Overview on survey design differences in IDCR/SOWER between the second and the third circumpolar cruises

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ABSTRACT

This paper outlines the changes in the survey design of IWC/IDCR/SOWER cruises. Changes in the survey design between the second (CPII) and third (CPIII) circumpolar cruises was made in the 1992/93 cruise in austral summer season. The priority of the survey design in CPII considered mainly longitudinal coverage and the whole IWC management area was surveyed in a single season. On the other hand, the survey design of CPIII took precedent latitudinal coverage and consequently it took two or more season to cover the whole area. The difference in this survey design was expressed by the survey area per unit of search efforts (SPSE) in the research strata. The SPSE in CPIII become larger through each research stratum than that in CPII. The negative correlation was found between the SPSE and the density index (DI). The difference in abundance estimate between CPII and CPIII could be caused by the following two factors, 1) Northern expansion of north stratum of research area. 2) Latitudinal expansion of south stratum. In addition, yearly difference of the shape of the ice edge line could have influenced greatly the abundance estimation.

KEY WORDS: SURVEY DESIGN, IDCR/SOWER, SOUTHERN OCEAN, ANTARCTIC MINKE WHALES

INTRODUCTION

This paper presents an overview on survey design differences in the IDCR/SOWER cruises between CPII and III. The International Whaling Commission/International Decades of Cetacean Research (IWC/IDCR; 1978/79 until 1995/96) and IWC/Southern Ocean Whale and Ecosystem Research (IWC/SOWER; since 1996/97) have been conducted in austral summer season. With the start of the SOWER programme, a blue whale research component was added, but all cruises were designed for abundance estimation of the Antarctic minke whale (Butterworth *et al.* 1994).

The first circumpolar series, hereafter CPI (i.e. all six management Areas covered longitudinally) was between 1978/79 and 1983/84, CPII was between 1984/85 and 1990/91, while CPIII was between 1991/92 and 2003/04. During the early years, there was a major change in emphasis of cruises, with a shift from whale marking to sighting surveys. Procedural modification in survey design was made in 1992/93 season. Since then the complete coverage in each 10 degree longitudinal sector between 60°S and ice edge was aimed because this corresponded to the choice of "small areas" in the application of the Revised Management Procedure to the Antarctic minke whales (Rowlett *et al*.1993).

SURVEY ITEM

Research area

First and second circumpolar series

One of the IWC Antarctic Management Areas (Fig.1, see Donovan, 1991) was surveyed during each cruise in CP I and CPII. In each Area, longitudinal coverage took precedence over latitudinal coverage. The northern boundary of each Area was established around 60°S-61°S in Areas IV and VI, 62°S-65°S in Areas I and III, and 58°S-59°S in Areas II and V.

Third circumpolar series

During CPIII, on all cruises since the 1991/92 cruise, priority has been given to latitudinal coverage (from the ice-edge to 60°S) instead of longitudinal coverage (i.e. there was additional coverage of northern waters compared with the first and second circumpolar cruises). The aim of the modification was to estimate abundance between 60°S and the northern boundary of earlier surveys. As a consequence of this modification, the southern stratum was also expanded to the north.

Survey design

The transition from CPI to CPIII by the change of the survey design was summarized in Table 1 (Matsuoka *et al.* 2003). A major change of survey design is the shift from whale marking to the sighting. CPI is conducted mainly as the whale marking survey, while CPII and III were conducted as the sighting survey only. The first year of CP II was spent on an experiment cruise for standardization of the sighting survey.

Although the Normal Searching Closing mode (NSC) was applied for the whale marking survey, Independent Observer Passing mode (IOP) was adopted as standard specification of the sighting survey from 1985/86 season by introduction of the second platform.

The sighting experiment was conducted in 1984/85 cruise. The difference in the position of an observer platform which was different by the type of ship might influence in the collection of sighting information data. Full-scale sighting survey was started in 1985/86. Shonan-Maru type (SM) vessel was more suitable than Toshi-Maru type (TM) vessel as standard specification, and SM vessels were used in CPII and CPIII series. As for IOP, collection of the data used for presumption of g (0) in Antarctic Ocean was adopted. NSC and Normal Sighting Passing (NSP) modes are applied the two primary observers on the top barrel. Two primary observers in IOP were stationed at the top barrel and one primary observer was an IOP barrel.

Each IWC management area was stratified into two equally east and west sectors. This stratification was continued until CPIII. The north-south stratification was made into two layers or three layers depending on the number of research vessels. It was only 1985 / 86 and 1986/87 cruises in CPII which three layers were adopted in east and west sectors (1984 / 85 cruise was conducted sighting survey on three layers only in the west sector because of sighting experiment year).

The width of southern stratum from ice to 30n.miles offing, and the northern stratum was from a northern boundary of the southern stratum to 5 degree (300n.miles) in latitude. In 1983/84 cruise, a different research range was set up. 60°S was set as the north-side boundary of the research area. The research area was stratified north and south at 65°S. The north strata were able to cover in the first half of the CPII by three sighting vessels. Then the south- stratum was set up in the range from ice to 60n.miles offing. The area from the north-side boundary of south strata to 60° S was divided further to north and south. The north one was called to north stratum and on the south one was medium stratum. Two sighting vessels were used in the CPII in 1886/87 cruise and afterwards. The research range was stratified into north and south. In South stratum was set to the range of 60 n.miles offing from ice edge. North stratum was set to the range of 5 degrees latitude from the

north-side boundary of the south stratum. CPIII aimed into more coverage of longitude than the coverage of latitude. The full coverage of all six management areas were made around in six years in CPI and CPII, it will spend 13 years in CPIII.

Sighting survey track line in CPI was parallel to ice edge line in south stratum, and the lattice-like track line was adopted in north stratum. The zigzag track line was adopted both in the north and south strata from 1983/84 cruise. The number of sighting survey track line is set up corresponding to number of research days and the area of research area. The number of sighting survey track line in each stratum was set up more than four evenly. The lattice-like track line is only adopted in south strata in 1988/89 cruise through CPII and CPIII. In CPIII, two zigzag track lines were set up at intervals of the five degrees longitude in south strata and ten degrees longitude in north strata.

The ice-edge line from 1978/79 to 1986/87 cruises was mapped based on the visual information by survey vessel. In 1987 /88 cruises and afterwards, it was mapped based on the ice information by the satellite data.

RESULTS

The distribution of Antarctic minke whale

The distribution of Antarctic minke whales with survey track-lines in each Area was shown in Figure 5.In Area I, the ice edge line of CPII was located in more south than that of CPIII. The difference was remarkable in west sector. In east sector, ice edge line turned north in eastern sector by Antarctic Peninsula. The northern part of south strata in CPIII overlaps the southern part of north strata in CPII. The difference in the position of the ice edge line between CPII and CPIII has influenced greatly the distribution of Antarctic minke whales in research area.

In Area II, shape of ice edge line differs remarkably between CPII and CPIII. The difference in the shape is remarkable in the western sector. On the eastern sector, south strata in CPIII overlap with north strata in CPII. A sighting distribution of the minke whale in the southern stratum has depended on the difference in shape of ice edge line. The shape and size of the survey area in north strata differ greatly each other in CPII and III. These differences reflected into a difference in sighting distribution of minke whale.

The positions of the ice edge line in Area III differed greatly between CPII and CPIII. For this reason, the covered area of the western sector in the research area differs remarkably. The south strata in CPIII overlap north strata in CPII completely. These differences reflected into a difference in sighting distribution of minke whale.

