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EXECUTIVE SUMMARY

The ECSI summer trawl survey was discontinued in 2001, leaving no survey-based method to monitor the status of inshore demersal species. Even though the ECSI trawl survey was reinstated as a winter survey in 2007, it was expressly not optimised to estimate biomass for elephantfish (ELE), red gurnard (GUR), or the flatfish complex (FLA). This was because the timing was considered to be suboptimal for elephantfish, the minimum depth was not appropriate for red gurnard, and the trawl gear was not appropriate for all flatfish species. To monitor the status of these groups in a cost-effective manner, an industry vessel based "hybrid" survey has been proposed, essentially adding quantitative survey tows to normal fishing activities in predetermined random locations to build a survey dataset over time.

Translating this concept into a quantitative survey design with supporting logistical detail is an indispensable exercise, and is the objective of this project. We developed a scope and overall survey design, in terms of area to be surveyed, depth range, sample size, and timing. We then described four survey platform options, consisting of: a single "hybrid" vessel adding survey tows during a fishing trip, a multiple vessel "hybrid" design with three vessels conducting survey tows while fishing, a dedicated survey on a single vessel where all tows are survey tows, and finally a modification of the current *Kaharoa* winter survey to address the survey needs for these species.

The four alternative survey approaches are compared and contrasted for a number of logistical, effectiveness, and cost criteria. This report details the positive and negative aspects of each approach as a basis for making future survey design specifications.

Several recommendations were made.

- A survey scope of January to February with a depth range of 10–60m will sample ELE, GUR, and FLA well.
- If FLA is not a priority, then a *Kaharoa* survey is economical, standardised, and would provide the most data (target and ancillary species). FLA may be better monitored using alternative methods such as improved data collection on catch, or a focused recruitment index.
- If new gear and shallow fishing are required, multiple hybrid vessels are less expensive than a dedicated contract vessel (assuming no charter cost), but are also long duration and most likely to fail for logistical reasons.
- Augmenting the *Kaharoa* survey would result in additional benefits of the collecting ancillary data on other species, potentially reducing the coefficient of variation (c.v.) on other target species due to the increase in number of tows, and better standardisation in data analysis.
- Additional work is needed to examine the spatial distribution of tows in existing surveys relative to phase II station allocation, and species distribution, especially for ELE and GUR. This analysis could provide insight into interpreting the length compositions, biomass, and biomass c.v. trends in the earlier winter survey series, as well as the summer survey series. It would also inform spatial tow allocation of any additional stations added to the current winter survey.
- Embarking on any new survey design entails a new time series and a corresponding commitment from managers, industry, and potential vessels for at least several to many years.
- We note that the current Kaharoa survey uses a different codend for the 10–30m strata. This design feature should be revisited.

1. INTRODUCTION

The inshore bottom trawl fishery off the central eastern coast of the South Island targets several species, some on a seasonal basis. Elephantfish (*Callorhinchus milii*), red gurnard (*Chelidonichthys kumu*), and the inshore flatfish complex (consisting of black flounder (*Rhombosolea retiaria*), greenback flounder (*R. faparim*), sandflounder (*R. plebeia*), yellowbelly flounder (*R. leporine*), lemon sole (*Pelotretus flavilatus*), New Zealand sole (*P. novaezealandiae*), brill (*Colistium gunethen*), and turbot (*C. nudipinnis*)) are significant targets for inshore vessels. Monitoring the trends in biomass for these three groups using a bottom trawl survey has been problematic due to optimisation of the survey timing and gear for other species, high coefficients of variation (c.v.) for biomass estimates, and a curious dramatic oscillation of biomass point estimates in alternating years (Beentjes & Stevenson 2001, Stevenson & Beentjes 2001, 2002, Beentjes et al. 2004). Suboptimal timing for gurnard and elephantfish led to switching from a winter (primarily red cod) trawl survey series (1991–1996), to a summer trawl survey series (1996–2001). High inter-annual variability in biomass estimates then led to cancelling the trawl survey altogether as of 2001. The loss of a trawl survey for tracking relative changes in biomass resulted in no fishery-independent method to assess stock status for a suite of species.

Since then, the status of selected species (including ELE and GUR) has been monitored using standardised CPUE analysis and incorporating information from industry logbook and sampling programmes for those species involved in the Adaptive Management Programme (AMP, SeaFIC 2007a, 2007b). During this period, discussions also began to develop an industry vessel based survey as a cost-effective approach to monitor elephantfish, gurnard, and flatfish abundance.

Current management issues in this fishery are a perceived increase in the abundance of ELE and GUR, uneconomic deemed values for GUR, and a perceived decrease in the abundance of some flatfish species (ESO, YBF, SFL).

In 2007, the winter trawl survey was reinstated. The redesigned winter survey takes place in May, and targets red cod (*Pseudophycis bachus*), dark ghost shark (*Hydrolagus novaezelandiae*), sea perch (*Helicolenus* spp.), giant stargazer (*Kathetostoma giganteum*), and tarakihi (*Nemadactylus macropterus*); species for which biomass estimates with appropriate levels of precision are achievable (Beentjes et al. 2004). It expressly is not optimised to survey elephantfish, red gurnard, or flatfish, leaving discussions of an industry vessel based survey to focus on these groups.

The specific objective of this projective is to design a survey that will effectively determine the relative abundance and distribution of elephantfish, red gurnard, and flatfish off the east coast of the South Island from Shag Point to Waiou River using a hybrid survey over the depth range 5 to 30 m. The target coefficients of variation (c.v.s) of the biomass estimates for these species are 20–30% for each species.

The purpose of this document then is to provide advice on survey design, scope, and cost options to use industry vessels to monitor the abundance of elephantfish (juveniles and adults), red gurnard, and flatfish off the ECSI from Shag Point to the Waiau River.

2. SURVEY SCOPE

2.1 Area

The distributions of the elephantfish (ELE 3), red gurnard (GUR 3), and the flatfish complex (FLA 3) target fisheries are concentrated between Banks Peninsula and Oamaru (SeaFIC 2007a, 2007b). More than 89% of the AMP tows and the catch for all three target groups occurs in statistical area 022 (Table 1). Overall, their distributions fall within the shallow strata surveyed by the *Kaharoa* trawl survey series (Figure 1). Although AMP data do not show significant effort north of Banks Peninsula, CELR landings data from area 020 and discussions with Timaru inshore trawl fishermen indicate the recent ELE catch has been increasing in that area (*Kaharoa* survey stratum 18) (SeaFIC 2007a). From CELR data, more than 85% of ELE and 65% of GUR catch occurs in areas 020 and 022 (Tables 2, 3). Little AMP effort occurred in stratum 1, especially for ELE and GUR, which is the northern edge of statistical area 24 (Tables 1, 2, 3). One way to minimise the extent of the coastal area surveyed is to exclude survey stratum 1 and estimate biomass only from the Waiau River to Cape Wranbrow,.

