NIWA
Taihoro Nukurangi

Indices of abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in QMA 2 (2003 and 2004)

Martin Cryer
Bruce Hartill
Jim Drury
Crispin Middleton
Helena Armiger
Matt Smith

Final Research Report for
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SCI2003/02 (Objectives 1 & 2)

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FINAL RESEARCH REPORT

1. **Date:** 31 October 2004

2. **Contractor:** National Institute of Water & Atmospheric Research Ltd

3. **Project Title:** "Measuring the abundance of scampi"

4. **Project Codes:** SCI 2003/02

5. **Project Leader:** Martin Cryer

6. **Duration of Project:**

Start date:	15 December 2003
Expected completion date:	30 September 2004

7. **Executive Summary:**

The second photographic survey of scampi burrows and visible animals in QMA 2 was completed in February 2004, including 40 stations spread among strata 701, 702, 703, 801, 802, and 803. The total area accepted for screening was 4 700 m^2 from 1298 images (compared with 5 157 m^2 from 788 images in 2003), at an average of 3.62 m^2 per image (about 45% smaller than the mean of 6.54 m^2 per image in 2003 to counter the effects of lower water clarity, especially in shallow stations). Six readers applied a rigorous screening protocol to these images. The overall density of visible scampi (and, hence, minimum absolute biomass) in the core area of the QMA 2 scampi trawl fishery in 2004 was 0.009 m^{-2}, about double the 0.004 m^{-2} recorded in QMA 2 in 2003 and similar to recent results for QMA 1. Based on these first two estimates of minimum absolute biomass, the current catch limit of 245 t in QMA 2 is between 35 and 70% of total biomass. This estimate may be conservative because it can be expected that not all scampi will have been visible at the time of the survey. However, the estimate of average weight (35.4 g) came from a QMA 1 photographic length frequency distribution and an analogous estimate has not yet been derived for QMA 2. The estimated density of major openings in QMA 2 in 2004 was 0.074 m^{-2}, very similar to the 0.067 m^{-2}, recorded in 2003, but slightly lower than recent results in QMA 1. Based on these first two burrow density estimates, an assumed occupancy of 100%, and the same average weight, biomass in QMA 2 from burrow counts was estimated to be about 6 000 t. The current catch limit of 245 t is about 4% of this biomass, but this estimate may not be conservative because not all burrows may be occupied and unobserved animals may be smaller than those used to estimate the length frequency distribution and, hence, average weight.

8. Objectives:

Overall Objective:

1. To estimate the abundance of scampi (*Metanephrops challengeri*).

Specific Objectives:

1. To estimate the relative abundance of scampi using photographic techniques in QMA 2 during February-March 2004.

2. To update the relative abundance index for scampi in QMA 2.

9. Methods:

9.1 Field sampling

In early 2003 and 2004, we undertook stratified random photographic surveys of scampi burrows within the core area of the QMA 2 scampi fishery, Mahia Peninsula to Castle Point, 200–500 m depth (Figure 1). We used custom built digital camera systems based on 1.3 Megapixel (Mp) *Minolta D'Image EX1500* cameras (2003) or 5.0 Mp *Nikon Coolpix 5000* (2004) cameras. We conducted complementary trawling and acoustic sampling during both surveys. Positions of stations within strata were randomised using RAND_STN (v 1.7 for PCs; MAF Fisheries 1990) arbitrarily constrained to keep the midpoints of all stations at least 1 km apart (although Watson & Cryer (2003) found very little spatial autocorrelation in QMA 1 surveys). Both QMA 2 surveys were conducted using a single transect of (nominally) 40 photographs at each station, compared with older designs of several shorter transects of fewer photographs in each (Cryer et al. 2003). This was originally a result of a shortage of time, but the efficacy of this approach was confirmed by the results of a study of the effects of spatial distribution of scampi burrows on survey design and efficiency (Watson & Cryer 2003). Within a transect, photographs were taken as the ship drifted, using a time delay sufficient to ensure that adjacent photographs did not overlap (Cryer & Hartill 1998, Cryer et al. 2001). We took photographs 3–5 m from the seabed (closer in 2004 than in 2003) using custom-built steel cages suspended on a trawl warp. The camera was triggered using an interval timer. Image sizes were estimated using parallel lasers 200 mm apart on the camera frame; two red dots from the lasers are visible in almost all images, and these were used to estimate the linear dimensions of the image and its area.

