Chapter 36

Using a top predator to monitor a fish resource: juvenile Cape hake (*Merluccius capensis*) early growth parameters, birth date estimates and recruitment index: the 2005 cohort

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Using otoliths recovered in fur seal scat samples, the recruitment of Cape hake, *Merluccius capensis*, is monitored along the Namibian coast. Growth parameters as well as birth dates can be estimated for each cohort and results are presented here for the cohort spawned in 2005. Birth date estimates of pre-recruits spawned in 2005 ranged from mid-July to mid-September, however the fish that survived to one year had a median birth date of 15 September 2005. The growth parameters of the fitted von Bertalanffy growth function are K = 1.164, L_∞ = 30.739 and T_{zero} = -0.280. The strength of the cohort is estimated at 2.34 billion fish. Fish less than 8cm length were found predominantly in samples from the north-central area, suggesting that spawning occurred mainly in this region. The southern region around Lüderitz seems to be a nursery area for fish between 8 and 20 cm length. There is a remarkable spatial coherence in growth, over more than seven degrees of latitude. The Cape fur seal proved to be very efficient juvenile hake sampler, allowing us to obtain detailed information on juvenile hakes that are not accessible to surveys nor commercial fisheries. In addition, the technique is extremely cost effective compared to other fish survey methods.

Abbreviations

In the following documents the names of the seal colonies where scats were sampled have been abbreviated as follows (from North to South):

TB:	Torra Bay: 20°19'S
CC:	Cape Cross: 21°46'S
PPt:	Pelican Point: 22°52'S
AWB:	Atlas-Wolf Bay: 26°49'S
VRB:	Van Reenen Bay: 27°23'S

Early growth

Following the methods detailed in Roux (2004), size frequency distributions of juvenile Cape hakes were reconstituted using measurements of otoliths retrieved from seal scat samples, collected regularly at several mainland colonies. In 41 samples from 5 different colonies collected between August 2005 and October 2006, 11 502 fish length estimates were obtained. They are presented in 0.5 cm classes in Fig 1 (a to e).

The first signs of pre-recruits from the 2005 cohort were two individuals in the CC 22 Aug 05 sample (Fig. 1a). Between October and the end of December, the 2005 cohort was well represented in the northern samples but absent from the south. Modal lengths varied between 5.1 and 7.8 cm during this period and no growth was apparent. It seems that these fish originated from different spawning batches and did not survive past 8 cm modal length.

The sample PPt 16 Dec 05 (Fig 1b top) shows a bimodal distribution (Modes at 6.0 cm and 8.0 cm). Subsequent samples show the disappearance of the larger component and the growth of the smaller one with good spatial coherence between all sites. Before the end of December the 2005 pre-recruits were only present in the northern samples. This pattern suggests that these pre-recruits originated from a successful spawning batch in the north-central area and spread to the southern region in January–February. The growth of this cohort can be clearly followed at all sites (Fig. 1b to 1e) with good spatial coherence (Fig. 2), and these pre-recruits reached a modal length of 21 cm between the second half of September and beginning of October 2006.

From December 2005 to May 2006 in particular most samples show the co-occurrence of the 2005 cohort and the 2004 cohort. This pattern suggests that these two cohorts are sharing the same habitat during this period. The size difference between these two cohorts suggests that cannibalism may take place under these conditions.

In June and July 2006, signs of the subsequent (2006) cohort are apparent in the northern samples again (Fig. 1d) but not in the southern region.

Birth date estimation

Using the LFDA5.0 package (Kirkwood et al. 2001) a non-seasonal von Bertalanffy Growth Function (VBGF) was fitted to the size frequency distributions of the samples from 19 November 05 to October 06 (N = 7 621 in 30 samples from 5 localities). The earlier three samples were excluded as these fish do not seem to have survived past 8 cm TL (see above). The fitted function has the following estimated parameters:

K = 1.164
L_∞ = 30.739
T_{zero} = –0.280

The T_{zero} value (after a 5 day correction for the delay between the ingestion by seals and the scat collection) gives an estimated date of birth of 15 September 2005.

The VBGF fit is illustrated in Fig. 3 together with the averages and medians of the individual sample distributions.