Table 1: Percentage of catch for target species for each statistical area based on 2001–2007 AMP data. FLATS= BFL, BRI, ESO, GFL, LSO, SFL, TUR, and YBF plus FLA, FLO and SOL.

Statistical area	ELE	GUR	FLA	Grand total
020	1	1	0	1
022	93	96	89	93
024	4	4	11	4
026	3	0	0	2
Grand total	100	100	100	100

2.2 Depth

The depth distribution of the ELE 3 fishery changes seasonally, moving to deeper water in the winter months (Figure 2). However, from October to May the depth range of both the target tows and the high CPUEs remains in a fairly constant depth zone of 10–60 m (Figure 3). Elephantfish move into very shallow waters in October and November to spawn, often shallower than 10 m. However, trawl fishermen in the Canterbury Bight have implemented a Code of Practice to protect these spawning areas from disturbance by not trawling within 1 nautical mile of shore, limiting bottom disturbance shallower than about 10–15 m (Raymond Mitchell, Timaru, pers. comm.). Consequently, the depth's targeted by the fishery during November-December are likely to indicate elephantfish are deeper than they really are. Set netting still occurs in this zone, but new regulations to minimise potential for Hector's dolphin bycatch will limit set netting in this region to outside of 4 nautical miles from shore (Ministry of Fisheries 2008). Trawl fishing within 2 nautical miles of shore will also be curtailed unless a low headline height trawl is used, as of 1 October 2008.

Interpretation of biomass trends from the *Kaharoa* summer survey was difficult because the survey did not extend shallower than 10 m, missing significant summertime ELE biomass as evidenced by the *Compass Rose* surveys in 2000 and 2001 (Stevenson & Beentjes 2002, SeaFIC 2007a). However, by January, adult elephantfish are moving back offshore (Gorman 1963, Robert Odey, Timaru, personal communication). Juvenile elephantfish (under 50 cm) are thought to remain in shallow waters for up to 3 years before dispersing to shelf feeding grounds (Gorman 1963). Excluding the offshore period from April to September, 92% of target elephantfish catch occurs shallower than 60 m. Therefore, if elephantfish were to be surveyed after January, a depth range of 10–60 m is appropriate. If surveyed during the summer spawning period, the depths would need to be much shallower.

Table 2: Total landings (t) and distribution of landings (%) of elephantfish from trips which landed ELE 3 by statistical area group and fishing methods, summed from 1989–90 to 2005–06. Landings (t) have been scaled to the QMR totals. Reproduced from SeaFIC 2007a.

Statistical Area/Region	Bottom trawl	Set net	Danish seine	Other	Total	Bottom trawl	Set net	Danish seine	Other
	Landings (t)					Distribution (%)			
018	137	82	0	0	218	1	4	0	5
020	2 049	57	21	1	2 127	19	3	43	21
022	6 952	1 564	28	2	8 546	66	74	57	59
024	900	391		0	1 290	9	19	0	6
026	499	10		0	509	5	0	0	3
SubAnt	17	0		0	17	0	0	0	7
Total	10 553	2 103	49	3	12 708	100	100	100	100

Table 3: Total landings (t) and distribution of landings (%) of red gurnard from trips which landed GUR 3 by statistical area group and important fishing methods, summed from 1989–90 to 2005–06. Landings (t) have been scaled to the QMR totals. Reproduced from SeaFIC 2007b.

Statistical Area/Region	Bottom trawl	Set net	Danish seine	Other	Total	Bottom trawl	Set net	Danish seine	Other
	Landings (t)					Distribution (%)			
018	232	14	1	0	248	2	25	1	2
020	2545	11	115	2	2673	24	18	74	24
022	4278	11	38	13	4340	40	19	25	39
024	648	7		0	655	6	12	0	6
026	475	0	0	1	477	4	0	0	4
025	742	3		9	753	7	5	0	7
030-032	1185	4	0	1	1191	11	7	0	11
027-029	325	0		15	340	3	0	0	3
ChatRise	337	8		7	352	3	13	0	3
SubAnt	3	0		1	4	0	0	0	0
Total	10770	58	155	51	11032	100	100	100	100

Red gurnard tows are also shallow, ranging from 10–50 m throughout the year, with the largest catches in the winter months (Figures 2, 3). Flatfish catch is also shallow in general, with the exception of lemon sole (LSO) which can be caught as deep as 300 m. Still, 100% of the FLA tows in the AMP occur between 10 and 60 m (Figures 2, 3). There is no observed seasonal trend in the depth of targeted FLA tows.

Therefore, the optimal depth range for the three target groups is 10–60 m if the survey is not conducted in the main winter months of June-September or the summer spawning season of November-December for elephantfish. Confining a survey to the period after spawning minimises problems associated with surveying elephantfish while they are moving into the spawning areas and while moving back out to shelf waters. Strata deeper than 60 m can be omitted. For comparability, strata boundaries used by the *Kaharoa* surveys should be maintained and, fortunately, the main 30–100 m strata were split into 10–30 and 30–60 m strata in 1997, so the appropriate strata for this survey are already defined by the *Kaharoa* new winter surveys which began in 2007 (Beentjes & Stevenson unpublished data).

2.3 Sample size

The number of tows needed in these strata is a function of the variability of catch rates for the species and size classes targeted. Typically, swept-area biomass c.v.s of less than 30% are desired. The *Kaharoa* summer survey series (including shallow water tows by *Compass Rose* in 2000 and 2001) provides observations of swept-area catch that were used to estimate a target biomass CV given the variability in the strata observed (Table 4, Francis 2006). This was done for all strata shallower than 100 m, and for a subset of those strata focusing on 10–60 m depths and excluding stratum 1 (Shag Point to Cape Wranbrow). Theses estimates should be interpreted with caution, however, as the *Kaharoa* summer survey was not optimised to target ELE, GUR, or FLA. In the summer survey, strong year classes were not tracked in successive years, and size selectivity varied more than expected from a biological perspective (Beentjes et al. 2004). Juvenile elephantfish biomass estimates are especially suspect as the survey did not fish in their shallow habitat (under 10 m) at this time of year and *Compass Rose* had very different catch rates in shallow strata (Stevenson & Beentjes 2002). As the new survey is planned as a summer survey, winter *Kaharoa* survey data were not used to estimate c.v.s.

Table 4. Estimated c.v. for target species for a survey of A) 10–100 m from Shag Point to the Waiau River and B) 10–60 m from Cape Wranbrow to Banks Peninsula. Each column shows the number of tows in each survey scenario. Juvenile ELE are < 50 cm. Estimates based on summer *Kaharoa* and *Compass Rose* survey data.