In Area IV, the southern stratum in CPIII overlaps the northern stratum in CPII. The south strata in CPII were surveyed under the lattice-like track line. A sighting distribution of a minke whale is concentrated on the south portion of track line in southern stratum, and there is almost no sighting on the north portion of track line. These differences reflected into a difference in sighting distribution of minke whale.

As for the research area of Area V, the position of ice edge line has jutted out in CPIII compared with CPII. As for the southern stratum of eastern sector, the research area is remarkably narrow. The southern stratum of the western sector in CPIII overlaps the northern stratum of that in CPII. These differences reflected into a difference in sighting distribution of minke whale.

In Area VI, there is no significant difference in the position of ice edge line and the range of the research area between CPII and CPIII. There is no substantial difference in the sighting distribution of a minke whale between CPII and CPIII.

Survey area (n.miles^2)

The size of survey area (n.miles) for every circumpolar and research stratum in six Antarctic management Areas were shown in Figure3 (Branch and Butterworth, 2001). When CPIII is

compared with CPII, the size of survey areas increased in Areas I, II, III, and V. Conversely, Areas IV and V were decreased. As for the Areas IV and V, the part of un-surveyed area is not included. Each research stratum of CPIII has expanded than that of CPII with change of a survey design.

Survey area per unit of search efforts (SPSE)

The survey area per unit of search efforts (SPSE) in each research area was shown in Figure 4. The Area I show that the value of CPIII is large in north and south strata. The Area II showed the high value except for the north-west stratum in each stratum of CPIII. The north-west stratum of CPII showed the highest value through all IDCR/SOWER cruises. There is no conspicuous difference SPSE between CPII and CPIII in Areas III, IV, V and VI Areas.

Relation between a density index (DI) and SPSE

Relation between DI and SPSE in each research area were shown in Figure 5(Branch and Butterworth 2001). The DI in Area I showed smaller value in CPIII than CPII. As For the SPSE, CPIII was larger value than CPII.

As for DI in Area II, CPIII showed lower value than CPII except for north-west stratum. As for SPSE, CPIII showed larger value than CPII except for north-west stratum.

The DI and the SPSE is not different between CPII and CPIII in the Area III. The estimated mean school size ($E_{(S)}$) showed the larger value in CPII than CPIII. This might be caused by the difference in the ice edge line between CPII and CPIII.

The SPSE in the Area IV does not have a difference between CPII and CPIII. As for the DI and the $E_{(S)}$, CPII showed the value higher than CPIII by south strata. This was caused by the difference in the design of track line between CPII and CPIII.

About the Area V, the opposite correlation in the SPSE and the DI is shown between CPII and CPIII. As for the difference in the $E_{(S)}$, position and its shape in the ice edge line might be influenced.

The DI and SPSE is no conspicuous difference between CPII and CPII in the Area VI. The $E_{(S)}$ showed the larger value at CPII than CPIII. This has suggested the influence by the difference in the ice edge line between CPII and CPIII.

DISCUSSION

The change in the survey design between CPII and CPIII cruises was made in the 1992/93 season. A survey design of CPII took precedence the coverage of longitude and surveyed one area in a single season. On the other hand, the survey design of CPIII took precedent latitudinal coverage and consequently it took two or more years. The difference in this survey design was expressed by the SPSE in the research strata. The SPSE in CPIII was suggested to become large through each sub research area than that of CPII. The negative correlation was shown between the DI and SPSE. It confirmed that the northern strata of CPII overlapped to the southern strata of CPIII. The survey design changes of CPIII brought a result which increased survey coverage at lower latitudes in the northern strata where most minke whales are solitary and the sea state trends to be worse. This has suggested that $g_{(0)}$ is changing between CPII and CPIII (Murase *et al*, 2004 in-prep.).

Further, the ice edge position of CPII located more south rather than CPIII and it might bring a result lower DI in the southern strata in CPIII. Such difference of ice edge position might influence also DI in the northern strata and $E_{(S)}$ in the southern strata in CPIII. The difference in abundance estimate between CPII and CPIII suggests the following two points as a factor related to a survey design, 1) Northern expansion of north stratum of research area. 2) Latitudinal expansion of south stratum. These two factors brought decrease in abundance estimate from CPII to CPIII.

It is concluded that direct comparisons of abundance estimates between CPII and CPIII are difficult. Further analyses are required to remove effect of survey design changes between CPII and CPIII. Whether such differences in survey design affect on abundance estimate can be

investigated by simulation studies.

REFFERNCE

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Table 1. The transition from CPI to CPIII by the change of the survey design (Data are quoted from Matsuoka *et al* 2003)

Circumpolar	CPI		CPII					CPIII
Year	1978/79—1982/83	1983/84	1984/85	1985/86 ·1986/87	1987/88	1988/89	1989/90-1990/91	1991/92-
Research activity	Marking > Sighting	Sighting > Marking	Sighting = Experiment	Sighting	Sighting	Sighting	Sighting	Sighting
Vessel	Toshi-Maru type:Two vessels	Toshi-Maru type: one vessel, Shonan-Maru type: Two vessels	Toshi-Maru type: one vessel, Shonan-Maru type: Two vessels	Toshi-Maru type: one vessel, Shonan-Maru type: Two vessels	Shonan-Maru type: Two vessels	Shonan-Maru type: Two vessels	Shonan-Maru type: Two vessels	Shonan-Maru type: Two vessels
Sighting survey mode	NSC>NSP	NSC>NSP	NSC=NSP	NSC=IOP	NSC=IOP	NSC=IOP	NSC=IOP	NSC=IOP
Stratum of research area	Research area was divided two sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	Research area was divided two sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	Research area was divided two sectors, by the middle position in the longitudinal range. The part of western sector was further divided three strata in latitudinal range.	Research area was divided three sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	Research area was divided two sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	Research area was divided two sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	Research area was divided two sectors, by the middle position in the longitudinal range. These sectors were further divided two strata in latitudinal range.	The research area was divided two strata in latitudinal range.
Range of research area	East and West sectors: 30 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from the 30 n.miles from ice-edge. Northern stratum: on the 30 n.miles from ice-edge and on the locus from 65S latitude line.	East and West sectors: 35 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from 65S latitude line. Northern stratum: on the locus from 65S latitude line and 60S latitude line.	East and West sectors: 30 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from the 60 n.miles from ice-edge. Northern stratum: these were divided in mideum range of latitude between on the 60 n.miles from ice-edge and on the locus from 60S latitude.	East and West sectors: 30 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from the 60 n.miles from ice-edge. Northern stratum: these were divided in mideum range of latitude between on the 60 n.miles from ice-edge and on the locus from 60S latitude.	East and West sectors: 35 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from the 60 n.miles from ice-edge. Northern stratum: on the 60 n.miles from ice-edge and on the locus from 65S latitude line.	East and West sectors: 30 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from 65S latitude line. Northern stratum: on the locus from 65S latitude line and 60S latitude line.	East and West sectors: 30 digrees in range of longitude. Southern stratum: on the ice-edge and on the locus from 65S latitude line. Northern stratum: on the locus from 65S latitude line and 60S latitude line.	Each 10 degree longitudinal sector with inter stratum boundary established on fixed latitudinal line.
Track-line	Soutern stratum: wriggle line along ice edge. Northen stratum: lattice shape line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line	Southern and Nortern strata: zig-zag line
Ice edge line	The ice edge was mapped by the soutern survey vessel.	The ice edge was mapped by the soutern survey vessel.	The ice edge was mapped by the soutern survey vessel.	The ice edge was mapped by the soutern survey vessel.	Estimaton of the position of the ice-edge from saterallite information.	Estimaton of the position of the ice-edge from saterallite information.	Estimaton of the position of the ice-edge from saterallite information.	Estimaton of the position of the ice-edge from saterallite information.