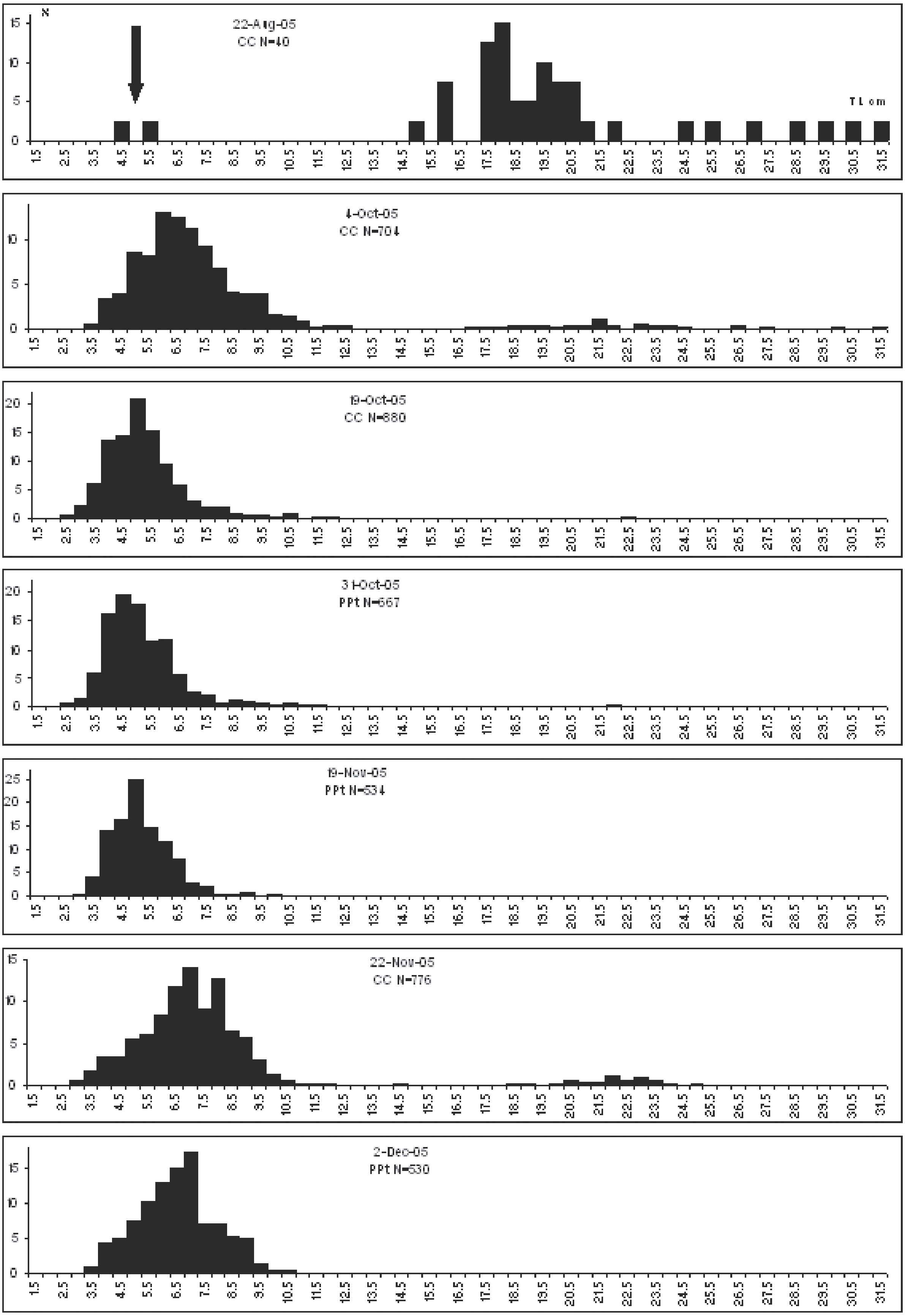

Figure 1a: Size frequency distribution of juvenile Cape hakes in the diet of seals (samples where the 2005 cohort was absent have been omitted). The 2005 cohort first appeared in August 2005 (N=2, black arrow, top). For samples between August and 19 November 2005 no growth was apparent, probably indicating batches of fish spawned at different times and not surviving beyond a modal length of 5 to 7 cm