9.2 Image selection and scoring

Images were examined and scored using a standardised protocol (developed under project SCI2000/02, Cryer et al. 2002) applied by a team of six trained readers. For each image, the main criteria of usability are 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 are met, the image is "adopted" and "initiated" (see Appendices in Cryer et al.

2002). The percentage of the frame within which the seabed is clearly and sharply visible is estimated and marked using polygons in "Didger" image analysis software. Each reader then assesses 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 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 2). We classify 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. 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 (assuming that burrow occupancy is high). Many ICES stock assessments of the related *Nephrops norvegicus* are conducted using relative abundance indices based on counts of "burrows" (rather than burrow openings) (Tuck et al. 1994, 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 (e.g., Marrs et al. 1998).

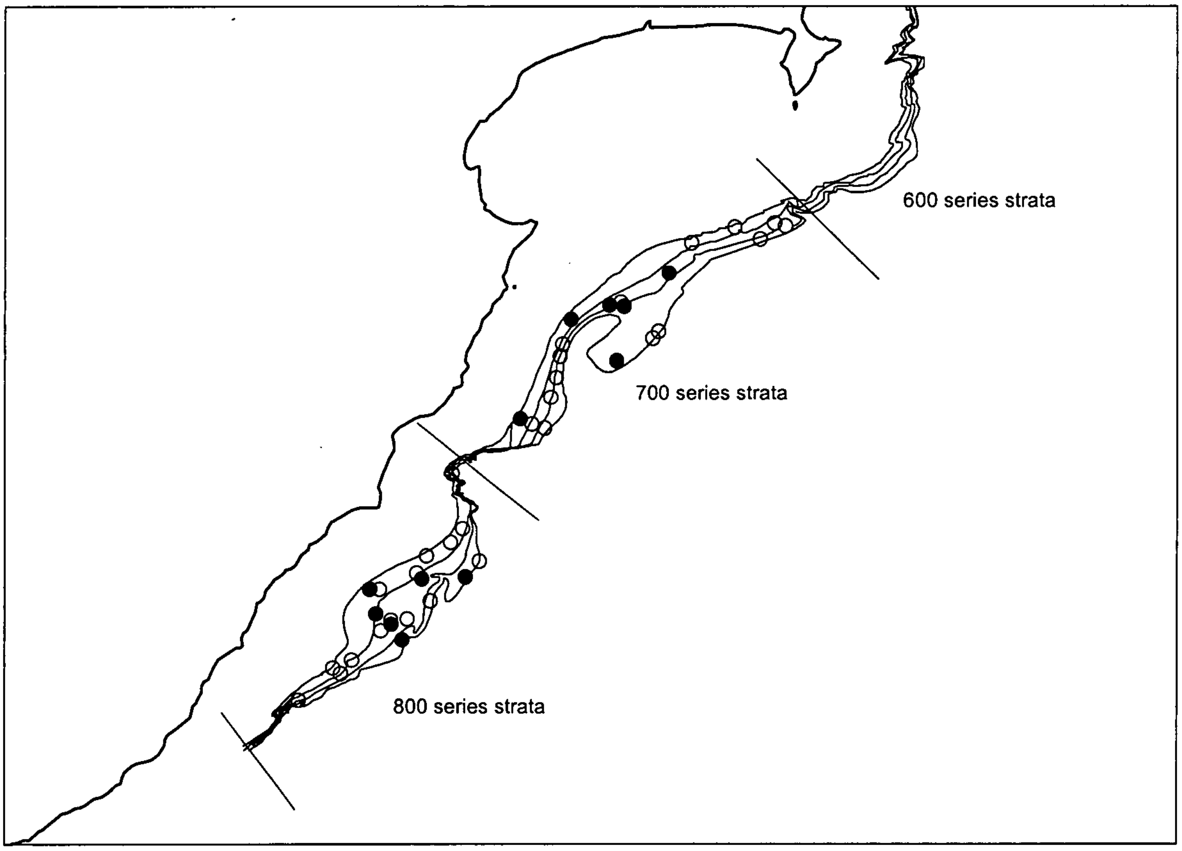

Figure 1: Location of stations where photographic transects (open symbols) and both photographic transects and trawling (closed symbols) were completed during the photographic survey of scampi and scampi burrows in the main area of the QMA 2 fishery in January–February, 2004.

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 (see Appendices in 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" (not "maybe") a scampi burrow. Scores are recorded in spreadsheets and annotated, low resolution copies (one for each reader) of the image files (to establish 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 is more than 1 are re-examined by all readers (who may or may not change their score). 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 read 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, all are encouraged 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.