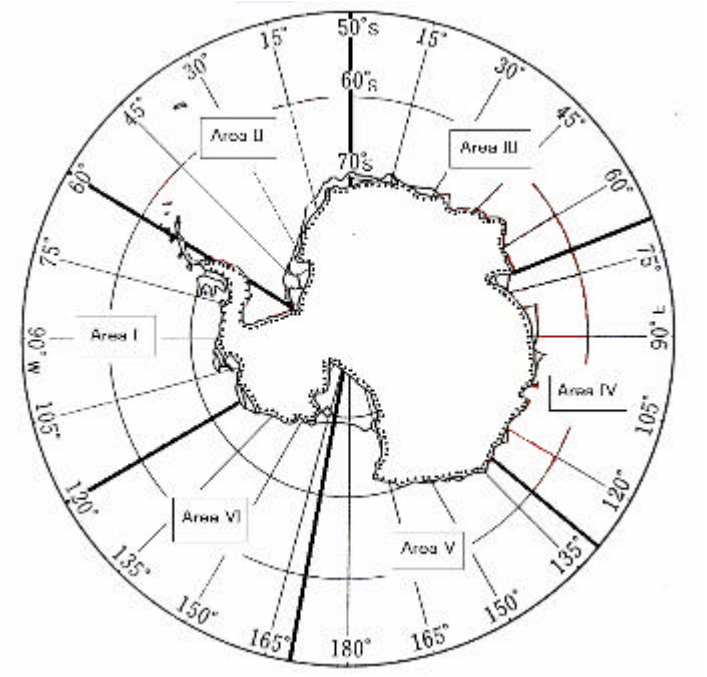

Figure1. The IWC Antarctic Areas for the management of baleen whale species

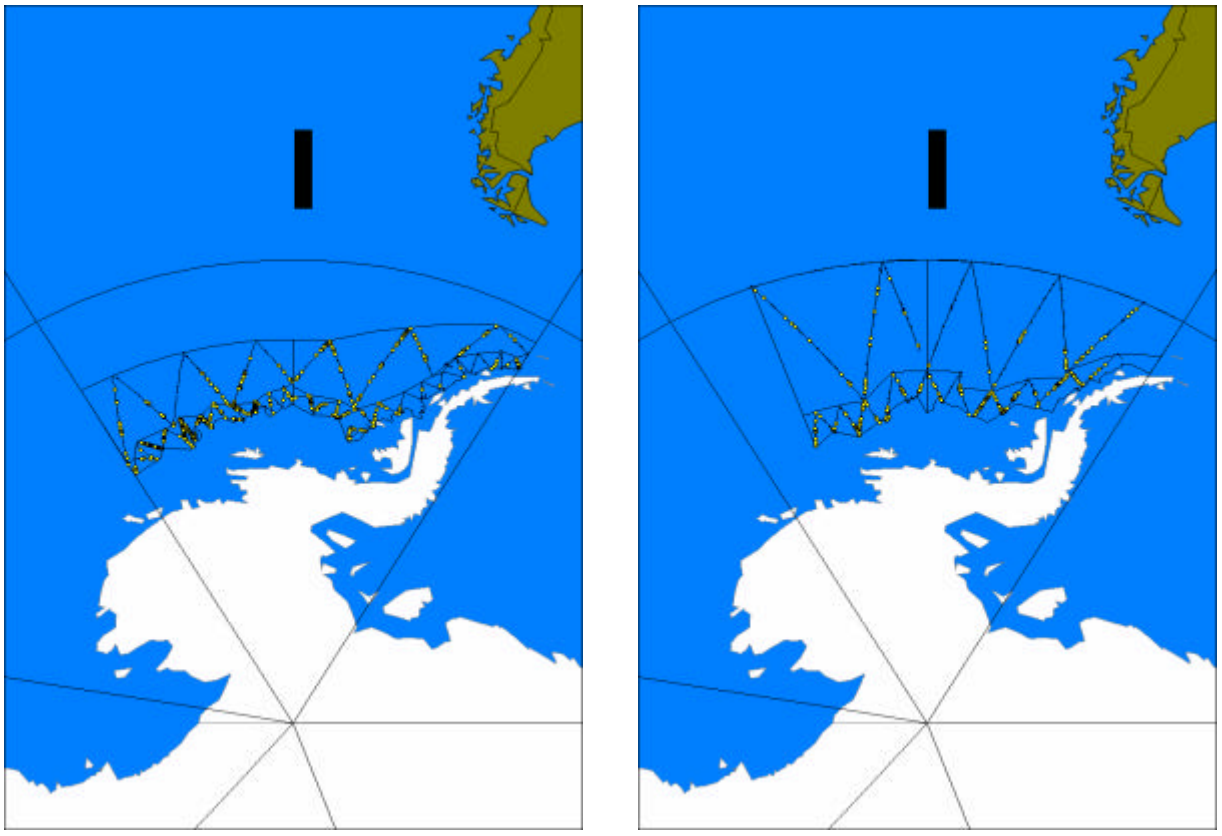

Figure2-a. The sighting distribution of Antarctic minke whales with survey track-lines in Area I (Left: CPII. Right: CPIII)