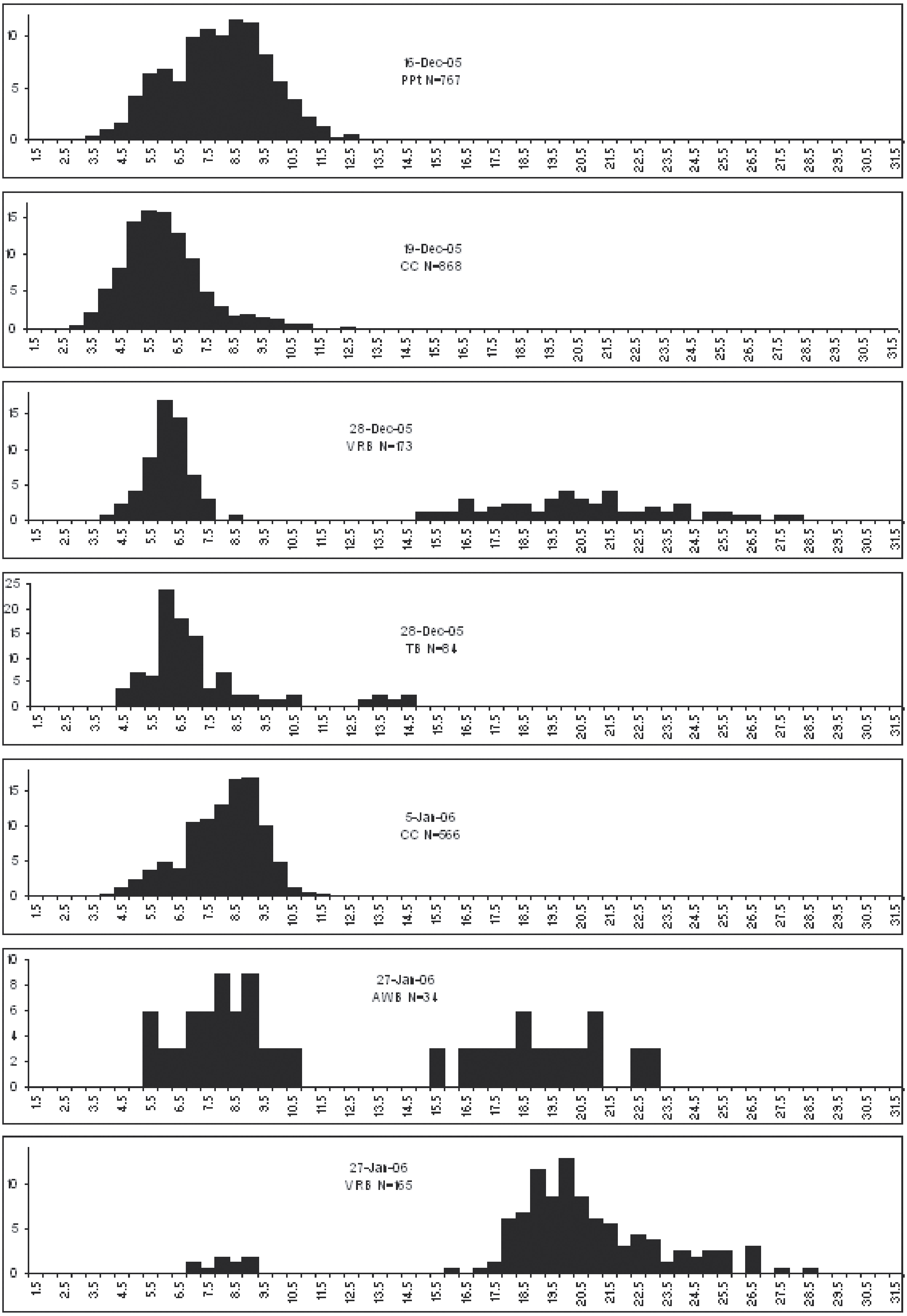

Figure 1b: Size frequency distribution of juvenile Cape hakes in the diet of seals: Late December 05 – January 06. The 2005 cohort first appeared in the south at the end of December (VRB) and January 2005 (AWB). Note the spatial coherence in size between the different sites and the co-occurrence of the 2004 and 2005 cohorts in December 05 at VRB and January 06 at AWB and VRB