Species	50 tows	75 tows	100 tows	150 tows
A)				
FLA	-	19.4	17.0	13.6
GUR	-	15.4	13.4	10.7
ELE Juv	-	39.5	39.2	32.3
ELE Adult	-	31.7	30.4	24.8
B)	50 tows	75 tows	100 tows	150 tows
FLA	22.0	18.4	15.9	-
GUR	19.9	17.1	14.8	-
ELE Juv	39.0	35.0	30.4	-
ELE Adult	33.5	30.2	26.2	-

2.4 Target fish size

A significant issue for this new survey is how much effort to expend to survey juvenile elephantfish. Even though smaller inshore trawl vessels can fish in 5–10 m depths, their ability to do so is still limited by weather conditions, especially swell. Trawl performance at these depths is also variable due to the length of warp needed, the impacts of swell on trawl speed and bottom tending, and the likely existence of sand waves parallel to the trawl track that may allow bottom tending species to escape under the groundrope. Obtaining a significant number of tows in these strata will be very difficult.

2.5 Survey gear

An additional significant survey design issue is the type of trawl gear to use. The *Kaharoa* trawl is not designed to catch flatfish. The groundrope is large (35 m with 160–200 mm rubber rollers on wire rope with 12 steel cannonball weights (12 kg) and dropper chains), there is a significant gap (about 5 cm) between the ground gear and the fishing line, and the headline height (about 4.5 m) is much higher than needed for strictly demersal species (and would not be compliant with new Hector's dolphin regulations). Given the three species groups targeted by this survey, a smaller, inshore trawl is warranted. Inshore trawl fishermen suggested a 21–23 m groundrope, 2-seam, full wing trawl with a headline height of 1–2 m, a chain groundrope with dropper chains, low wings, 15-m bridles and 80-m sweeps (Peter Hunter and Chris Parrish, Timaru, pers. comm.). This design differs from the *Kaharoa* trawl mainly in scale (35-m groundrope) and in groundrope type. Because this would be a separate trawl survey series, the gear difference is not a significant issue. However, combining biomass estimates from other surveys, such as the previous *Kaharoa* ECSI surveys, would not be possible.

3. SURVEY PLATFORM

The concept of developing a new trawl survey to monitor ELE, GUR, and FLA includes using industry vessels by adding survey tows to their normal fishing activity. Designing a trawl survey to incorporate this feature, yet still produce a reliable swept-area biomass estimate, generates some logistical issues and the need to design the survey as a package that includes operational details. For example, the number of vessels determines the survey duration which constrains the choice of survey timing. We considered several design options to provide a range of alternatives that could be compared for effectiveness, efficiency, and cost (Table 5).

3.1 Single hybrid vessel

The term “hybrid” refers to an industry vessel that would conduct survey tows while on an active fishing trip. Logistically, the vessel would receive a list of randomly allocated survey stations and would agree to conduct tows at those locations during the survey period using prescribed gear and fishing methods. The catch from these tows would be sampled for species composition, weight, length, sex, and biological samples. Participation would be on a volunteer basis, or for minimal cost reimbursement for fuel and supplies.

The positive aspects of this arrangement are that the vessel cost could be avoided or at least minimised by taking advantage of an experienced vessel already fishing in the vicinity with a standard and well defined gear type on board. The consistency of vessel, operator, and gear effects minimises variance in catchability and is paramount in survey data interpretation. Local fishing vessels are typically long standing participants in an area, and consistency in participation across years is desirable.

Negative aspects of a single “hybrid” vessel design centre on catch sampling and logistical issues. One of the proposed designs for a hybrid survey would have the vessel carry no observer but would conduct a survey tow as the last tow before coming to port. The catch would be segregated on board and when offloaded could be sampled for species composition, weight, length distribution, and biological samples by scientific staff. First, because the vessel is effectively surveying only part time, the survey duration is extended. Even if fishing day trips and conducting the last tow of each day as the survey tow, a 100 tow survey conducting 5 tows per week would last 5 months. The design feature of random position tows means that many tows will not be in an area usually fished by a vessel, especially at a given time. Additional travel time to each station incurs a higher cost and may reduce the incentive of a vessel to continue surveying or participate in future years. In addition, although inshore vessels are long-term participants in the fishery, there is no guarantee that they will participate in every survey as desired, especially if they have no financial incentive to do so. For example, vessels may volunteer or provide survey tows at a minimal cost now, but if fuel prices increase dramatically, or the vessel decides not to participate for some other reason, the survey will suffer. An additional logistical constraint is that surveys typically use a small mesh codend, which is smaller than the minimum legal mesh size and would require a permit to use and would have to be interchanged with the legal codend for normal fishing activity.

A more significant limitation on this design is that at a rate of one tow per trip, the vessel would likely exhaust its regular fishing quota long before 100 trips were made. In fact, very few AMP vessels conduct more than 100 trips in an entire year. Therefore, this design is not feasible without sampling multiple survey tows per trip, if not multiple tows per day. The constraint on the single-vessel design is the lack of an observer. Therefore, this design option is described with an observer on board to sample targeted species from the catch.

With an observer on board, much of the shore-based sampling logistical and data quality issues can be avoided too. Significant issues of segregating specific tows, landing all catch, landing unprocessed catch, spoilage, and coordinating with an onshore sampler could all affect data quality and quantity. In discussions with Timaru fishermen, they readily realised these problems and proposed that an observer (either Ministry of Fisheries observers or contracted scientific staff) be placed on the vessel. The size of industry vessels potentially involved in this survey is larger than average ECSI trawlers (because of gear, workspace, and staff constraints) and would be able to accommodate an observer. The fishermen also saw value in the data quality, efficiency of on deck sampling, and information objectivity provided by an independent observer or scientist.

3.2 Multiple hybrid vessels

The use of multiple hybrid vessels can address the issue of the number of tows each vessel would need to conduct. An observer requirement was not included in this design because the number of days and multiple vessels involved would require significant staff time. With assumptions of two trips per week = two survey tows per week by three vessels, survey duration is estimated to be 3.8 months (111 d). This is long for a survey snapshot, but it could be scheduled to avoid periods when fish migrate out of the survey area. Continuity by at least some vessels would be more likely if multiple vessels are involved, creating more stability in vessel effects (compared to the risk of losing a single "hybrid" survey vessel).

In general, the negative aspects of a multiple vessel hybrid survey are similar to the negative aspects of a single hybrid vessel with the addition of a few more issues. Variation due to vessel effects would require a greater number of tows, partially reducing the benefit in survey duration of adding more vessels. Also, because vessels often fish in distinct areas, more overlap in survey locations is needed to account for a vessel and survey area effect. The number of tows needed to account for vessel effects depends on the size of the vessel effect relative to the variability in the catch rates, and could require a significant number of overlapping tows for all vessels involved, which adds cost. In describing this option, we simply added 20 tows to the overall survey, but this would need to be addressed once catch rates for participating vessels could be evaluated. Standardising gear across vessels is difficult, but not impossible, and will reduce the vessel effect. The expense of providing gear and backup gear for multiple vessels could be significant. This scenario also requires onshore sampling with the potential problems identified above. The coordination role in this scenario is also amplified by having more vessels involved and onshore sampling, adding administration expense to the project.