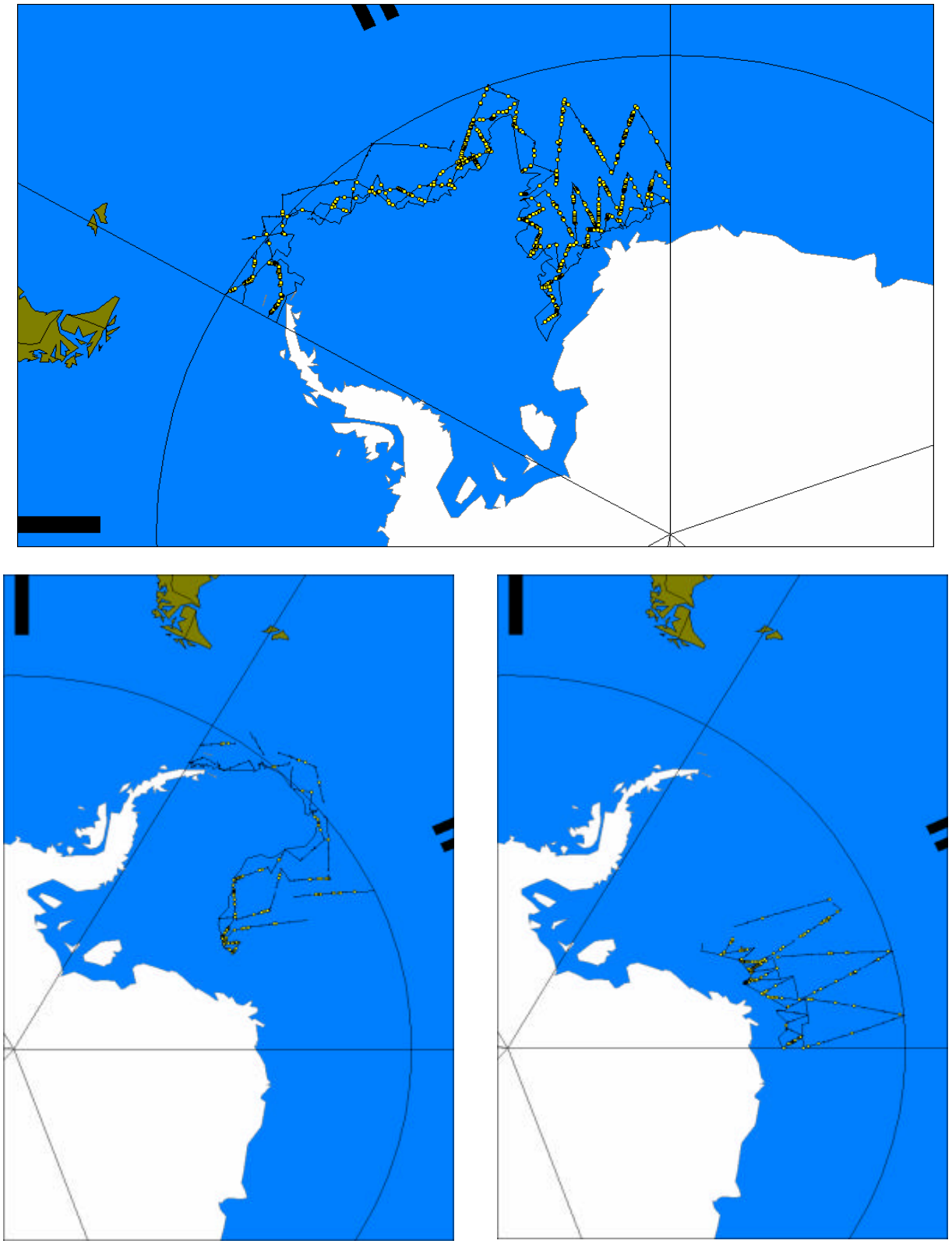

Figure2-**b**. The sighting distribution of Antarctic minke whales with survey track-lines in Area II (Upper: CPII. Lower left: Western sector in CPIII. Lower right: Eastern sector in CPIII)

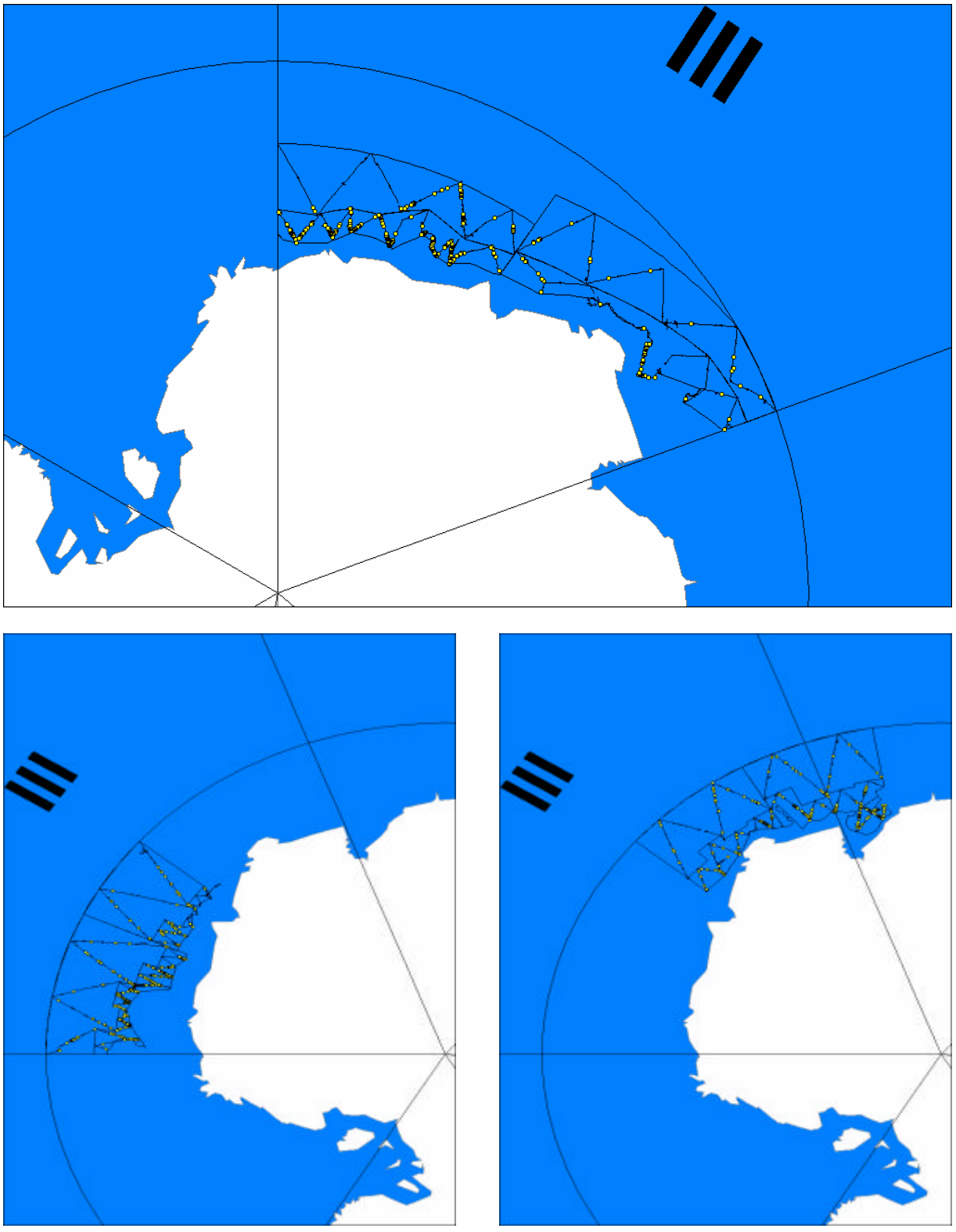

Figure2- **C** . The sighting distribution of Antarctic minke whales with survey track-lines in Area III (Upper: CPII. Lower left: Western sector in CPIII. Lower right: Eastern sector in CPIII)

