Ministry for Primary Industries
Manatū Ahu Matua

Estimating the abundance of scampi in SCI 1 (Bay of Plenty) and SCI 2 (Wairarapa / Hawke Bay) in 2015

New Zealand Fisheries Assessment Report 2016/17

I.D. Tuck,
D. Parkinson,
H. Armiger,
M. Smith
A. Miller
N. Rush,
K. Spong

ISSN 1179-5352 (online)
ISBN 978-1-77665-215-0 (online)
April 2016

New Zealand Government

Growing and Protecting New Zealand

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-resources/publications.aspx
http://fs.fish.govt.nz go to Document library/Research reports

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Tuck, I.D.; Parkinson, D.; Armiger, H.; Smith, M.; Miller, A.; Rush, N.; Spong, K. (2016). Estimating the abundance of scampi in SCI 1 (Bay of Plenty) and SCI 2 (Wairarapa / Hawke Bay) in 2015.

***New Zealand Fisheries Assessment Report 2016/17*. 56 p.**

Photographic and trawl surveys of scampi in SCI 1 and SCI 2 were conducted in February and March 2015 from the RV *Kaharoa*. These areas were last surveyed in 2012. On each voyage, the photographic survey component was completed first, followed by the trawl survey component. Both the photographic and trawl surveys of SCI 1 suggest that population biomass and abundance has remained relatively stable since the last survey (2012). Current estimates from the trawl survey are 170 tonnes (or 3.1 million individuals). Current estimates from the photographic survey are 161 million burrows, and 23 million visible scampi. The SCI 2 surveys both show an increase in biomass and abundance since 2012, continuing the trend of improvement in the stock since 2006. Current estimates from the trawl survey are 224 tonnes (or 3.7 million individuals). Current estimates from the photographic survey are 234 million burrows, and 37 million visible scampi. Given that scampi live in burrows and are only available to trawl gear when they emerge on the seabed, trawl survey estimates are likely to be considerable underestimates of the stock biomass or abundance.

About 5600 scampi were tagged and released, as part of an investigation into growth, with releases distributed across the fishing grounds. To date, a small number of tagged scampi have been recaptured. Eighty scampi were released with acoustic tags, divided between six moorings (three on each survey), to investigate emergence patterns. Five of the moorings were successfully recovered, one being lost in SCI 2. Eight tags appeared to have been detectable for the full deployment. Analysis of these tags identified daily and/or tidal cycles in detectability. Detectability data has been used in conjunction with burrow and animal counts from the photographic survey to estimate animal availability (catchability).

1. INTRODUCTION

The scampi fishery is based on the species *Metanephrops challengeri,* which is widely distributed around New Zealand (Figure 1). National scampi landings in 2014/15 were 875 t (limit 1231 t). The landings for scampi in SCI 1 were 116 t (TACC 120 t) in 2014/15, consistent with the average over recent years, while landings for scampi in SCI 2 were 142 t (TACC 133 t) increasing on recent years. The other major fisheries are SCI 3 (TACC 340 t), SCI 4A (TACC 120 t), and SCI 6A (TACC 306 t). Scampi are taken by light trawl gear, which catches the scampi that have emerged from burrows in the bottom sediment. The main fisheries are in waters 300 – 500 m deep, although the range is slightly deeper in the SCI 6A region (350 – 550 m). Little is known about the growth rate and maximum age of scampi.

Scampi occupy burrows in muddy substrates, and are only available to trawl fisheries when emerged on the seabed (Bell et al. 2006). Scampi emergence (examined through catch rates, both of European and New Zealand species) has been shown to vary seasonally in relation to moult and reproductive cycles, and over shorter time scales in relation to diel and tidal cycles (Aguzzi et al. 2003; Bell et al. 2006). Uncertainty over trawl catchability associated with these emergence patterns has led to the development of survey approaches based on visual counts of scampi burrows rather than animals (Froglia et al. 1997; Tuck et al. 1997; Cryer et al. 2003a; Smith et al. 2003), although these approaches still face uncertainties over burrow occupancy and population size composition (ICES 2007; Sardà & Aguzzi 2012). Photographic surveying has been used extensively to estimate the abundance of the European scampi, and has been carried out in New Zealand since 1998. Seven previous surveys have been conducted in SCI 1 (1998, 2000, 2001, 2002, 2003, 2008, and 2012) (Cryer et al. 2003b; Tuck et al. 2009b; Tuck et al. 2013), and five previous surveys have been conducted in SCI 2 (2003 to 2006 and 2012) (Tuck et al. 2006; Tuck et al. 2013). Shorter survey series are available for SCI 3 (2001 – 2013, five surveys) and SCI 6A (2007 – 2013, four surveys).

These photographic surveys provide two abundance indices: the density of visible scampi (as an index of minimum absolute abundance), and the density of major burrow openings. The index of major burrow openings has been used as an abundance index in recent stock assessments for SCI 1 and SCI 2 (Tuck & Dunn 2012; Tuck 2014), although the relationship between scampi and burrows may be different in SCI 6A (Tuck et al. 2007; Tuck & Dunn 2009).

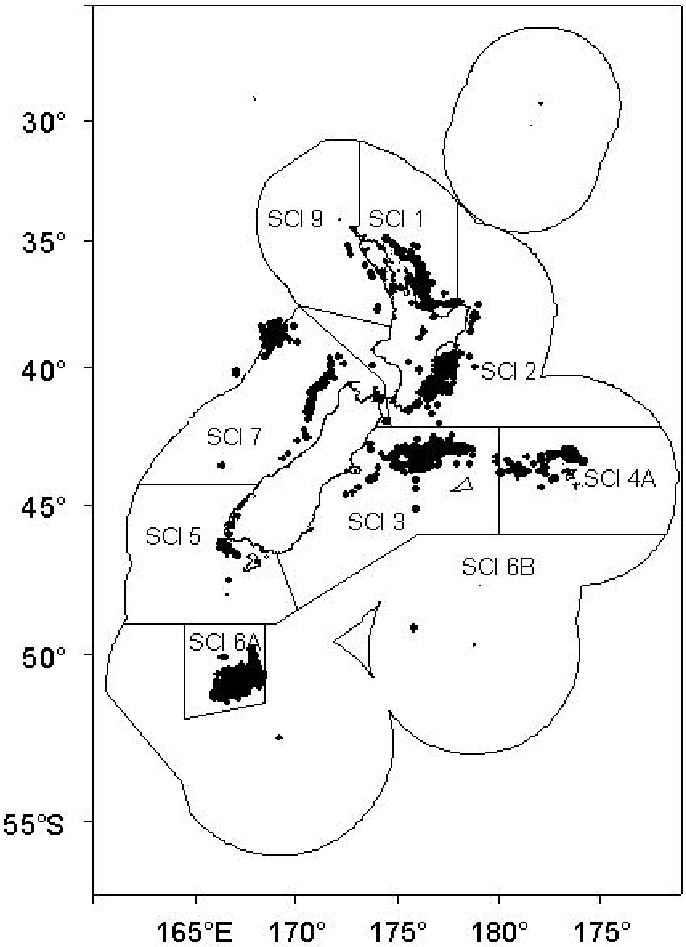


Figure 1: Spatial distribution of the scampi fishery since 1988–89 (ungroomed data). Each dot shows the mid-point of one or more tows recorded on TCEPR with scampi as the target species.

OVERALL OBJECTIVE: To estimate the abundance of scampi (*Metanephrops challengeri*) in SCI 1 and SCI 2.

OBJECTIVES:

1. To estimate the relative abundance of scampi using photographic techniques and trawl survey information.
2. To estimate growth of scampi from tagging.
3. To investigate scampi emergence rates through acoustic tagging.

2. METHODS

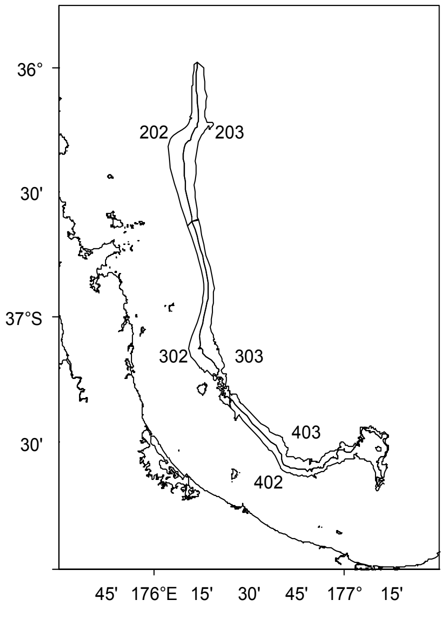
The survey design was presented to the MPI Shellfish Working Group and submitted to MPI in late 2014, and follows the design of the 2012 survey. The survey coverage for both trawl and photographic surveys in SCI 2 have remained consistent over the time series (survey strata 702, 703, 802, 803), but for SCI 1, the earliest (trawl only) surveys covered a large area (survey strata 202, 203, 302, 303, 402, 403) which was reduced (excluding strata 202 and 203) in 1998 when photographic surveys were introduced. Given the proportion of the fishery taking place within strata 202 and 203, these were reintroduced to the survey coverage in 2012 (Tuck et al. 2012).

Following previous survey designs, a random stratified survey was conducted, with stratification on the basis of depth (the main fishery areas having been divided into 300 – 400 m and 400 – 500 m depth bands) and general region. Survey coverage and strata for each fishery are shown in Figure 2.

Stations were allocated to strata on the basis of burrow abundance data from the 2012 surveys using the *allocate* package (Francis 2006), minimising the CV for a fixed number of stations. Random locations for photographic stations were generated within each stratum using the Random Stations package (Doonan & Rasmussen 2012), constrained to keep all stations at least 2 nautical miles apart. The first three random photographic stations from each stratum were taken as trawl stations, with minimum distance between each trawl station checked, and a station dropped and the next on the list selected if the distance was less than 4 nautical miles. Numbers of stations allocated to each stratum and revised stratification are provided in Table 1 and Figure 3.

Table 1: Details of strata and number of stations planned for SCI 1 and SCI 2 survey in 2015.

Area	Stratum	Depth (m)	Area (km^2)	Photo stations	Trawl stations
SCI 1	202	300–400	306.69	11	3
SCI 1	203	400–500	311.20	12	3
SCI 1	302	300–400	261.95	9	3
SCI 1	303	400–500	266.36	7	3
SCI 1	402	300–400	379.74	10	3
SCI 1	403	400–500	290.31	11	3
SCI 2	702	300–400	321.41	7	3
SCI 2	703	400–500	543.59	19	3
SCI 2	802	300–400	386.11	9	3
SCI 2	803	400–500	230.54	5	3



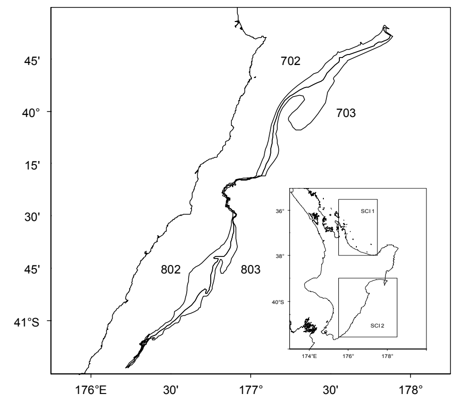


Figure 2: Survey strata for the 2012 photographic survey of SCI 1 (left) and SCI 2 (right).

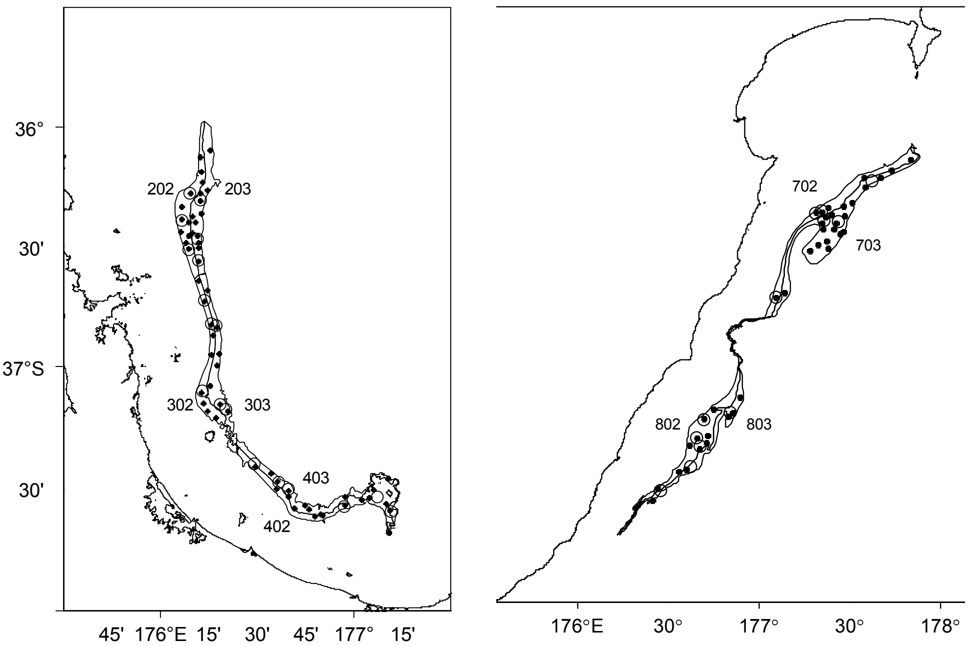


Figure 3: Station locations for the 2015 photographic survey of SCI 1 (left) and SCI 2 (right) (black dots indicating the station midpoints). Open circles represent stations also sampled by trawling.

In February/March 2015 we undertook stratified random photographic surveys of scampi burrows within SCI 1 (Bay of Plenty, 300–500 m depth) and SCI 2 (Hawke Bay / Wairarapa, 300–500 m depth), from the NIWA research vessel *Kaharoa*, using the survey design as discussed with and approved by the MPI Shellfish Working Group. These were the eighth and sixth photographic surveys of the SCI 1 and SCI 2 areas respectively. The survey was stratified on the basis of depth (100 m bands) and region (Figure 2). The survey coverage accounts for about 99% (SCI 1) and 98% (SCI 2) of landings from the fisheries over their history.

2.1 Photographic survey

As discussed above, a target of 60 (SCI 1) and 40 (SCI 2) photographic stations was set, on the basis of survey duration, and these were allocated to strata using the *allocate* package in R (to minimise the overall survey CV), on the basis of burrow densities observed in the 2012 surveys. Photographic sampling was undertaken between about 0600 and 1800 NZST to coincide with the period of maximum trawl catchability of scampi. Although the time of day should have no direct effect on the counting of scampi burrows and their constituent openings, sampling at a time when the greatest number of scampi are likely to be out of their burrows has two main advantages. First, a larger number of individuals can be measured for a photographic length frequency distribution, and second the presence of scampi at or near burrow openings is an excellent aid to the identification of certain burrow types as belonging to scampi.

We used NIWA's deepwater digital camera system, with an automatic flash exposure providing almost instantaneous triggering and exposure. Images were stored on 1 GB "flash" cards in the camera, allowing us to save images in raw format. After the completion of each station, the images were downloaded from the camera via USB cable (avoiding the need to open the camera housing after each station), and the images were saved to the hard drives of a dedicated PC, and backed up on a portable hard drive.

The camera was triggered using a combination of a time-delay switch and a micro ranger, as its cage was held in the critical area 2–4 m off bottom using a modified Furuno CN22 acoustic headline monitor displaying distance off-bottom in "real time" on the bridge. The micro ranger triggered the camera to take a picture in the critical altitude range, while the timer triggered the camera to also take a picture, once the time limit was reached. Our target was to expose roughly 40 frames per station as the ship drifted, using a time delay sufficient to ensure that adjacent photographs did not overlap. Visibility was good at most sites, but at some stations the substantial swell meant that maintenance of the critical altitude off the bottom was difficult, and run duration was extended to allow for images lost to over and under exposure. Also when visibility was poor, some stations were repeated later in the trip. Almost all of the photographs exposed in the critical area were of good or excellent quality.

Image selection and scoring

Images were examined and scored using a standardised protocol (developed under MPI project SCI2000/02) (Cryer et al. 2002) applied by a team of six trained readers. For each image, the main criteria of usability were the ability to discern fine seabed detail, and the visibility of more than 50% of the frame (free from disturbed sediment, poor flash coverage, or other features). If these criteria were met, the image was "adopted" and "initiated" (Cryer et al. 2002). The percentage of the frame within which the seabed is clearly and sharply visible was estimated and marked using polygons in NICAMS (NIWA Image Capture and Manipulation System, developed using the ImageJ software). Each reader then assessed the number of burrow openings using the standardized protocol (Cryer et al. 2002). We have defined "major" and "minor" burrow openings which are, respectively, the type of opening at which scampi are usually observed, and the "rear" openings associated respectively with most burrows. Based on our examination of a large number of images of scampi associated with burrows, "major" and "minor" openings each have their own characteristics and should be scored separately (Figure 4). We classified each opening (whether major or minor) as "highly characteristic" or "probable", based on the extent to which each is characteristic of burrows observed to be used by New Zealand scampi. A recent investigation into mud burrowing megafauna in scampi grounds concluded that it is unlikely that other species present would generate burrows that would be confused with those generated by scampi (Tuck & Spong 2013). Burrows and holes which could conceivably be used by scampi, but which are not "characteristic" are not counted. Our counts of burrow openings may, therefore, be conservative. Many ICES stock assessments of the related *Nephrops norvegicus* are conducted using relative abundance indices based on counts of "burrow systems" (rather than burrow openings) (Tuck et al. 1994; Tuck et al. 1997). We count burrow openings rather than assumed burrows because burrows are relatively large compared with the quadrat (photograph) size and accepting all burrows totally or partly within each photograph is positively biased by edge effects (Marrs et al. 1996; Marrs et al. 1998).

The criteria used by readers to judge whether or not a burrow should be scored are, of necessity, partially subjective; we cannot be certain that any particular burrow belongs to a *M. challengeri* and is currently inhabited unless the individual is photographed in the burrow. However, after viewing large numbers of scampi associated with burrows, we have developed a set of descriptors that guide our decisions (Cryer et al. 2002). Using these descriptors as a guideline, each reader assesses each potential burrow opening (paying more attention to attributes with a high ranking such as surface tracks, sediment fans, a shallow descent angle) and scores it only if it is "probably" a scampi burrow. Scores are saved within a database within the NICAMS system, for later compilation into an ACCESS database containing all scampi image data. Within NICAMS, features counted by each reader are individually identifiable within each image, providing an audit trail.

Once the images from any particular stratum or survey have been scored by three readers, any images for which the greatest difference between readers in the counts of major openings (combined for "highly characteristic" and "probable") is more than 1 are re-examined by all readers (who may or may not change their score, in the light of observations from other readers). All images where there is any difference between readers on the count of visible scampi (even a difference of interpretation as to whether a scampi is "in" or "out" of a burrow) are re-examined by all readers. During the second reading process, each reader has access to the score and annotated files of all other readers and, after re-assessing their own interpretation against the original image, are encouraged to compare their readings with the interpretations of other readers. Thus, the re-reading process is a means of maintaining consistency among readers as well as refining the counts for a given image.

To enable comparison of the 2015 survey data with previous surveys, the reference sets for SCI 1 (generated in 2008, and including images from 1998 to 2003)(Tuck et al. 2009b), and augmented with images from 2008 in 2012 (Tuck et al. 2013) and SCI 2 (generated in 2012, and including images from 2003 to 2006)(Tuck et al. 2013) were augmented with images from 2012, and reread in 2015 (at the same time as the 2015 survey images), with each image in each reference set being read by all six readers, using the standard image scoring and re-reading procedure.

Data analysis

Burrow and scampi counts from photographs were analysed using methods analogous to those in the *SurvCalc* Analysis Program (Francis & Fu 2012) for trawl surveys, as previously described to the Shellfish Fishery Assessment Working Group (SFAWG). To exclude a possible image size effect (burrows perhaps being more or less likely to be accepted as the number of pixels making up their image decreases), the approach adopted has been that images with a very small (less than 2 m^2) or very large (more than 16 m^2) readable area have been excluded. The mean density of burrow openings at a given station was estimated as the sum of all counts (major or minor openings) divided by the sum of all readable areas. For any given stratum, the mean density of openings and its associated variance were estimated using standard parametric methods, giving each station an equal weighting. The total number of openings in each stratum was estimated by multiplying the mean density by the estimated area of the stratum. The overall mean density of openings in the survey area was estimated as the weighted average mean density, and the variance for this overall mean was derived using the formula for strata of unequal sizes (Snedecor & Cochran 1989):

For the overall mean, $\bar{x}_{(y)} = \sum W_i . \bar{x}_i$

and its variance, $s^2{}_{(y)} = \sum W_i^{\,2} . S_i^{\,2} . (1 - \phi_i) / n_i$

where $s^2{}_{(y)}$ is the variance of the overall mean density, $\bar{x}_{(y)}$, of burrow openings in the surveyed area, W_i is the relative size of stratum i, and S_i^2 and n_i are the sample variance and the number of samples respectively from that stratum. The finite correction term, $(1 - \phi_i)$, was set to unity because all sampling fractions were less than 0.01.

