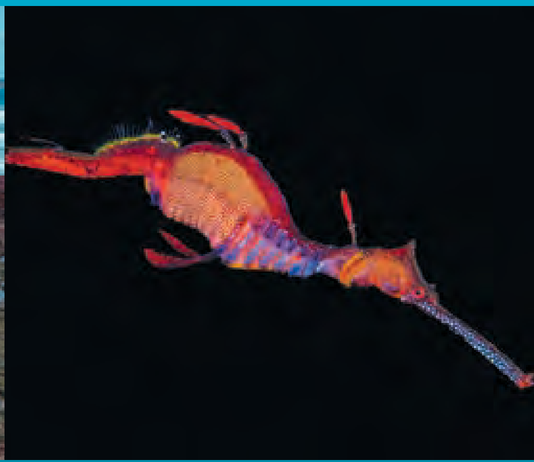

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Victorian Subtidal Reef Monitoring Program:

The Reef Biota at Point Cooke Marine Sanctuary, May 2015

Matt Edmunds

Australian Marine Ecology Pty. Ltd.

May 2015

Executive summary

Shallow reef habitats cover extensive areas along the Victorian coast and are dominated by seaweeds, mobile invertebrates and fishes. These reefs are known for their high biological complexity, species diversity and productivity. They also have significant economic value through commercial and recreational fishing, diving and other tourism activities. To effectively manage and conserve these important and biologically rich habitats, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). The SRMP is implemented throughout Victoria and has been operating for over 16 years. It provides information on the status of Victorian reef flora and fauna and determine the nature and magnitude of trends in species populations and species diversity through time.

This report describes the monitoring of the Point Cooke Marine Sanctuary and reference sites, involving seven surveys from 2004 to 2015. The monitoring uses standardised underwater visual census methods on reefs 5 m deep. There are two sites, one inside the marine sanctuary at Point Cooke and one reference site, to the south near the RAAF airbase.

This report aims to provide:

- a general descriptions of the biological communities and species populations at each monitoring site and any changes over the monitoring period;
- an identification of any unusual biological phenomena such as interesting communities, strong temporal trends and the presence of any introduced species;

The ongoing monitoring surveys used a standardised procedure along a 200 m line divided into four transects. Each transect was surveyed for:

- abundance and size structure of large fishes;
- abundance of cryptic fishes and benthic mobile invertebrates;
- percentage cover of macroalgae;
- abundance of a string kelp, *Macrocystis pyrifera*, if present; and
- abundance of manufactured debris.

Key observations during the monitoring program were:

- The seaweed community at both of the Point Cooke sites was initially comprised of kelp *Ecklonia radiata* and green algal *Caulerpa* mats. This changed to a very low cover of seaweed (sea urchin barren) in 2009-2011 and predominance of crustose coralline algae. There was a subsequent shift toward more *Caulerpa* mat coverage in 2015.
- The dominant invertebrate species was the common sea urchin *Heliocidaris erythrogramma*, which varied in abundance at Point Cooke between 40-260 individuals per 50 m^2. There was an exceptionally high peak in abundance of sea urchins at the RAAF Base reference site in 2009, with 760 individuals per 50 m^2.
- The peaks in sea urchin abundances coincided with the very low seaweed abundance in 2009-2011.
- There were large changes in sediment coverage at Point Cooke, with higher coverage of 40 % occurring during periods of higher *Caulerpa* coverage and low sediment coverage (< 10 %) associated with the sea urchin barren period. The highest sediment coverage was in 2015.
- There were relatively high densities of blacklip abalone *Haliotis rubra* at both sites in 2003, with a decline to low abundances in 2009. Abundances remained low to 2015.
- The abundance of eleven-armed seastars *Coscinasterias muricata* was relatively high in the period 2009 to 2015. The abundance of other native seastars was relatively low in 2013 and 2015.
- The fish community at both sites is dominated by southern hulafish *Trachinops caudimaculatus*. The abundances of this planktivore varied markedly over the monitoring period, with a peak in abundance in 2009.
- There were no other major shifts in community structure attributable to climate change.
- There were occasional sightings of the introduced Mediterranean fanworm *Sabella spallanzanii* and Northern Pacific seastar *Asterias amurensis* at both sites. The density of *A. amurensis* was highest in 2015. The introduced Japanese kelp was frequently observed at both sites, however the survey timing is outside their macroscopic growth season of late winter to early summer. The observed abundances indicated that the seasonal recruitment of the larger growth phase was earlier than usual.
- Manufactured debris was observed at both sites.

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1 Introduction

1.1 Subtidal Reefs of Northern Port Phillip Bay

Victoria's shallow reefs are a very important component of the marine environment because of their high biological complexity, species diversity and productivity. Subtidal reef habitats also have important social and cultural values, which incorporate aesthetic, recreational, commercial and historical aspects. Shallow subtidal reefs also have significant economic value, through commercial fishing of reef species such as wrasses, morwong, rock lobster, abalone and sea urchins, as well as recreational fishing, diving and other tourism activities. Reefs in the north of Port Phillip Bay are highly accessible components of the marine environment because of their proximity to the large population centres of Melbourne and surrounding suburbs. Consequently, these reef ecosystems are subject to particular pressures arising from urban human activities.

Rocky reefs in Port Phillip Bay are generally restricted to the near-shore regions of headlands and points. Reefs in the northwest of the bay, along the Geelong Arm, are predominantly near Point Lillias, Point Wilson and Kirks Point. These reefs occur in short coastal strips from the intertidal zone to 2-4 m depth, bounded by bare sediment and seagrass habitats a short distance from shore. Occasional small patches of reef, 10-50 m across, are present further offshore, particularly between Point Wilson and Kirks Point. These patch reefs are mostly 1-3 m deep.

Along the northern shore of the bay, small patches of shallow reef, interspersed by silty sands, are also present in the vicinity of Point Cooke, Western Beach (north of Point Cooke), Altona, Point Cooke (Williamstown Rifle Range), Point Gellibrand and Point Ormond. These reefs are generally no deeper than 4 m. More extensive reef habitat is present from Sandringham to Point Cooke, extending 50-200 m from the shore and to a depth of approximately 6 m.

In general, the reefs on the north shore of the bay are quite sheltered from the prevailing north-westerly to south-westerly weather and are not subject to large waves, strong currents or swell. Reefs on the north-eastern side of the bay, particularly between Half Moon Bay and Point Cooke, are exposed to the prevailing westerly weather across a relatively long fetch of water. Consequently, these reefs are occasionally subject to turbulent wind-driven waves. These north-eastern reefs are also influenced, to some extent, by the Yarra River plume and east-coast drainages.

Reef habitats in the north of Port Phillip Bay are different from the open coast reef habitats in Victoria. The northern bay reefs are in semi-estuarine conditions and are subject, at times, to lower salinities from coastal runoff, rivers and drains, as well as considerable temperature ranges (as low as 8° C in winter and as high as 23° C in summer). These reefs are also frequently subject to turbid conditions from phytoplankton blooms and disturbance of moderate to fine sediments. While there are similar species inhabiting both sheltered reefs in the north of the bay and reefs on more exposed coasts, there are substantial and important differences in community structure between the bay and open coast reef environments. Seaweeds are the predominant biological habitat providers in both locations however the cover of large canopy forming species such as crayweed *Phyllospora comosa* and common kelp *Ecklonia radiata* is much reduced on reefs in the bay. Smaller species of brown algae (10–30 cm high), such as *Sargassum* spp., red thallose algae and *Caulerpa* green algae are often the dominant habitat forming species on reefs in the bay (Figure 1.1). Species of *Caulerpa* can form large patches of mixed-species assemblages, creating meadow-like habitat in some locations. Grazed algal turfs and hard encrusting layers of coralline algae are also important species growing directly over the rocky substratum. The introduced Japanese wakame seaweed *Undaria pinnatifida* has been present in northern Port Phillip Bay since the early 1990's and has been spreading ever since.