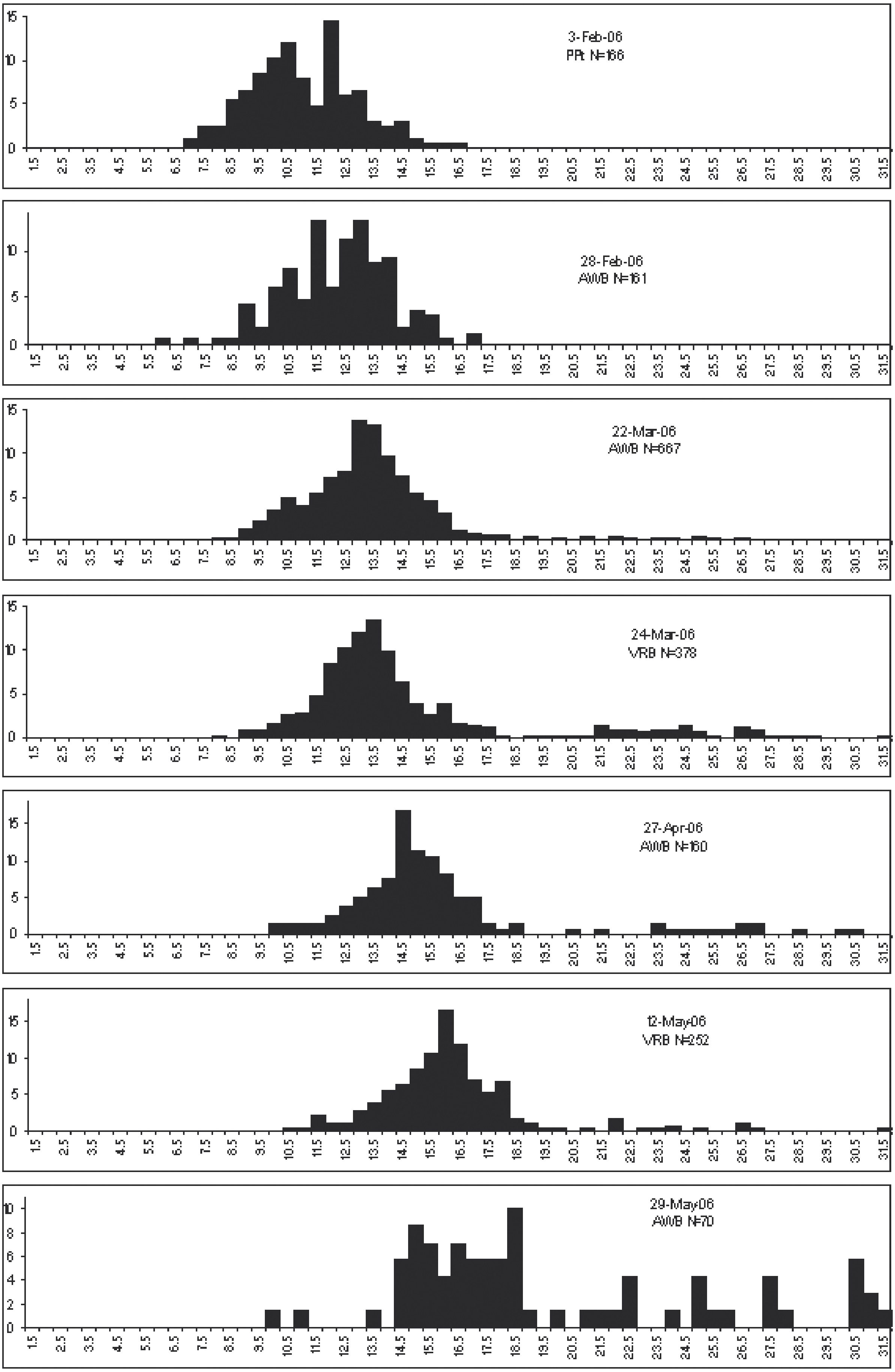

Figure 1c: Size frequency distribution of juvenile Cape hakes in the diet of seals: February to May 2006. Between February and May 2006, modal length changed from 10.5 to 16.5 cm. In most samples fish of the previous cohort (at an approximate modal length of 25 cm) are still represented