Separate indices were calculated for major and minor openings, for all visible scampi, and for scampi “out” of their burrows (i.e., walking free on the sediment surface). Only indices for major burrow openings and for visible scampi are presented here because the SFAWG has agreed that these are likely to be the most reliable indices. The minor sensitivity of the indices to the reader “bias” identified for SCI 1 (Cryer et al. 2002) was investigated with reader_year “correction factors” calculated for each reader in each survey, and a “corrected” density index for major burrow openings is also provided. Confidence in the estimates was examined through a bootstrapping procedure, resampling stations (with replacement) within strata, selecting one reader (from three) within station.

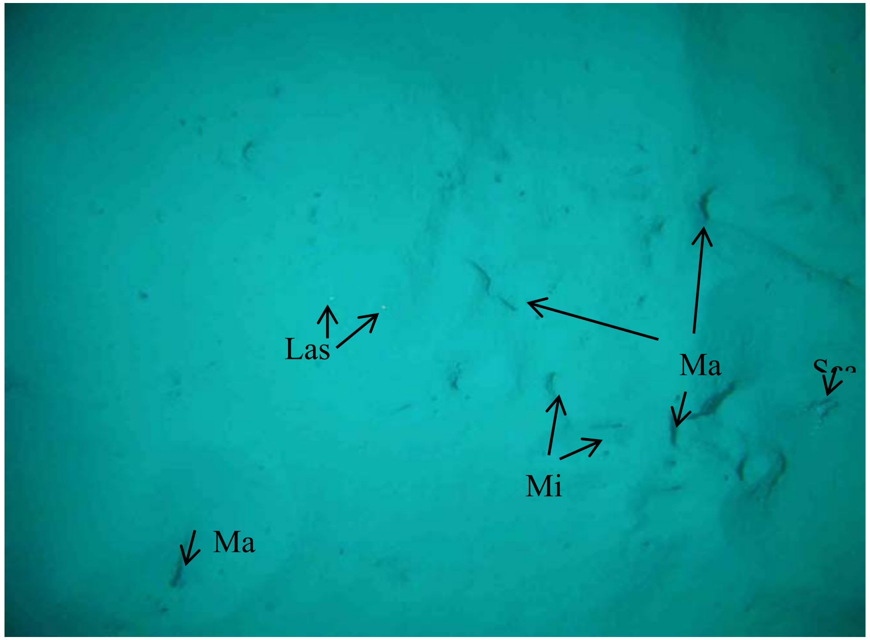


Figure 4: Example image from March 2006 survey in SCI 2 showing laser scaling dots, several characteristic scampi burrows and one large visible scampi.

2.2 Trawl survey

Trawl survey sampling was undertaken between roughly 0600 and 1800 NZST, during the second half of each component of the voyage, after the photographic survey had been completed. The first three random photographic stations allocated to each stratum were reselected as trawl stations. Trawl sampling was conducted with the *RV Kaharoa* scampi trawl, as with previous scampi surveys from this vessel (Cryer et al. 2003c; Tuck et al. 2011).

Scampi tagging

The second objective of the voyages was to tag and release scampi to investigate growth. Where time allowed, all scampi caught on each tow that were considered to be in good health were tagged and released. All scampi were rapidly sorted from the catch, and stored in darkened non-draining bins of well aerated seawater. Any animals with carapace punctures were excluded, and any damaged or missing limbs were recorded. Animals were tagged between the carapace and cuticle of the first abdominal segment through the musculature of the abdomen (Figure 5) with sequentially numbered streamer tags (Hallprint type 4S), Hallprint T-bar tags, or both. The streamer tags have been used successfully in previous scampi studies (Cryer & Stotter 1997; Cryer & Stotter 1999; Tuck & Dunn 2012), although tag return data suggest that some tag loss may be occurring at the moult, and therefore the T-bar tag approach has also been examined. Previous tagging investigations from recent surveys in these fisheries have had poor recoveries, and a chilled water recirculating system was employed to hold animals at bottom water temperature (8–12 ^{o}C) rather than ambient surface water temperature (18–21 ^{o}C), in an attempt to improve survival. The next scheduled research sampling in SCI 1 and SCI 2 will be in 2018, and so it is anticipated that recoveries will be from commercial fishing activity. At the request of MPI and the Shellfish Working Group, no tag mortality component was included in the survey, as it was considered very unlikely that tag recapture data would be used to estimate stock size for this fishery.

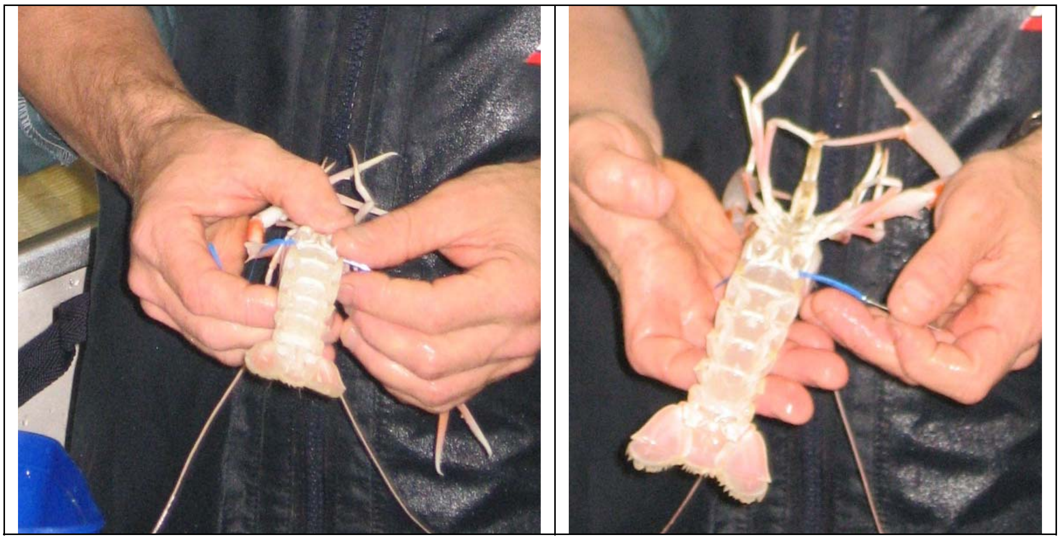


Figure 5: Photographs showing location of streamer tag in scampi.

Acoustic tagging

The third objective of the study was to investigate burrow emergence patterns through acoustic tagging of scampi. This used an acoustic tagging approach used successfully in previous scampi surveys (Tuck et al. 2015b). Forty scampi were released with acoustic tags in both SCI 1 and SCI 2, as part of acoustic mooring deployments, to investigate scampi emergence patterns, split between three separate moorings (13 or 14 at each). A small Vemco (V7-2L) acoustic tag (20 mm×7 mm diameter, 0.75 g in water) was attached to each animal, positioned between the walking legs (Figure 6). The moorings were deployed on 17th February 2015 (SCI 2) and 5th March 2015 (SCI 1), and recovered by RV *Ikatere* in late March (SCI 2) and by the Western Work Boats Ltd *Karen D* in late April (SCI 1), with a deployment duration of up to 48 days. One mooring was not recovered from SCI 2. These slightly larger tags were used, rather than the V7-1L used in previous deployments on scampi (Tuck et al. 2013; Tuck et al. 2015a). This change was on the basis of advice from Vemco, based on the battery life, the number of tags at each mooring, and the optimal delay for minimum interference between tags. Mooring design is shown in Figure 7.

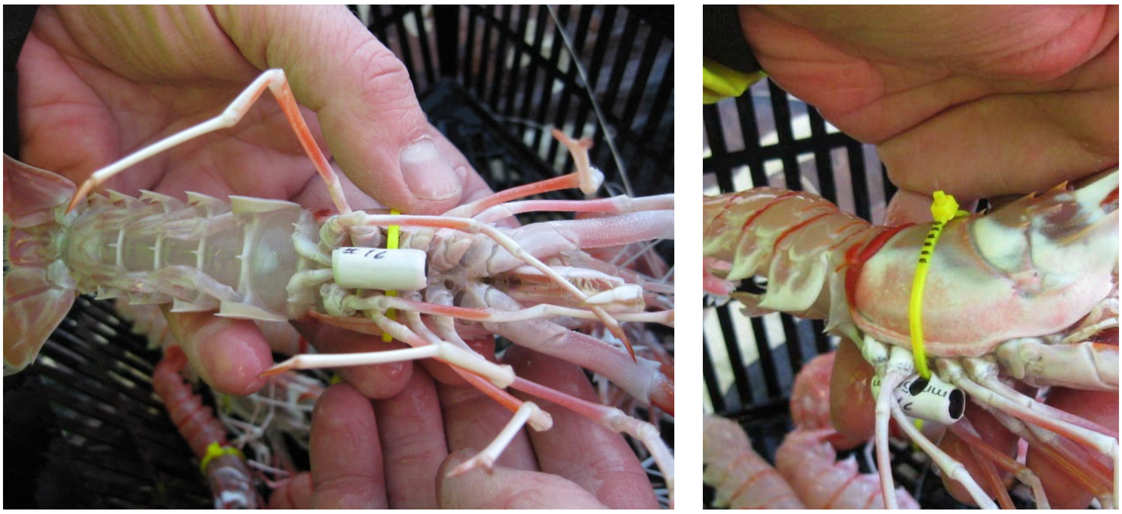


Figure 6: Scampi with acoustic tag attached.

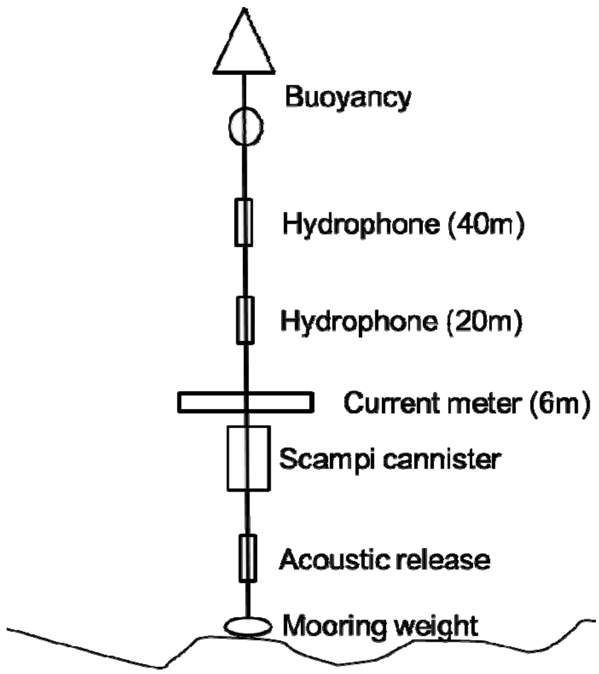


Figure 7: Diagram of acoustic mooring for deployment of scampi and hydrophones.

3. RESULTS

The voyage was completed successfully between 2nd February and 15th March 2015. All but one photographic stations were completed, and all trawl stations were completed, despite very poor weather during some parts of the voyage, and six days being lost.

3.1 SCI 1 Photographic survey

Visibility was generally good at most sites, and almost all of the photographs exposed in the critical area were of good or excellent quality. Over the whole SCI 1 survey, a total area of 17 975 m^2 of seabed was viewed (acceptable quality images), with an average of 46.9 images at each station, an average seabed area viewed by each image of 6.39 m^2, providing an average area viewed of 299.59 m^2 at each station. All planned photographic stations were achieved (Table 2).

Following suggestions from the Shellfish Working Group, calibration across years and between readers was conducted in a single analysis, rather than the two stage process implemented previously (Tuck et al. 2009a). All the image count data (including reference set counts) were combined into a single dataset. Terms were created for reader_year (combination of reader and the year in which the image was read), strata_year (combination of survey strata and year the image was recorded in) and station_year (combination of station number and survey year). Burrow count data from individual images were examined within a generalised linear mixed modelling framework, with strata_year, reader_year and readable area (offset) as explanatory variables, and image and station_year as random effects, and a poisson error distribution. The significance of effects was tested by sequentially adding terms, and a model testing the null hypotheses that there were no strata_year or no reader_year differences between burrow counts over time, detected highly significant effects (both considered as factors) (Table 3).

Table 2: Details of strata and number of photo stations completed for SCI 1 survey in 2015.

			Photo stations	
Stratum	Area (km^2)	Depth (m)	Planned	Completed
202	306.69	300–400	11	11
203	311.20	400–500	12	12
302	261.95	300–400	9	9
303	266.36	400–500	7	7
402	379.74	300–400	10	10
403	290.31	400–500	11	11

Table 3: Analysis of deviance for a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 1.

	Df	Sum sq	Mean Sq	F value	P
Strata_year	35	118.78	3.3936	3.3936	<0.0001
Reader_year	24	257.32	10.7217	10.7217	<0.0001

Canonical indices of the reader_year terms are presented in Table 4 and plotted in Figure 8. These were calculated from the GLMM indices and covariance matrix (Francis 1999).

The correction factor (Table 4) for each reader_year (C_i) is defined as follows

$$C_i = \frac{\bar{c}}{c_i}$$

where c_i is the index of the ith reader_year, and $\bar{c}$ is the average of the reader_year indices. These correction factors were applied to the individual reader reads for the analysis of the image data, estimating overall abundance.

Table 4: Canonical indices (and variance, CV and upper and lower 95% CI) for reader_year terms from a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 1.

Reader_Year	Indices	Variance	CVs	Upper 95%	Lower 95%	Correction factor
AM_2012	1.18	0.003414	0.049368	1.300393	1.066676	0.852736
AM_2015	1.19	0.010000	0.083878	1.392228	0.992222	0.846521
BH_2003	0.98	0.003201	0.058005	1.088486	0.862189	1.034763
BH_2008	0.91	0.003304	0.063468	1.020555	0.790648	1.114445
BH_2012	0.86	0.007669	0.101900	1.034550	0.684257	1.174353
CM_2003	1.15	0.004826	0.060451	1.288101	1.010227	0.878241
DP_2008	1.25	0.005441	0.059005	1.397626	1.102576	0.807329
DP_2012	0.82	0.001795	0.051821	0.902191	0.732742	1.234599
DP_2015	1.18	0.009862	0.084124	1.379065	0.981844	0.854961
HA_2003	0.94	0.003169	0.059658	1.056167	0.830997	1.069587
HA_2008	0.94	0.003783	0.065321	1.064599	0.818577	1.071853
HA_2012	0.87	0.002098	0.052567	0.962976	0.779755	1.158232
HA_2015	1.11	0.008706	0.084192	1.294847	0.92163	0.910673
IT_2008	0.94	0.003506	0.063077	1.057153	0.820305	1.075117
IT_2012	0.96	0.00244	0.05138	1.060226	0.862632	1.049732
IT_2015	1.04	0.007738	0.084748	1.213929	0.862058	0.972302
JD_2003	0.93	0.003302	0.06168	1.046594	0.816734	1.083269
JD_2008	0.86	0.003378	0.067388	0.978698	0.746219	1.170193
MC_2003	1.13	0.003967	0.055879	1.25318	1.001231	0.89535
MS_2003	1.17	0.004842	0.059232	1.313993	1.035646	0.859063
MS_2008	1	0.004313	0.065621	1.132202	0.869494	1.008388
MS_2012	1.14	0.003274	0.050323	1.251514	1.022631	0.88758
MS_2015	1.08	0.008297	0.0845	1.260141	0.895788	0.936249
NR_2012	0.78	0.001747	0.053429	0.865813	0.698638	1.290221
NR_2015	0.82	0.004995	0.086123	0.961953	0.679261	1.229874

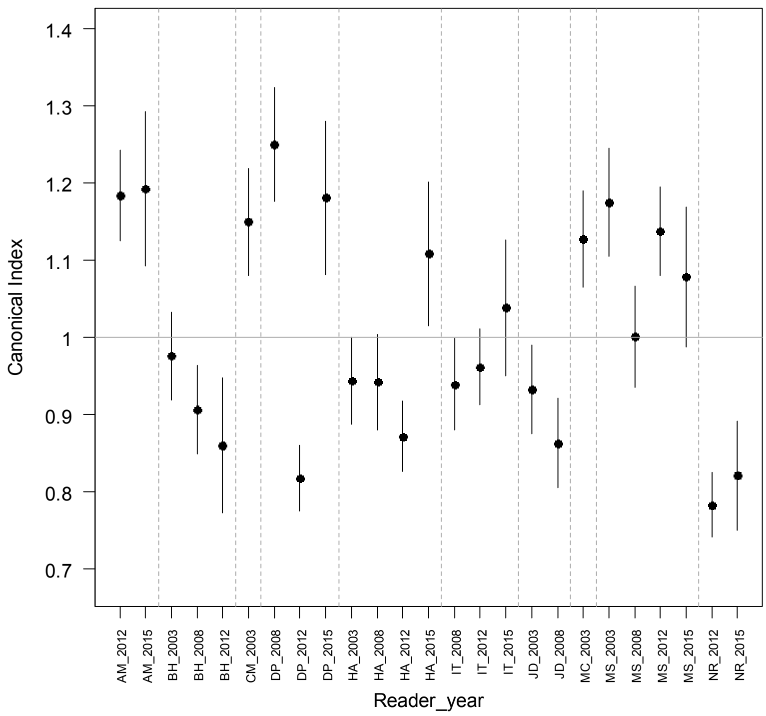


Figure 8: Canonical indices (and CV) for reader_year terms from a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 1.

Reader_year effects were also tested for counts of visible scampi in the same way, but were not found to be significant, supporting our previously assumed (but untested) view that identification and counting of scampi is far less subjective than that of burrow openings.

The number of completed stations by strata are provided in Table 2. The locations of photographic stations, and relative burrow densities, are shown in Figure 9. The uncorrected burrow density estimates varied from 0.02 – 0.21 m^{-2}, and reader correction factors had only minimal effects on overall density estimates. Densities of all scampi, and scampi out of their burrows ranged from 0 to 0.05 (Figure 10) and 0.02 m^{-2}, respectively. Scaling the densities to the combined area of the strata (1816 km^2) leads to abundance estimates from 161 million burrows or, assuming 100% occupancy, a maximum abundance estimate of the same number of animals (Table 5). Analysis of all SCI 1 surveys (with and without reader_year corrections) are presented in Appendix 1.

Overall, the density of major scampi burrow openings was estimated to be 0.09 m^{-2}. The density was highest in the stratum 303, but other than stratum 302 (which had the lowest average density), were reasonable consistent. The CVs from the bootstrapped estimates (bootstrapping of the reader_year corrected estimates, resampling stations with replacement within strata, and selecting one of the three readers for each station) were very similar to those of the corrected estimates (Table 5).

The estimated mean density of all visible scampi was 0.01 m^{-2}, with the highest density observed in the strata 402 and 403. Scaling the observed densities of visible scampi to strata area leads to a minimum abundance estimate of 23 million animals for the surveyed area (Table 6). Counting animals out of burrows and walking free on the surface reduced this estimate to 5 million animals (Table 7). The CVs for visible scampi and scampi out of burrows from the bootstrapped estimates were comparable with those of the original estimates.