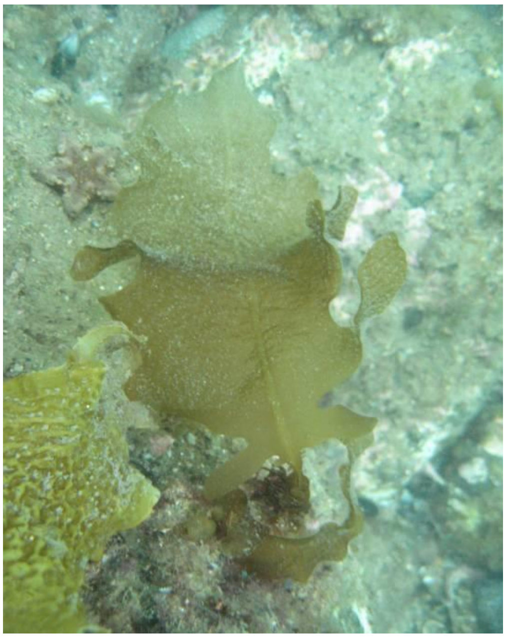
Mobile invertebrates are prominent animal inhabitants of the reef (Figure 1.2). Large grazing species such as the urchin *Heliocidaris erythrogramma* and blacklip abalone *Haliotis rubra* can occur in very high densities and represent a large percentage of the biomass of the bay's reef communities. These species can significantly influence the growth and survival of habitat forming algal species and so are important habitat modifiers of reef communities. Important predatory invertebrates include octopus such as *Octopus berrima* and seastars including *Coscinasterias muricata* and *Uniophora granifera*. Predatory gastropod molluscs (shellfish) include the dogwhelk *Dicathais orbita* and *Australaria australasia*.

Filter feeding species feed on phytoplankton and detritus and can be important for transferring nutrients and energy from the water column to other species directly inhabiting reefs. Filter feeding species on reefs in the north of the bay include aggregations of mussels *Mytilus galloprovincialis*, ascidians such as *Herdmania momus* and *Pyura stolonifera*, sponges and the introduced European fanworm *Sabella spallanzanii*. Other filter feeders are colonial species including sponges, bryozoans, the soft corals *Erythropodium hicksoni* and the stony coral *Plesiastrea versipora*.

Fish on open coast reefs are usually dominant components of reef ecosystems both in terms of biomass and ecological function, however the fish component is not a major component of northern Port Phillip Bay reefs (Figure 1.3). Reef fish assemblages include predators such as snapper *Pagrus auratus*, omnivores including zebrafish *Girella zebra*, planktivores such as the southern hulafish *Trachinops caudimaculatus* and picker-feeders such as horseshoe leatherjacket *Meuschenia hippocrepis*. Schools of small baitfish, particularly tommy rough, sardines, pilchards and sprats are common over reef habitats in the north of the bay. The reef communities in the north and east of the bay provide important habitat for juveniles of many fish species including snapper *Pagrus auratus*. Many fish species play a substantial ecological role in the functioning and structuring of reef ecosystems.


Green alga *Ulva sp*


Green alga *Caulerpa remotifolia*


Juvenile introduced Japanese seaweed *Undaria pinnatifida*


Common kelp *Ecklonia radiata*


Green alga *Caulerpa longifolia*

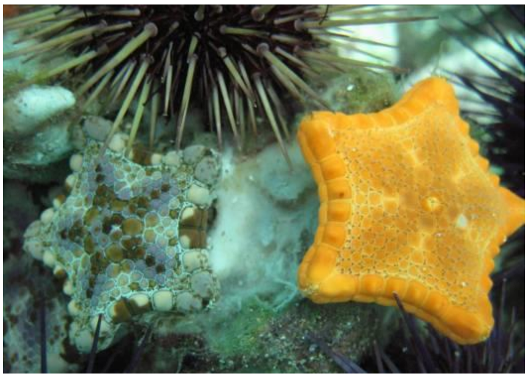

Brown alga *Sargassum* sp, next to hard coral *Plesiastrea versipora*

Figure 1.1. Examples of common macroalgae in northern Port Phillip Bay.

Native feather worm *Sabellastarte australiensis*

Black-lipped abalone *Haliotis rubra*

Eleven-armed seastar *Coscinasterias muricata* on yellow hyphae sponge



Two colour morphs of the biscuit star *Tosia australis*.

Sea urchin *Heliocidaris erythrogramma*

Nudibranch *Ceratosoma brevicaudatum*

Figure 1.2. Examples of common invertebrate species in northern Port Phillip Bay.


Globefish *Diodon nichthemerus*


Old wife *Enoplosus armatus*


Scalyfin *Parma victoriae*


Southern hulafish *Trachinops caudimaculatus*


Smooth toadfish *Tetractenos glaber*


Banjo ray *Trygonorrhina fasciata*

Figure 1.3. Examples of common reef fishes in the Central Victoria bioregion.

1.2 Subtidal Reef Monitoring Program

1.2.1 Objectives

An important aspect of the management and conservation of Victorian marine natural resources and assets is assessing the condition of the ecosystem and how this changes over time. Combined with an understanding of ecosystem processes, this information can be used to manage any threats or pressures on the environment to ensure ecosystem sustainability.

Consequently, the Victorian Government has established a long-term Subtidal Reef Monitoring Program (SRMP). The primary objective of the SRMP is to provide information on the status of Victorian reef flora and fauna (focussing on macroalgae, macroinvertebrates and fish). This includes monitoring the nature and magnitude of trends in species abundances, species diversity and community structure. This is achieved through regular surveys at locations throughout Victoria, encompassing both representative and unique habitats and communities.

Information from the SRMP allows managers to better understand and interpret long-term changes in the population and community dynamics of Victoria's reef flora and fauna. As a longer time series of data are collected, the SRMP will allow managers to:

- compare changes in the status of species populations and biological communities among highly protected marine national parks and marine sanctuaries and other Victorian reef areas (*e.g.* Edgar and Barrett 1997, 1999);
- determine associations among species and among species and environmental parameters (*e.g.* depth, exposure, reef topography) and assess how these associations vary through space and time (*e.g.* Edgar *et al.* 1997; Dayton *et al.* 1998; Edmunds, Roob and Ferns 2000);
- provide benchmarks for assessing the effectiveness of management actions, in accordance with international best practice for quality environmental management systems (Holling 1978; Meredith 1997); and
- determine the responses of species and communities to unforeseen and unpredictable events such as marine pest invasions, mass mortality events, oil spills, severe storm events and climate change (*e.g.* Ebeling *et al.* 1985; Edgar 1998; Roob *et al.* 2000; Sweatman *et al.* 2003).

