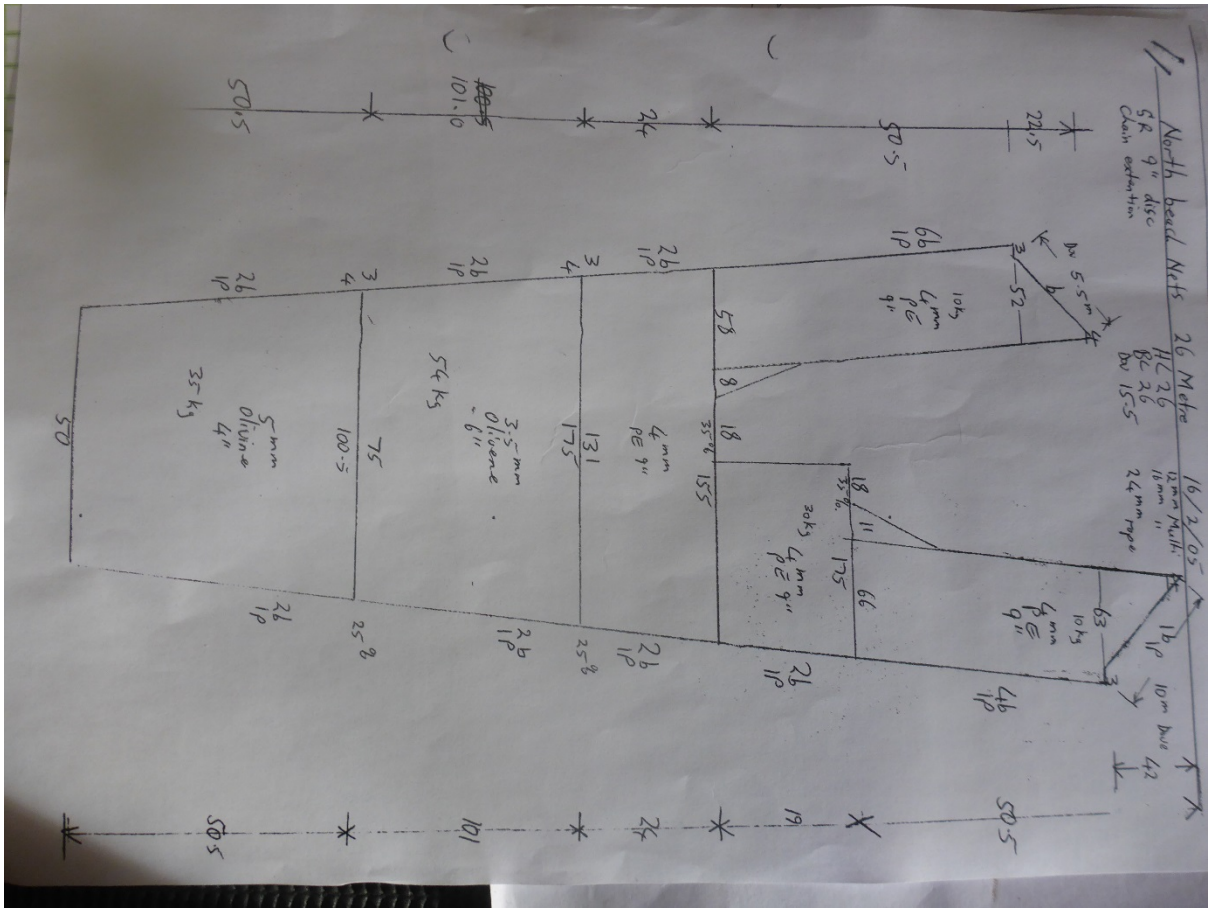
Appendix A Net plan for the trawl net used during the 2016 survey of the Cook Canyon area



Appendix B Trawl data for the 2016 ORH 7B survey

Table B-1. Summary of wide-area abundance and spawning aggregation mark identification tow details for the 2016 Cook Canyon area survey (trip code CCA1601). Gear performance codes for these tows were 1 (Excellent) or 2 (Satisfactory, catch unlikely to be reduced by performance), and all code 1 and 2 tows were used for abundance estimation. Type shows the type of tow completed "Rx" random survey tow, "TN" targeted tow.

Station number	Type	Stratum	Time (hhmm)	Date	Latitude	Longitude	Gear performance	Distance towed (nm)	Total catch (kg)	Roughy catch (kg)
1	RN	0001	1942	2016-07-08	43 03.41	168 57.04 E	1	1.50	54	0
2	RN	0001	2154	2016-07-08	43 02.48	168 55.28 E	1	1.16	81	2
3	RN	0001	0008	2016-07-08	42 59.48	168 52.56 E	1	1.45	150	2
4	RN	0001	0237	2016-07-09	43 02.37	168 52.59 E	2	1.60	84	2
5	RN	0001	0446	2016-07-09	43 00.34	168 48.35 E	1	1.72	135	2
6	RD	0002	0859	2016-07-09	43 011.5	168 38.25 E	1	1.56	72	2
7	RD	0002	1109	2016-07-09	43 09.84	168 42.52 E	1	1.55	141	5
8	RD	0001	1410	2016-07-09	43 07.33	168 57.53 E	1	1.57	147	15
9	TN	0001	1854	2016-07-09	43 06.88	169 03.33 E	1	0.69	18 053	18 000
10	RD	0001	1310	2016-07-10	43 02.81	169 08.46 E	2	1.67	276	112
11	RD	0001	1522	2016-07-10	43 04.62	169 08.14 E	2	1.50	270	26
12	RD	0001	1754	2016-07-10	43 05.48	169 08.38 E	1	1.93	274	200
13	RT	0001	2047	2016-07-10	43 00010	169 03.67 E	2	1.38	133	35
14	RT	0002	2326	2016-07-10	43 10.32	169 009.4 E	2	1.61	76	14
15	RN	0001	0309	2016-07-11	43 06.81	169 04.12 E	1	1.44	708	600
16	RN	0001	0538	2016-07-11	43 05.58	169 00.05 E	1	1.47	188	40
17	RT	0001	0824	2016-07-11	43 02.81	168 49.52 E	1	1.94	171	5
18	RD	0002	1059	2016-07-11	42 056.7	168 47.98 E	1	1.58	76	4
19	RD	0002	1324	2016-07-11	42 58.86	168 56.82 E	1	1.95	213	8
20	RT	0001	1604	2016-07-11	43 02.83	168 54.33 E	2	1.52	129	4
21	RN	0001	1815	2016-07-11	43 02.04	168 55.98 E	1	1.60	199	8
22	RT	0002	2054	2016-07-11	42 59.49	169 01.19 E	1	1.70	286	12
23	RT	0002	2338	2016-07-11	43 06.25	169 08.65 E	1	2.36	244	100