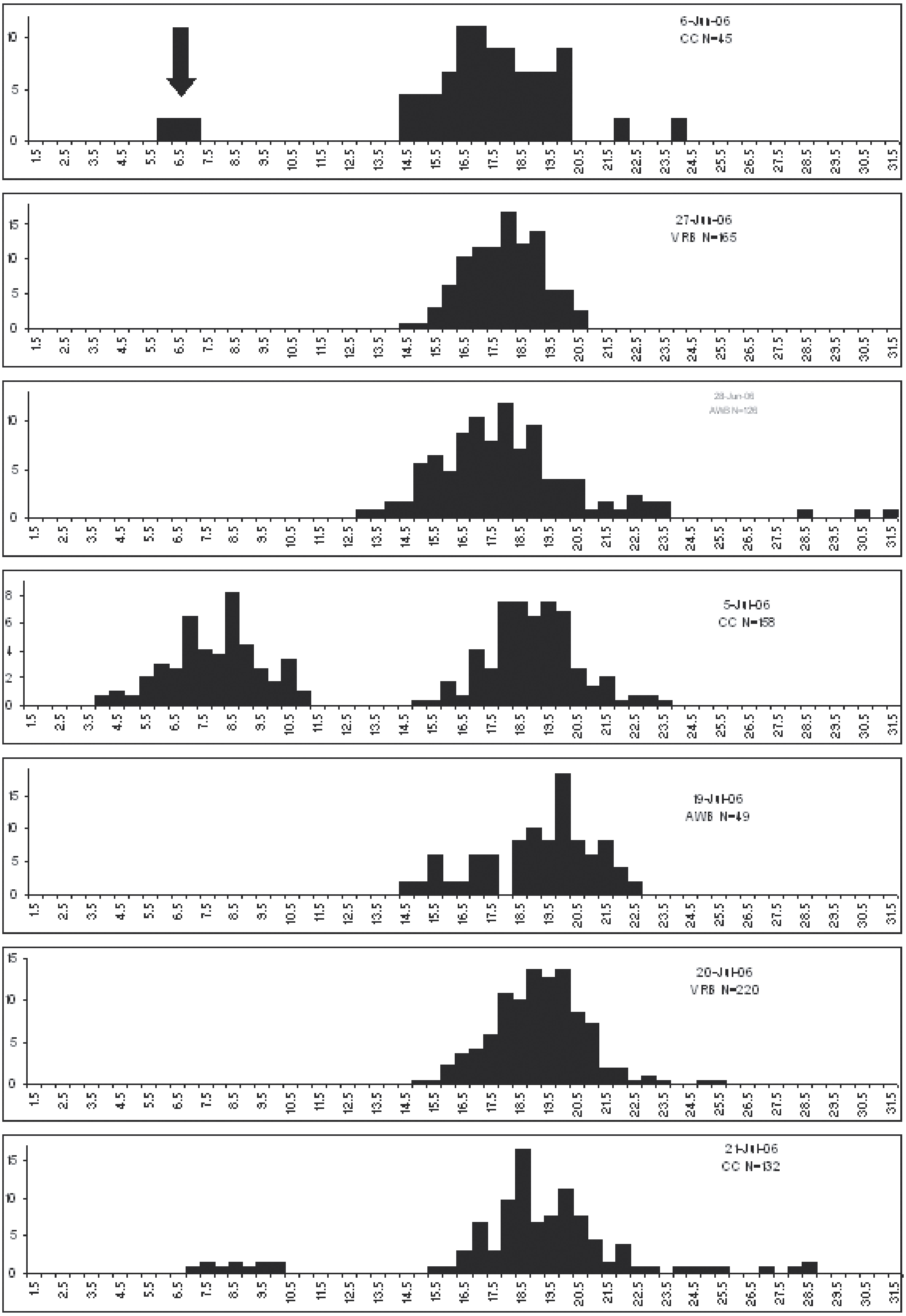

Figure 1d: Size frequency distribution of juvenile Cape hakes in the diet of seals: June to July 2006. Modal length reached 19.5 cm in July. The 2006 cohort first appeared at Cape Cross at the beginning of June (black arrow) at about 6.5 cm, reaching about 8.5 cm in July, but was absent from the southern colonies