A monitoring survey gives an estimate of population abundance and community structure at a small window in time. Patterns seen in data from periodic surveys are unlikely to exactly match changes in the real populations over time or definitively predict the size and nature of future variation. Plots of changes over time will not exactly match the changes in real populations because changes over shorter time periods and actual minima and maxima may not be adequately sampled (*e.g.* Figure 1.4). Furthermore, because the nature and magnitude of environmental variation is different over different time scales, variation over long periods may not be adequately predicted from shorter-term data. Sources of environmental variation can operate at the scale of months (*e.g.* seasonal variation, recruitment and harvesting), years (*e.g.* El Niño), decades (*e.g.* pollution, extreme storm events) or even centuries (*e.g.* tsunamis, global warming). The monitoring program will begin to adequately reflect average trends and patterns as the surveys continue over longer periods (multiple years to decades). Results of this monitoring need to be interpreted within the context of the monitoring frequency and duration.

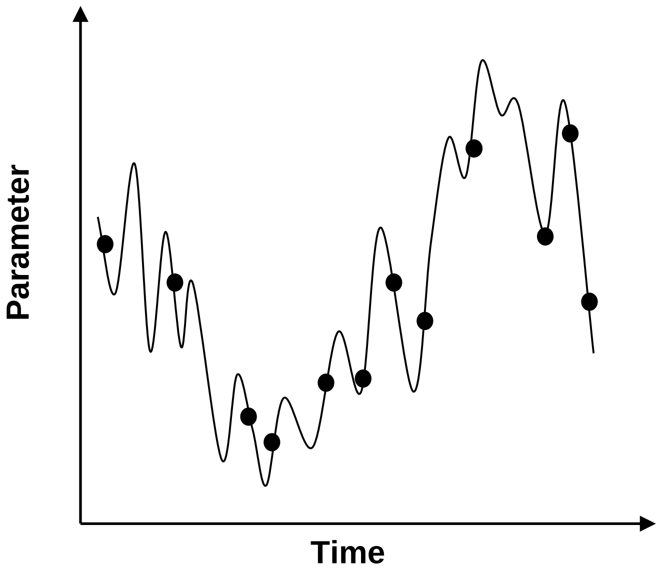


Figure 1.4. An example plot depicting change in an environmental, population or community variable over time (days, months or years) and potential patterns from isolated observations.

1.2.2 Monitoring Protocols and Locations

The SRMP uses standardised underwater visual census methods based on an approach developed and applied in Tasmania by Edgar and Barrett (1997). Details of standard operational procedures and quality control protocols for Victoria's SRMP are described in Edmunds and Hart (2003). The procedures have been added to since that publication.

The SRMP was initiated in May 1998 in the vicinity Port Phillip Heads Marine National Park. In 1999 the SRMP was expanded to reefs in the vicinity of the Bunurong Marine National Park, Phillip Island, Wilsons Promontory Marine National Park and Point Addis Marine National Park.

In 2003 and 2004, the Subtidal Reef Monitoring Program was further extended to include Marine National Parks and Marine Sanctuaries throughout Victoria.

1.3 Monitoring at Point Cooke Marine Sanctuary

This report describes the subtidal reef monitoring program at Point Cooke Marine Sanctuary and the reference site near the RAAF Base. The objectives of this report were to:

1. provide an overview of the methods used for the SRMP;
2. provide general descriptions of the biological communities and species populations at each monitoring site over the monitoring period;
3. describe changes and trends that have occurred over the monitoring period;
4. identify any unusual biological phenomena such as interesting or unique communities or species; and
5. identify any introduced species at the monitoring locations.

2 Methods

2.1 Site Selection and Survey Times

Monitoring sites were established at Point Cooke (Site 4101) inside the Marine Sanctuary and at RAAF Base (Site 4102; Figure 2.1; Table 2.1).

Seven surveys were completed between March 2003 and May 2015. The survey times are in Table 2.2.

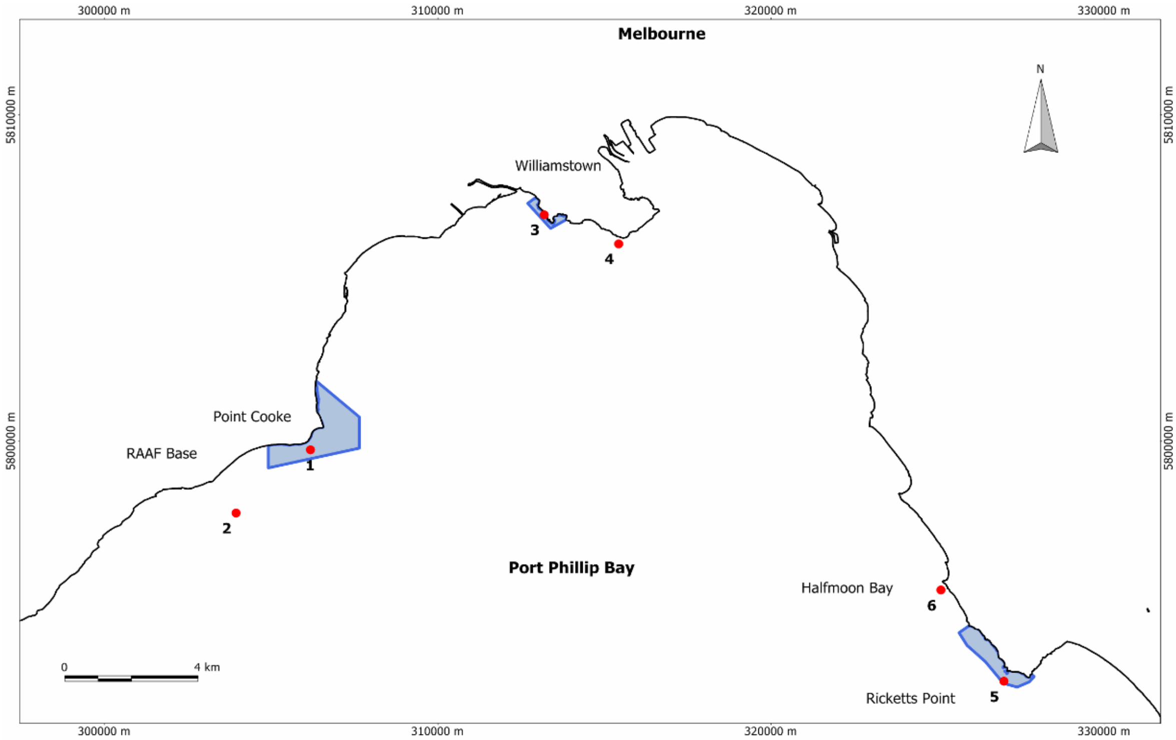


Figure 2.1. Location of marine sanctuary monitoring sites in northern Port Phillip Bay.

Table 2.1. Subtidal reef monitoring sites for Point Cooke MS.

Region	No.	Description	Status	Depth (m)
Port Phillip Bay	4101	Point Cooke Pines	MS	5
	4102	RAAF Base	Reference	5

Table 2.2. Subtidal reef monitoring survey times at Point Cooke MS.

Survey	Time	Sites
1	March 2003	4101; 4102
2	April 2004	4101; 4102
3	April 2005	4101; 4102
4	April 2009	4101; 4102.
5	June 2011	4101; 4102
6	April-May 2013	4101; 4102
7	May 2015	4101; 4102

2.2 Census Method

2.2.1 General Description

The Edgar-Barrett methods (Edgar and Barrett 1997, 1999; Edgar *et al*. 1997) are used for the repeated visual census of a set of sites within locations (usually within 10s km of the coastline). The position of each site is fixed, as with the position of transects surveyed within each site. Two hundred metres of four contiguous 50 m transects are surveys at each site. In accordance with the new Reef Life Survey methods data are now recorded for each side of the transect, termed 'blocks'.