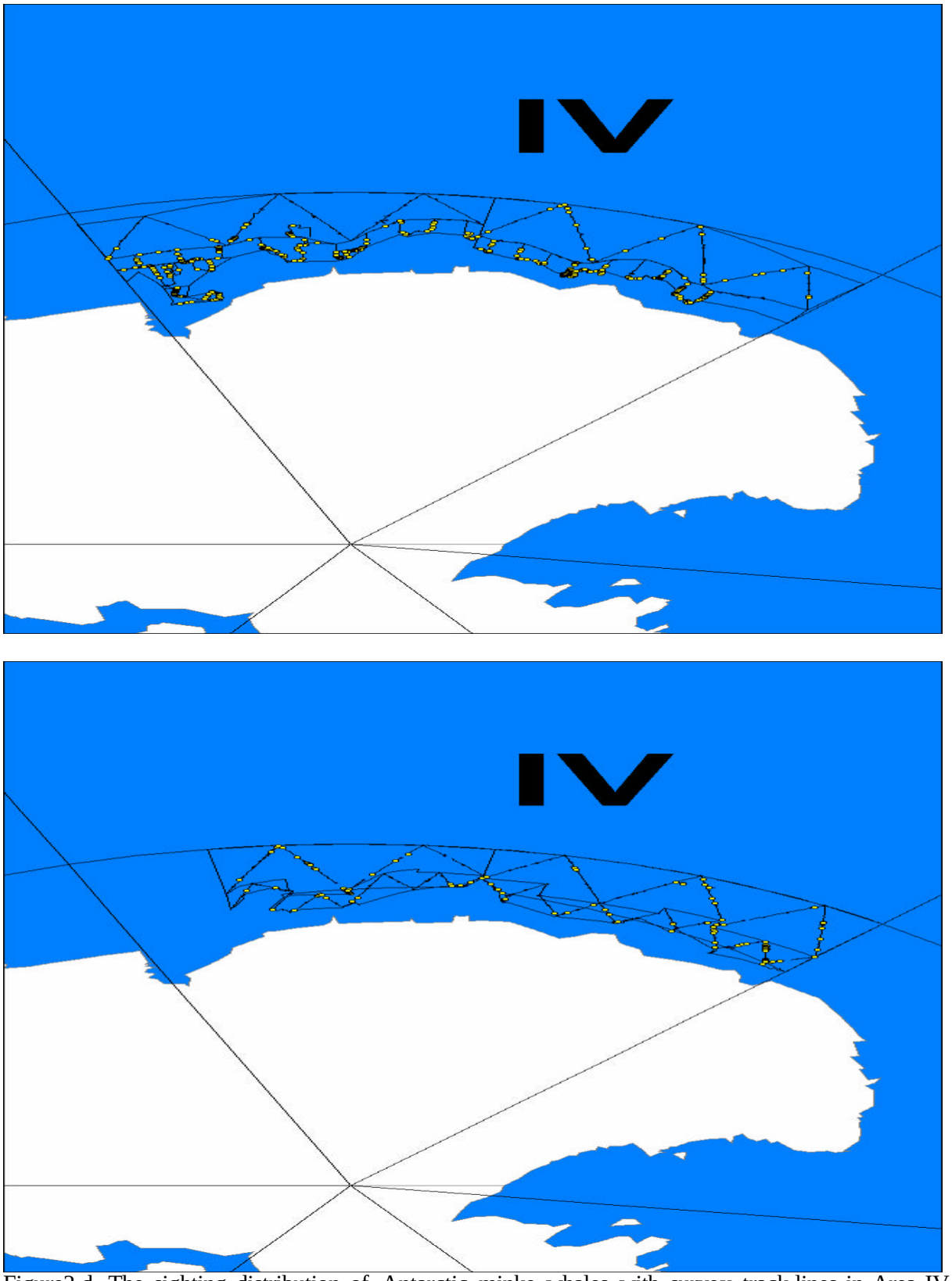

Figure2-d. The sighting distribution of Antarctic minke whales with survey track-lines in Area IV (Upper: CPII. Lower: CPIII)

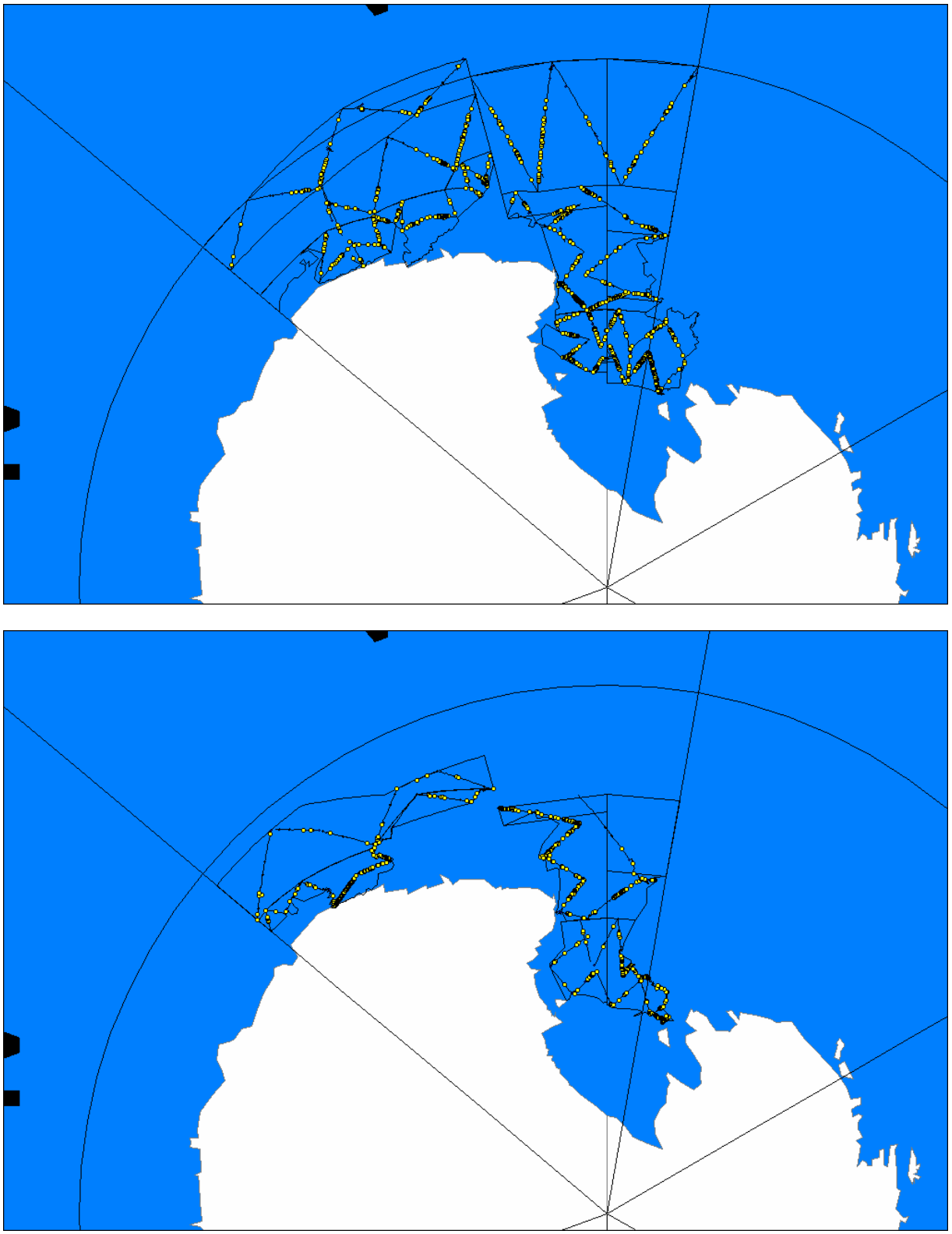

Figure2-e. The sighting distribution of Antarctic minke whales with survey track-lines in Area V (Upper: CPII. Lower: CPIII)