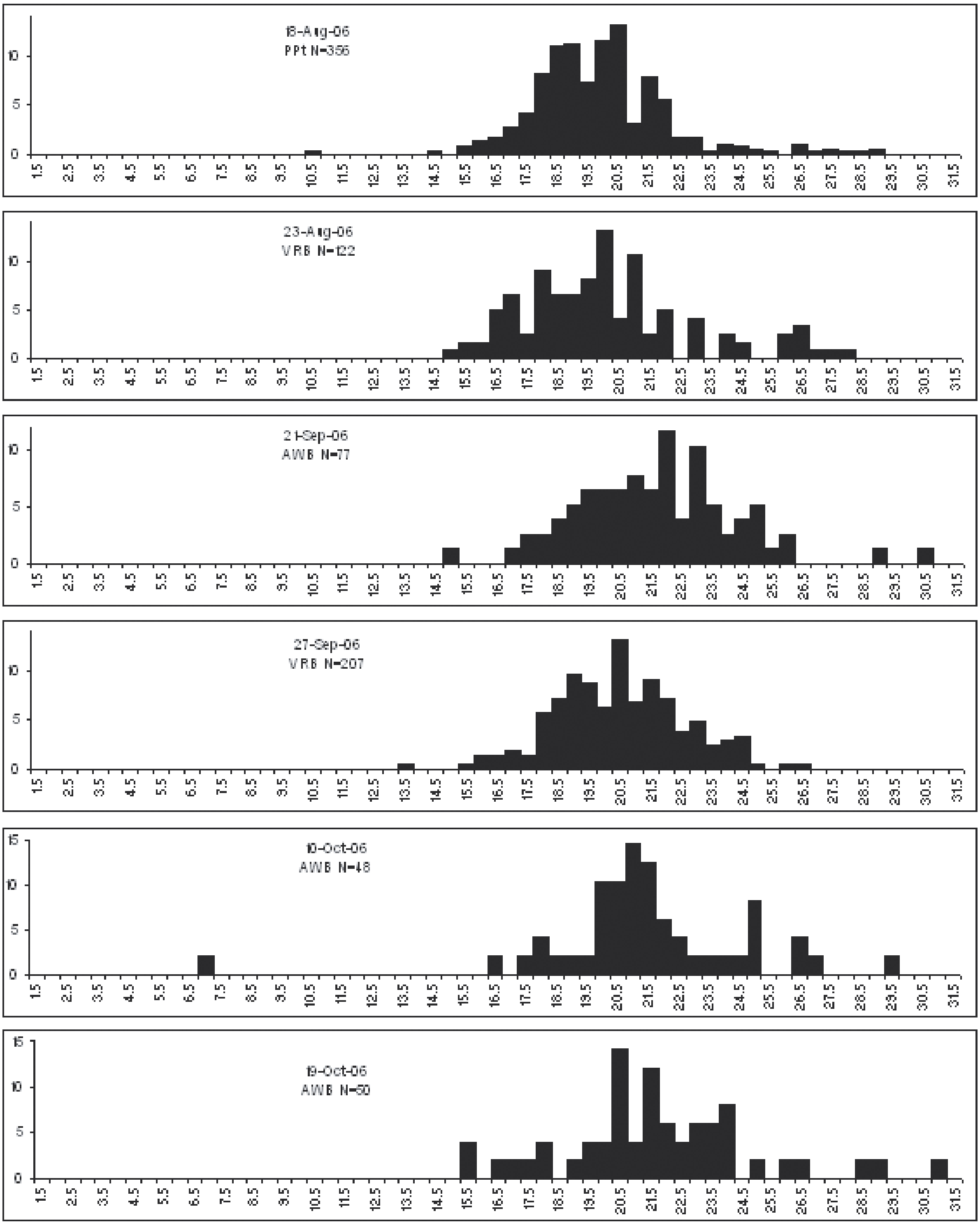

Figure 1e: Size frequency distribution of juvenile Cape hakes in the diet of seals: August to October 2006. Modal length reached 21 cm during this period. Despite the small sample size a slowing down of the growth is apparent together with good spatial coherence

Assuming similar growth parameters, the fish present in the early samples would originate from spawning batches giving birth dates (T_{zero}) centred on the following dates:

12 July 2005
15 August 2005
28 August 2005

However the great majority of the fish, which survived to one year of age, originated from a subsequent spawning period with a median birth date estimated as 15 September 2005.

The low value estimated for L_∞ (30.74 cm) comes from the observed slowing of the growth during the second half of winter and spring. This feature has been observed for the nine consecutive hake cohorts for which growth curved could be fitted. It may be a seasonal effect or the result of the change in feeding ecology that *M capensis* undergo between 17 and 25 cm length (becoming more piscivorous).