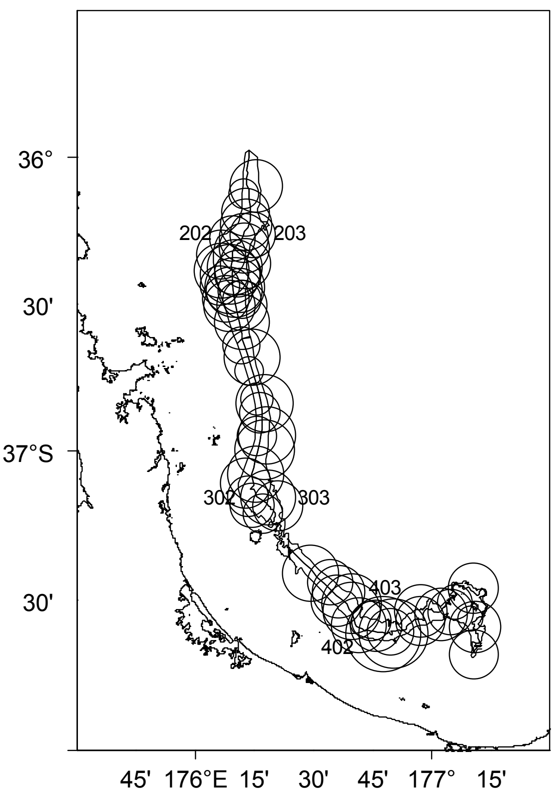


Figure 9: Station locations for the 2015 photographic survey of SCI 1 (area of symbol represents relative burrow density). Largest circle represents 0.21 burrows .m^{-2} (uncorrected for reader_year).

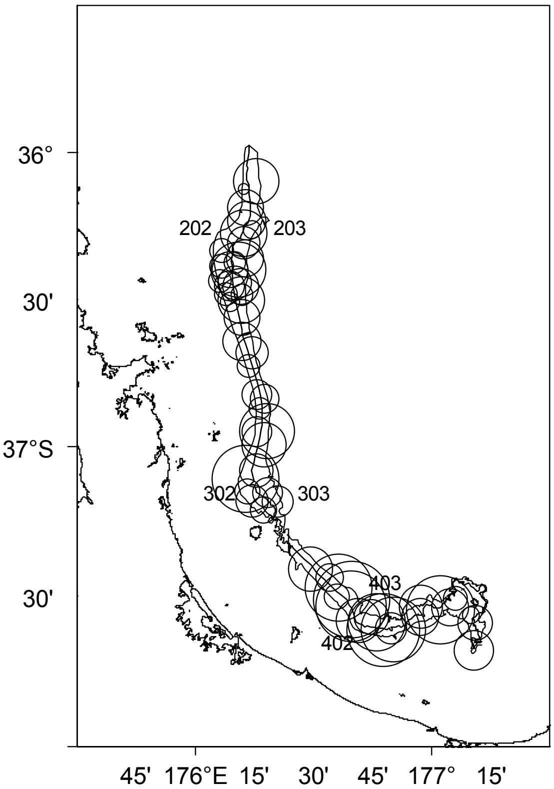


Figure 10: Station locations for the 2015 photographic survey of SCI 1 (area of symbol represents relative visible scampi density). Largest circle represents 0.047 visible scampi .m^{-2}.

Table 5: Estimates of the density and abundance of major burrow openings from the SCI 1 survey for 2015. Counts by each reader have been scaled by correction factors for reader_year. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Major burrows	202	203	302	303	402	403	Fishery	Bootstrap
Area (km^2)	306.69	311.20	261.95	266.36	379.74	290.31	1816	
Stations	11	12	9	7	10	11	60	
Mean density (.m^{-2})	0.0840	0.0888	0.0575	0.1066	0.0977	0.0938	0.0888	
CV	0.11	0.07	0.12	0.05	0.16	0.07	0.05	0.05
Abundance (Millions)	25.79	27.63	15.07	28.36	37.14	27.20	161.18	161.5

Table 6: Estimates of the density and abundance of visible scampi from the SCI 1 survey for 2015. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Visible scampi	202	203	302	303	402	403	Fishery	Bootstrap
Area (km^2)	306.69	311.20	261.95	266.36	379.74	290.31	1816	
Stations	11	12	9	7	10	11	60	
Mean density (.m^{-2})	0.0059	0.0116	0.0101	0.0117	0.0172	0.0195	0.0129	
CV	0.21	0.17	0.33	0.22	0.26	0.24	0.11	0.11
Abundance (Millions)	1.81	3.60	2.64	3.12	6.55	5.67	23.39	23.20

Table 7: Estimates of the density and abundance of scampi out of burrows from the SCI 1 survey for 2015. Scampi "out" were defined as those for which the telson was not obscured by the burrow. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Scampi out	202	203	302	303	402	403	Fishery	Bootstrap
Area (km^2)	306.69	311.20	261.95	266.36	379.74	290.31	1816	
Stations	11	12	9	7	10	11	60	
Mean density (.m^{-2})	0.0008	0.0022	0.0011	0.0014	0.0049	0.0055	0.0028	
CV	0.57	0.48	0.52	0.67	0.53	0.42	0.26	0.25
Abundance (Millions)	0.25	0.68	0.29	0.37	1.87	1.59	5.05	4.92

The trend in abundance in major burrow openings is shown in Figure 11 (for individual strata) and Figure 12 (for larger areas). For the consistently surveyed area (surveyed since 1998), the abundance shows a decline in the early 2000s, but has remained very stable since this time. Estimated abundance for the current survey extent (encompassing over 98% of scampi targeted fishing in the SCI 1 management area) suggests a slight increase between 2012 and 2015. The survey estimates uncorrected for reader_year effect (Appendix 1) are similar to the corrected estimates, and show a similar pattern. The indices of scampi abundance (visible scampi, and scampi out of burrows) are presented in Figure 13. These show a similar decline in the early 2000s, but with visible scampi increasing to a peak in 2012 and declining by 2015. Estimates of scampi out of burrows are far lower, and show less temporal pattern after the initial decline in the early part of the series.

Overall survey mean densities for the current and previous surveys in SCI 1 are provided in Table 8. The count of visible scampi as a percentage of burrows (which could be considered a minimum estimate of occupancy) was just over 20%. The range observed is comparable with other SCI survey data (Tuck et al. 2013). The proportion of scampi seen out of their burrows (scampi out as a proportion of all visible scampi) was 22% in 2015, which is comparable with recent other surveys in SCI 1, SCI 2 and SCI 3 (Tuck et al. 2013), but lower than observed in SCI 6A (Tuck et al. 2015a).

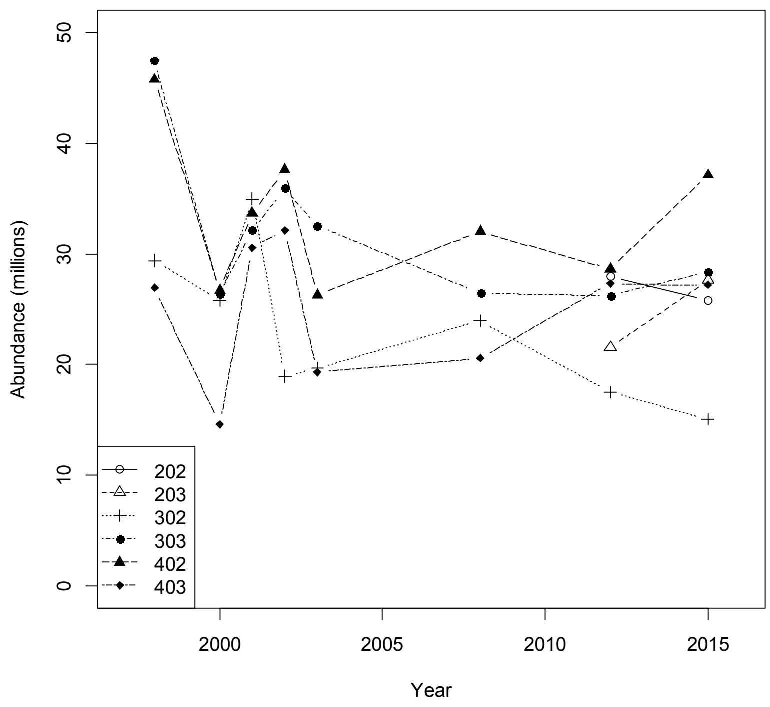


Figure 11: Estimated abundance of scampi major burrow openings for SCI 1 by strata.

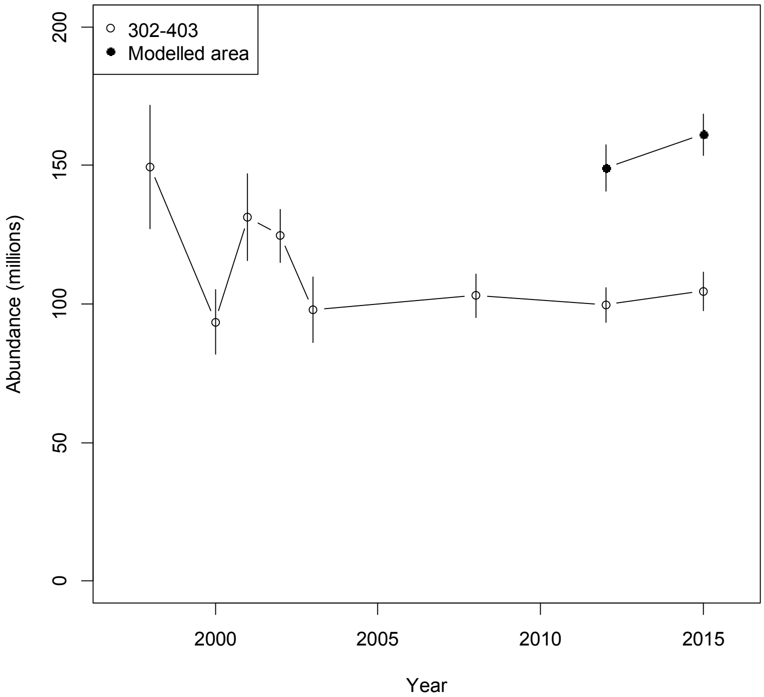


Figure 12: Estimated abundance of major scampi burrow openings (± CV) for SCI 1 for combined 302, 303, 402 and 403 strata (which have been covered by all photographic surveys), and whole SCI 1 survey area (only covered since 2012).

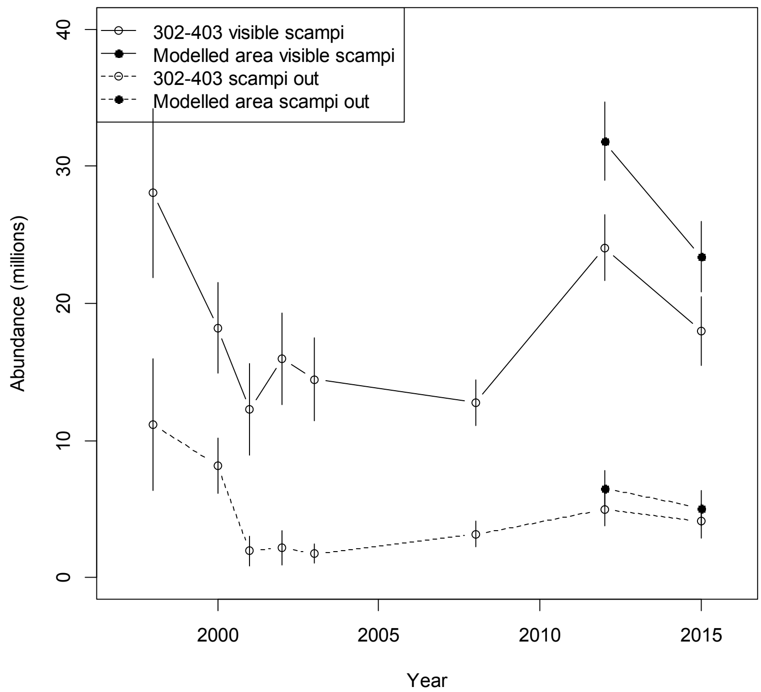


Figure 13: Estimated abundance of scampi (± CV) for SCI 1 for combined 302, 303, 402 and 403 strata (which have been covered by all photographic surveys), and whole SCI 1 survey area (only covered since 2012).

Table 8. Overall survey mean densities (m^{-2}) of major burrow openings, visible scampi and scampi out of burrows, for the series of SCI 1 surveys (data for the combined 302, 303, 402 and 403 strata and the current survey coverage presented in separate blocks).

	Major opening	Visible scampi	Scampi "out"	Scampi as % of openings	% of visible scampi "out"
302–403					
1998	0.1249	0.0234	0.0093	0.19	0.40
2000	0.0781	0.0152	0.0068	0.19	0.45
2001	0.1096	0.0102	0.0016	0.09	0.16
2002	0.1040	0.0133	0.0018	0.13	0.14
2003	0.0817	0.0121	0.0015	0.15	0.12
2008	0.0860	0.0107	0.0026	0.12	0.25
2012	0.0832	0.0201	0.0042	0.24	0.21
2015	0.0873	0.0150	0.0034	0.17	0.23
SCI 1					
2012	0.0821	0.0266	0.0054	0.32	0.20
2015	0.0888	0.0195	0.0042	0.22	0.22

3.2 SCI 1 Trawl survey

The locations of trawl survey stations, and relative scampi catch rates, are shown in Figure 14. Biomass estimates are provided by strata for the 2015 survey in Table 9, and are compared with previous surveys estimated over the same strata in Table 11. Equivalent abundance estimates are provided for the 2015 survey in Table 10, and are compared with previous surveys in Table 12.

Table 9: Trawl survey estimates by strata for SCI 1. Mean values expressed as kg.nautical mile^{-1} with the *Kaharoa* scampi trawl gear.

	Stratum						
Strata	202	203	302	303	402	403	Total
Area (km^2)	307	311	262	266	378	290	1814
N. stations	3	3	3	3	3	3	18
Mean (kg.mile^{-1})	1.62	6.15	0.33	5.65	2.72	9.89	4.35
CV	0.48	0.22	0.61	0.06	0.37	0.29	0.13
Biomass (tonnes)	10.71	41.37	1.89	32.46	22.21	61.96	170.59

Table 10: Trawl survey estimates (abundance) by survey and stratum for SCI 1. Mean values expressed as numbers mile^{-1} with the *Kaharoa* scampi trawl gear.

	Stratum						
Strata	202	203	302	303	402	403	Total
Area (km^2)	307	311	262	266	378	290	1814
No. of stations	3	3	3	3	3	3	18
Mean (No. mile^{-1})	28.02	89.25	6.79	94.32	58.60	197.45	78.64
CV	0.63	0.16	0.62	0.04	0.41	0.31	0.15
Abundance (millions)	0.19	0.60	0.04	0.54	0.48	1.24	3.08

The overall raised trawl survey estimate was 170 tonnes (13% CV) (Table 9), or 3.1 million individuals (15% CV) (Table 10). Given that scampi live in burrows and are only available to trawl gear when they emerge on the seabed, this is likely to be a considerable underestimate of the stock biomass. This is comparable with the 2012 estimate (186 t, 21% CV), but a decline on the peak biomass estimates of the mid 1990s (Table 11 and Figure 15). The trends in scampi abundance (in numbers) estimated from the trawl surveys follow very similar patterns to those shown by biomass (Table 12).

Table 11: Time series of raised trawl survey scampi stock estimates (tonnes) by survey strata for SCI 1. Time step relates to assessment model, with surveys in December – January allocated to step 1, and those in February – April allocated to step 2.

	202	203	302	303	402	403	Total	3/402 and 3/403	Time step
1993	22.01	32.34	71.63	37.14	80.71	27.79	271.61	217.26	1
1994	51.37	24.45	48.46	42.88	130.23	66.64	364.03	288.21	1
1995	58.81	59.95	132.84	98.01	134.10	26.65	510.37	391.61	1
1996			52.53	63.91					2
1998			71.70	19.29	71.74	11.25		173.98	1
2000	34.61	9.17	57.08	57.16	54.19	12.90	225.10	181.33	2
2001			21.45	39.40	70.99	47.69		179.52	1
2002			33.05	24.66	44.22	28.69		130.62	2
2008			24.63	57.34	67.52	62.42		211.91	2
2012	8.30	28.28	14.22	49.59	55.27	30.89	186.55	149.97	2
2015	10.71	41.37	1.89	32.46	22.21	61.96	170.59	118.52	2

Table 12: Time series of raised trawl survey scampi stock estimates (millions) by survey strata for SCI 1. Time step relates to assessment model, with surveys in December – January allocated to step 1, and those in February – April allocated to step 2.

	202	203	302	303	402	403	Total	3/402 and 3/403	Time step
1993	0.36	0.54	1.47	0.89	2.17	0.75	6.18	5.28	1
1994	0.89	0.47	0.91	0.85	2.82	1.21	7.14	5.78	1
1995	1.03	1.05	2.39	1.77	2.69	0.34	9.28	7.20	1
1996			0.88	1.22					2
1998			0.69	0.58	1.76	0.16		3.19	1
2000	0.64	0.14	0.95	0.92	1.35	0.24	4.23	3.45	2
2001			0.31	0.57	1.16	0.67		2.72	1
2002			0.15	0.71	0.98	0.55		2.39	2
2008			0.45	0.93	1.86	1.24		4.47	2
2012	0.18	0.56	0.25	1.05	0.66	0.50	3.20	2.46	2
2015	0.19	0.60	0.04	0.54	0.48	1.24	3.08	2.30	2

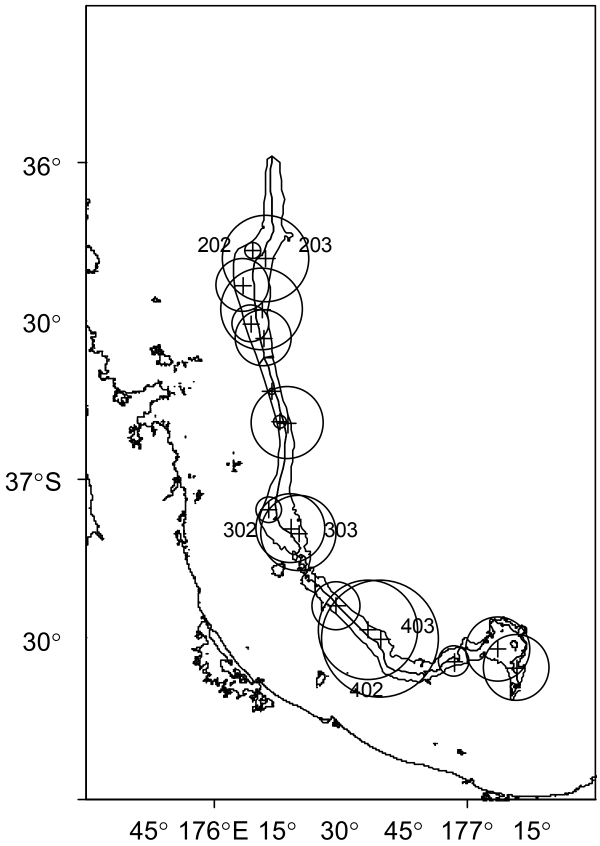


Figure 14: Trawl station locations for the 2015 photographic survey of SCI 1 (area of symbol represents relative scampi catch rate). Largest circle represents 14.5 kg.mile^{-1}.

Over the whole SCI 1 trawl survey, 225 kg of scampi were caught, accounting for about 4% of the total catch (5672 kg), with scampi being the sixth most abundant species. By weight, the most dominant species in the catches were sea perch (16.3%), hoki (12.2%), javelin fish (9.0%), silver roughy (8.1%), ling (5.4%), and scampi (4.0%). In commercial fishing activities, scampi forms a greater proportion of the total catch, as bycatch mitigation approaches reduce fish catch.

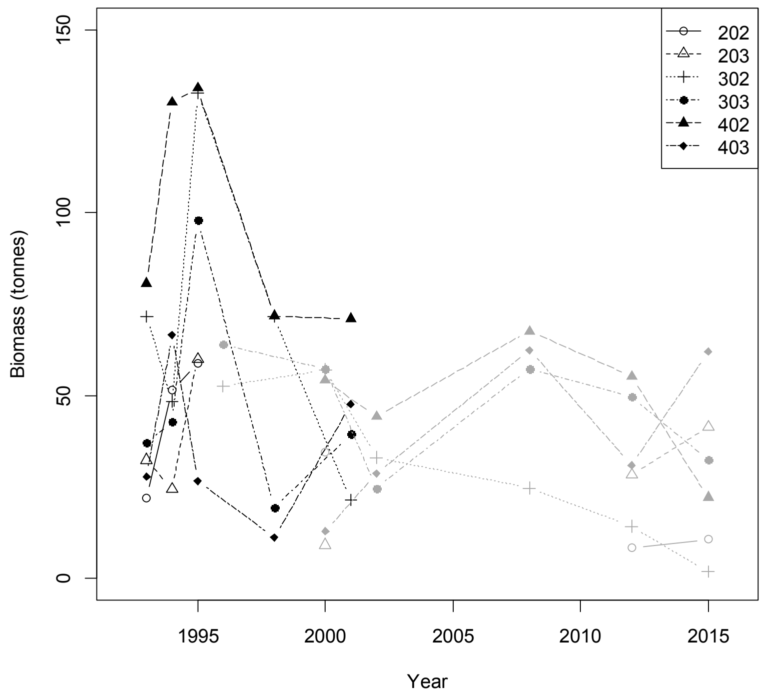


Figure 15: Plot of time series of trawl survey biomass estimates (± CV) for SCI 1.