3.3 Single contracted vessel

This option is similar to developing a dedicated survey. The vessel could be any vessel that could complete the survey requirements (industry or science contractor). It would be desirable to use a vessel that would be available in the long term. The positive aspects of this design are similar to the single hybrid vessel platform, except that a dedicated vessel would finish the survey in 3–4 weeks, making the assumption of a population biomass snapshot more credible. In addition, because fishing and surveying are not confounded, scientific staff on board could sample the catches, the vessel could operate on a single permit, and a two-phase survey design could be used to optimise biomass c.v.s.

Negative aspects of a contracted vessel, relative to the two hybrid options, are mostly costs in that the vessel, crew, and science staff would need to be funded for all aspects of operation for a significant period of time. Two scientific staff is an absolute minimum given that a typical survey of this scale on the *Kaharoa* would fully occupy six scientific staff. Two was chosen as a maximum number that inshore vessels would be able to accommodate.

3.4 Extending the *Kaharoa* winter survey

This last survey design option provides an alternative to developing a new survey series but has some design constraints that alter aspects of the original proposal. The *Kaharoa* winter ECSI survey was reinstated in 2007 and occurs in May and early June, surveying much of the same area as the proposed survey. The survey currently has tows allocated to the 10–30 m strata but these are a lower priority and can be (and many have been) dropped due to weather constraints. In the year the winter and summer surveys were done (1996), survey biomass estimates were not significantly different, although imprecise (Figure 4). The survey targets red cod, dark ghost shark, sea perch, giant stargazer, and tarakihi. The survey biomass estimates and c.v.s for ELE and GUR were variable in the 5-year winter series of the early 1990s survey (Figures 5,6; Beentjes & Stevenson 2000) but these surveys did not sample shallower than 30 m depth. Since being reinstated in 2007, the c.v.s for adult elephantfish and red gurnard have been acceptable and the biomass estimates have not fluctuated dramatically (Table 6). Gurnard estimates have been imprecise in the new winter survey, likely due to the lack of sampling in shallower than 30 m actually achieved in the surveys.

Table 5. Details of four bottom trawl survey platform designs to monitor ELE, GUR and FLA abundance off the ECSI.

Issue	One hybrid Vessel	Three hybrid vessels	One dedicated vessel	Add tows to *Kaharoa* *(No FLA)*
Number of vessels	Fishing vessel	3 Fishing vessels	Contracted vessel	Contracted vessel
Personnel needed at sea	Normal vessel crew+observer	Normal vessel crew	Scientific staff (2+ crew)	Scientific staff (6)
Gear used/Standardisation	Standard provided gear from doors down	Standard provided gear from doors down	Standard provided gear from doors down	*Kaharoa* survey trawl
Gear mensuration, monitoring	Pre-Calibrated gear (Spread, height, BCS, Warps, Environment)	Pre-Calibrated gear (Spread, height, BCS, Warps, Environment)	Mensurated gear (Spread, height, BCS, Warps, Environment)	Mensurated gear (Spread, height, BCS, Warps, Environment)
Survey design	Stratified random design	Stratified random by vessel	Stratified random, 2 phase design	Stratified random, 2 phase design
Survey duration	75 stations @2/day+ = 58 d	95 stations @ 6/week = 111d	75 stations @ 4/day = 25d	Add 30 shallow stations (9d)
Survey timing	Jan-Feb	Jan-Apr	Jan/Feb	May/Jun
Strata surveyed	Strata 10–30 m 30–60 m Waiau R. to Cape Wranbrow	Strata 10–30 m 30–60 m Waiau R. to Cape Wranbrow	Strata 10–30 m 30–60 m Waiau R. to Cape Wranbrow	Strata 10–30 m 30–60 m +
Sampling location	Observer: real time for targets	Shed sampling at landing	Real time for target species	Real time for target species
Samples collected	Catch weight Key species length Biological as time permits	Catch weight Key species length Biological as time permits	Catch weight Key species length Biological as time permits	All catch weight QMS species length More biologicals possible

Table 6. Biomass estimates (c.v.) for ECSI winter trawl survey for 2007 and 2008 (NIWA, unpublished data).

	2007	2008
ELE adult	518 (21%)	777 (27%)
GUR all	1 453 (35%)	1 309 (35%)

Note: GUR c.v.s in the 1991-1996 winter survey series were 40, 30, 31, 34, and 27%. ELE (all) CVs were 40, 32, 33, 32, 30% (Beentjes et al. 2004).

Adding tows to the 10–60 m strata in the current winter survey should minimise the c.v.s associated with the biomass estimates for these two species. The reason for the dramatic swings in biomass estimates was never determined conclusively, but was attributed either to annual variability in the distribution of the fish on the survey grounds or annual changes in catchability due to trawl performance (Beentjes et al. 2004). If environmentally driven, then a new survey, even with hybrid vessels or a dedicated contract vessel, could have the same catchability issues.

Further work is needed to address the issue of potential winter survey performance for both ELE and GUR. In addition to the high c.v.s on biomass, the modes of strong year classes do not track inter-annually in a consistent manner for either species. For both ELE and GUR, the length compositions within a year were similar for males and females in both the winter and summer surveys (Beentjes and Stevenson 2000, 2001). However, the length progression for each species is apparent only between 1992 and 1993 (Figure 7). The spatial distribution of tows within a stratum in each year varies considerably as do the number and distribution of phase 2 survey stations. This raises questions about the potential impact of survey effort in the larger strata that contain areas deeper than ELE and GUR habitat. For example, in 1994, ELE were caught only in the smaller strata on the north and south ends of the survey area but were rare or absent in the main large 30–100 m strata of Canterbury Bight. There were almost no stations in the shallow regions of strata 2, 3, or 4 (Beentjes 1998). The effect of this station distribution on both length composition and biomass estimates is unknown, as is the effect of scaling length distributions to entire strata instead of the actual depth range of the species. The spatial distribution within these strata in 1992 and 1993 provided more even coverage, especially shallower, and juvenile cohorts were more apparent (Beentjes 1995). No survey was conducted in 1995, making the 1996 length compositions uninformative, and the 1991 catch did not show a juvenile cohort to follow. However, the area was surveyed twice in 1996, and both surveys generated consistent length compositions for ELE and GUR (Beentjes & Stevenson 2000, 2001). Therefore, a detailed cohort analysis to examine biomass and length composition trends from earlier surveys relative to the spatial distribution of ELE and GUR may improve our understanding of how the stratum definitions, distribution of tows, addition of phase 2 stations, and depth gradients in size distribution for both species influences the biomass estimates and c.v.s from the surveys.

Another survey design difference is that the *Kaharoa* trawl is not designed to target flatfish. Simply adding tows to the current survey will likely not produce flatfish complex catches that will provide a reliable biomass index because the survey trawl is not designed to target small flatfish. However, FLA biomass c.v.s were low in the summer survey (see Table 4), so more tows in shallow water may provide a workable FLA biomass estimate even though the gear is not an optimal flatfish target gear. Juvenile elephantfish were also not indexed well in previous (summer and winter) surveys, likely due to their shallow distribution, often shallower than the 10 m or 30 m minima. None of the options presented here are a good solution to monitoring the abundance of juvenile elephantfish in shallow water.