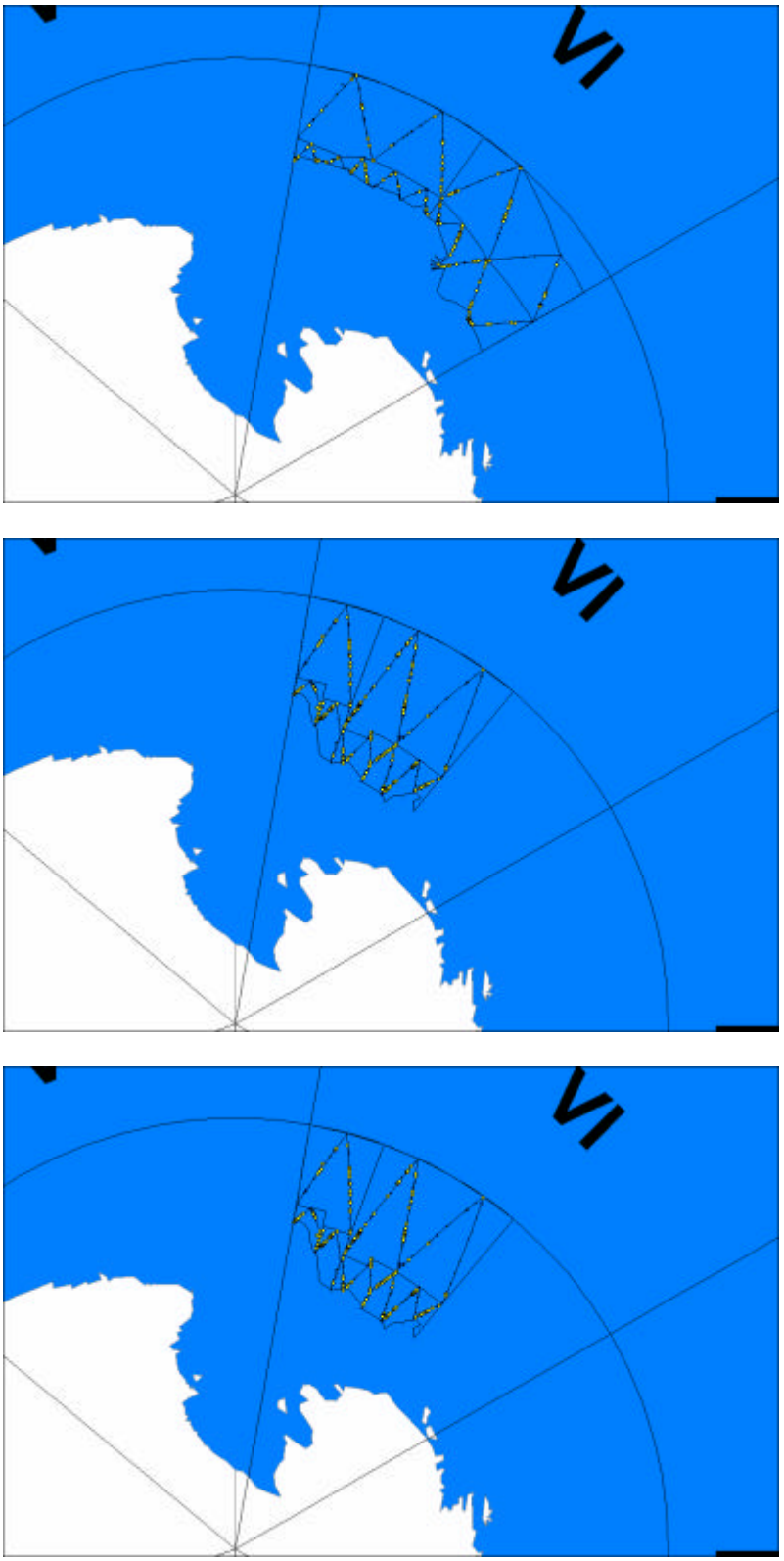

Figure2-**d**. The sighting distribution of Antarctic minke whales with survey track-lines in Area VI (Upper: CPII. Middle: Eastern sector in CPIII. Lower: Western sector in CPIII)

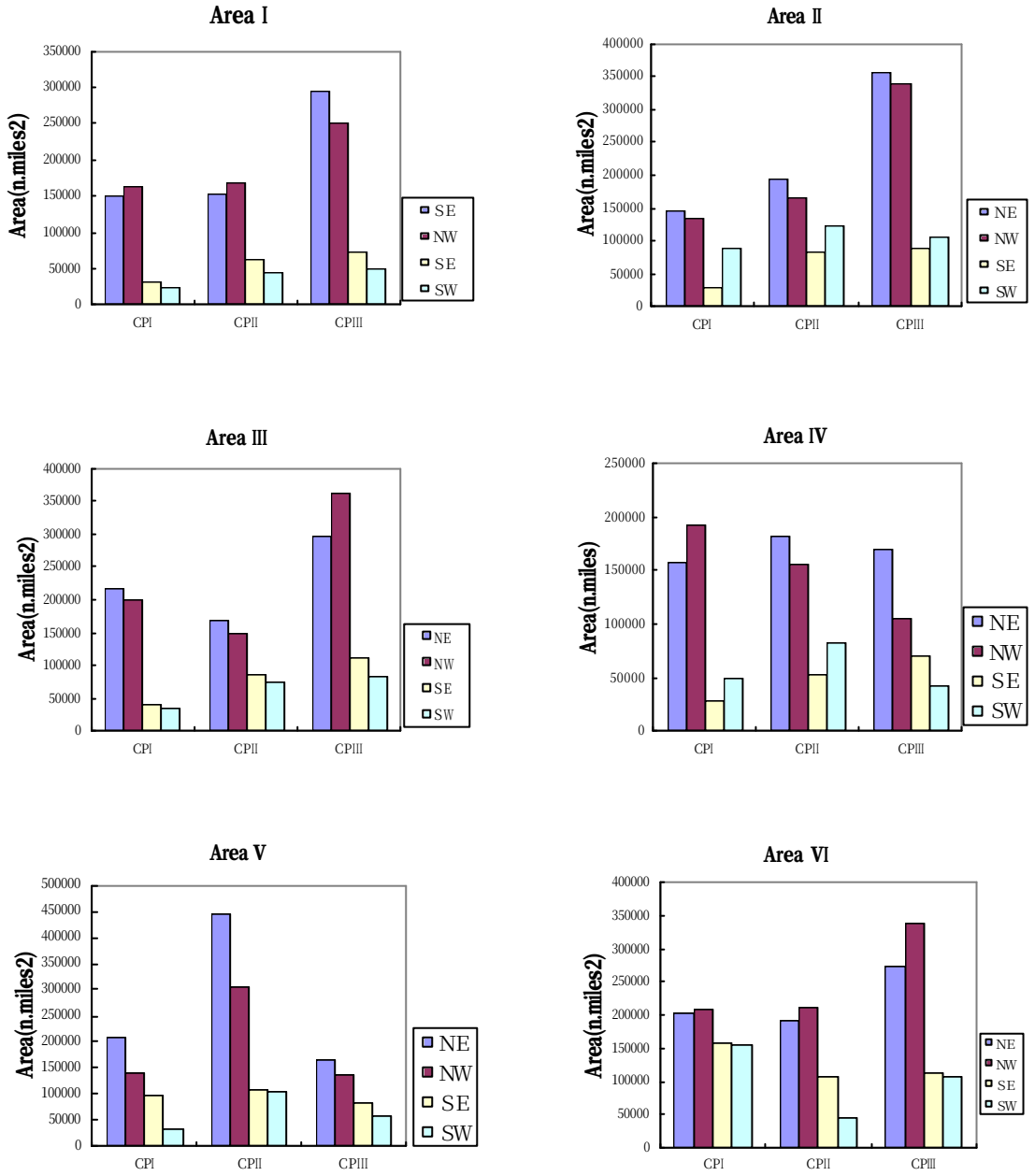

Figure3. The survey area (n.miles^2) in Antarctic Areas for the management of baleen whale species (Data are quoted from Branch and Butterworth 2001)