Across the survey series, strata level estimates of abundance from trawl and photographic survey methods (burrows and visible animals) showed positive relationships (Figure 16 and Figure 17). Across the whole time series correlations were quite poor (r^2 = 0.15), but examined on an individual year basis they were far better (r^2 values generally around 0.4, but as high as 0.9).

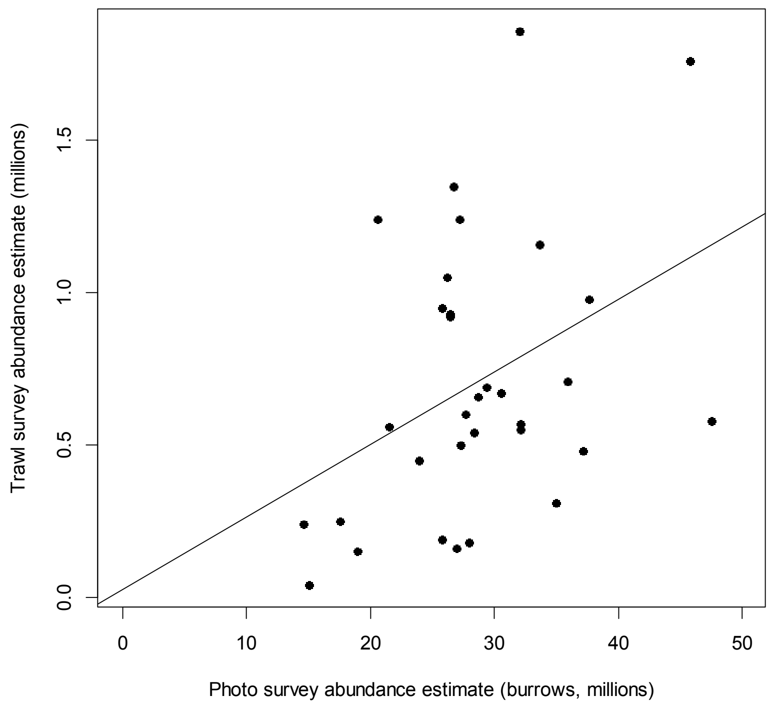


Figure 16: Relationship between strata level photographic survey estimates of burrow abundance and trawl survey estimates of scampi abundance. Line represents least squares linear regression (r^2 = 0.15).

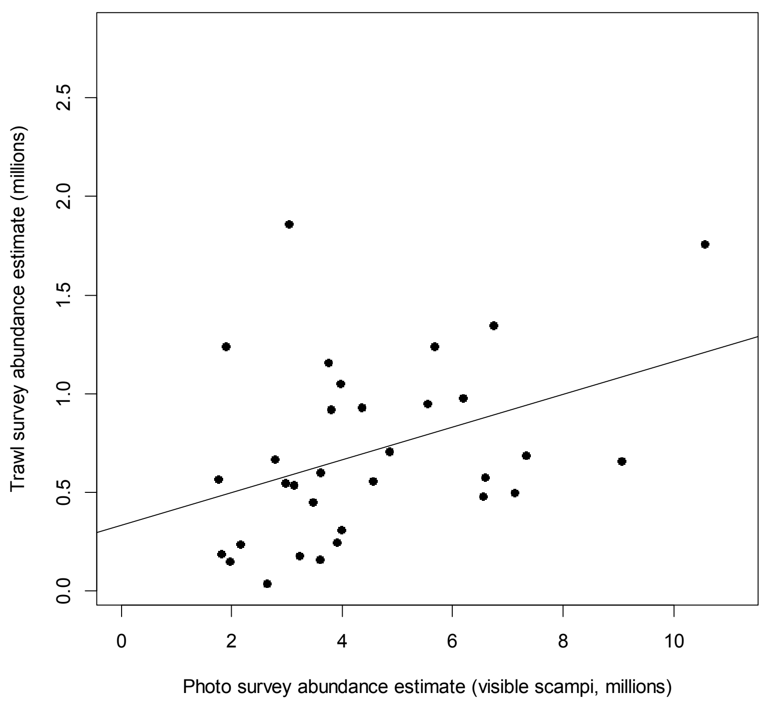


Figure 17: Relationship between strata level photographic survey estimates of visible scampi abundance and trawl survey estimates of scampi abundance. Line represents least squares linear regression (r^2 = 0.15).

3.3 SCI 1 Tagging

Undamaged active scampi were tagged from each trawl catch, and released for the growth investigation. The next scheduled research sampling in SCI 1 will be in 2018, and so it is anticipated that recoveries will be from commercial fishing activity. Over the SCI 1 component of the survey, over 3013 scampi were tagged with either streamer (2562) or T-bar (451) tags, which were then released. Tagging did not target specific size ranges, and the length distribution of tagged animals reflects the size distribution of suitable animals from the catches. The length distribution of the tagged scampi is presented in Figure 18. The predominance of males in catches and tag releases is consistent with previous surveys in SCI 3 at this time of year (Tuck et al. 2011). The tagged scampi were released at 19 separate locations (Figure 19). No scampi were released while the vessel was fishing, and no recaptures were made by the RV *Kaharoa* during the survey. Tagging mortality was not investigated during this voyage (following recommendations of the Shellfish Assessment Working Group), but when examined elsewhere, short term (up to seven days) survival has been estimated at 76% in SCI 2 (Tuck et al. 2013) and 88% in SCI 6A (Tuck et al. 2015a), the difference assumed to be related to warmer surface water temperatures in SCI 2.

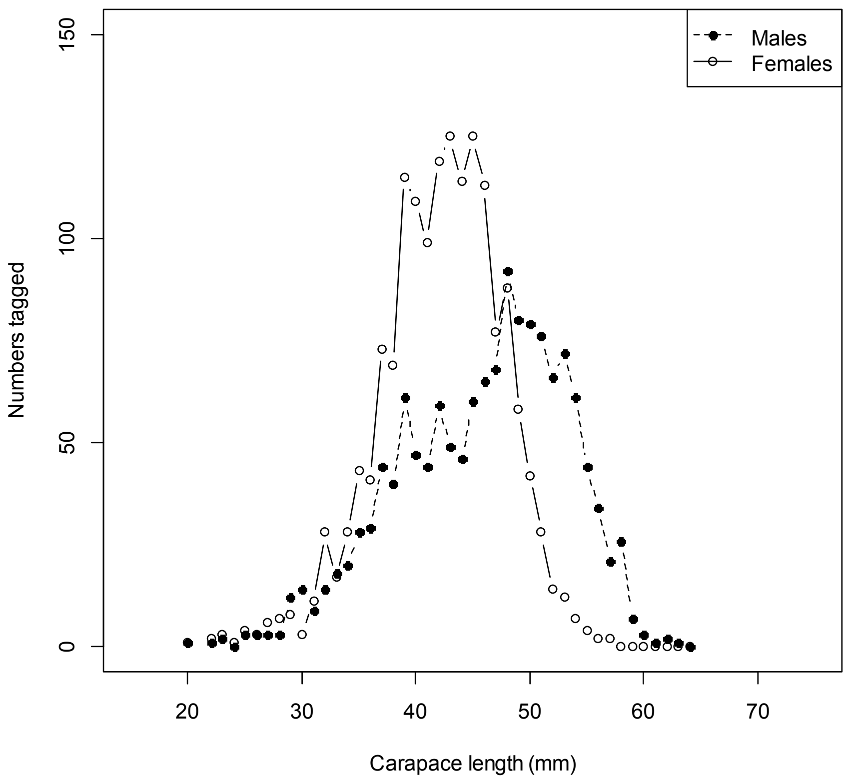


Figure 18: Length distribution of scampi tagged and released in SCI 1 during the KAH1501 voyage.

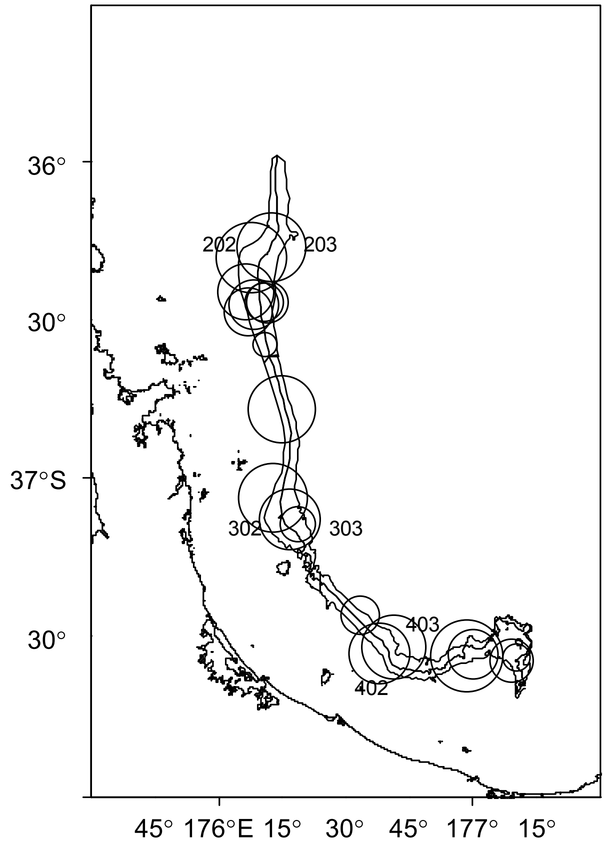


Figure 19: Map showing distribution of 2015 scampi release locations in SCI 1, and relative numbers released at each location. Largest circles represent 285 animals. The smallest release batch was 36 animals, and the average release batch was 158 animals.

To date (January 2016) no recoveries have been reported to NIWA from SCI 1. Historically tag recoveries generally been low from SCI 1 and SCI 2. The same tagging approach is used in all areas, and it is unclear why recovery rates are so different, although the colder surface waters in SCI 6A may contribute to increased survival.

3.4 SCI 2 Photographic survey

As with the SCI 1 component of the survey, visibility was generally good, and almost all of the photographs exposed in the critical area were of good or excellent quality. Over the whole SCI 2 survey, a total area of 11 222 m^2 of seabed was viewed (acceptable quality images), with an average of 49.9 images at each station, an average seabed area viewed by each image of 5.77 m^2, providing an average area viewed of 287.75 m^2 at each station. All but one planned photographic station was achieved (Table 13).

Following the approach described for SCI 1 (Section 3.1), calibration across years and between readers was conducted in a single analysis. The significance of effects was tested by sequentially adding terms, and a model testing the null hypotheses that there were no strata_year or reader_year differences between burrow counts over time, detected highly significant effects (both considered as factors) (Table 14). Correction factors were calculated for each reader_year from the canonical indices (Table 15; Figure 8).

Table 13: Details of strata and number of photo stations completed for SCI 2 survey in 2015.

			Photo stations	
Stratum	Area (km^2)	Depth (m)	Planned	Completed
702	321.41	300–400	7	7
703	543.59	400–500	19	18
802	386.11	300–400	9	9
803	230.54	400–500	5	5

Table 14: Analysis of deviance for a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 2.

	Df	Sum sq	Mean Sq	F value	P
Strata_year	31	203.13	6.5527	6.5527	<0.0001
Reader_year	36	841.64	23.3788	23.3788	<0.0001

Table 15: Canonical indices (and variance, CV and upper and lower 95% CI) for reader_year terms from a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 2.

Reader_Year	Indices	Variance	CVs	Upper 95%	Lower 95%	Correction factor
AM_2012	1.850927	0.01805	0.072585	2.119626	1.582228	0.577748
AM_2015	1.207139	0.008364	0.075762	1.390049	1.024229	0.885871
BH_2003	1.110715	0.048110	0.197476	1.549395	0.672035	0.962775
BH_2004	0.966437	0.029907	0.178941	1.312309	0.620566	1.106507
BH_2005	1.102589	0.029917	0.156872	1.448520	0.756658	0.969871
BH_2006	1.406306	0.035573	0.134115	1.783520	1.029093	0.760410
BH_2012	0.739589	0.016315	0.172704	0.995049	0.484129	1.445897
CM_2003	1.715953	0.062508	0.145701	2.215984	1.215922	0.623193
CM_2004	1.518722	0.074284	0.179461	2.063824	0.973620	0.704124
DP_2005	1.047505	0.033265	0.174116	1.412280	0.682730	1.020873
DP_2006	1.028645	0.020814	0.140253	1.317186	0.740104	1.039591
DP_2012	0.806059	0.004426	0.082534	0.939114	0.673004	1.326664
DP_2015	0.979463	0.005825	0.077925	1.132113	0.826813	1.091792
HA_2003	1.134091	0.032915	0.159974	1.496941	0.771242	0.942931
HA_2004	0.871201	0.021463	0.168163	1.164208	0.578193	1.227466
HA_2005	1.711233	0.07207	0.156880	2.248149	1.174318	0.624912
HA_2006	1.446499	0.037615	0.134080	1.834392	1.058605	0.739281
HA_2012	0.831620	0.004326	0.079090	0.963165	0.700074	1.285888
HA_2015	0.749243	0.003692	0.081094	0.870761	0.627725	1.427266
IT_2006	1.743126	0.052316	0.131216	2.200580	1.285673	0.613478
IT_2012	0.781755	0.004145	0.082358	0.910522	0.652987	1.367909
IT_2015	0.876278	0.004849	0.079463	1.015542	0.737015	1.220354
JD_2003	0.643589	0.010323	0.157870	0.846796	0.440382	1.661572
JD_2004	0.342314	0.005084	0.208285	0.484912	0.199716	3.123944
JD_2005	0.361262	0.004777	0.191319	0.499494	0.223029	2.960097
JD_2006	0.608882	0.008321	0.149819	0.791326	0.426438	1.756284
MC_2003	1.166662	0.039391	0.170118	1.563603	0.769721	0.916606
MC_2004	0.923534	0.022948	0.164028	1.226504	0.620564	1.157910
MC_2005	1.195938	0.037720	0.162396	1.584369	0.807507	0.894168
MS_2003	1.314179	0.038168	0.148660	1.704911	0.923447	0.813717
MS_2004	0.915460	0.022662	0.164439	1.216535	0.614385	1.168122
MS_2005	1.618175	0.062170	0.154087	2.116855	1.119495	0.660849
MS_2006	1.410573	0.038246	0.138643	1.801706	1.019440	0.758110
MS_2012	1.069050	0.006809	0.077187	1.234083	0.904017	1.000299
MS_2015	0.835000	0.004418	0.079604	0.967939	0.702062	1.280681
NR_2012	0.810538	0.004477	0.082546	0.944352	0.676724	1.319333
NR_2015	0.726413	0.003382	0.080063	0.842730	0.610096	1.472123

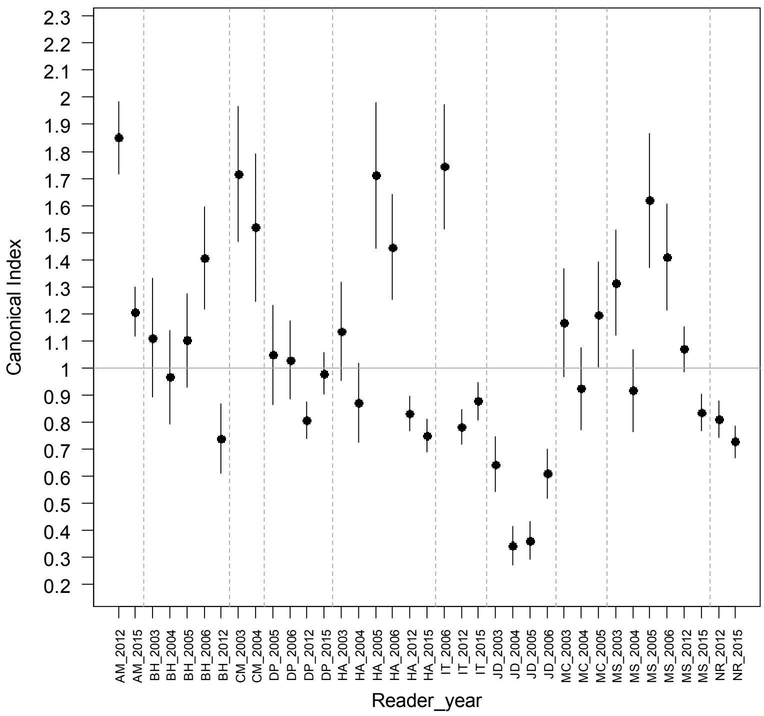


Figure 20: Canonical indices (and CV) for reader_year terms from a generalised linear mixed model relating the count of major burrow openings to reader_year, strata_year, and readable area for SCI 2.

As with SCI 1, reader_year effects were also tested for scampi counts in the same way, but were not found to be significant, supporting our previously assumed (but untested) view that identification and counting of scampi is far less subjective than that of burrow openings.

The number of completed stations by strata are provided in Table 13. The locations of photographic stations, and relative burrow densities, are shown in Figure 21. The uncorrected burrow density estimates varied from 0.05 – 0.27 m^{-2}, and correction factors had only minimal effects on overall density estimates. Densities of all scampi, and scampi out of their burrows ranged from 0 to 0.06 (Figure 22) and 0.04 m^{-2}, respectively. Scaling the densities to the combined area of the strata (1482 km^2) leads to abundance estimates from 234 million burrows or, assuming 100% occupancy, a maximum abundance estimate of the same number of animals (Table 16). Analysis of all SCI 2 surveys (with and without reader_year corrections) are presented in Appendix 2.

Overall, the density of scampi major burrow openings was estimated to be 0.16 m^{-2}. The density was highest in strata 702 and 803. The CVs from the bootstrapped estimates (bootstrapping of the reader_year corrected estimates, resampling stations with replacement within strata, and selecting one of the three readers for each station) were very similar to those of the original corrected estimates (Table 16).

The estimated mean density of all visible scampi was 0.02 m^{-2}, with the highest density observed in stratum 702. Scaling the observed densities of visible scampi to strata area leads to a minimum abundance estimate of 37 million animals for the surveyed area (Table 17). Counting animals out of burrows and walking free on the surface reduced this estimate to 12 million animals (Table 18). The CVs for visible scampi and scampi out of burrows from the bootstrapped estimates were comparable with those of the original estimates.

The trend in abundance in major burrow openings is shown in Figure 23 (for individual strata) and Figure 24 (for the whole survey). The strata show a relatively consistent pattern (reflected in the whole area) of an increase in abundance in 2004, a decline to 2006, and an increase to 2012, and a further increase to 2015. Over the whole survey area, estimated abundance of major burrow openings has almost quadrupled between 2006 and 2015. The survey estimates uncorrected for reader_year effect (Appendix 2) are similar to the corrected estimates, and show a similar pattern. The indices of scampi abundance (visible scampi, and scampi out of burrows) are presented in Figure 25. These show a very similar relative change between 2006 and 2015 to major burrow openings, but a greater relative change between 2006 and 2012, with a smaller increase to 2015.

Overall survey mean densities for the current and previous surveys in SCI 2 are provided in Table 19. The count of visible scampi as a percentage of burrows (which could be considered a minimum estimate of occupancy) was 10–20%. The range observed is comparable with other SCI survey data (Tuck et al. 2013). The proportion of scampi seen out of their burrows (scampi out as a proportion of all visible scampi) was 33% in 2015, which is slightly higher than that observed in SCI 1 in 2015, but comparable with recent other surveys in SCI 1, SCI 2 and SCI 3 (Tuck et al. 2013), and lower than observed in SCI 6A (Tuck et al. 2015a).