Where possible, sampling was along the 5 m (± 1 m) depth contour, to minimise spatial variability between sites. The depth of 5 m was considered optimal for monitoring because diving times are not limited by decompression schedules and these reefs are subjected to heavy fishing pressure from wrasse fishers, rock lobster fishers and divers. Sampling at some sites had to be deeper or shallower, depending on the available habitat and exposure to wave action (with sites ranging from 2 to 12 m deep).

Each site was located using GPS and numbered and weighted transect lines were run along the appropriate depth contour. The resulting 200 m of line was divided into four contiguous 50 m transects (T1 to T4). The orientation of the transects was the same for every survey, with T1 toward the north or east along the coast (i.e. anticlockwise along the open coast: T1 is in the direction of "land-to-the-left").

For each transect, five different census methods were used to obtain adequate descriptive information on reef communities at difference spatial scales. These involved the census of: the abundance and size structure of large fishes (Method 1); the abundance of cryptic fishes and benthic invertebrates (Method 2); the percent cover of macro algae (Method 3); the density of string-kelp *Macrocystis* plants (Method 4); and the abundance and size structure of mobile fishes using a diver-operated stereo video system, DOVS (Method 5). The depth, horizontal visibility, sea state and cloud cover are recorded for each site. Horizontal visibility was gauged by the distance along the transect line to detect a 100 mm long fish (female wrasse). All field observations are recorded on underwater paper. The DOVS method records observations to a calibrated stereo video pairs.

2.2.2 Method 1 – Mobile Fishes and Cephalopods

The densities of mobile large fishes and cephalopods were estimated by a diver swimming up one side of the 50 m transect (5 m wide x 5 m high x 50 m long block). The observer recorded the number and estimated size-class of fish, within 5 m of each side of the line (50 x 10 m area). The size-classes for fish are 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 375, 400, 500, 625, 750, 875 and 1000+ mm. The data for easily sexed species were recorded separately for males and female/juveniles. Such species include the blue-throated wrasse *Notolabrus tetricus*, herring cale *Olisthops cyanomelas*, barber perch *Caesioperca rasor*, rosy wrasse *Pseudolabrus rubicundus* and some monacanthids. A total of four 50 m transects (two blocks per transect) were censused for mobile fish at each site. Common fish species observed in Port Phillip Bay are listed in Table 2.3.

2.2.3 Method 2 – Invertebrates and Cryptic Fishes

Cryptic fishes and mega faunal invertebrates (non-sessile: *e.g.* large molluscs, echinoderms, crustaceans) were counted along the transect lines used for the fish survey. A diver counted animals within 1 m of one side of the line (a total of four 1 x 50 m transects). The diver had a known arm-length to chest measurement to standardise the 1 m distance. The maximum length of abalone and the carapace length and sex of rock lobsters were measured *in situ* using Vernier calliper, where possible. Some sites were designated abalone size monitoring sites (‘Ab100’ sites) and a minimum of 100 abalone were measured at these sites (where possible within diving limits). Sessile animals were not counted with the exception of any marine pest species of pre-determined ecological interest (such as the introduced feather worm *Sabella spallanzanii* and the native feather worm at Point Hicks *Sabellastarte australis*).

Selected specimens were collected for identification and preservation in a reference collection. Common cryptic fish and invertebrate species in Port Phillip Bay are listed in Table 2.4.

2.2.4 Method 2b – Manufactured Debris

Manufactured debris items were counted along the invertebrate transect. The debris were classified into categories: fishing gear; plastic; cloth; metal; glass; wood; other and none (to indicate it was looked for but none seen). It was also recorded whether the debris was left or removed.

2.2.5 Method 3 – Macroalgae

The abundance of macrophytes (kelp, seaweeds, and seagrass) was quantified using a points-cover method. A quadrat, 0.5 m x 0.5 m, was placed at 10 m intervals along the transect line (5 quadrats per transect). The quadrat was divided into a grid of 7 x 7 perpendicular lines, giving 50 points (including one corner). Cover was estimated by counting the number of points intersecting with a species (Figure 2.2). The points-cover was determined independently for each species. Where there was a canopy or layers, the total number of points-counts from all species may be greater than 50. Selected specimens were collected for identification and preservation in a reference collection. Common macrophyte species in Port Phillip Bay are listed in Table 2.6.

2.2.6 Method 4 – Macrocystis

Where present, the density of string kelp *Macrocystis pyrifera* was estimated at the same time by the seaweed (Method 3) observer. While swimming between quadrat positions, the diver counted all observable *Macrocystis* plants within 5 m either side of the transect for each 10 m section of the transect (10 x 10 m sections). This survey component commenced in spring 1999.

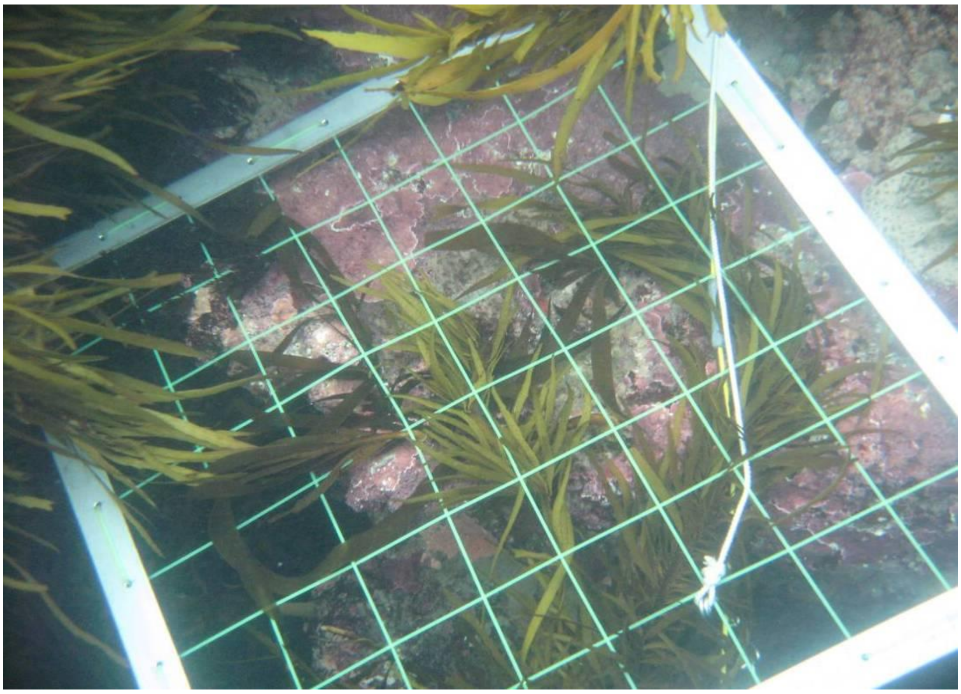


Figure 2.2. The cover of macrophytes is measured by the number of points intersecting each species on the quadrat grid.