9.3 Data analysis

Counts from photographs were analysed using methods analogous to those in the *Trawlsurvey* Analysis Program (Vignaux 1994) for trawl surveys. 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) images with a very small (< 1 m^2) or very large (> 16 m^2) readable area were excluded. This was a small proportion (5%) of all images. The mean density of burrow openings at a given station was estimated as the sum of all counts (major or minor openings or scampi) 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 the stratum were 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 given by Snedecor and 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.

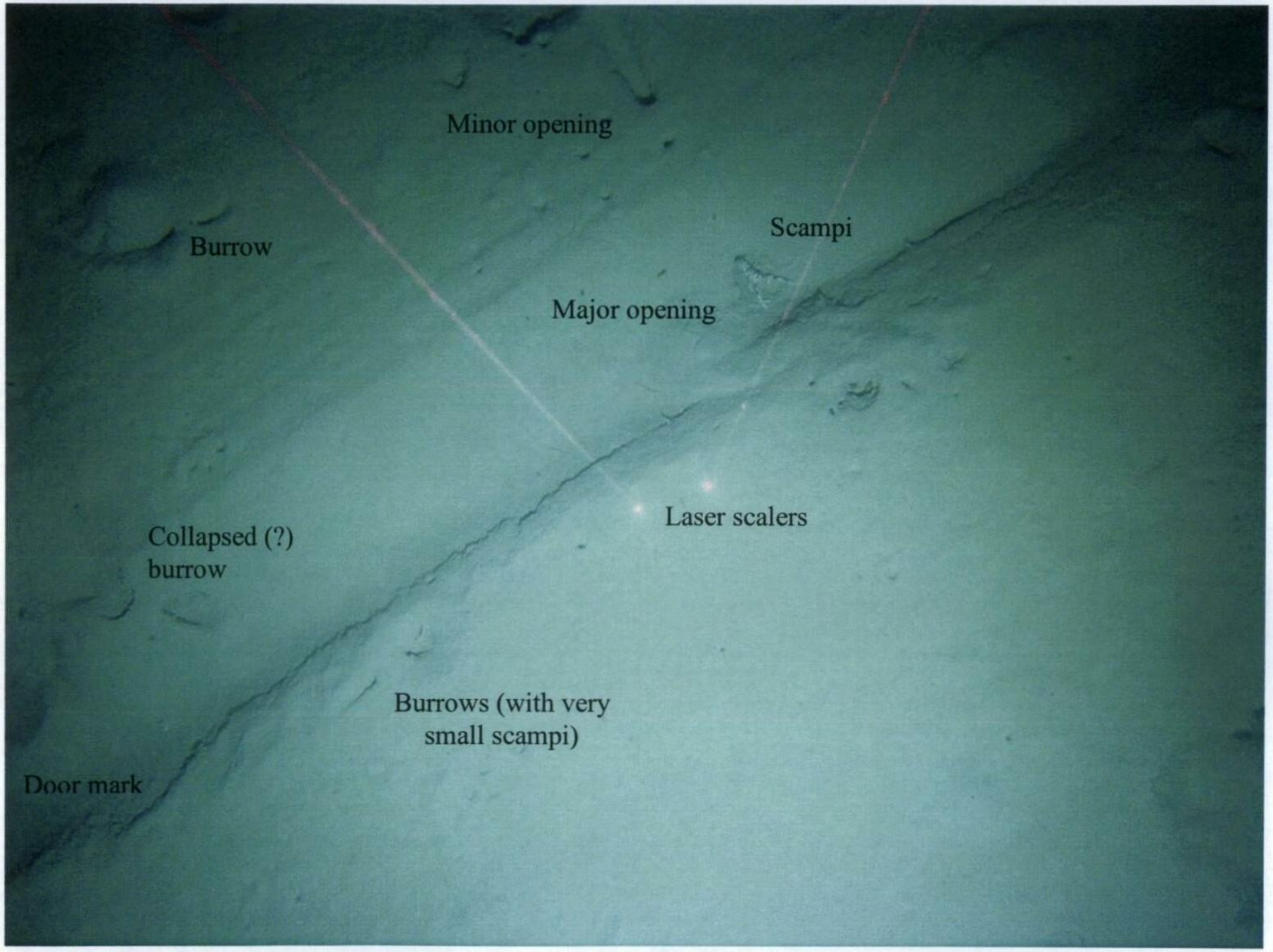

Figure 2: Sample image from April 2002 survey in QMA 1 showing laser scaling dots, several characteristic scampi burrows, one large and one very small visible scampi, and a seabed mark probably caused by a trawl door.