In conclusion, if FLA biomass estimates are not as high a priority, elephantfish distribution and catchability is constant in early winter months (May-June), and cost is a constraint, simply extending the *Kaharoa* survey to increase sampling density in 10–60 m may provide acceptable biomass estimates for adult ELE and GUR.

4. SURVEY ADMINISTRATION

Many of the logistical issues discussed are due to the survey scope or survey platform chosen. However, these are not the only costs involved in generating useful biomass estimates. The coordination and administration needed to conduct the survey are significant and vary somewhat depending on the scope and platform details chosen (Table 7). Purchasing and coordinating survey gear and supplies, scientific instruments, and administering vessel contracts, samplers, and potentially observers is a significant task that should be considered and included in comparing design and cost options. In addition, if vessel compliance must be monitored, the cost and administration of additional tools such as video observation should be considered.

After the survey is complete, data analysis and report writing are also a significant undertaking. In three of the four scenarios, the administration and data analysis could be conducted by a different party from the actual survey. In that case, a host of other logistical issues arise, such as which data are recorded, how they are stored, database structure, and biomass estimation procedures with custom data input files, all need to be considered. Although it is fairly constant cost among design options, it is greatly simplified by extending the *Kaharoa* survey because much of this analysis is done in any case, just with fewer stations.

5. CONCLUSIONS

It is not the purpose of this report to choose among designs that could each accomplish the objective of conducting the survey, but rather to describe the costs and benefits associated with each. Depending on the details of the survey design chosen, several other design features must be considered. If a hybrid design is chosen, then administrative issues such as coordinating, acquiring, and enforcing permit conditions will need discussion. Developing incentives for a vessel or vessels to continue to participate will be important to long-term data interpretation. Who owns the fish caught or discarded, how is it to be sold, who is responsible for lost gear, and who has responsibilities for completing survey tows according to some set of specifications needs careful consideration. Significant rule development for minor aspects can greatly influence how informative the data will be in the future. Therefore, before committing to any of the survey designs, it is important to ask if given the logistical, analytical, and biological uncertainties involved in the chosen design, will the resulting information be acceptable for management purposes?

6. RECOMMENDATIONS

- A survey scope of January to February with a depth range of 10–60 m will sample ELE, GUR, and FLA well.
- If FLA is not a priority, then a *Kaharoa* survey is economical, standardised, and would provide the most data (target and ancillary species). FLA may be better monitored using alternative methods such as improved data collection on catch, or a focused recruitment index.
- Augmenting the *Kaharoa* survey would result in additional benefits of the collecting ancillary data on other species, potentially reducing c.v. on other target species due to the increase in number of tows, and better standardisation in data analysis.
- If new gear and shallow fishing are required, multiple hybrid vessels are less expensive than a dedicated contract vessel (assuming no charter cost), but are also long duration and most likely to fail for logistical reasons.

- Additional work is needed to examine the spatial distribution of tows in existing surveys relative to phase 2 station allocation, and species distribution, especially for ELE and GUR. This analysis could provide insight into interpreting the length compositions, biomass, and biomass c.v. trends in the earlier winter survey series, as well as the summer survey series. It would also inform spatial tow allocation of any additional stations added to the current winter survey.
- Embarking on any new survey design entails a new time series and a corresponding commitment from managers, industry, and potential vessels for at least several to many years.
- We note that the current *Kaharoa* survey uses a different codend for the 10–30m strata. This design feature should be revisited.

Essentially, a hybrid design is in concept somewhere between a dedicated single-vessel survey and a standardised CPUE study. The question is how much standardisation of gear, vessels, fishing behaviour, and catch sampling is needed to generate credible and robust estimates of biomass for these species groups. On one side is cost and to some degree the ability to predict how effective the survey design will be. Balancing this is the need to standardise survey characteristics as much as possible to minimise survey variation. With a clear description of the survey goal, target species, and focus area, an appropriate plan of action can be determined within the scope described here.

7. ACKNOWLEDGMENTS

We thank Michael Stevenson for Figure 1, and *Kaharoa* ECSI strata data, and preliminary biomass estimates from the ECSI winter surveys in 2007 and 2008. Paul Starr and SeaFIC provided tables and figures from the ELE and GUR AMP programme review. Timaru fishermen Raymond Mitchell, Robert Odey, Peter Hunter, and Chris Parrish provided invaluable discussion on species distribution, migration timing, effective gear design, gear cost, and feasibility of design options. We thank Pete Dawson, Dave Banks, and SeaFIC for access to AMP data. Discussions with Neil Bagley and Mike Beentjes helped to develop design details and cost estimates for each option. We thank M. Vignaux and M. Beardsell for their helpful reviews. This work was funded by the Ministry of Fisheries under Project SAP2007–11.

Table 7. Comparison of estimated costs to survey ELE, GUR and FLA off the ECSI based on different design options.

Item	One hybrid vessel	Three hybrid vessels	One dedicated vessel	Add tows to winter *Kaharoa*
Vessel and crew charter	75 trawls@ 2/day =38 d	95 trawls@ 6/week =111 d	25d@$4,000= $100,000	NA
Calibration setup- staff time	2*2 d=$2,500	2*5d=$6,000	2*2 d=$2,500	Included
Mensuration gear rental (Simrad,BCS,weather)	$50*60 d= $3,000	3*$50*115 d= $17,250	$50*30 d=$1,500	Included
Science staff	Observer= 40 d@ $1000/d+ 20 d @ $350= $47,000	Sampling at sheds: 100@ ½ d=$50,000 Observer for compliance?	Science staff: 25 d*2 people+seatime= $62,000	NA
Gear standardisation	Trawl & doors= 10+4+4=$18,000	3 Trawl & doors= $46,000	Trawl & doors= 10+4+4=$18,000	Included
Data collection gear	$100*60=$6,000	$100*100=$10,000	$100*30=$3,000	$100*10=$1,000
Independent compliance	None	Video?	None	Not relevant
Shipping and travel	$3,000	$5,000	$5,000	Included
Project admin (permits, instructions etc)	25,000	38,000	25,000	Included
Data analysis	37,000	40,000	37,000	NA
Total estimated cost	**$141,500**	**$212,250**	**$254,000**	**$171,000**