2.2.7 Method 5 – Fish Stereo Video

A diver operated stereo video system (DOVS; SeaGIS design) was used alongside the diver UVC fish surveys. The videos were Canon HG21 handycams recording in 1080p format. The cameras were calibrated before and after each excursion using a SeaGIS calibration cube and SeaGIS CAL software for calibration of internal and external camera parameters. The cameras were mounted permanently to a diver frame. A flashing LED mounted on a pole in front of both frames was used for synchronisation of paired images from each camera.

The stereo camera system was operated simultaneously by the diver who did the UVC fish and done at the same time. The stereo camera frame had the underwater UVC slate mounted on it for the simultaneous observations. The camera system was pointed parallel with the transect line and downward 30º with the diver swimming 2.5 m to one side of the transect and 1.3 m above the canopy, as with the UVC method. The camera unit was tilted vertically (up or down) according to the fish seen to ensure adequate video for size measurements, but was generally tilted down at an angle of 30º. Lateral movement of the unit was minimised. The survey speed was 10 m per minute (0.17 m s^{-1}).

In the laboratory, the stereo video footage was converted from MTS to AVI format. The SeaGIS EventMeasure and PhotoMeasure software were then used for extracting and recording fish density and fish length estimates from the stereo video footage. Measured fish were those without body flexure and orientated transverse to the camera, as well as with the measurement points visible. Standard lengths (SL) were measured (tip of snout to end of caudal fin ray). The original video footage and frames used for fish length measurements were archived. The results of this method were archived for future analysis and were not reported here.

2.2.8 Method 0 – Off-Transect Sightings

Any species of interest sighted off-transect, or on transect but not during the formal survey, was recorded with the designation of Method 0 and Transect 0. Note that additional off transect abalone measurements were recorded as Method 2, Transect 0.

Table 2.3. Mobile fishes and cephalopods (Method 1) taxa commonly censused in Port Phillip Bay.

Method 1		
Cephalopoda	**Mobile Bony Fishes**	**Mobile Bony Fishes**
Octopus maorum	*Pempheris multiradiata*	*Neoodax balteatus*
	Platycephalus bassensis	*Neosebastes scorpaenoides*
	Acanthopagrus australis	*Nesogobius* spp
Sharks and Rays	*Siphamia cephalotes*	*Acanthaluteres spilomelanurus*
Trygonorrhina fasciata	*Upeneichthys vlaminghii*	*Acanthaluteres vittiger*
Dasyatis brevicaudata	*Girella tricuspidata*	*Brachaluteres jacksonianus*
Urolophus cruciatus	*Girella zebra*	*Scobinichthys granulatus*
Urolophus paucimaculatus	*Scorpis aequipinnis*	*Meuschenia freycineti*
Trygonoptera testacea	*Scorpis lineolata*	*Meuschenia hippocrepis*
	Tilodon sexfasciatus	*Aracana ornata*
Mobile Bony Fishes	*Enoplosus armatus*	*Tetractenos glaber*
Caesioperca rasor	*Parma victoriae*	*Diodon nichthemerus*
Trachinops caudimaculatus	*Cheilodactylus nigripes*	
Arripis spp	*Dactylophora nigricans*	**Mammals and Reptiles**
Arripis georgianus	*Notolabrus tetricus*	*Arctocephalus pusillus*
Pagrus auratus		
Atherinidae spp		

Table 2.4. Invertebrate and cryptic fish (Method 2) taxa commonly censused in Port Phillip Bay.

Method 2		
Molluscs	**Crustacea**	**Echinoderms**
Haliotis rubra	*Strigopagurus strigimanus*	*Comanthus trichoptera*
Dicathais orbita	Paguridae spp (other)	*Heliocidaris erythrogramma*
Australaria australasia		*Amblypneustes* spp
Pterynotus triformis		*Tosia magnifica*
Noumea sp		*Tosia australis*
Ceratosoma brevicaudatum		*Petricia vernicina*
Elysia sp	**Cryptic Fishes**	*Meridiastra gunnii*
Hoplodoris nodulosa	*Pempheris multiradiata*	*Meridiastra calcar*
Ostrea angasi	*Gnathanacanthus goetzeei*	*Parvulastra exigua*
Octopus berrima	*Aetapcus maculatus*	*Uniophora granifera*
Octopus maorum	*Bovichtus angustifrons*	*Coscinasterias muricata*
	Heteroclinus johnstoni	*Asterias amurensis*
Annelida	*Heteroclinus perspicillatus*	*Australostichopus mollis*
Sabella spallanzanii	*Cristiceps australis*	
Sabellastarte australiensis	*Cliniid* spp	
	Trinorfolkia clarkei	
Crustacea	*Vincentia conspersa*	
Guinusia chabrus	*Nesogobius* spp	
Nectocarcinus integrifrons	*Diodon nichthemerus*	
Petrocheles australiensis	*Brachaluteres jacksonianus*	
Naxia aurita	*Urolophus paucimaculatus*	
Austrodromidia octodentata		

Table 2.5. Manufactured debris (Method 2b) categories.

Method 2		
Fishing gear	Metal	Glass
Plastic	Cloth	Wood

Table 2.6. Common macroalgae and seagrass (Method 3) taxa censused in Port Phillip Bay.

Method 3		
Chlorophyta (green algae)	**Chromista (brown algae)**	**Rhodophyta (red algae)**
Ulva spp	*Cystophora siliquosa*	*Peyssonnelia* spp
Ulva compressa	*Cystophora retroflexa*	*Dictymenia harveyana*
Caulerpa longifolia	*Cystophora subfarcinata*	*Echinothamnion hystrix*
Caulerpa trifaria	*Caulocystis cephalornithos*	*Gigartina* spp
Caulerpa scalpelliformis	*Acrocarpia paniculata*	*Hypnea ramentacea*
Caulerpa remotifolia	*Phyllotricha decipiens*	*Laurencia filiformis*
Caulerpa brownii	*Phyllotricha sonderi*	*Laurencia tumida*
Caulerpa flexilis	*Phyllotricha varians*	*Laurencia botryoides*
Caulerpa flexilis var *muelleri*	*Phyllotricha verruculosum*	*Rhodymenia australis*
Caulerpa obscura	*Sargassum fallax*	
Caulerpa sedioides f. *geminata*	*Sargassum spinuligerum*	
Caulerpa hodgkinsoniae	*Sargassum* spp	
Caulerpa simpliciuscula	Ectocarpus spp (filamentous)	
Codium fragile		
Codium harveyi	**Rhodophyta (red algae)**	
Codium lucasi	Thallose red algae	
Codium duthieae	Red turfing algae	
Codium galeatum	Filamentous red algae	
Codium spp	Encrusting coralline algae	
Cladophora spp	*Plocamium angustum*	
	P. cirrhosum	
Chromista (brown algae)	*P. cartilagineum*	
Dictyota dichotoma	*P. leptophyllum*	
Dictyota marginatus	*Callophyllis rangiferina*	
Dictyota gunniana	*Gracilaria cliftoni*	
Zonaria turneriana	*Champia* spp	
Distromium flabellatum	*Champia viridis*	
Leathesia difformis	*Ceramium* spp	
Lobophora variegata	*Griffithsia monilis*	
Splanchnidium rugosum	*Solieria robusta*	
Ecklonia radiata	*Pterocladiella capillacea*	
Undaria pinnatifida	*Jania sagittata*	
Cystophora brownii	*Jania rosea*	
Cystophora monilifera	*Arthrocardia wardii*	
Cystophora moniliformis	*Ballia callitricha*	

2.3 Data Analysis – Condition indicators

2.3.1 Approach

Reef quality indicators were developed to encompass key features of MNP performance assessment and management interest. The selection of indicators for reef ecosystem management were reviewed by Turner *et al.* (2006) and further theoretical and field considerations are provided by Thrush *et al.* (2009). Both reviews suggest a variety of indicators, of both ecosystem structure and function, should be used. Rapport (1992) noted that stressors causing adverse changes in an ecosystem stand out beyond the natural range of variability observed in a system in 'good health'. Adverse changes to an ecosystem include:

- a shift to smaller organisms;
- reduced diversity with loss of sensitive species;
- increased dominance by weedy and exotic species;
- shortened food chain lengths;
- altered energy flows and nutrient cycling;
- increased disease prevalence; and
- reduced stability/increased variability (Rapport *et al.* 1995).