Comparable estimates of relative abundance (with estimated CV's) were generated for surveys of the core area of the QMA 2 scampi fishery in 2003 and 2004. 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 Shellfish Fishery Assessment Working Group has agreed that these are likely to be the most reliable indices. The minor sensitivity of the indices to the reader "bias" identified by Cryer et al. (2002) has not yet been assessed by "correcting" the counts made by each reader, but this will be done from the third and subsequent surveys (before using the results in a stock assessment model).

10. Results:

10.1 Images potentially available for indices of relative abundance

Excluding images with estimated areal coverage of less than 1 m^2 or more than 16 m^2 changed the three reported indices by 5% or less, and not always in the same direction, so we think it had very little effect on any trends. The mean number of photographs accepted for a station in QMA 2 in 2004 was 32.4, compared with 30.3 in 2003. The total area accepted for screening (i.e., excluding all poor photographs and all parts of acceptable photographs occluded by silt or grossly over- or under-exposed) was 9 857 m^2 for an overall average of 4.72 m^2 per image. This is considerably smaller than the average image area for QMA 1 as a result of the cloudier near-bottom conditions in QMA 2, especially at "shallower" stations. The availability of better equipment in 2004 allowed us to vary the camera's distance off-bottom (and consequent image size) in response to changing turbidity, largely explaining the decrease from 6.54 m^2 per image in 2003 to 3.62 m^2 per image in 2004.

10.2 Indices of abundance and biomass in QMA 2

The estimated overall density of major burrow openings in QMA 2 in 2004 was 0.074 m^{-2} (Table 1), about 10% higher than the 0.067 m^{-2} recorded in 2003 and 15% lower than the last observed density in QMA 1 (0.085 m^{-2} in 2003, Cryer et al. 2003). The distribution of burrows among strata was quite even (range 0.05–0.12 m^{-2}) compared with 2003 when the two shallowest strata (200–400 m depth) in Hawke Bay had very low densities (0.02 m^{-2}). The estimated density of visible scampi (a much less equivocal estimate than that of burrow openings) was 0.009 m^{-2} in QMA 2 in 2004, about double the 0.004 m^{-2} recorded in 2003, and similar to the 0.012 m^{-2} recorded in QMA 1 in 2003. Most of the increase in visible scampi was in the deeper strata, and we observed only one scampi on the seabed surface in water shallower than 300 m (none in 2003). We classified about one-third of the visible scampi as being out of their burrows in 2004, compared with only about 10% in 2003. Scaling the estimated density of visible scampi by the combined area of the sampled strata (2363 km^2) leads to an estimated abundance of 20.4 million animals, and scaling this by the estimated average weight of 35.4 g (from QMA 1, Cryer et al. (2001)) leads to a "near-minimum" biomass estimate of 720 t. By similar arithmetic, the estimated density of major burrow openings suggests an abundance of 174.7 million, and a biomass of 6184 t, assuming 100% occupancy and the same average weight.

Table 1: Comparison of estimated mean densities (m^{-2}) of major burrow openings, visible scampi, and scampi free of burrows in QMA2 2003 and 2004. The reported ratio is the estimated density in 2004 divided by that in 2003.

	2003		2004		
Measure	Density	C.V. (%)	Density	C.V. (%)	Ratio
Major openings	0.0667	11.5%	0.0739	11.2%	1.108
All scampi	0.0042	38.6%	0.0086	27.2%	2.048
Scampi "out"	0.0004	74.3%	0.0027	43.8%	6.750

Table 2: Estimates of the abundance (millions) of major burrow openings and visible scampi within the core area of the QMA 2 scampi fishery (strata 701, 702, 703, 801, 802, 803) in 2003 and 2004.

	Major burrow openings			Visible scampi		
	Abundance (millions)	Biomass (t)	C.V. (%)	Abundance (millions)	Biomass (t)	C.V. (%)
2003	157.7	5 583	11.5	10.0	355	38.6
2004	174.7	6 184	11.2	20.4	721	27.2

At this stage it is not possible to be certain which is the best index of abundance for scampi. An index based on the density of characteristic burrows should not be affected by changes in emergence behaviour in scampi and can be estimated using photographs taken at any time of day (although it would be badly affected by changes in occupancy rate). Results from photographic surveys before and after the short fishing season in QMA 3 (Cryer et al. 2003), however, suggest that there may be major seasonal changes in the density or characteristics of burrows, as there is for *Nephrops norvegicus* ((ICES1998). This would militate against indices based on burrow densities estimated at different times of year. Indices of absolute abundance based on visible scampi are almost certainly negatively biased, and will also be affected by the seasonal and diel timing of photography (because emergence behaviour is likely to vary daily and seasonally, Cryer & Oliver 2001).