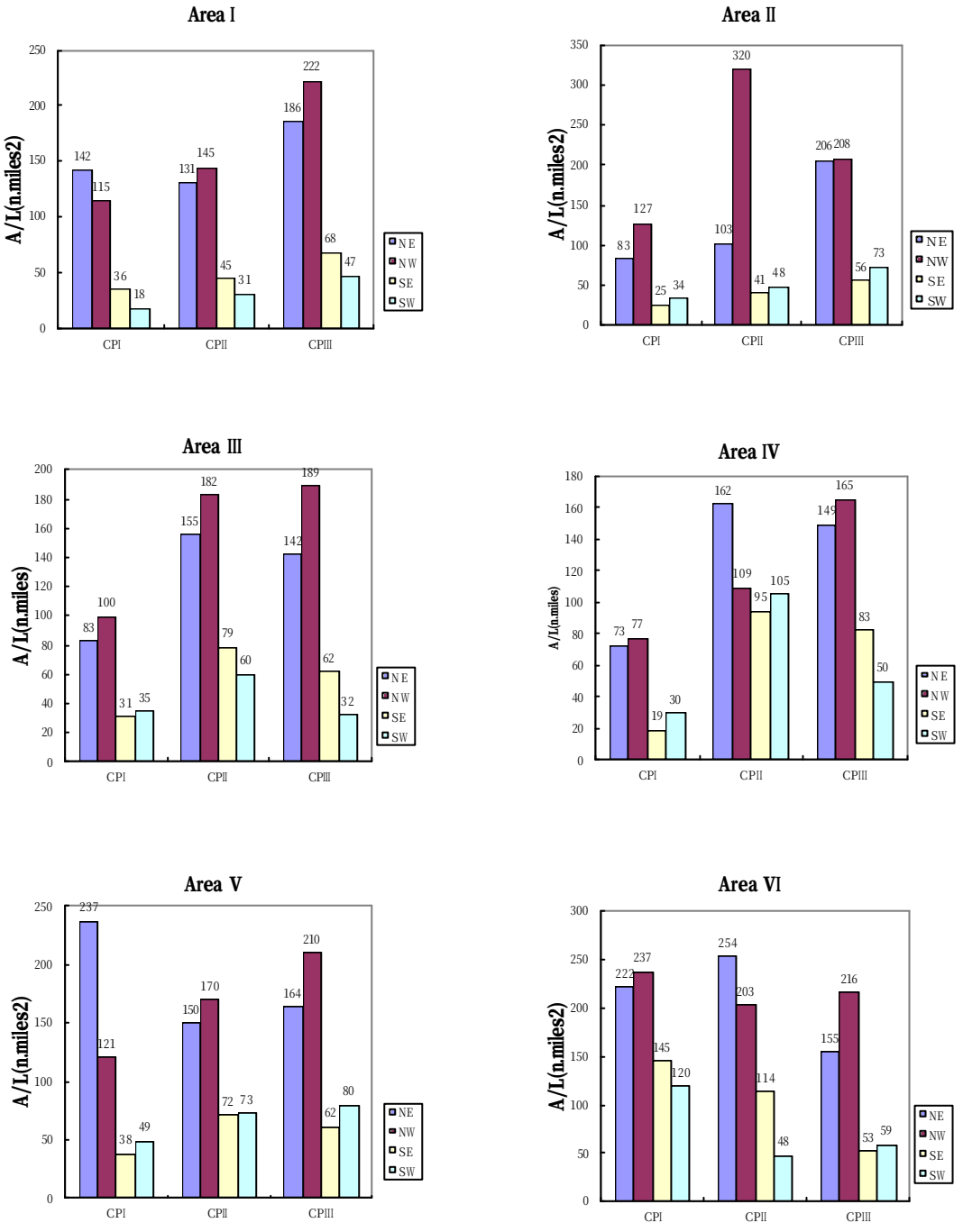

Figure 4. The Coverage Survey area per amount of search Efforts (CSE) in each research area (Data are quoted from Branch and Butterworth 2001)

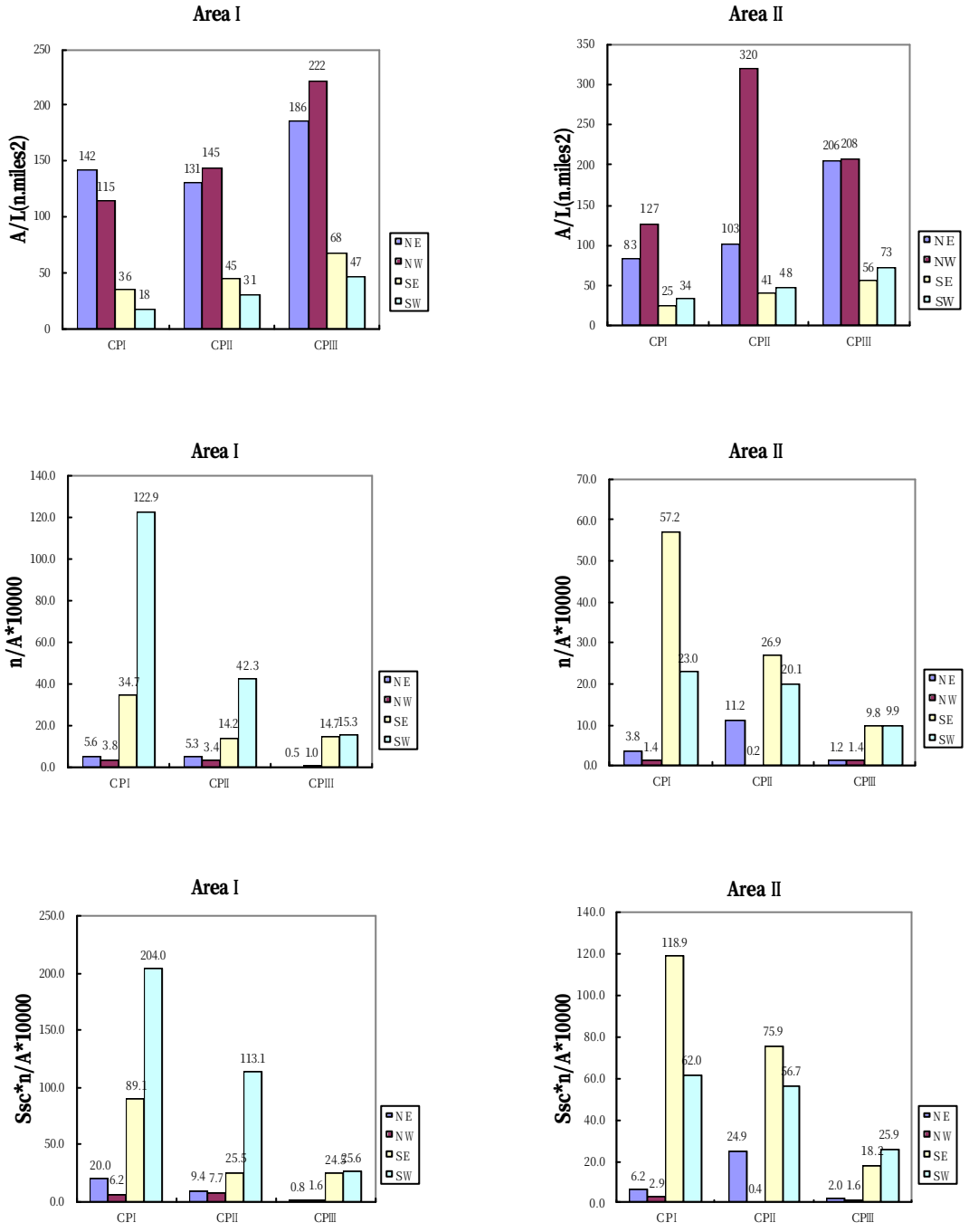

Figure 5-a. Relation between DI and CSE in Areas I and II (Data are quoted from Branch and Butterworth 2001).