A suite of indicators was developed for the Tasmanian reef monitoring program, which uses the same Edgar-Barrett underwater visual census methods (Stuart-Smith *et al.* 2008). The indicators are grouped into the general categories: biodiversity; ecosystem functions; introduced pests; climate change and fishing. The Stuart-Smith indicators were followed and adapted for the Victorian SRMP. These indices are consistent with the reviews mentioned above. Key adaptations were the use of absolute values rather than proportions, as the Victorian data had considerable concurrent variation in the numerator and denominator of many indices, making proportional indices difficult to interpret. The Stuart-Smith approach for examining community changes was extended by using the multivariate control charting method of Anderson and Thompson (2004).

The indicators were calculated separately for the three survey components, fishes, invertebrates and algae.

The indicators presented in this report provide a basis for assessment and further refinement of indicators for marine protected area performance assessment and management.

2.3.2 Biodiversity

Community Structure

Community structure is a multivariate function of both the type of species present and the abundance of each species. The community structure between pairs of samples was compared using the Bray-Curtis dissimilarity coefficient. This index compares the abundance of each species between two samples to give a single value of the difference between the samples, expressed as a percentage (Faith *et al.* 1987; Clarke 1993).

Count data were log transformed and points-cover values were not transformed prior to multivariate analyses.

For fishes, only site-attached species were included in the analyses.

The multi-dimensional information in the dissimilarity matrix was simplified and depicted using non-metric multidimensional scaling (nMDS; Clarke 1993). This ordination method finds the representation in fewer dimensions that best depicts the actual patterns in the hyper-dimensional data (reduces the number of dimensions while depicting the salient relationships between the samples). The nMDS results were then depicted graphically to show differences between the sample periods at each location. The distance between points on the nMDS plot is representative of the relative difference in community structure.

Kruskal stress is an indicator statistic calculated during the ordination process and indicates the degree of disparity between the reduced dimensional data set and the original hyper-dimensional data set. A guide to interpreting the Kruskal stress indicator is given by Clarke (1993): (< 0.1) a good ordination with little real risk of drawing false inferences; (< 0.2) can lead to a usable picture, although for values at the upper end of this range there is potential to mislead; and (> 0.2) likely to yield plots which can be dangerous to interpret. These guidelines are simplistic and increasing stress is correlated with increasing numbers of samples. Where high stress was encountered with a two-dimensional data set, three-dimensional solutions were sought to ensure adequate representation of the higher-dimensional patterns.

Trends in Community Structure

Multivariate control charting was used to examine the degree of changes in community structure over time. Two criteria are applied for the SRMP, the first being the deviation in community structure at a time *t* from the centroid of baseline community structures (1998 to 2002). This criterion is more sensitive to the detection of gradual changes over time away from the baseline conditions. In this case, there was no before-period because the no-take zone was already established. The first two surveys were used as a baseline period to detect longer term deviations. The second criterion was the deviation in community structure at time *t* to the centroid of all previous times. This criterion is more sensitive at detecting abrupt or pulse changes.

Control charts were prepared for each site. The control chart analysis used the methods of Anderson and Thompson (2004) and calculations were done using the software ControlChart.exe (Anderson 2008). The analysis used the Bray-Curtis dissimilarity coefficient and the same data transformations described above. Bootstrapping was used to provide control-chart limits for identifying changes that are 'out of the ordinary'. In this case, a 90th and 95th percentile statistic was calculated from 1000 bootstrap samples as provisional limits. The 50th percentile was also presented to assist in interpreting the control charts.

Species Diversity

The total number of individuals, *N*, was calculated as the sum of the abundance of all individuals across species.

Species richness, *S*, was given as the number of species observed at each site. Cryptic, pelagic and non-resident reef fishes were not included.

Species diversity, as a measure of the distribution of individuals among the species, was indicated using Hill's N_2 statistic (which is equivalent to the reciprocal of Simpson's index). In general, Hills N_2 gives an indication of the number of dominant species within a community. Hills N_2 provides more weighting for common species, in contrast to indices such as the Shannon-Weiner Index (Krebs 1999), which weights the rarer species.

The diversity statistics were averaged across sites for the marine protected area and reference regions.

Abundances of Selected Species

Mean densities of selected species were plotted over time for the marine protected area and reference regions. The species presented included abundant or common species as well as any with unusual changes over time.

2.3.3 Ecosystem Functional Components

Plant Habitat and Production

Biogenic habitat and standing stocks of primary producers was indicated by the pooled abundances of macrophyte groups:

- crustose coralline algae;
- canopy browns – defined here as *Ecklonia radiata, Undaria pinnatifida, Lessonia corrugata, Macrocystis pyrifera*, *Durvillaea potatorum, Phyllospora comosa, Seirococcus axillaris, Acrocarpia paniculata, Cystophora platylobium, C. moniliformis, C. pectinata, C. monilifera, C. retorta* and *C. retroflexa;*

- smaller browns (all other brown species except Ectocarpales);
- erect coralline algae;
- thallose red algae (except filamentous species);
- green algae; and
- seagrass *Amphibolis antarctica*.

Invertebrate Groups

The abundances of invertebrates were pooled into the functional groups:

- grazers and habitat modifiers, including gastropods and sea urchins;
- filter feeders, including fanworms and feather stars;
- predators, including gastropods, crabs and lobsters but excluding seastars; and
- seastars, which are mostly predators, although *Meridiastra gunnii* may also be a detritus feeder.

Fish Groups

The abundances of fishes were also pooled into trophic groups:

- herbivores and omnivorous grazers;
- foraging predators, including pickers and foragers of stationary, benthic prey such as amphipods, crabs and gastropods;
- hunter predators, including fishes that hunt mobile prey, particularly other fishes, as chasers and ambushers; and
- planktivores, including feeders of zooplankton and small fish in the water column.

Sediment Cover

The percentage cover of sand and sediment on the survey transect (using Method 3) is the only relevant abiotic parameter measured for the SRMP. This index may indicate changes in hydrodynamic or coastal processes.

2.3.4 Introduced Species

The status of introduced species is initially reported as presence-absence of species. Where a species is established and the SRMP measures the abundance of that species, indicators of status are:

- number of introduced species;
- total abundance of introduced species; and

- where the data are suitable, time series of abundance of selected introduced species – noting the timing of surveys may influence the time series.