Our "minimum" biomass estimates suggest that current landings of scampi from QMA 2 (245 t) could represent a substantial fraction of the QMA 2 biomass (69% using the 2003 data, 34% using 2004 data). Conversely, biomass estimates made from burrow counts suggest that fishing takes a relatively small fraction of total biomass, (4.4% in 2003, 4.0% in 2004). It is not possible to say which of these is the more likely but, clearly, assuming that the exploitation rate is quite high would be more precautionary. Given that we have conducted only two surveys in QMA 2, it may not be realistic to compare trends in our indices with trends in CPUE. However, the most recent update (Hartill & Cryer 2004) included data up to September 2003, roughly half way between our two surveys. That analysis (Figure 4) suggested a modest increase in commercial CPUE (standardised only by restricting the analysis to key vessels) in the most recent year, after a consistent decline since about 1995. This is consistent with our observed increase in the density of visible scampi.

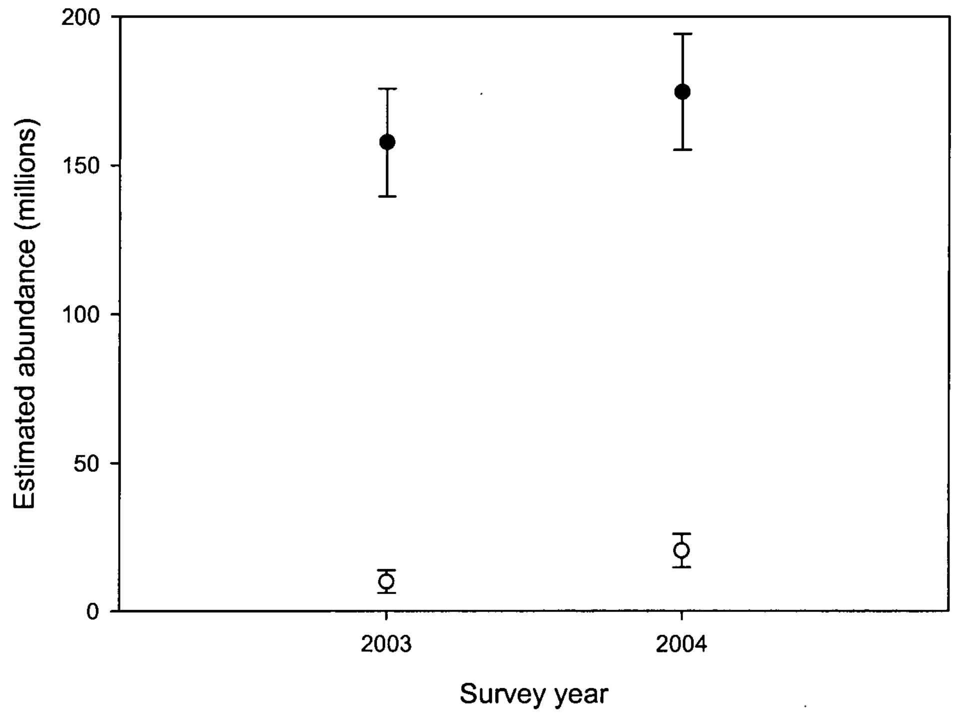

Figure 3: Estimated abundance (± one standard error) of major burrow openings and visible scampi within the core area of the QMA 2 scampi fishery (strata 701, 702, 703, 801, 802, 803) in 2003 and 2004.