Recruitment

Following the methodology developed in Roux (2004) the

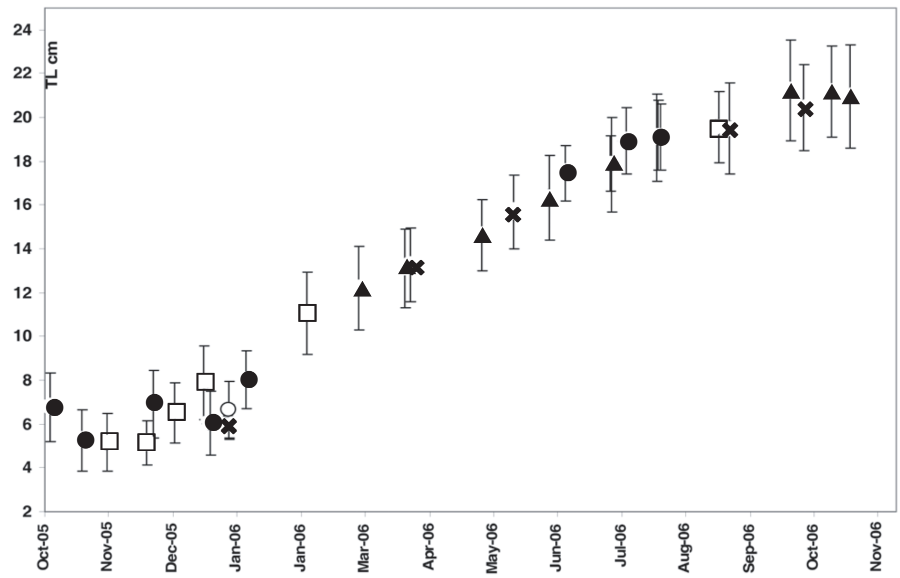

Figure 2: Changes in average fish length (+/– Sd) of the 2005 Cape hake cohort between October 2005 and October 2006 (small samples omitted). To illustrate the spatial coherence, the samples are coded as follows:
○ = Torra Bay,
● = Cape Cross,
□ = Pelican Point,
▲ = Atlas–Wolf Bay and
✖ = Van Reenen Bay.
The distance between Torra Bay and Van Reenen Bay is in excess of 800 km

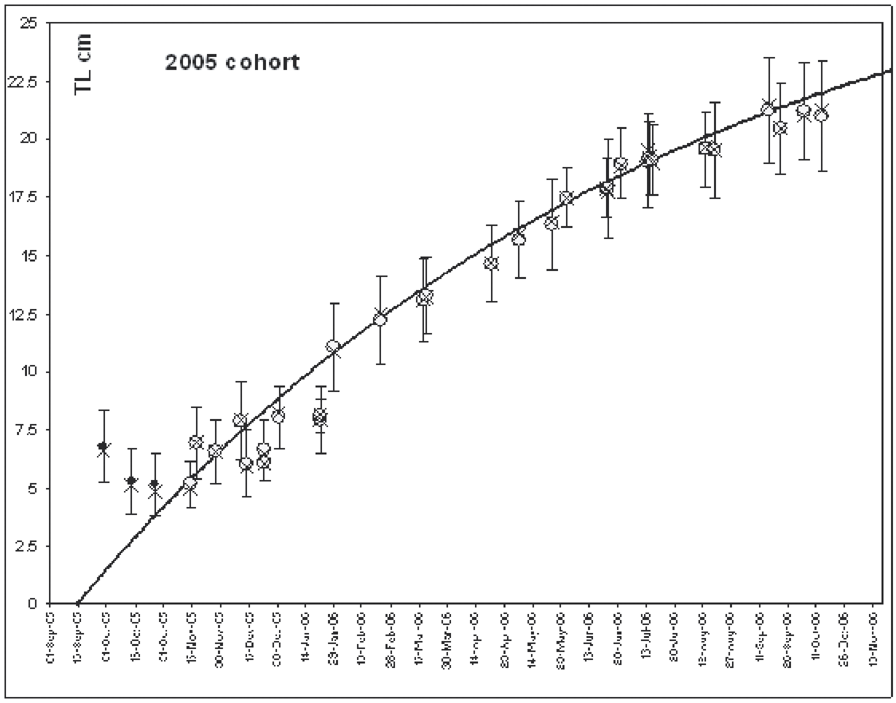

Figure 3: Fitted growth model (non-seasonal VBGF) plotted together with average +/– Sd (empty circles and error bars) and medians (black crosses) fish length of the used size frequency distributions.
The three early samples (small black circles) were excluded from the analysis.
The time scale has been corrected for the delay between ingestion and scat collection (–5 days)

recruitment index for *M. capensis* hakes from seal diet at Wolf and Atlas Bay for the cohort spawned in 2005:

Seal Index = 2.34 “billion fish”, Sd = 1.73 (see Fig 4).

This is slightly below the 1993 to 2005 average of 2.88 “billion fish”, which is however very variable (Sd = 2.43). This preliminary estimate for 2005 may change slightly once all the recounting of otoliths in the samples has been completed. It is to be noted that the standard deviation (and therefore the uncertainty around the estimate) for 2005 is high compared to previous years. A contributing factor to this is the relatively small scat sample sizes collected at the Wolf and Atlas Bay colonies during 2006.

Effect of inter-cohort cannibalism on recruitment

It became apparent that the predation by the previous cohort (Y–1) could have a large impact on the current cohort as indicated in my reports from the last two years (Roux 2004, 2006). The data from the cohort strength estimates between 1993 and 2004 showed a concave relationship with a “limit curve” approximated by a log-linear relation and a few outliers all situated below the limit curve. This pattern could be interpreted as the result of inter-cohort predation with a “top-down” trophic control, and strong initial cohort-strength in most years, the outliers (all below the limit curve) being cohorts impacted by other factors like detrimental environmental factors.