2.3.5 Climate Change

Species Composition

Climate change is likely to cause changes to current strengths and circulation patterns which affect both the ambient temperature regime and the dispersion and recruitment of propagules or larvae. In Victoria, there may be increased incursions of the East Australia Current into eastern Victoria and the South Australia Current into western Victoria and Bass Strait. Biological responses to such changes are potentially indicated by biogeographical changes in the species composition, toward that of adjacent, warmer bioregions. For this analysis, each species was assigned a nominal geographical range:

- cold water species, reflecting the 'Maugean' province, from approximately Kangaroo Island in South Australia, around Tasmania and into southern New South Wales;
- western species, reflecting the 'Flindersian' province, from southern Western Australia, along the Great Australian Bight and South Australia to western Victoria;
- eastern species, reflecting the 'Peronian' province, encompassing New South Wales and into eastern Victoria;
- southern species, including species ranging widely along the southern Australian coast; and
- northern species, including warm temperate and tropical species in Western Australia and New South Wales and northward.

The number of species and total number of individuals was calculated for the cold water, western and eastern groups.

Macrocystis pyrifera

The string kelp *Macrocystis pyrifera*, which includes the former species *M. angustifolia* (Macaya and Zuccarello 2010), is considered potentially vulnerable to climate change through reduced nutrient supply from drought and nutrient poorer warmer waters (Edyvane 2003). The mean abundance of *M. pyrifera* were plotted using densities from Method 4, or cover estimates from Method 4 where density data were unavailable. *Macrocystis pyrifera* provides considerable vertical structure to reef habitats and can also attenuate water currents and wave motion. The loss of *M. pyrifera* habitats may reflect ecosystem functional changes.

Centrostephanus rodgersii

The geographical range of the long-spined sea urchin, *Centrostephanus rodgersii,* has increased conspicuously over the past decades (Johnson *et al.* 2005). This grazing species can cause considerable habitat modification, decreasing seaweed canopy cover and increasing the area of urchin barrens. Abundances are determined using Method 2 and average abundances are plotted through time. The extent of urchin barrens, of any sea urchin species, will be monitored using data from Method 6, as time series data become available. The abundance of *C. rodgersii* are also influenced by interactions with abalone as competitors for crevice space, Abalone divers may periodically 'cull' urchins within a reef patch and the species is also of interest to urchin harvesters.

Durvillaea potatorum

The bull kelp *Durvillaea potatorum* is a cold water species that is likely to be vulnerable to increased ambient temperatures. There is anecdotal evidence of a retraction of the northern distribution down the New South Wales coast by approximately 80 km. Most of the SRMP sites specifically avoid *D. potatorum* habitats as these occur on highly wave-affected and turbulent reefs. Some sites contain *D. potatorum* stands, providing limited data on population status. *Durvillaea potatorum* is potentially two species, having genetically and morphologically distinct eastern and western forms (Fraser *et al.* 2009).

2.3.6 Fishing

Abalone

Indicators of harvesting pressure on abalone were mean density, mean size and the size frequency structure. The size structure indicators were the intercept and slope of the size spectrum. Size frequencies were first compiled for 10 mm size classes centred at 105, 115, 125, 135, 145, 155 and 165 mm and the spectrum slope and intercept was determined by a linear regression of ln(count + 1) versus ln(size + 1). The indicators were calculated for the blacklip abalone, *Haliotis rubra,* in most regions and for the greenlip abalone, *H. laevigata,* where present in suitable densities (in central and western Victoria).

Rock Lobster

The southern rock lobster, *Jasus edwardsii,* is present throughout Victoria. The monitoring transects generally did not traverse rock lobster microhabitats. Abundances and sizes were reported where data were available.

Fish

Potential fishing impacts or recovery of fishing impacts within marine protected areas were indicated by:

- abundances of selected fished species;
- mean size of selected fished species;
- total biomass of fished fish species and the portion of biomass > 200 mm length, this being the approximate legal minimum size for most fished species;
- biomass of fishes > 200 mm length, calculated using length-weight relationships; and
- parameters of the size-spectrum of fished species.

The size structure indicators were the intercept and slope of the size spectrum. Size frequencies were first compiled for 50 mm size classes centred at 100, 150, 200, 250, 300, 350, 400, 450, 500 and 550 mm and the spectrum slope and intercept was determined by a linear regression of ln(count + 1) versus ln(size + 1).

Biomass was calculated for the predominantly fished species, excluding incidentally caught or by-catch species. Lengths were converted to weights using published conversion factors for the power relationship:

$$weight(grams) = a \times Length(cm)^b$$

The weight estimations used the coefficients compiled by FishBase (www.fishbase.org). The length-weight parameters used are provided in Table 2.7.

Table 2.7. Fish length-weight conversion parameters used to calculate the biomass of fished species. Where parameters were unavailable, parameters for a similar species were applied.

Species	a	b	Source
Cheilodactylus spectabilis	0.01660	3.00	Fishbase
Cheilodactylus nigripes	0.01202	3.02	Fishbase
Cheilodactylus fuscus	0.01202	3.02	Fishbase
Latridopsis forsteri	0.01660	3.00	Fishbase: *C. spectabilis*
Notolabrus tetricus	0.00977	3.07	Fishbase: *N. fucicola*
Notolabrus fucicola	0.00977	3.07	Fishbase
Notolabrus gymnogenis	0.0977	3.07	Fishbase: *N. fucicola*
Achoerodus viridis	0.01800	3.044	Fishbase: *A. gouldii*
Achoerodus gouldii	0.01800	3.044	Fishbase
Sphyraena novaehollandiae	0.00813	2.80	Fishbase
Sphyraena obtusata	0.00776	2.91	Fishbase
Sillago flindersi	0.00851	3.09	Fishbase
Sillaginodes punctata	0.00389	3.15	Fishbase
Seriola lalandii	0.01820	2.944	Fishbase
Seriola hippos	0.01820	2.944	Fishbase: *S. lalandii*
Scorpis aequipinnis	0.01000	3.04	Fishbase: generic parameters
Pentaceropsis recurvirostris	0.01000	3.04	Fishbase: generic parameters
Pagrus auratus	0.02399	2.94	Fishbase
Meuschenia scaber	0.02884	2.96	Fishbase
Meuschenia hippocrepis	0.02884	2.96	Fishbase: *M. scaber*
Meuschenia freycineti	0.02884	2.96	Fishbase: *M. scaber*
Acanthaluteres vittiger	0.02089	2.92	Fishbase: *M. scaber*

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3 Results

3.1 Macroalgae

The algal community at Point Cooke Marine Sanctuary was initially dominated by the canopy brown *Ecklonia radiata* and various *Caulerpa* species, prior to 2009. There was a subsequent disappearance of these species, coinciding with a sharp increase in the population of the sea urchin *Heliocidaris erythrogramma*. The algal community at Point Cooke was subsequently composed mostly of crustose coralline algae and filamentous brown algae, along with blooms of the introduced alga *Undaria pinnatifida*. It is suspected that the establishment of *Undaria pinnatifida* contributed to the significant natural seaweed and sea urchin changes.

The MDS analysis indicated the algal communities at Point Cooke and the reference site occupy non-overlapping multivariate space. Both the MDS and control charts clearly showed the shift from *Ecklonia-Caulerpa* assemblages to sea urchin barrens. This first happened at the reference site in 2009 followed by the Point Cooke MS in 2011 (Figures 3.3 and 3.4). Both of these analyses indicated that assemblages stabilised as alternative states until recently. In 2015, there was shift back towards the original assemblage structure, with increased abundance of *Caulerpa remotifolia*, *Ulva* spp and fine thallose red algal species (Figures 3.1 to 3.4).