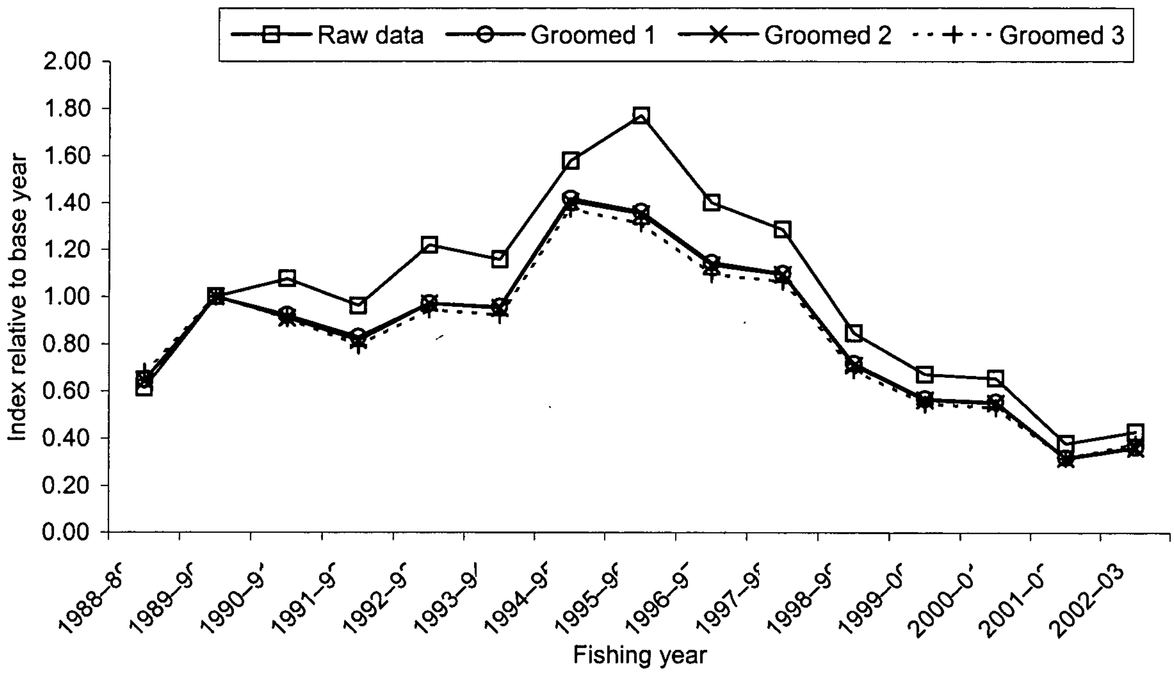

Figure 4: Indices of unstandardised catch rate (total catch divided by total effort, hours) for QMA 2 calculated using data from those four vessels that fished throughout the period. "Raw data", all data with no grooming; "Groomed 1", groomed data with irreconcilable errors included; "Groomed 2", groomed data with irreconcilable errors excluded; "Groomed 3", groomed data with irreconcilable errors and tows with a zero catch of scampi excluded. After Hartill & Cryer 2004.

11. Conclusions:

1. Two photographic surveys of scampi burrows in the core part of the QMA 2 scampi fishery were conducted in 2003 and 2004. About 800 images were adopted for quantitative analysis from the 2003 survey, about 1300 (smaller) images in 2004. The area of seabed screened was similar for the two surveys (~5000 m^2).

2. The density of visible scampi in the core area of QMA 2 (Mahia to Castle Point, 200–500 m depth) was lower than in QMA 1 in 2003, but had increased to a similar level to QMA 1 by 2004. This is broadly consistent with commercial CPUE in QMA 2 but the high CVs render any inferences about trends purely speculative.

3. There was no significant difference between the 2003 and 2004 estimates of the density of major burrow openings in the core area of QMA 2. Their density is slightly lower than in QMA 1.

4. Recent average landings of scampi from QMA 2 represent about 34–69% of our minimum estimates of biomass (calculated from the density of visible scampi and a photographic estimate of mean animal weight from QMA 1), and the current catch limit of 245 t is about 34% of the 2004 minimum biomass estimate. These estimates may be conservative.

5. Biomass estimates made by scaling estimates of burrow abundance by mean animal weight (thereby assuming 100% burrow occupancy and similar sizes of hidden and visible animals) suggest that the current catch limit of 245 t in QMA 2 is about 4% of total biomass. These estimates may not be conservative.

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12. Publications:

There are no publications related to Objectives 1 and 2 other than a Voyage Programme and a Voyage Report for voyage KAH0401. Objective 3 (developing a length-based model for scampi in QMA 1) is being documented separately.

13. Data Storage:

Data from trawl and photographic stations are in the Empress database *trawl*. Original and annotated photographic images are held as lightly compressed JPEG files on a secure, backed-up server and in three additional copies on CD-ROM at two different NIWA sites. Copies have also been provided for the Ministry's Data Manager at Greta Point. Image details and records of readings are centralised in a formal MS-Access database on a secure, backed-up server at NIWA Auckland. Various analytical files in MS-Excel and presentations in MS-PowerPoint reside on the same server. These will be copied to the Ministry's Data Manager at Greta Point on completion of the project.