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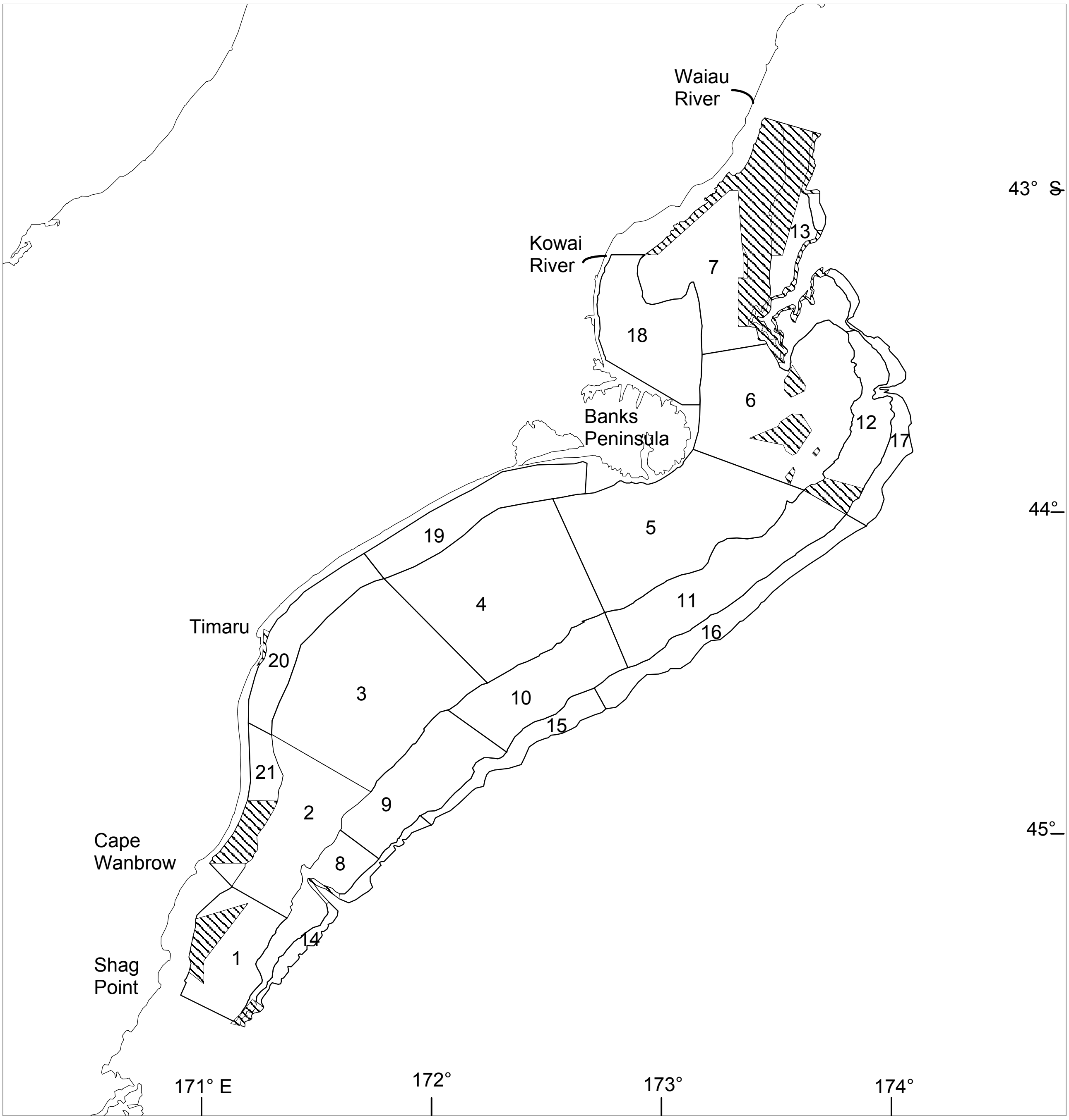

Figure 1: Strata surveyed by the *Kaharoa* during the ECSI winter trawl survey. From Beentjes & Stevenson (2004).

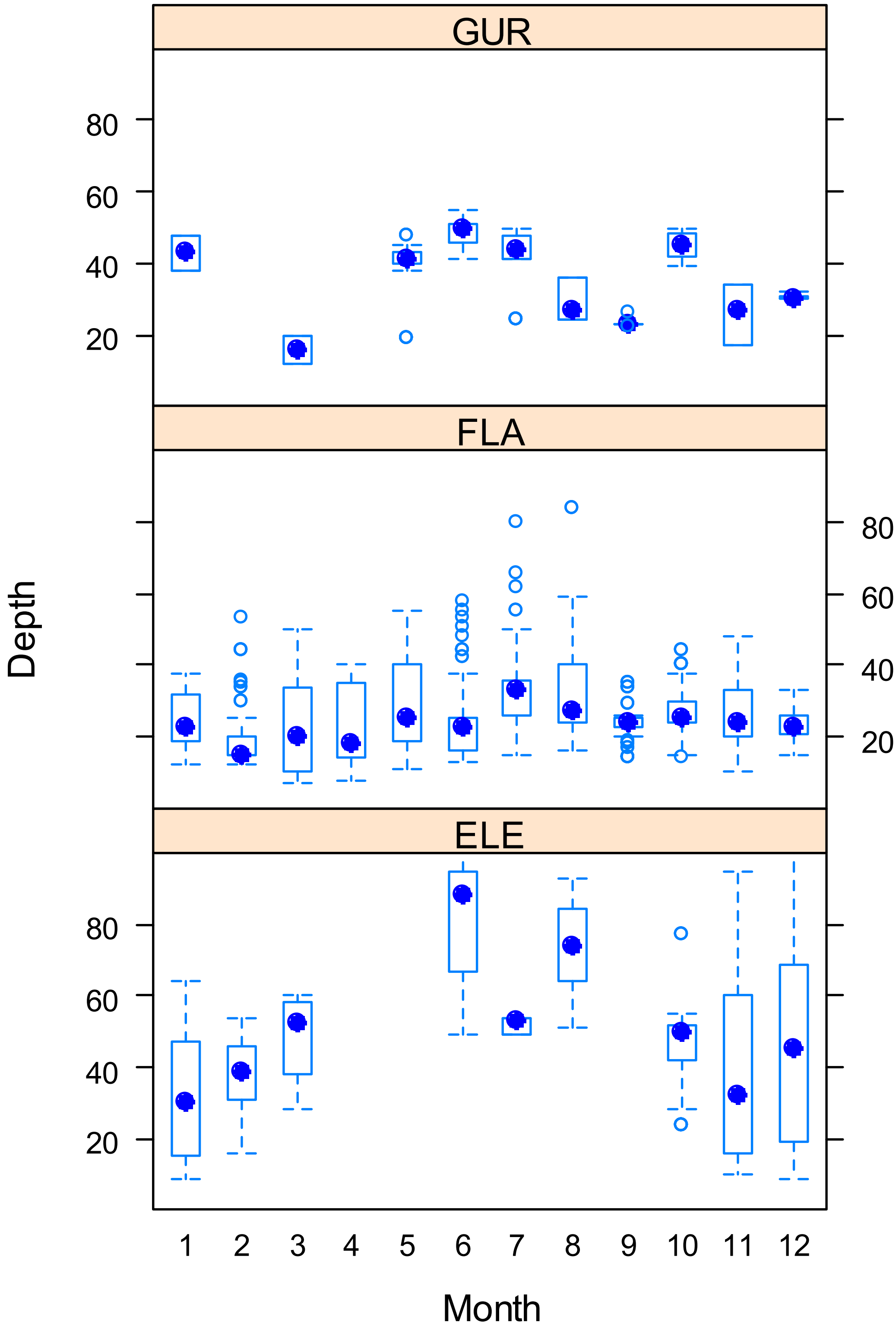

Figure 2: Median (solid dot), inter-quartile range (box), and twice the IQR (error bars) and outliers of depth distribution for tows targeting GUR, FLA, or ELE by month based on AMP data from 2001 to 2007.