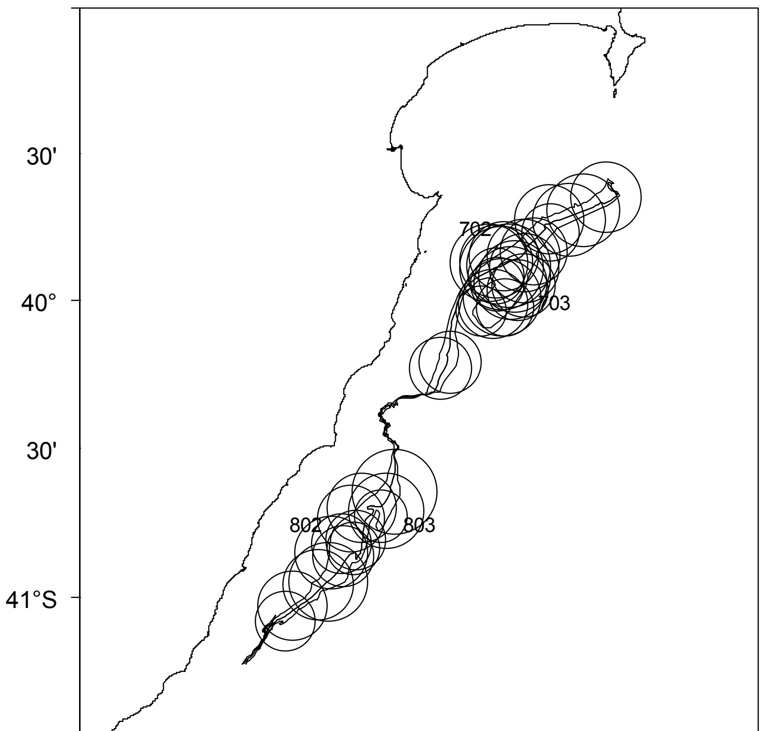


Figure 21: Station locations for the 2015 photographic survey of SCI 2 (area of symbol represents relative burrow density). Largest circle represents 0.27 burrows .m^{-2} (uncorrected for reader_year).

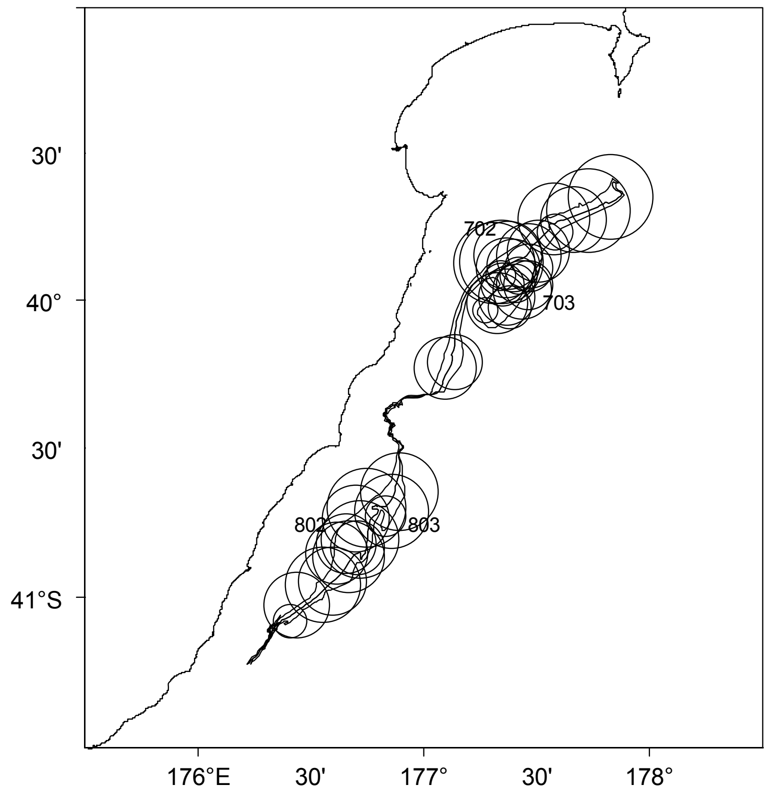


Figure 22: Station locations for the 2015 photographic survey of SCI 2 (area of symbol represents relative visible scampi density). Largest circle represents 0.057 visible scampi .m^{-2}.

Table 16: Estimates of the density and abundance of major burrow openings from the SCI 2 survey for 2015. Counts by each reader have been scaled by correction factors for reader_year. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Major burrows	702	703	802	803	Fishery	Bootstrap
Area (km^2)	321.41	543.59	386.11	230.54	1482	
Stations	7	18	9	5	39	
Mean density (.m^{-2})	0.1771	0.1519	0.1384	0.1783	0.1580	
CV	0.07	0.10	0.09	0.23	0.06	0.05
Abundance (Millions)	56.85	82.64	53.41	41.18	234.08	233.80

Table 17: Estimates of the density and abundance of visible scampi from the SCI 2 survey for 2015. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Visible scampi	702	703	802	803	Fishery	Bootstrap
Area (km^2)	321.41	543.59	386.11	230.54	1482	
Stations	7	18	9	5	39	
Mean density (.m^{-2})	0.0422	0.0120	0.0297	0.0235	0.0249	
CV	0.13	0.17	0.14	0.37	0.09	0.09
Abundance (Millions)	13.55	6.51	11.46	5.43	36.96	37.07

Table 18: Estimates of the density and abundance of scampi out of burrows from the SCI 2 survey for 2015. Scampi "out" were defined as those for which the telson was not obscured by the burrow. Bootstrap estimates of density and abundance (for the whole survey) based on median of 1000 sets of resampling stations within strata and reader within station.

Scampi out	702	703	802	803	Fishery	Bootstrap
Area (km^2)	321.41	543.59	386.11	230.54	1482	
Stations	7	18	9	5	39	
Mean density ($.m^{-2}$)	0.0205	0.0025	0.0098	0.0023	0.0083	
CV	0.20	0.34	0.20	0.44	0.13	0.12
Abundance (Millions)	6.59	1.34	3.79	0.53	12.24	12.18

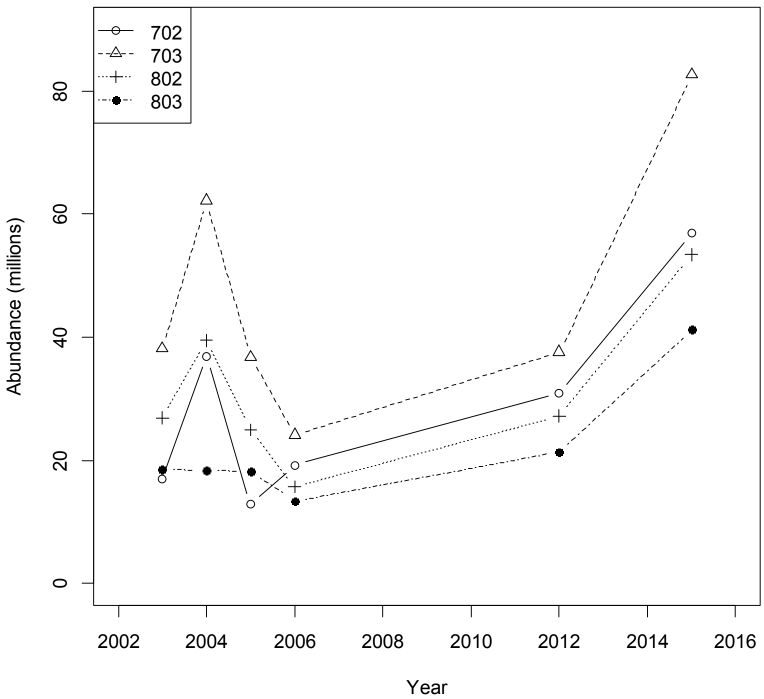


Figure 23: Estimated abundance of major scampi burrow openings for SCI 2 by strata.

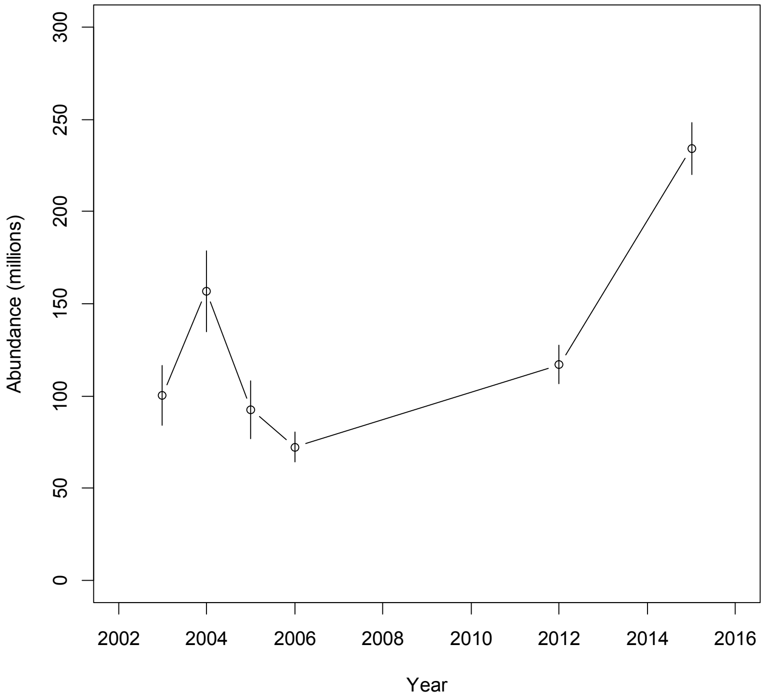


Figure 24: Estimated abundance of scampi major scampi burrow openings (± CV) for SCI 2.

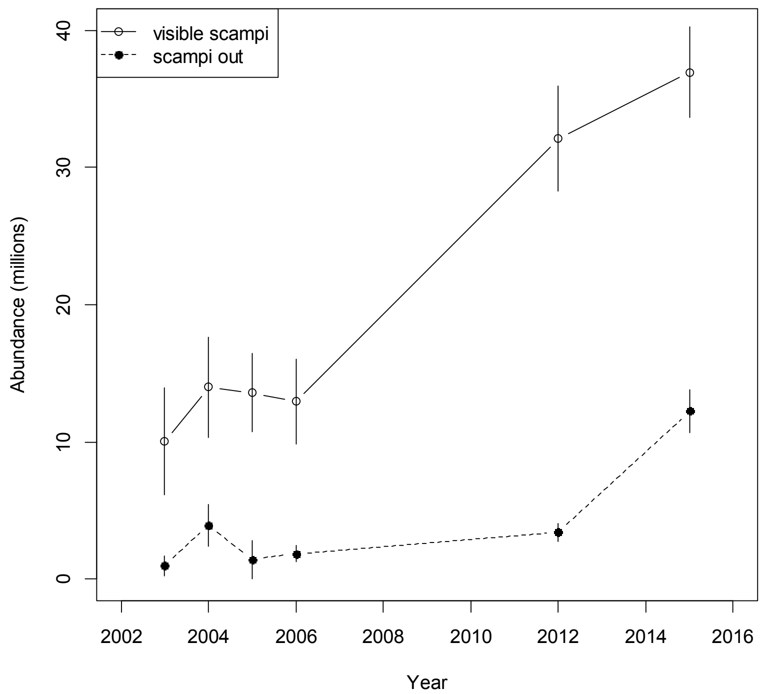


Figure 25: Estimated abundance of scampi (± CV) for SCI 2.

Table 19. Overall survey mean densities (m^{-2}) of major burrow openings, visible scampi and scampi out of burrows, for the series of SCI 2.

	Major opening	Visible scampi	Scampi "out"	Scampi as % of openings	% of visible scampi "out"
2003	0.0678	0.0068	0.0006	0.10	0.09
2004	0.1059	0.0094	0.0027	0.09	0.28
2005	0.0625	0.0092	0.0010	0.15	0.10
2006	0.0488	0.0087	0.0012	0.18	0.14
2012	0.0789	0.0217	0.0023	0.27	0.11
2015	0.1579	0.0249	0.0083	0.16	0.33

3.5 SCI 2 Trawl survey

The locations of trawl survey stations, and relative scampi catch rates, are shown in Figure 26. Biomass estimates are provided by strata for the 2015 survey in Table 20, and are compared with previous surveys estimated over the same strata in Table 22. Equivalent abundance estimates are provided for the 2015 survey in Table 21, and are compared with previous surveys in Table 23.

Table 20: Trawl survey estimates by strata for SCI 2. Mean values expressed as kg.nautical mile^{-1} with the *Kaharoa* scampi trawl gear.

	Stratum				
Strata	702	703	802	803	Total
Area (km^2)	321	544	386	231	1482
N. stations	3	3	3	3	12
Mean (kg.mile^{-1})	18.07	1.40	8.38	2.56	7.01
CV	0.24	0.71	0.41	0.42	0.19
Biomass (tonnes)	125.31	16.51	69.85	12.79	224.46

Table 21: Trawl survey estimates (abundance) by survey and stratum for SCI 2. Mean values expressed as numbers mile^{-1} with the *Kaharoa* scampi trawl gear.

	Stratum				
Strata	702	703	802	803	Total
Area (km^2)	321	544	386	231	1482
No. of stations	3	3	3	3	12
Mean (No. mile^{-1})	346.08	18.58	108.22	31.75	114.92
c.v.	0.19	0.56	0.43	0.34	0.16
Abundance (millions)	2.40	0.22	0.90	0.16	3.68

The overall raised trawl survey estimate was 224 tonnes (19% CV) (Table 20), or 3.7 million individuals (16% CV) (Table 21). Given that scampi live in burrows and are only available to trawl gear when they emerge on the seabed, this is likely to be a considerable underestimate of the stock biomass. This is an increase on the 2012 estimate (164 t, 28% CV), and is comparable with the peak biomass estimates of the early to mid 1990s (Table 22 and Figure 27). The trends in scampi abundance (in numbers) estimated from the trawl surveys follow very similar patterns to those shown by biomass (Table 23).

Over the whole SCI 2 trawl survey, 264 kg of scampi were caught, accounting for 4.2% of the total catch (6254 kg), with scampi being the seventh most abundant species. By weight, dominant species in the catches were javelin fish (21.0%), sea perch (20.2%), banded bellowsfish (9.5%), ling (7.1%), hoki (6.6%), Oliver's rattail (4.9%), and scampi (4.2%). As with SCI 1, in commercial fishing activities, scampi forms a greater proportion of the total catch, as bycatch mitigation approaches reduce finfish bycatch.

Table 22: Time series of raised trawl survey scampi stock estimates (tonnes) by survey strata for SCI 2. Time step relates to assessment model, with surveys in December – January allocated to step 1, and those in February – April allocated to step 2.

	702	703	802	803	Total	Time step
1993	93.85	24.96	113.00	6.37	238.18	1
1994	83.19	40.20	44.89	1.77	170.05	1
1995	85.26	67.13	59.40	4.41	216.19	1
2000			36.23	49.29		1
2000			33.35	4.49		2
2003	3.72	8.25	8.65	7.42	28.05	2
2004	18.14	5.44	19.21	4.08	46.88	1
2005	9.93	17.23	19.21	4.41	50.78	2
2006	2.99	5.06	6.96	7.87	22.88	2
2012	83.53	18.47	52.75	9.39	164.15	2
2015	125.31	16.51	69.85	12.79	224.46	2

Table 23: Time series of raised trawl survey scampi stock estimates (millions) by survey strata for SCI 2. Time step relates to assessment model, with surveys in December – January allocated to step 1, and those in February – April allocated to step 2.

	702	703	802	803	Total	Time step
1993	1.89	0.70	2.28	0.11	4.97	1
1994	1.88	0.72	0.88	0.02	3.50	1
1995	1.46	1.13	1.02	0.15	3.75	1
2000			0.48	0.64		1
2000			0.80	0.13		2
2003	0.06	0.15	0.22	0.11	0.54	2
2004	0.42	0.08	0.49	0.08	1.06	1
2005	0.26	0.26	0.44	0.11	1.08	2
2006	0.20	0.24	0.17	0.15	0.76	2
2012	1.82	0.36	0.94	0.14	3.26	2
2015	2.40	0.22	0.90	0.16	3.68	2

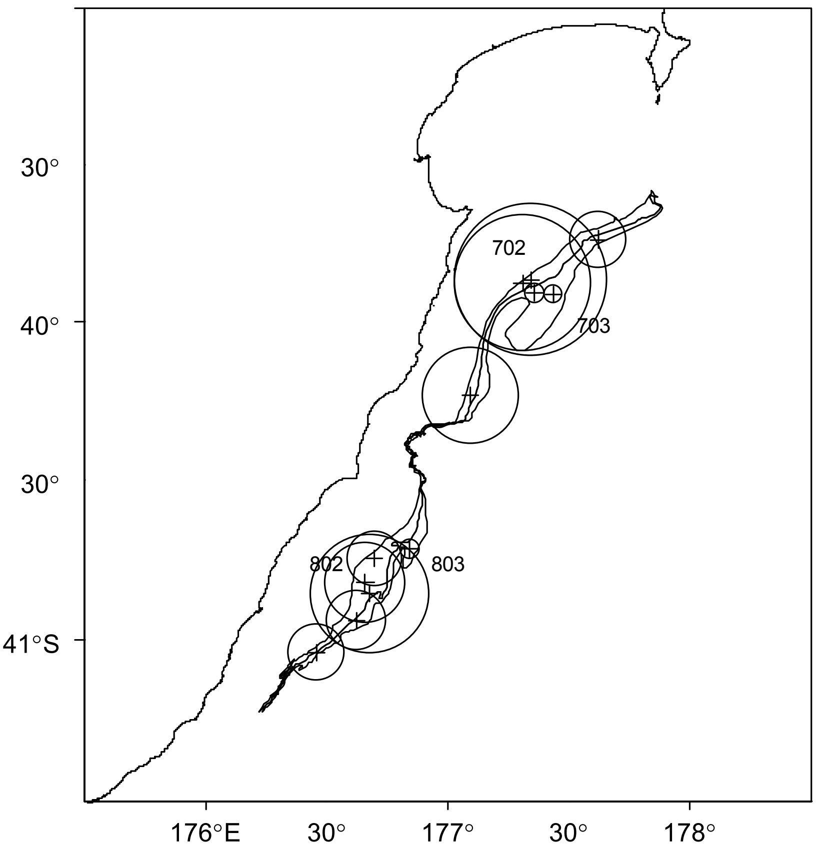


Figure 26: Trawl station locations for the 2015 photographic survey of SCI 2 (area of symbol represents relative scampi catch rate). Largest circle represents 24.5 kg.mile^{-1}.

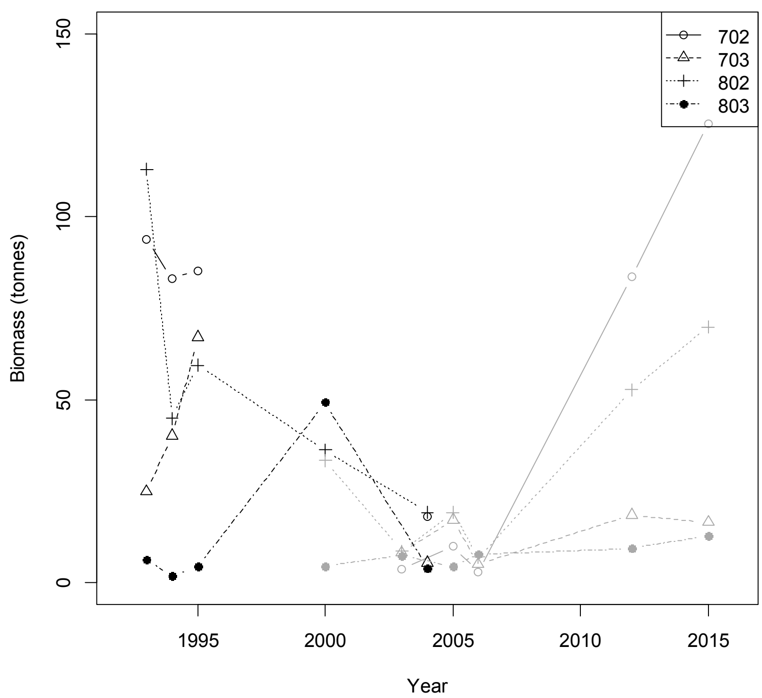


Figure 27: Plot of time series of trawl survey biomass estimates (± CV) for SCI 2.

Across the survey series, strata level estimates of abundance from trawl and photographic survey methods (burrows and visible animals) show a weak positive relationship (r^2= 0.09 for major burrow openings, and r^2= 0.47 for visible scampi, respectively) (Figure 28 and Figure 29).