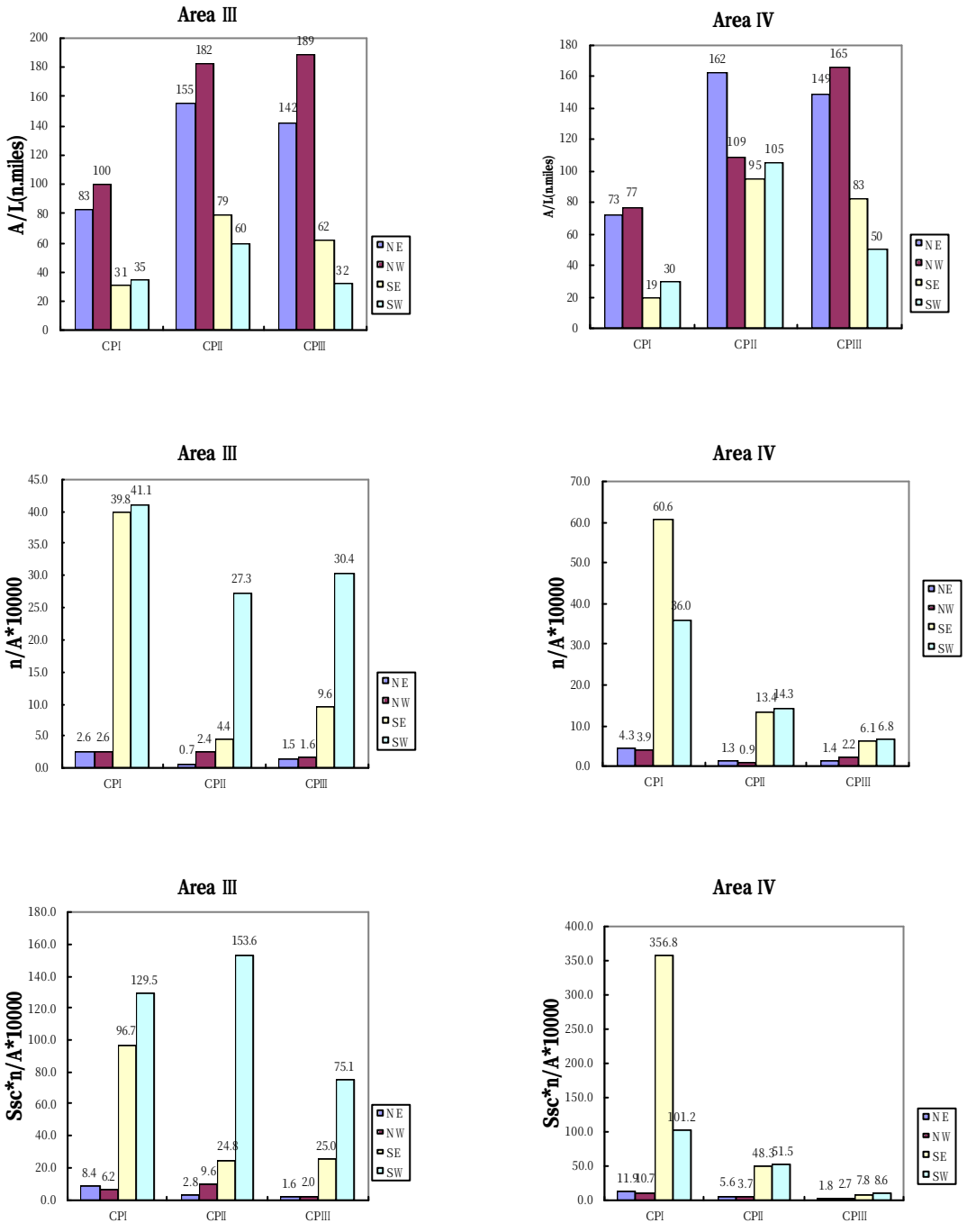

Figure 5-b. Relation between DI and CSE in Areas III and IV (Data are quoted from Branch and Butterworth 2001).

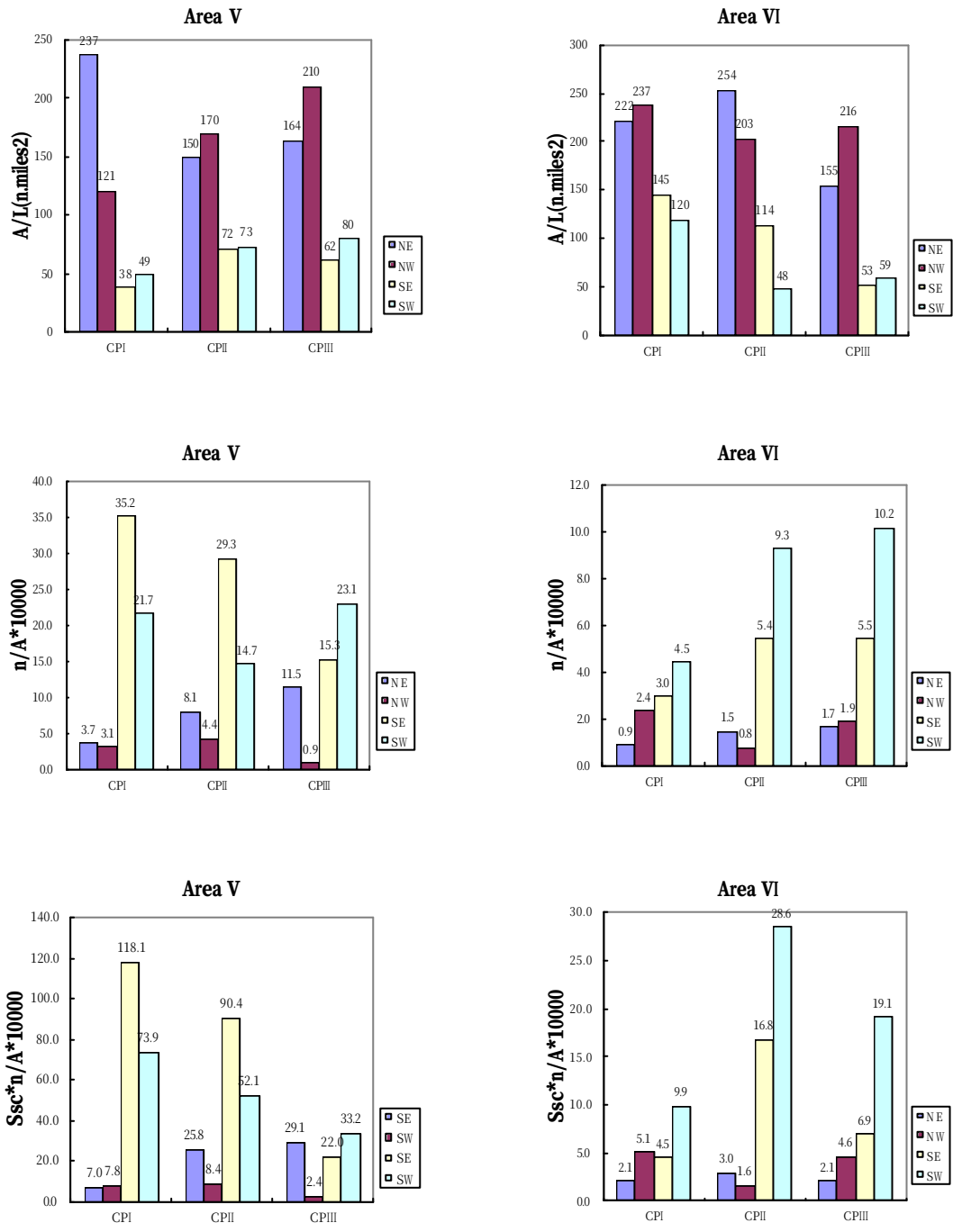

Figure 5-c. Relation between DI and CSE in Areas V and VI (Data are quoted from Branch and Butterworth 2001).