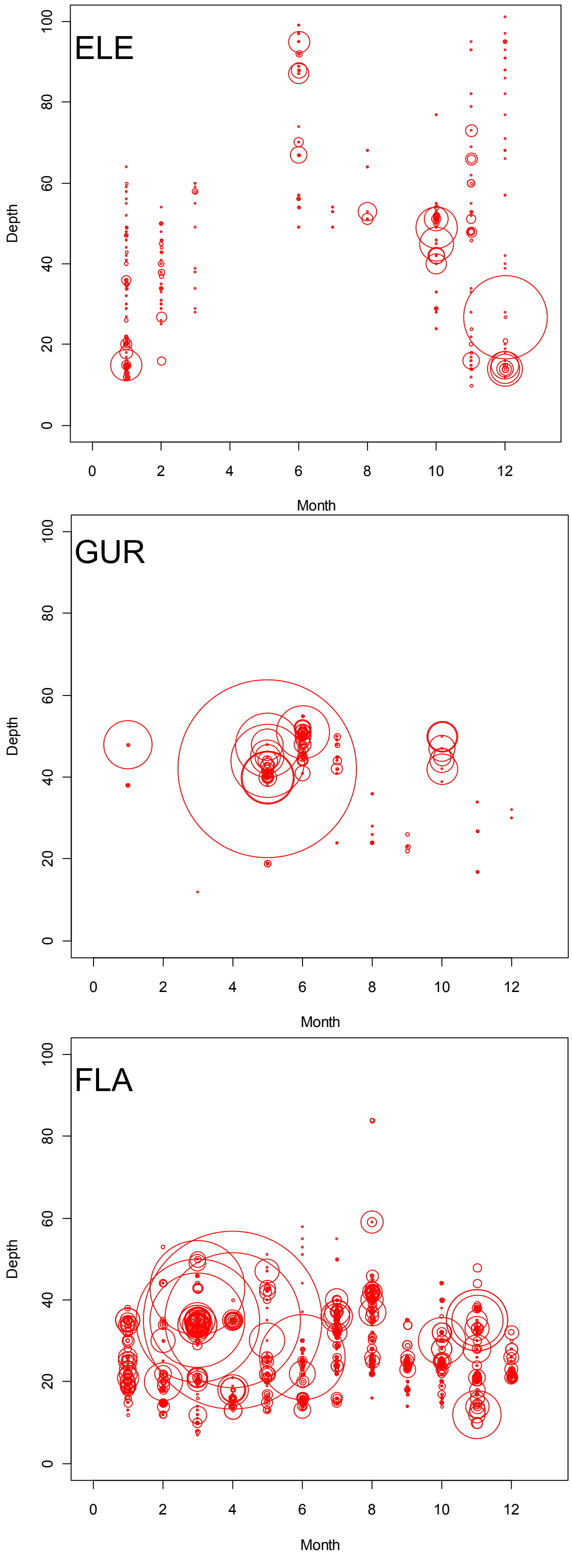

Figure 3: Catch rates by depth and month for the three bottom trawl target groups from AMP bottom trawl data from 2001 to 2007. Circle size is proportional to the maximum catch rate for each group.

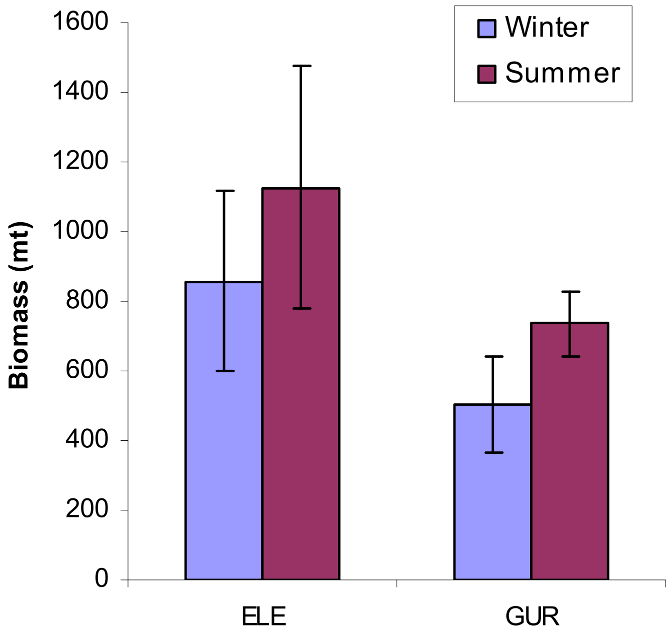

Figure 4: Comparison of biomass estimates for ELE and GUR made in the summer and winter *Kaharoa* surveys of 1996.

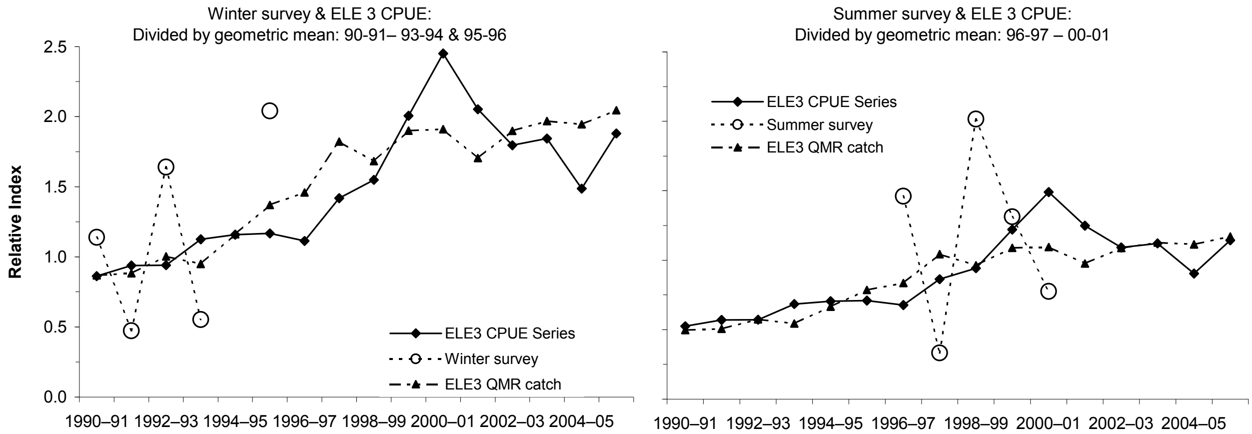

Figure 5: Comparison of the available ELE 3 biomass indices: 1990–91 to 2005–06. Indices of recruited biomass (≥50 cm) are plotted for the two surveys. Only the non-zero lognormal BT(RCO) CPUE indices are plotted. Each of these series have been plotted relative to the geometric mean of the 1990–91 to 1995–96 fishing years [left panel] or of the 1996–97 to 2000–01 fishing years [right panel]. (Reproduced from SeaFIC 2007a).