As can be seen in Fig. 5, the 2005 cohort-strength estimate (in blue), lies very close to the “limit curve” (black line) and only 3 outliers are identified 1995, 2001 and 2004 (in red).

This result suggests that in most years, including during 2006 (for the cohort spawned in 2005) the main factor explaining the hake recruitment level could be predation by the previous cohort and that other predation mortality or the effects of detrimental environmental factors have very little in-

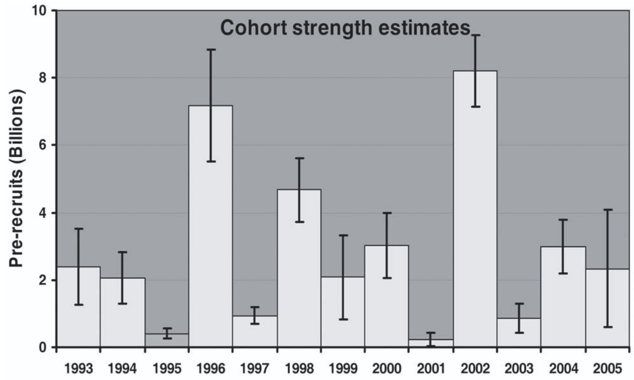

Figure 4: Time series of cohort strength estimates (in billions +/– Sd) derived from the fur seal winter diet at Wolf and Atlas Bay for the cohorts spawned since 1993

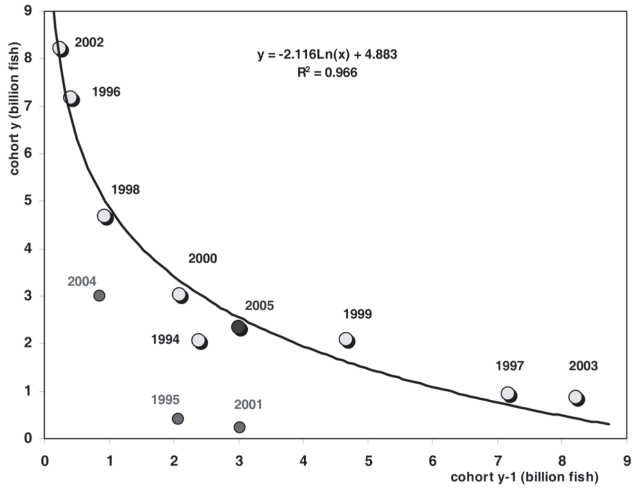

Figure 5: Relationship between the strength of successive cohorts estimated at 1.5 to 2 years of age. The cohorts are labelled according to their year of birth

fluence. However environmental anomalies like the 1995 Benguela-Niño can also affect hake cohort strength. The low availability of alternative forage fish in the ecosystem could be the reason for such a strong "top-down" trophic control (in the southern Benguela, medium size Cape hakes feed extensively on small pelagic fish like anchovy and sardine pre-recruits, which are virtually absent from the Namibian part of the ecosystem). Therefore the present low biomass of small pelagic fish could limit the recruitment potential of the Cape hake stock by enhancing inter-cohort cannibalism.

Conclusions

- The observed growth parameters imply a very high growth rate between December 2005 and June 2006. This high growth rate might be the result of differential mortality of slow growers due at least in part to cannibalism (predation by the 2004 cohort) as postulated by Roux (2006). The apparent slowing down of growth after June 2006 could be related to the change in ecology of young hakes of that size (becoming more piscivorous) as well as a relaxation of the predation mortality (from cannibalism).
- Several spawning batches were detected between July and September 2005, however most of the fish that survived to 1 year had an estimated median birth date of 15 Sept 2005.
- Pre-recruits of less than 8 cm TL were mostly distributed in the North–Central region (Cape Cross, Pelican Point) until January February 2006 (possibly an indication that the main spawning area is in this region).
- Between January and February 2006 these pre-recruits (between 8 and 12 cm TL) seem to disperse southwards, and the Lüderitz region could constitute a nursery area for fish between 8 and 20 cm TL.
- This cohort shows a remarkable spatial coherence over more than 800 km of coast, suggesting that these fish originate from the same source and experience the same growth (and mortality) over a large portion of the Namibian shelf.
- Using the fitted growth function, the extrapolated modal length of the 2005 cohort is 24.2 cm in mid-January 2007 (start of the next hake survey).
- The time series of recruitment indices suggests that inter-cohort cannibalism has a major effect on recruitment at present in the Northern Benguela. This effect could be the result of the lack of adequate alternate prey for two-year-old juvenile hakes.
- To improve the estimates of growth parameters and recruitment, the size of the samples collected on the southern colonies should be improved.

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