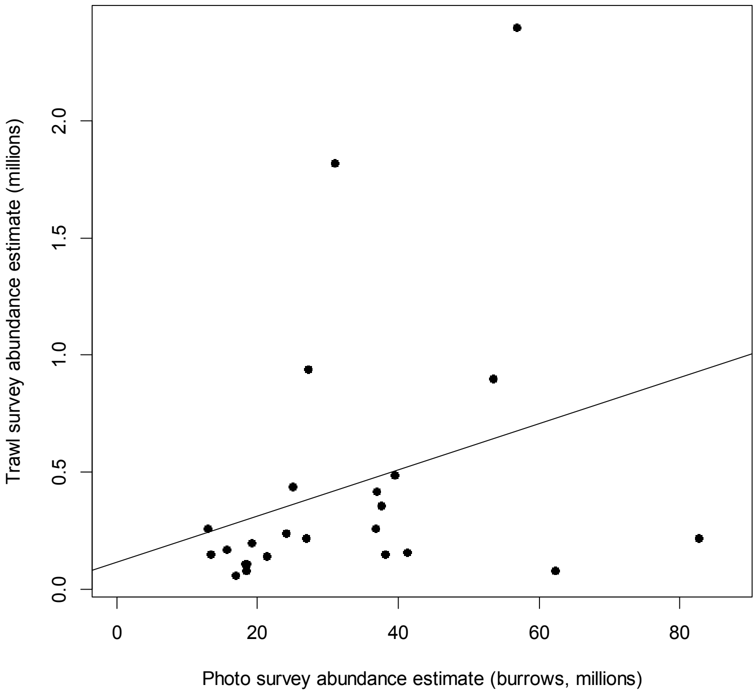


Figure 28: Relationship between strata level photographic survey estimates of burrow abundance and trawl survey estimates of scampi abundance. Line represents least squares linear regression (r^2 = 0.09).

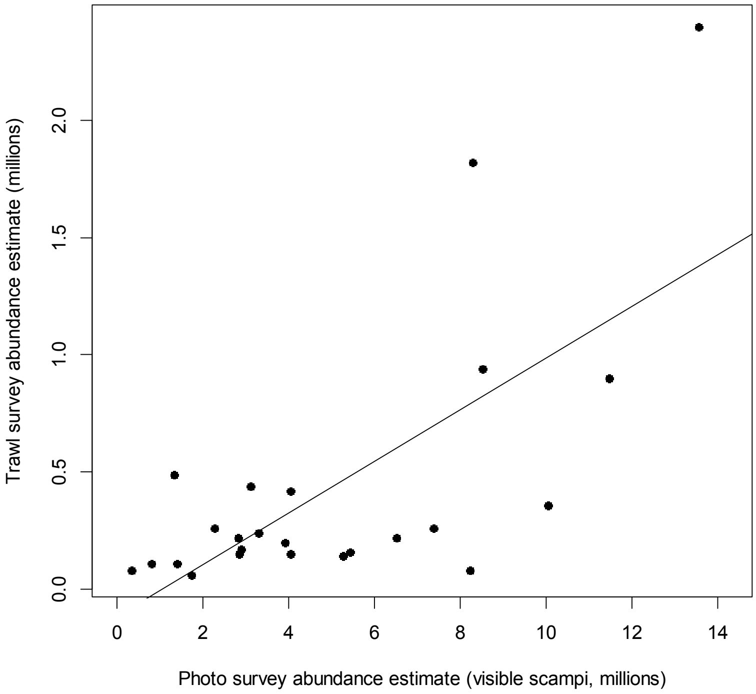


Figure 29: Relationship between strata level photographic survey estimates of visible scampi abundance and trawl survey estimates of scampi abundance. Line represents least squares linear regression (r^2 = 0.47).

3.6 SCI 2 Tagging

Undamaged active scampi were tagged from each trawl catch, and released for the growth investigation. The next scheduled research sampling in SCI 2 will be in 2018, and so it is anticipated that recoveries will be from commercial fishing activity. Over the SCI 2 component of the survey, almost 2800 scampi were tagged with either streamer (2035) or T-bar (760) tags, which were then released. Tagging did not target specific size ranges, and the length distribution of tagged animals reflects the size distribution of suitable animals from the catches. The length distribution of the tagged scampi is presented in Figure 30. The predominance of males in catches and tag releases is consistent with previous surveys in SCI 3 at this time of year (Tuck et al. 2011). The tagged scampi were released at 15 separate locations (Figure 31). No scampi were released while the vessel was fishing, and no recaptures were made by the RV *Kaharoa* during the survey. Tagging mortality was not investigated during this voyage (see Section 3.3).

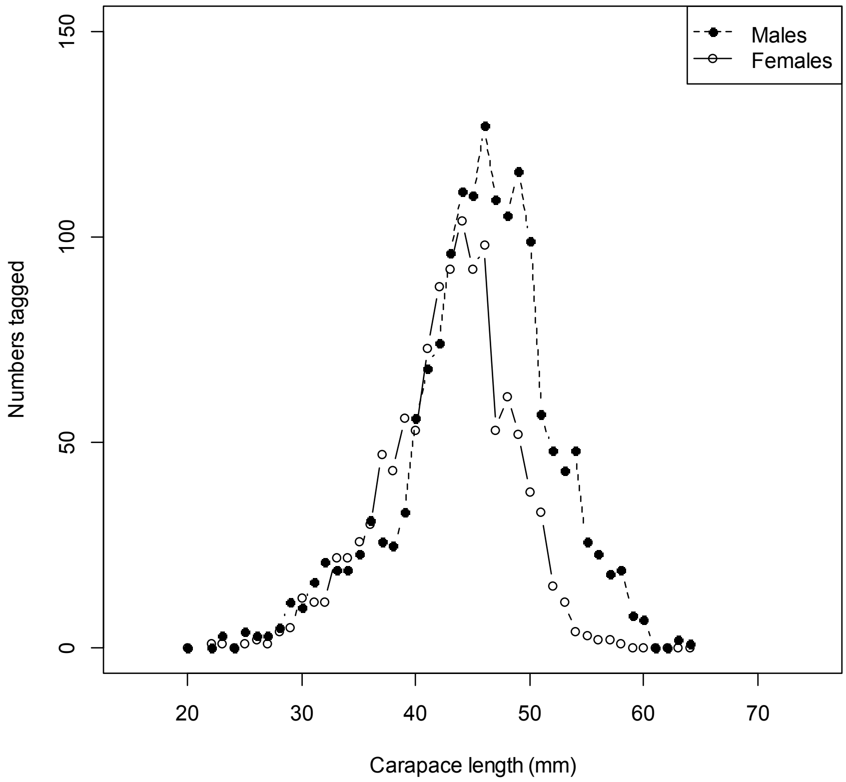


Figure 30: Length distribution of scampi tagged and released in SCI 2 during the KAH1501 voyage.

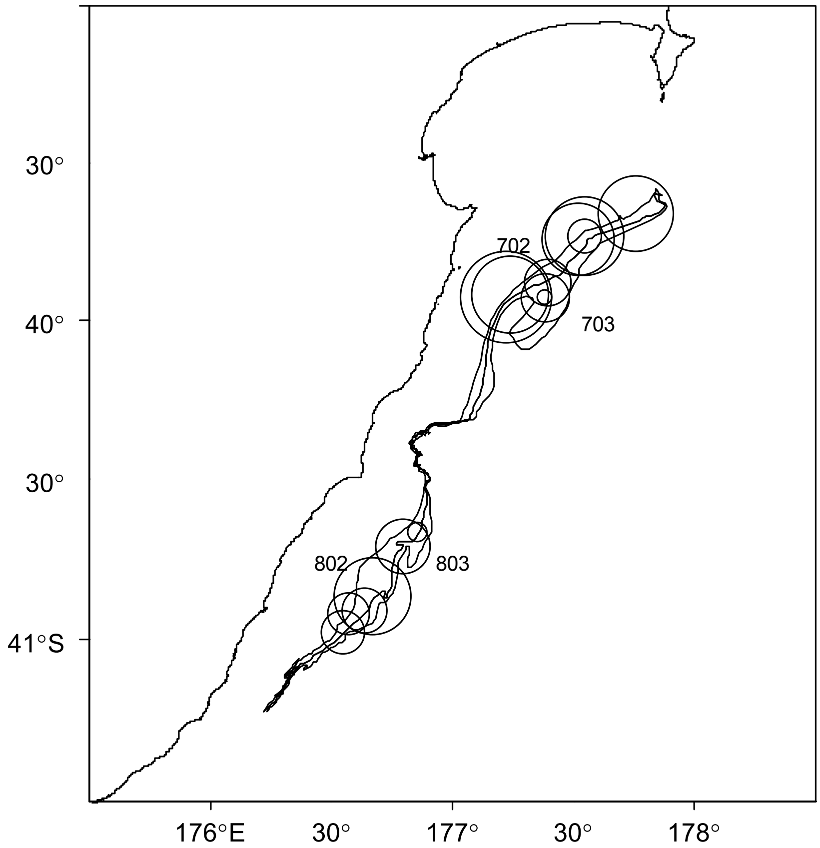


Figure 31: Map showing distribution of 2015 scampi release locations in SCI 2, and relative numbers released at each location. Largest circles represent 440 animals. The smallest release batch was 12 animals, and the average release batch was 186 animals.

To date (January 2016) ten recoveries have been reported to NIWA from SCI 2. Tag recoveries have generally been low from SCI 1 and SCI 2. The same tagging approach is used in all areas, and it is unclear why recovery rates are so different, although the colder surface waters in SCI 6A may contribute to increased survival.

3.7 Emergence patterns from acoustic tagging

Five of the six acoustic tagging moorings were recovered successfully, with one of the moorings from SCI 2 being lost (Table 24). Distances between moorings were 1 to 2 km. Maximum tag detection range is estimated to be up to 400 m when scampi are out of their burrows.

Summary details of detections by hydrophone for each tagged scampi are provided in Appendix 3. Across the five moorings recovered, data were received from 69 of the tags, but 4 of these tags were actually deployed with the lost mooring, and so these detections have been excluded. Of the 66 tags deployed at the five recovered moorings, 1 provided no data at all, 23 were not detected after the day of deployment, and a further 15 provided less than two weeks data (Figure 32). Fourteen of the tags were detected for over thirty days, although these were not always detected continually throughout the study. There was a clear split in the maximum number of detections for each scampi, with eight tags (all from the SCI 1 deployments) detected over 10 000 times (Figure 33).

Table 24: Details of acoustic tagging moorings.

Mooring	Latitude (deg min)	Longitude (deg min)	Depth (m)	Deployed	Recovered	Deployment duration (Days)	Tags
W1	40 57.381	176 32.419	344	17/02/2015	31/03/2015	42	13
W2	40 58.12	176 32.45	350	17/02/2015	31/03/2015	42	13
W3	40 57.815	176 33.275	395	17/02/2015		42	14
B1	37 24.399	176 31.774	458	5/03/2015	22/04/2015	48	13
B2	37 25.355	176 30.152	345	5/03/2015	22/04/2015	48	13
B3	37 26.631	176 32.043	362	5/03/2015	22/04/2015	48	14

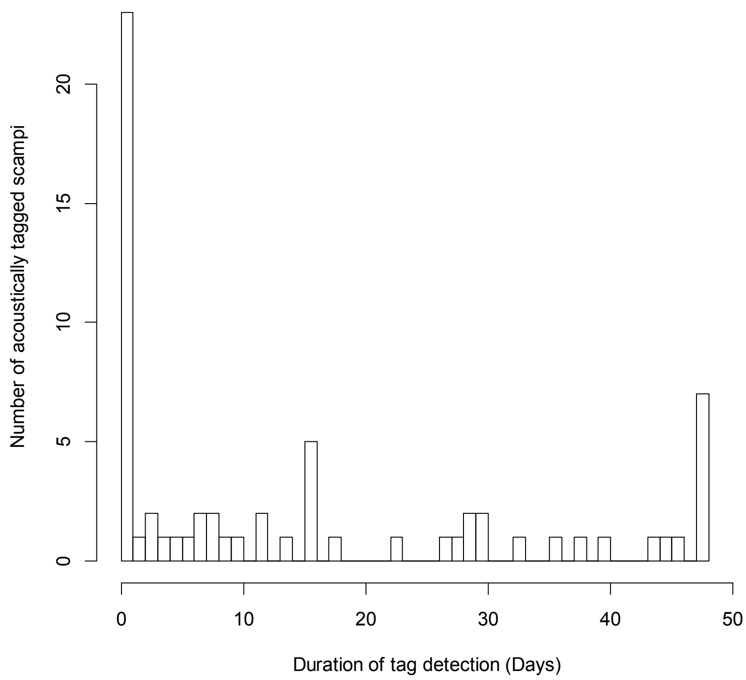


Figure 32: Histogram of tag detectability duration (time of last detection from deployment).

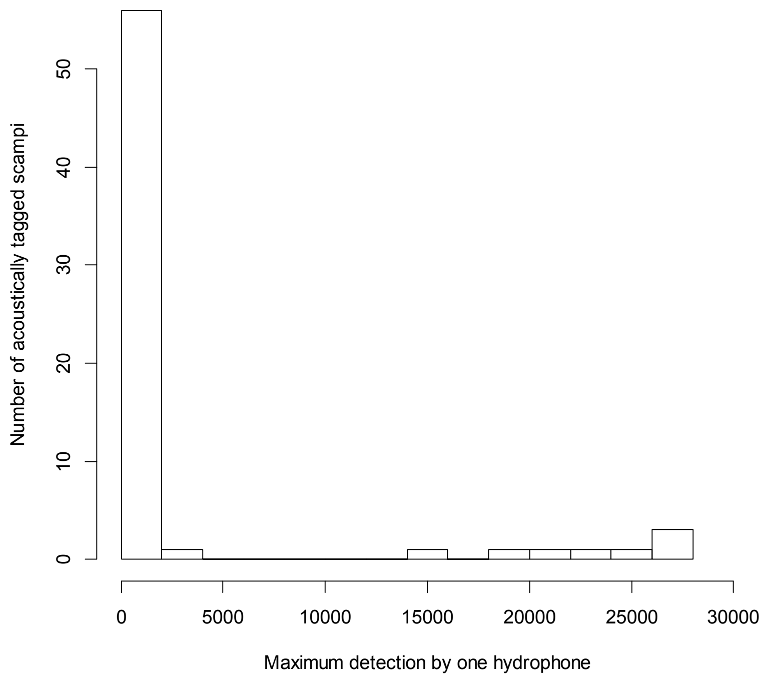


Figure 33: Histogram of maximum detections for each tagged scampi.

Detection plots (actograms) are provided in Figure 34 for each of the scampi tags detected over 10 000 times. Most of these animals showed evidence of daily or tidal periodicity, or both (Figure 35).

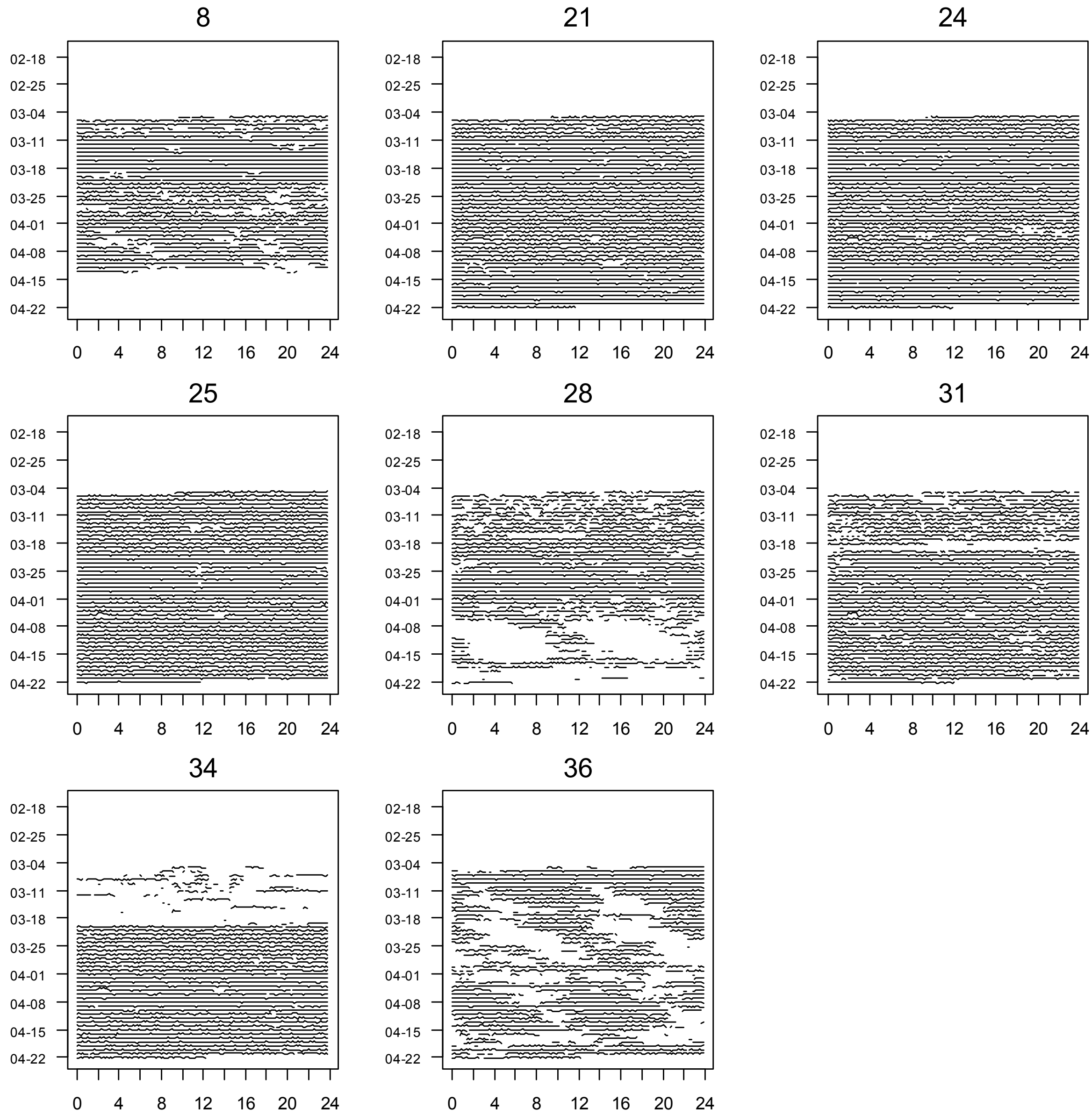


Figure 34: Detection plots (actograms) for scampi detected over 10000 times. Lines represent relative number of detections per 10 minute interval by date (y axis) and time of day (x axis).

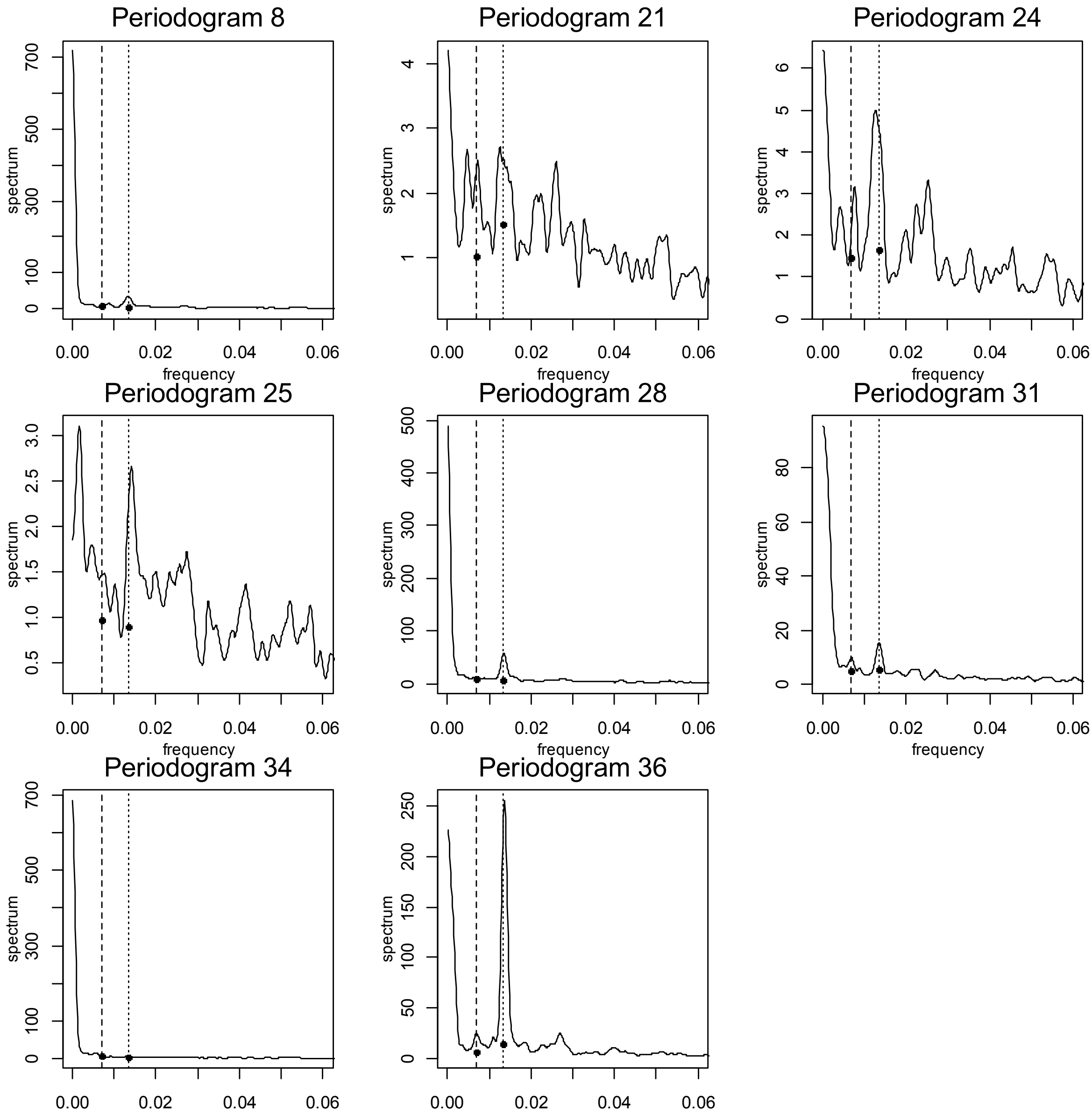


Figure 35: Smoothed periodogram for scampi with long periods of detections. Dashed line represents period of 24 hour cycle, dotted line represents period of 12.42 hour cycle. Closed symbols represent lower 95% confidence limits of the cycles at the 24 hour and 12.42 hour frequency.