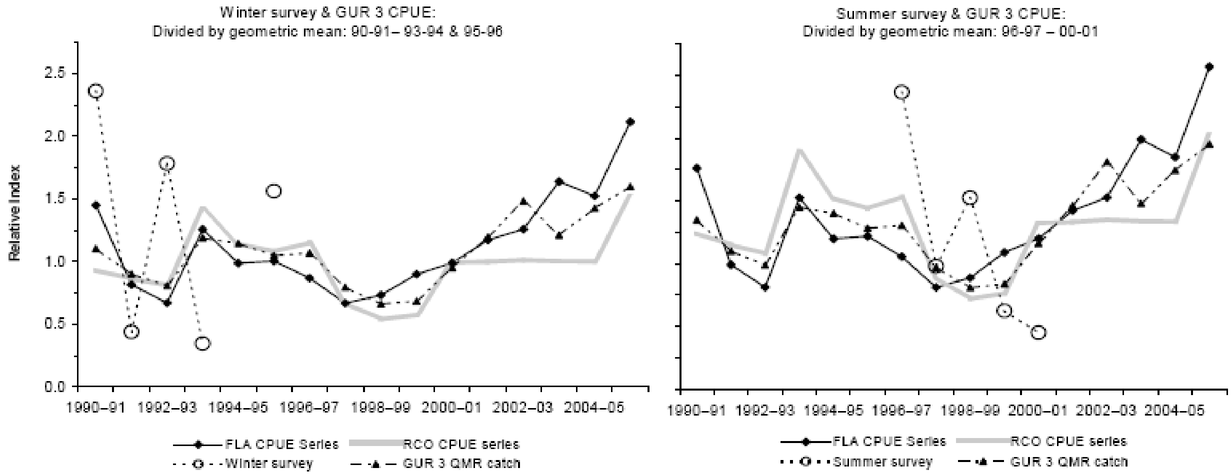

Figure 6: Comparison of the winter and summer RV *Kaharoa* trawl survey GUR biomass indices with the BT(FLA North) and BT(RCO) standardised CPUE biomass indices (from SeaFIC 2007b) and the time series of GUR 3 QMR catches. Each set of indices has been standardised relative to the geometric mean of the same years for the winter or summer series of observations. (Reproduced from SeaFIC 2007b).

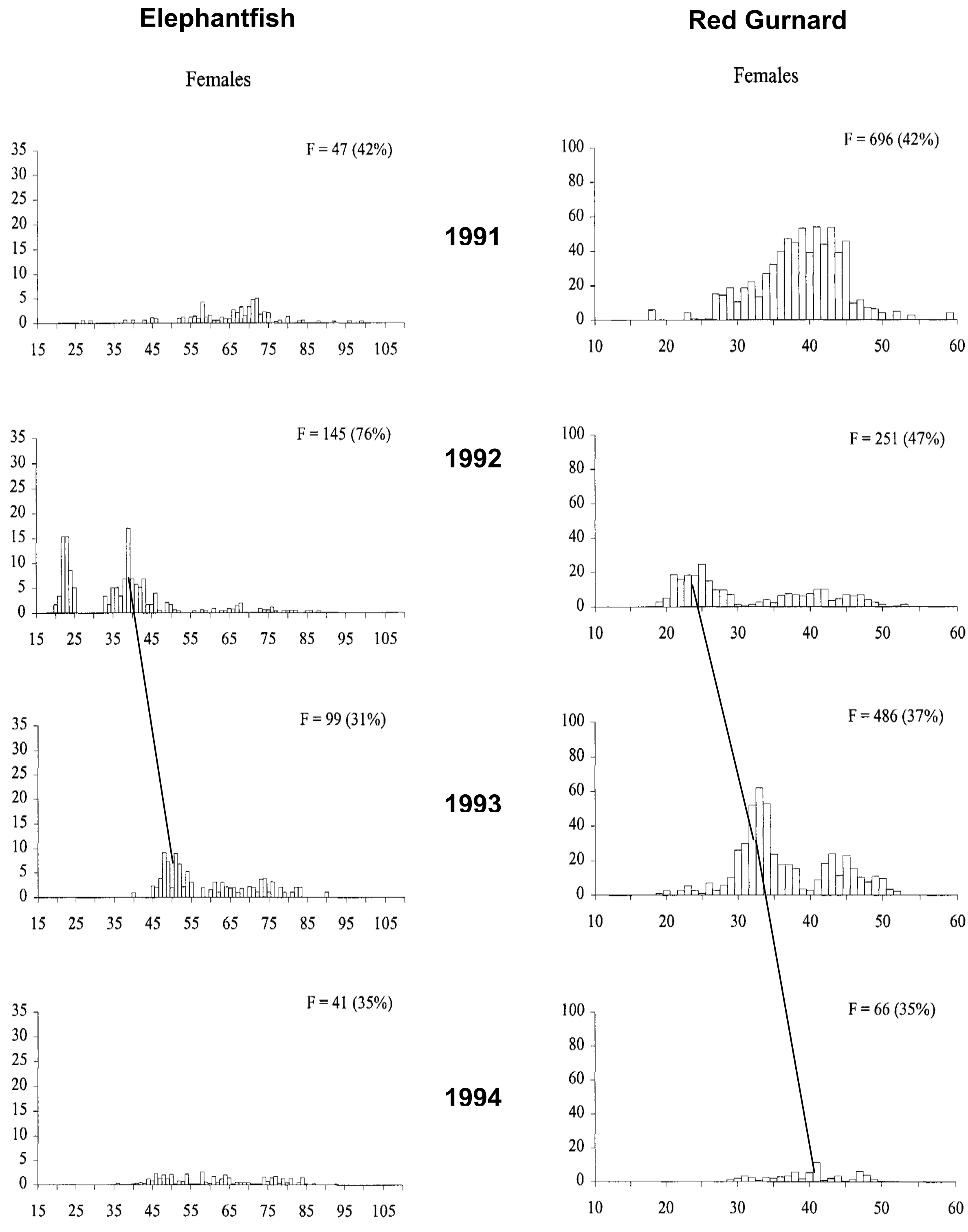

Figure 7. Length frequency plots (reproduced from Beentjes & Stevenson 2000) for female elephantfish and red gurnard showing some length mode progression in some years, and lack of cohort progression in other years.