Previous analyses of this type of scampi emergence data have combined data from a number of animals to estimate a population level detection pattern (Tuck et al. 2013; Tuck et al. 2015a; Tuck et al. 2015b). The tags have a nominal delay of 80 seconds, and so on average would be detected 7.5 times per 10 minute interval if they were continually available. Assuming that an animal would be seen if it is detectable more than 4 times per 10 minute interval, then the number of detectable animals (of the eight) can be estimated for each time interval. The periodogram for these combined data (Figure 36) shows weak evidence of 24 hourly and 12.42 hourly (tidal) periodicity in the numbers of scampi detectable. The previous application of this approach in SCI 1 and SCI 2 (Tuck et al. 2013; Tuck et al. 2015b) identified a clear daily and tidal periodicity in scampi detectability. The lack of any strong pattern in detectability in these data may relate to the low numbers of individuals included in the analysis.

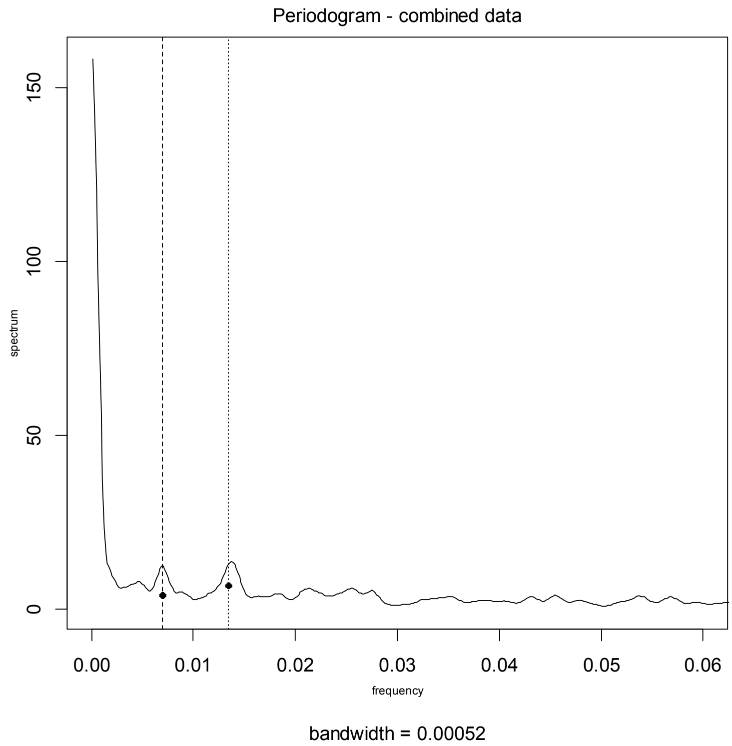


Figure 36: Smoothed periodogram of combined data for eight scampi from SCI 1.

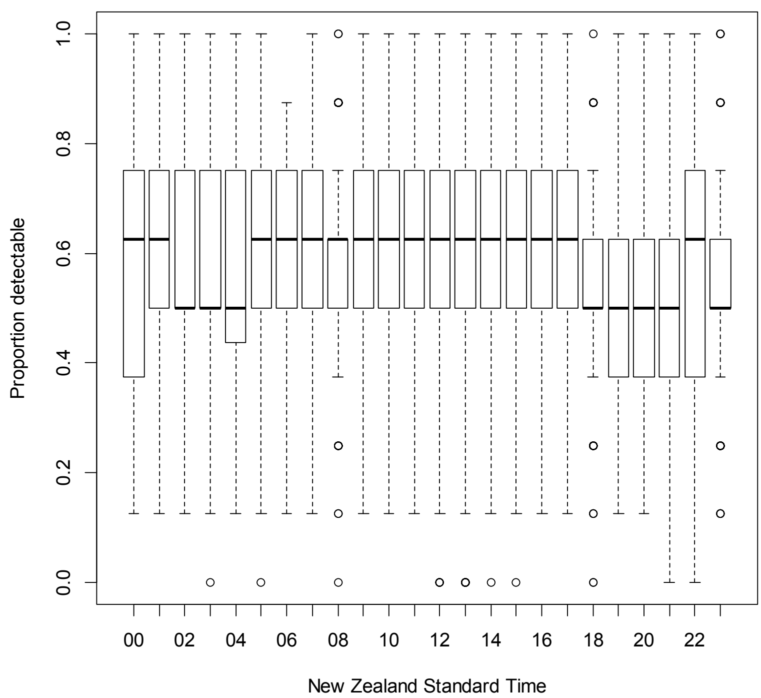


Figure 37: Boxplot of proportion detectable (individuals with at least 4 detections per 10 minute interval) in relation to time of day, averaged over full duration of SCI 1 study.

Over the whole deployment, the eight scampi were detectable (at least 4 detections per 10 minute interval) 57.4% of the time (mean value), with the 5% and 95% quantiles being 25.0% and 87.5%, respectively. There was some evidence of lower detectability between 0200 and 0400, and after 1800 (Figure 37).

Photographic surveys are only conducted during the hours of daylight. Limiting the analysis to the period between dawn and dusk increases the proportion detectable to 58.4%, with the 5% and 95% quantiles being 25.0% and 87.5%, respectively. Using the proportion detectable as an estimate of the proportion of scampi that would either be out of burrows or in their burrow entrance (as opposed to hidden within a burrow), the density of visible scampi from the survey can be scaled to a population density estimate, to in turn estimate burrow occupancy and various catchability terms (Table 25) required as priors in the assessment model (Tuck & Dunn 2012). Estimates from the 2015 SCI 1 survey vary from those previously estimated from SCI 1, but are likely to be sensitive to the low sample size, and potentially that tags showing little pattern in detectability (which might have a bigger effect in a smaller overall sample) may actually be dead animals, thus overestimating detectability and emergence.

Table 25: Best estimates of catchability terms for trawl caught scampi, visible scampi and scampi burrows, estimated from 2015 SCI 1 photo survey observations and scampi emergence study. Estimated values for 2012 SCI 1 (Tuck et al. 2015b) also provided for comparison.

	2015 SCI 1	2012 SCI 1	Source
Major opening	0.0888 m^{-2}	0.0772 m^{-2}	survey
Visible scampi	0.0184 m^{-2}	0.0174 m^{-2}	survey
Scampi "out"	0.0052 m^{-2}	0.0035 m^{-2}	survey
Scampi as % of openings	20.72%	22.6%	Visible/openings
% of scampi “out”	28.26%	20.3%	Out/visible
Median emergence	58%	46%	Acoustic tags
Estimated scampi density	0.0317 m^{-2}	0.0373 m^{-2}	Visible/emergence
Estimated occupancy	35.73%	49.3%	Est den/major
q trawl	0.164	0.094	Out/Est den
q scampi	0.58	0.46	Vis/Est den
q photo	2.799	2.012	Major/Est den

4. CONCLUSIONS

A photographic and trawl survey of scampi in SCI 1 and SCI 2 was conducted in February and March 2015, replicating the coverage of the 2012 surveys. For SCI 1, the photographic survey estimated a scampi burrow abundance of 161 million over the whole area, remaining similar to the 2012 estimate. Trawl survey catch rates in SCI 1 were also similar to 2012, and the estimate of scampi biomass over the whole SCI 1 survey area was 170 tonnes, compared to 186 tonnes in 2012. For SCI 2, the photographic survey estimated a scampi burrow abundance of 234 million over the whole area, continuing the increase in abundance since 2006. Trawl survey catch rates in SCI 2 also increased compared to 2012, and the estimate of scampi biomass over the whole SCI 2 survey area increased to 224 tonnes (164 tonnes in 2012), at a similar level to the highest biomass estimate of the early 1990s. Given that scampi live in burrows and are only available to trawl gear when they emerge on the seabed, these are likely to be considerable underestimates of the stock biomass.

Over the two surveys about 5600 scampi were tagged and released, as part of an investigation into growth, but to date, only 10 scampi have been recaptured. Eighty scampi were released with acoustic tags, divided between six hydrophone moorings, to investigate emergence patterns. The moorings were recovered after a 40 – 50 day deployment. Most tags were not detected after a few days, and of those that were detected through most of the deployment, few showed strong periodicity in detection. Of those tags considered to have continued operating throughout the deployment, scampi were estimated to have been detectable 58% of the time, with evidence of reduced detectability at night.

5. ACKNOWLEDGMENTS

This work would not have been possible without the advice and cooperation of the skipper and the crew of the *RV Kaharoa*. Derrick Parkinson led the voyage. Mooring positions were selected on the basis of advice from the fishing industry, and we are grateful for their cooperation in avoiding those locations during the duration of the mooring study. We thank the EPA for their help in complying with the requirements of the Exclusive Economic Zone and Continental Shelf Regulations 2013, in relation to deployment of the moorings. The acoustic moorings were provided by Mike Brewer and Fiona Elliot of the NIWA Marine Physics team. Scampi tag recoveries have been made and reported to NIWA by the fishing industry. The voyage was funded within project SCI201002D. This report was reviewed by Bruce Hartill.

6. REFERENCES

Aguzzi, J., Sarda, F., Abello, P., Company, J.B., Rotllant, G. (2003) Diel and seasonal patterns of *Nephrops norvegicus* (Decapoda : Nephropidae) catchability in the western Mediterranean. *Marine Ecology Progress Series*, 258: 201-211. <Go to ISI>://000185560800019

Bell, M.C., Redant, F., Tuck, I.D. (2006) *Nephrops* species. In: B. Phillips (Ed). *Lobsters: biology, management, aquaculture and fisheries*. Blackwell Publishing, Oxford: 412–461.

Cryer, M., Downing, K., Hartill, B., Drury, J., Armiger, H.J., Middleton, C., Smith, M.D. (2003a) Digital photography as a stock assessment tool for Metanephrops challengeri on New Zealand's continental slope. *FAO fisheries proceedings ; 3/1*, In:Deep Sea 2003 : Conference on the Governance and Management of Deep-sea Fisheries. Part 1. Conference reports. 1-5 December 2003, Queenstown, New Zealand / edited by Ross Shotton.: 299-307.

Cryer, M., Hartill, B., Drury, J., Armiger, H., Smith, M.D., Middleton, C. (2003b) Indices of relative abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in QMA 1 (1998–2003) and QMA 2 (2003). *Final Research Report for Ministry of Fisheries research project*, Objectives 1-3: 18.

Cryer, M., Hartill, B., Drury, J., Tuck, I.D., Armiger, H., Smith, M., Middleton, C. (2003c) Indices of relative abundance for scampi, *Metanephrops challengeri*, based on photographic surveys before and after fishing in QMA 3, 2001. *Final Research Report for Ministry of Fisheries research project*, Obj 3: 33.

Cryer, M., Hartill, B., Drury, J., Tuck, I.D., Cadenhead, H.J., Smith, M.D., Middleton, C. (2002) Indices of relative abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in QMA 1, 1998–2002. *Final Research Report for Ministry of Fisheries Research Project*.

Cryer, M., Stotter, D.R. (1997) Trawling and tagging of scampi off the Alderman Islands, western bay of Plenty, September 1995 (KAH9511). *New Zealand Fisheries Data Report*, 84.

Cryer, M., Stotter, D.R. (1999) Movement and growth rates of scampi inferred from tagging, Alderman Islands, western Bay of Plenty. *NIWA Technical Report No.*, 49.

Doonan, I.J., Rasmussen, S. (2012) Random Station User Manual (RandonStation v1.00-2012-06-13). *NIWA unpublished report*: 47.

Francis, R.I.C.C. (1999) The impact of correlations in standardised CPUE indices. *New Zealand Fisheries Assessment Research Document*: 30.

Francis, R.I.C.C. (2006) Optimum allocation of stations to strata in trawl surveys. *New Zealand Fisheries Assessment Report*, 2006/23: 50p.

Francis, R.I.C.C., Fu, D. (2012) SurvCalc v1.2. *NIWA Technical Report*, 134.

Froglia, C., Atkinson, R.J.A., Tuck, I.D., Arneri, E. (1997) Underwater television survey, a tool to estimate *Nephrops* stock biomass in the Adriatic trawling grounds. *Proceedings of the Croatian Acadamy, Split 1995*: 657–666.

ICES (2007) Report of the workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). *ICES ACFM*: 291.

Marrs, S.J., Atkinson, R.J.A., Smith, C.J. (1998) The towed underwater TV technique for use in stock assessment of *Nephrops norvegicus*. *ICES Report of the Study Group on life histories of Nephrops norvegicus*, La Coruna, Spain.,

Marrs, S.J., Atkinson, R.J.A., Smith, C.J., Hills, J.M. (1996) Calibration of the towed underwater TV technique for the use in stock assessment of *Nephrops norvegicus*. *Study project in support of the Common Fisheries Policy*: 155.

Sardà, F., Aguzzi, J. (2012) A review of burrow counting as an alternative to other typical methods of assessment of Norway lobster populations. *Reviews in Fish Biology and Fisheries*, 22(2): 409-422.

Smith, C.J., Marrs, S.J., Atkinson, R.J.A., Papadopoulou, K.N., Hills, J.M. (2003) Underwater television for fisheries-independent stock assessment of *Nephrops norvegicus* from the Aegean (eastern Mediterranean) Sea. *Marine Ecology Progress Series*, 256: 161–170.

Snedecor, G.W., Cochran, W.C. (1989) *Statistical Methods*. Iowa State University Press, Iowa.

Tuck, I.D. (2014) Characterisation and length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1) and Hawke Bay/Wairaraoa (SCI 2). *New Zealand Fisheries Assessment Report*, 2014/33: 172 p.

Tuck, I.D., Atkinson, R.J.A., Chapman, C.J. (1994) The structure and seasonal variability in the spatial distribution of *Nephrops norvegicus* burrows. *Ophelia*, 40: 13–25.

Tuck, I.D., Chapman, C.J., Atkinson, R.J.A., Bailey, N., Smith, R.S.M. (1997) A comparison of methods for the stock assessment of the Norway lobster, *Nephrops norvegicus* in the Firth of Clyde. *Fisheries Research*, 32: 89–100.

Tuck, I.D., Dunn, A. (2009) Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1) and Wairarapa / Hawke Bay (SCI 2). *Final Research Report for Ministry of Fisheries research projects*, Obj 1: 30.

Tuck, I.D., Dunn, A. (2012) Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1), Wairarapa / Hawke Bay (SCI 2) and Auckland Islands (SCI 6A). *New Zealand Fisheries Assessment Report*, 2012/1: 125 p.

Tuck, I.D., Hartill, B., Drury, J., Armiger, H., Smith, M., Parkinson, D. (2006) Measuring the abundance of scampi - Indices of abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in SCI 2 (2003-2006). *Final Research Report for Ministry of Fisheries research project*, Obj 1: 21.

Tuck, I.D., Hartill, B., Parkinson, D., Drury, J., Smith, M., Armiger, H. (2009a) Estimating the abundance of scampi - Relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 6A (2009). *Final Research Report for Ministry of Fisheries research project*, Objectives 1 & 2: 26.

Tuck, I.D., Hartill, B., Parkinson, D., Harper, S., Drury, J., Smith, M., Armiger, H. (2009b) Estimating the abundance of scampi - Relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 1 and SCI 6A (2008). *Final Research Report for Ministry of Fisheries research project*, Objectives 1 & 2: 37.

Tuck, I.D., Hartill, B., Parkinson, D., Smith, M., Armiger, H., Rush, N., Drury, J. (2011) Estimating the abundance of scampi – Relative abundance of scampi, Metanephrops challengeri, from photographic surveys in SCI 3 (2009 & 2010). *Final Research Report for Ministry of Fisheries research project*: 29.

Tuck, I.D., Parkinson, D., Armiger, H., Smith, M., Miller, A., Rush, N., Spong, K. (2015a) Estimating the abundance of scampi in SCI 6A (Auckland Islands) in 2013. *New Zealand Fisheries Assessment Report*, 2015/10: 52 p.

Tuck, I.D., Parkinson, D., Drury, J., Armiger, H., Miller, A., Rush, N., Smith, M., Hartill, B. (2012) Estimating the abundance of scampi in SCI 1 and SCI 2 (2012). *Final Research Report for Ministry for Primary Industries research project*: 53.

Tuck, I.D., Parkinson, D., Drury, J., Armiger, H., Miller, A., Rush, N., Smith, M., Hartill, B. (2013) Estimating the abundance of scampi - Relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 1 and SCI 2 (2012). *Final Research Report for Ministry of Fisheries research project*: 54.

Tuck, I.D., Parkinson, D., Hartill, B., Drury, J., Smith, M., Armiger, H. (2007) Estimating the abundance of scampi - relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 6A (2007). *Final Research Report for Ministry of Fisheries research project*, Objectives 1 & 2: 29.

Tuck, I.D., Parsons, D.M., Hartill, B.W., Chiswell, S.M. (2015b) Scampi (*Metanephrops challengeri*) emergence patterns and catchability. *ICES Journal of Marine Science*. 10.1093/icesjms/fsu244

Tuck, I.D., Spong, K. (2013) Burrowing megafauna in SCI 3. *New Zealand Fisheries Assessment Report*, 2013/20: 50p.

7. APPENDIX 1: SCI 1 Summary of photo survey workup

Uncorrected analysis

1998

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.1116	0.1784	0.1276	0.0992	0.1285
CV	0.35	0.29	0.29	0.18	0.15
Millions	29.24	47.46	48.51	28.77	153.97

Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0280	0.0247	0.0278	0.0124	0.0234
CV	0.57	0.24	0.30	0.49	0.22
Millions	7.33	6.58	10.56	3.59	28.05

Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0212	0.0093	0.0073	0.0012	0.0093
CV	0.75	0.43	0.49	0.82	0.43
Millions	5.55	2.48	2.77	0.36	11.16

Uncorrected analysis

2000

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	4	5	5	5	19
Mean (/sq m)	0.0984	0.0995	0.0708	0.0517	0.0786
CV	0.25	0.23	0.25	0.24	0.12
Millions	25.78	26.46	26.92	14.98	94.13

Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	4	5	5	5	19
Mean (/sq m)	0.0212	0.0142	0.0177	0.0074	0.0152
CV	0.28	0.23	0.38	0.50	0.18
Millions	5.54	3.79	6.74	2.15	18.22

Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	4	5	5	5	19
Mean (/sq m)	0.0071	0.0096	0.0077	0.0028	0.0068
CV	0.40	0.41	0.52	0.61	0.25
Millions	1.87	2.55	2.92	0.81	8.14

Uncorrected analysis

2001

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.1347	0.1209	0.0902	0.1061	0.1106
CV	0.29	0.15	0.31	0.07	0.12
Millions	35.30	32.17	34.27	30.76	132.50

Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0152	0.0066	0.0099	0.0096	0.0102
CV	0.39	0.21	0.36	0.92	0.27
Millions	3.98	1.76	3.75	2.78	12.27

Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0036	0.0005	0.0000	0.0030	0.0016
CV	0.64	1.00		1.00	0.55
Millions	0.95	0.14	0.00	0.86	1.95

Uncorrected analysis

2002

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	8	7	7	5	27
Mean (/sq m)	0.0787	0.1452	0.1076	0.1262	0.1141
CV	0.12	0.09	0.16	0.18	0.08
Millions	20.63	38.62	40.90	36.60	136.74

Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	8	7	7	5	27
Mean (/sq m)	0.0075	0.0182	0.0163	0.0102	0.0133
CV	0.28	0.27	0.43	0.53	0.21
Millions	1.96	4.85	6.19	2.96	15.96

Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	8	7	7	5	27
Mean (/sq m)	0.0010	0.0016	0.0039	0.0002	0.0018
CV	0.68	0.54	0.84	1.00	0.57
Millions	0.25	0.42	1.47	0.06	2.20

Uncorrected analysis

2003

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0764	0.1318	0.0702	0.0704	0.0853
CV	0.30	0.17	0.19	0.38	0.12
Millions	20.03	35.05	26.67	20.42	102.16
Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0174	0.0130	0.0088	0.0107	0.0121
CV	0.39	0.38	0.42	0.50	0.21
Millions	4.55	3.45	3.36	3.10	14.46
Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0010	0.0023	0.0018	0.0006	0.0015
CV	1.00	0.71	0.67	1.00	0.41
Millions	0.27	0.62	0.67	0.19	1.75

Uncorrected analysis

2008

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	10	9	10	10	39
Mean (/sq m)	0.0898	0.0935	0.0826	0.0698	0.0835
CV	0.13	0.16	0.15	0.15	0.08
Millions	23.53	24.87	31.39	20.23	100.02
Scampi	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	10	9	10	10	39
Mean (/sq m)	0.0132	0.0164	0.0080	0.0066	0.0107
CV	0.27	0.16	0.37	0.27	0.13
Millions	3.47	4.35	3.04	1.90	12.76
Out	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	10	9	10	10	39
Mean (/sq m)	0.0016	0.0055	0.0027	0.0007	0.0026
CV	0.91	0.31	0.67	0.89	0.30
Millions	0.42	1.47	1.04	0.21	3.15

Uncorrected analysis

2012

Major	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	9	11	10	10	11	9	40	60
Mean (/sq m)	0.0828	0.0654	0.0654	0.0943	0.0711	0.0882	0.0791	0.0774
CV	0.16	0.17	0.17	0.11	0.11	0.16	0.07	0.06
Millions	25.42	20.33	17.12	25.08	27.02	25.57	94.80	140.55
Scampi	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	9	11	10	10	11	9	40	60
Mean (/sq m)	0.0105	0.0146	0.0149	0.0149	0.0238	0.0246	0.0201	0.0175
CV	0.35	0.21	0.23	0.18	0.14	0.22	0.10	0.09
Millions	3.22	4.55	3.90	3.97	9.05	7.12	24.05	31.82
Out	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	9	11	10	10	11	9	40	60
Mean (/sq m)	0.0013	0.0035	0.0027	0.0027	0.0079	0.0018	0.0042	0.0036
CV	0.61	0.45	0.58	0.44	0.33	0.60	0.24	0.20
Millions	0.41	1.09	0.71	0.72	3.02	0.54	4.98	6.49

Uncorrected analysis

2015

Major	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	11	12	9	7	10	11	37	60
Mean (/sq m)	0.0882	0.0942	0.0605	0.1140	0.1034	0.0995	0.0954	0.0940
CV	0.10	0.07	0.11	0.05	0.16	0.08	0.06	0.05
Millions	27.08	29.29	15.85	30.32	39.28	28.87	114.31	170.69
Scampi	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	11	12	9	7	10	11	37	60
Mean (/sq m)	0.0059	0.0116	0.0101	0.0117	0.0172	0.0195	0.0150	0.0129
CV	0.21	0.17	0.33	0.22	0.26	0.24	0.14	0.11
Millions	1.81	3.60	2.64	3.12	6.55	5.67	17.98	23.39
Out	202	203	302	303	402	403	302–403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	11	12	9	7	10	11	37	60
Mean (/sq m)	0.0008	0.0022	0.0011	0.0014	0.0049	0.0055	0.0034	0.0028
CV	0.57	0.48	0.52	0.67	0.53	0.42	0.30	0.26
Millions	0.25	0.68	0.29	0.37	1.87	1.59	4.12	5.05

Reader_year corrected analysis

1998

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.1122	0.1786	0.1204	0.0929	0.1249
CV	0.35	0.29	0.29	0.18	0.15
Millions	29.39	47.50	45.76	26.94	149.59

Reader_year corrected analysis

2000

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	4	5	5	5	19
Mean (/sq m)	0.0984	0.0993	0.0704	0.0503	0.0781
CV	0.25	0.23	0.25	0.24	0.13
Millions	25.79	26.41	26.74	14.60	93.54

Reader_year corrected analysis

2001

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.1334	0.1208	0.0886	0.1054	0.1096
CV	0.29	0.15	0.31	0.07	0.12
Millions	34.94	32.12	33.68	30.57	131.31

Reader_year corrected analysis

2002

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	8	7	7	5	27
Mean (/sq m)	0.0723	0.1351	0.0990	0.1107	0.1040
CV	0.12	0.09	0.16	0.18	0.08
Millions	18.93	35.93	37.62	32.11	124.59

Reader_year corrected analysis

2003

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	5	5	5	5	20
Mean (/sq m)	0.0751	0.1222	0.0692	0.0667	0.0817
CV	0.30	0.17	0.19	0.38	0.12
Millions	19.69	32.51	26.29	19.34	97.83

Reader_year corrected analysis

2008

Major	302	303	402	403	Fishery
Area (sq km)	262	266	380	290	1198
Count (stations)	10	9	10	10	39
Mean (/sq m)	0.0914	0.0994	0.0843	0.0710	0.0860
CV	0.12	0.17	0.14	0.15	0.08
Millions	23.96	26.45	32.02	20.58	103.01

Reader_year corrected analysis

2012								
Major	202	203	302	303	402	403	302-403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	9	11	10	10	11	9	40	60
Mean (/sq m)	0.0911	0.0692	0.0668	0.0985	0.0754	0.0942	0.0832	0.0821
CV	0.16	0.17	0.16	0.10	0.10	0.14	0.06	0.06
Millions	27.97	21.52	17.51	26.20	28.64	27.31	99.65	149.14

Reader_year corrected analysis

2015								
Major	202	203	302	303	402	403	302-403	Fishery
Area (sq km)	307	311	262	266	380	290	1198	1816
Count (stations)	11	12	9	7	10	11	37	60
Mean (/sq m)	0.0840	0.0888	0.0575	0.1066	0.0977	0.0938	0.0873	0.0888
CV	0.11	0.07	0.12	0.05	0.16	0.07	0.07	0.05
Millions	25.79	27.63	15.07	28.36	37.14	27.20	104.59	161.18

8. APPENDIX 2: SCI 2 Summary of photo survey workup

Uncorrected analysis

2003

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	5	5	4	5	19
Mean (/sq m)	0.0543	0.0733	0.0857	0.0939	0.0756
CV	0.36	0.31	0.27	0.28	0.16
Millions	17.42	39.87	33.09	21.69	112.07
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	5	5	4	5	19
Mean (/sq m)	0.0054	0.0074	0.0074	0.0061	0.0068
CV	0.42	0.88	0.44	0.35	0.39
Millions	1.74	4.05	2.84	1.41	10.04
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	5	5	4	5	19
Mean (/sq m)	0.0000	0.0012	0.0000	0.0014	0.0006
CV		1.00		1.00	0.74
Millions	0.00	0.63	0.00	0.32	0.95

Uncorrected analysis

2004

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	8	11	5	32
Mean (/sq m)	0.0989	0.0966	0.0774	0.0558	0.0857
CV	0.21	0.19	0.37	0.41	0.13
Millions	31.74	52.54	29.88	12.89	127.05
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	8	11	5	32
Mean (/sq m)	0.0127	0.0151	0.0035	0.0015	0.0094
CV	0.41	0.38	0.64	1.00	0.26
Millions	4.06	8.23	1.34	0.35	13.99
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	8	11	5	32
Mean (/sq m)	0.0040	0.0034	0.0022	0.0000	0.0027
CV	0.71	0.50	1.00		0.39
Millions	1.28	1.83	0.83	0.00	3.94

Uncorrected analysis

2005

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0488	0.0530	0.0880	0.0826	0.0658
CV	0.21	0.36	0.23	0.20	0.14
Millions	15.68	28.82	33.97	19.08	97.54
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0071	0.0136	0.0081	0.0034	0.0092
CV	0.20	0.33	0.37	0.65	0.21
Millions	2.28	7.38	3.11	0.80	13.57
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0000	0.0026	0.0000	0.0000	0.0010
CV		1.00			1.00
Millions	0.00	1.41	0.00	0.00	1.41

Uncorrected analysis

2006

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0763	0.0542	0.0524	0.0698	0.0610
CV	0.21	0.14	0.25	0.30	0.10
Millions	24.51	29.49	20.21	16.12	90.33
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0122	0.0060	0.0075	0.0124	0.0087
CV	0.61	0.31	0.27	0.53	0.24
Millions	3.92	3.29	2.89	2.86	12.95
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0018	0.0008	0.0013	0.0012	0.0012
CV	0.55	0.67	0.57	1.00	0.33
Millions	0.59	0.45	0.52	0.28	1.84

Uncorrected analysis

2012

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	14	15	6	43
Mean (/sq m)	0.0807	0.0706	0.0654	0.0889	0.0743
CV	0.16	0.23	0.16	0.22	0.11
Millions	25.91	38.42	25.24	20.53	110.09
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	14	15	6	43
Mean (/sq m)	0.0258	0.0185	0.0221	0.0228	0.0217
CV	0.21	0.26	0.21	0.23	0.12
Millions	8.28	10.05	8.52	5.27	32.11
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	14	15	6	43
Mean (/sq m)	0.0020	0.0018	0.0030	0.0027	0.0023
CV	0.40	0.42	0.28	0.58	0.20
Millions	0.64	0.95	1.17	0.63	3.39

Uncorrected analysis

2015

Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	18	9	5	39
Mean (/sq m)	0.1468	0.1289	0.1162	0.1563	0.1338
CV	0.09	0.11	0.11	0.25	0.07
Millions	47.13	70.15	44.87	36.11	198.25
Scampi	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	18	9	5	39
Mean (/sq m)	0.0422	0.0120	0.0297	0.0235	0.0249
CV	0.13	0.17	0.14	0.37	0.09
Millions	13.55	6.51	11.46	5.43	36.96
Out	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	18	9	5	39
Mean (/sq m)	0.0205	0.0025	0.0098	0.0023	0.0083
CV	0.20	0.34	0.20	0.44	0.13
Millions	6.59	1.34	3.79	0.53	12.24

Reader_year corrected analysis

2003					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	5	5	4	5	19
Mean (/sq m)	0.0526	0.0702	0.0697	0.0801	0.0678
CV	0.36	0.31	0.27	0.28	0.16
Millions	16.88	38.16	26.89	18.51	100.44

Reader_year corrected analysis

2004					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	8	11	5	32
Mean (/sq m)	0.1147	0.1144	0.1023	0.0795	0.1059
CV	0.21	0.19	0.37	0.41	0.14
Millions	36.83	62.23	39.49	18.37	156.92

Reader_year corrected analysis

2005					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0401	0.0675	0.0646	0.0787	0.0625
CV	0.21	0.36	0.23	0.20	0.17
Millions	12.86	36.70	24.95	18.18	92.70

Reader_year corrected analysis

2006					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	9	7	6	29
Mean (/sq m)	0.0598	0.0443	0.0406	0.0577	0.0488
CV	0.21	0.14	0.24	0.30	0.11
Millions	19.21	24.09	15.69	13.33	72.31

Reader_year corrected analysis

2012					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	8	14	15	6	43
Mean (/sq m)	0.0962	0.0690	0.0704	0.0922	0.0789
CV	0.17	0.20	0.15	0.16	0.09
Millions	30.87	37.56	27.19	21.29	116.90

Reader_year corrected analysis

2015					
Major	702	703	802	803	Fishery
Area (sq km)	321	544	386	231	1482
Count (stations)	7	18	9	5	39
Mean (/sq m)	0.1771	0.1519	0.1384	0.1783	0.1580
CV	0.07	0.10	0.09	0.23	0.06
Millions	56.85	82.64	53.41	41.18	234.08

9. APPENDIX 3: Acoustic tagging data

Transmitter (scampi)	Mooring 1 Bottom	Mooring 1 Top	Mooring 2 Bottom	Mooring 2 Top	Mooring 4 Bottom	Mooring 4 Top	Mooring 5 Bottom	Mooring 5 Top	Mooring 6 Bottom	Mooring 6 Top	Deployment	Last date	Days at liberty
A69-1601-21705	0	0	0	0	0	0	2	1	80	89	4/03/2015	11/03/2015	7
A69-1601-21704	0	0	0	0	0	0	2	2	47	33	4/03/2015	21/03/2015	16
A69-1601-21703	0	0	0	0	0	0	19	19	498	544	4/03/2015	1/04/2015	28
A69-1601-21702	0	0	0	0	0	0	3	4	54	33	4/03/2015	21/03/2015	16
A69-1601-21701	0	0	0	0	0	0	0	0	183	223	4/03/2015	14/03/2015	10
A69-1601-21700	0	0	0	0	0	0	2	3	33	18	4/03/2015	21/03/2015	16
A69-1601-21699	0	0	0	0	0	0	17	19	112	59	4/03/2015	19/04/2015	46
A69-1601-21698	0	0	0	0	0	0	0	0	20515	21573	4/03/2015	13/04/2015	40
A69-1601-21697	0	0	0	0	0	0	0	1	42	13	4/03/2015	21/03/2015	16
A69-1601-21696	0	0	0	0	0	0	0	0	313	230	4/03/2015	6/03/2015	1
A69-1601-21695	0	0	0	0	0	0	1	0	43	35	4/03/2015	21/03/2015	16
A69-1601-21694	0	0	0	0	0	0	0	0	28	24	4/03/2015	4/03/2015	0
A69-1601-21693	0	0	0	0	0	0	0	0	305	138	4/03/2015	5/03/2015	1
A69-1601-21692	0	0	0	0	0	0	0	0	111	81	4/03/2015	5/03/2015	0
A69-1601-21691	0	0	0	0	0	0	57	58	0	0	4/03/2015	5/03/2015	0
A69-1601-21690	0	0	0	0	0	0	155	161	0	0	4/03/2015	18/04/2015	45
A69-1601-21689	0	0	0	0	0	0	91	80	0	0	4/03/2015	13/03/2015	8
A69-1601-21688	0	0	0	0	0	0	38	37	0	0	4/03/2015	4/03/2015	0
A69-1601-21687	0	0	0	0	0	0	49	23	0	0	4/03/2015	5/03/2015	0
A69-1601-21686	0	0	0	0	0	0	44	38	0	0	4/03/2015	5/03/2015	0
A69-1601-21685	0	0	0	0	0	0	26215	16697	0	0	4/03/2015	21/04/2015	48
A69-1601-21684	0	0	0	0	0	0	53	57	0	0	4/03/2015	5/03/2015	0
A69-1601-21683	0	0	0	0	0	0	34	19	0	0	4/03/2015	4/03/2015	0
A69-1601-21682	0	0	0	0	0	0	26308	18807	0	0	4/03/2015	21/04/2015	48
A69-1601-21681	0	0	0	0	0	0	26535	19521	0	0	4/03/2015	21/04/2015	48
A69-1601-21680	0	0	0	0	0	0	74	68	0	0	4/03/2015	23/03/2015	18
A69-1601-21679	0	0	0	0	0	0	191	188	0	0	4/03/2015	7/03/2015	2
A69-1601-21678	0	0	0	0	15879	7347	0	0	0	0	4/03/2015	21/04/2015	48
A69-1601-21677	0	0	0	0	242	130	0	0	0	0	4/03/2015	11/03/2015	6
A69-1601-21676	0	0	0	0	79	63	0	0	0	0	4/03/2015	9/03/2015	5
A69-1601-21675	0	0	0	0	22936	3551	0	0	0	0	4/03/2015	22/04/2015	48
A69-1601-21674	0	0	0	0	187	49	0	0	0	0	4/03/2015	17/04/2015	44
A69-1601-21673	0	0	0	0	33	23	0	0	0	0	4/03/2015	4/03/2015	0
A69-1601-21672	0	0	0	0	19220	15326	0	0	0	0	4/03/2015	22/04/2015	48
A69-1601-21671	0	0	0	0	116	45	0	0	0	0	4/03/2015	8/03/2015	4
A69-1601-21670	0	0	0	0	16560	25928	0	0	0	0	4/03/2015	22/04/2015	48
A69-1601-21669	0	0	0	0	2409	1398	0	0	0	0	4/03/2015	12/03/2015	8
A69-1601-21668	0	0	0	0	54	24	0	0	0	0	4/03/2015	16/03/2015	12
A69-1601-21667	0	0	0	0	52	50	0	0	0	0	4/03/2015	5/03/2015	0
A69-1601-21666	0	0	0	0	50	40	0	0	0	0	4/03/2015	8/03/2015	3
A69-1601-21664	8	13	4	3	0	0	0	0	0	0	9/03/2015	12/03/2015	3
A69-1601-21655	8	15	5	4	0	0	0	0	0	0	22/03/2015	28/03/2015	6
A69-1601-21654	0	0	3	2	0	0	0	0	0	0	7/03/2015	9/03/2015	1
A69-1601-21652	11	16	6	7	0	0	0	0	0	0	22/03/2015	30/03/2015	8
A69-1601-21651	0	0	33	32	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21650	0	0	18	19	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21649	9	0	24	18	0	0	0	0	0	0	16/02/2015	25/02/2015	9
A69-1601-21648	0	0	53	45	0	0	0	0	0	0	16/02/2015	17/02/2015	0
A69-1601-21647	0	0	811	944	0	0	0	0	0	0	16/02/2015	19/02/2015	3
A69-1601-21646	0	0	200	244	0	0	0	0	0	0	16/02/2015	17/02/2015	0
A69-1601-21645	12	24	64	55	0	0	0	0	0	0	16/02/2015	17/03/2015	29
A69-1601-21644	0	0	21	20	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21643	0	0	53	42	0	0	0	0	0	0	16/02/2015	17/02/2015	0
A69-1601-21642	0	0	9	5	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21641	0	0	42	38	0	0	0	0	0	0	16/02/2015	17/02/2015	0
A69-1601-21640	0	0	37	15	0	0	0	0	0	0	16/02/2015	16/03/2015	27
A69-1601-21639	0	0	27	31	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21638	80	85	0	0	0	0	0	0	0	0	16/02/2015	1/03/2015	12
A69-1601-21637	73	88	5	6	0	0	0	0	0	0	16/02/2015	12/03/2015	23
A69-1601-21636	124	127	3	3	0	0	0	0	0	0	16/02/2015	22/03/2015	33
A69-1601-21635	915	1105	0	0	0	0	0	0	0	0	16/02/2015	24/02/2015	7
A69-1601-21634	44	41	3	2	0	0	0	0	0	0	16/02/2015	17/03/2015	29
A69-1601-21633	446	1465	0	0	0	0	0	0	0	0	16/02/2015	2/03/2015	14
A69-1601-21632	43	40	0	0	0	0	0	0	0	0	16/02/2015	16/02/2015	0
A69-1601-21631	77	74	2	3	0	0	0	0	0	0	16/02/2015	18/03/2015	30
A69-1601-21630	163	183	0	0	0	0	0	0	0	0	16/02/2015	17/02/2015	0
A69-1601-21629	75	124	10	6	0	0	0	0	0	0	16/02/2015	25/03/2015	36
A69-1601-21628	136	156	5	4	0	0	0	0	0	0	16/02/2015	18/03/2015	30
A69-1601-21626	85	109	4	3	0	0	0	0	0	0	16/02/2015	26/03/2015	38