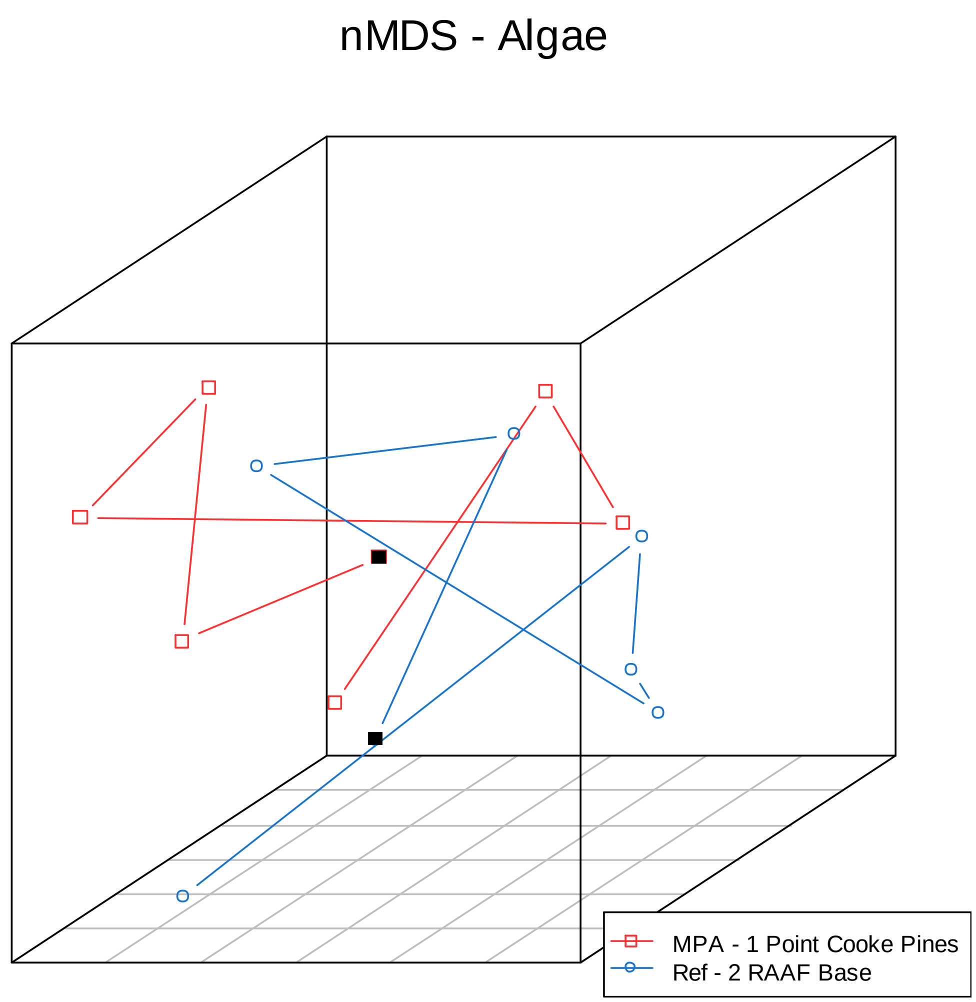


Figure 3.1. Three-dimensional nMDS plot of algal assemblage structure at Point Cooke MS. Black filled shapes denote the first survey time. Kruskal stress = 0.04.

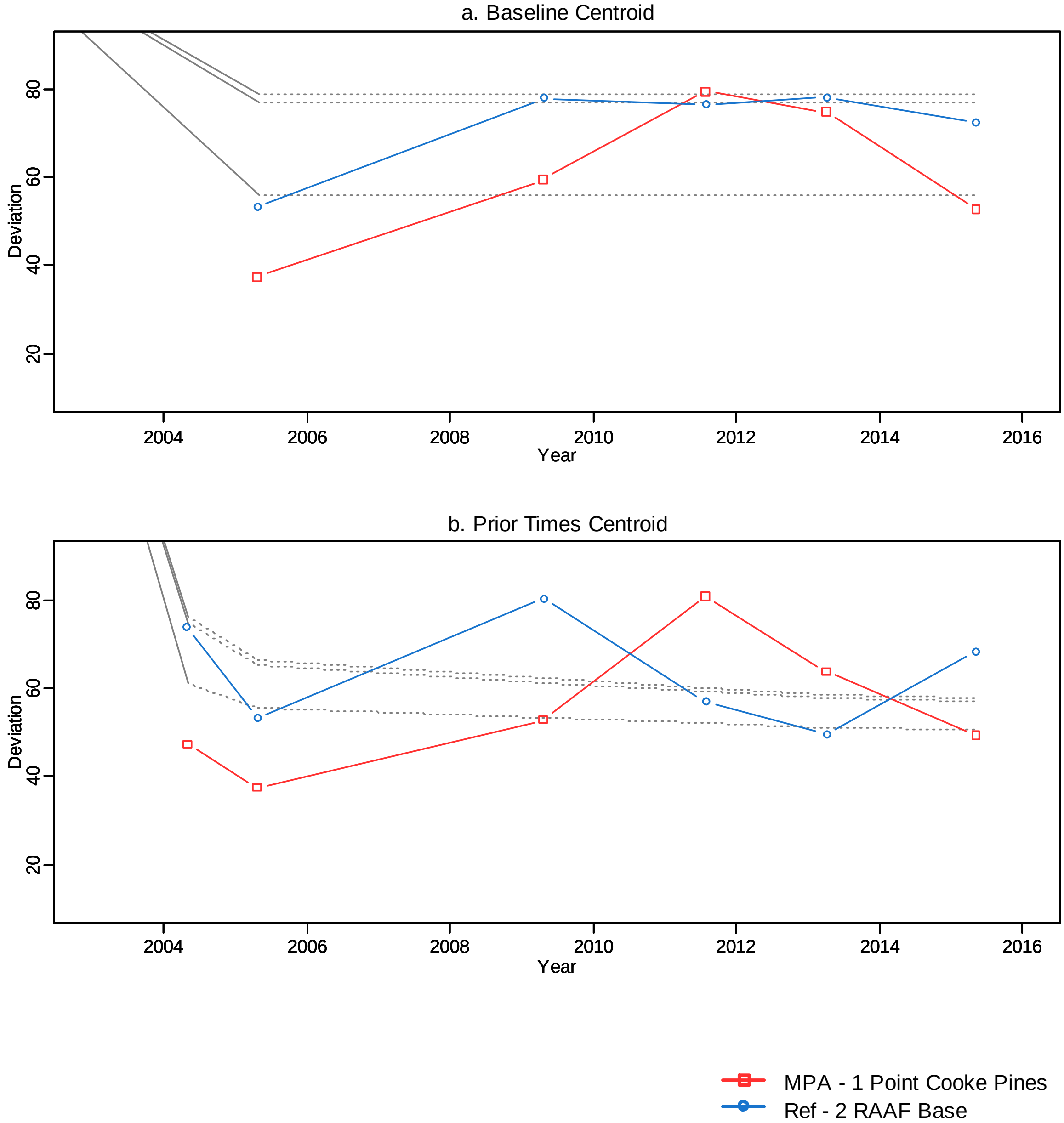


Figure 3.2. Control charts of algal assemblage structure at Point Cooke MS.

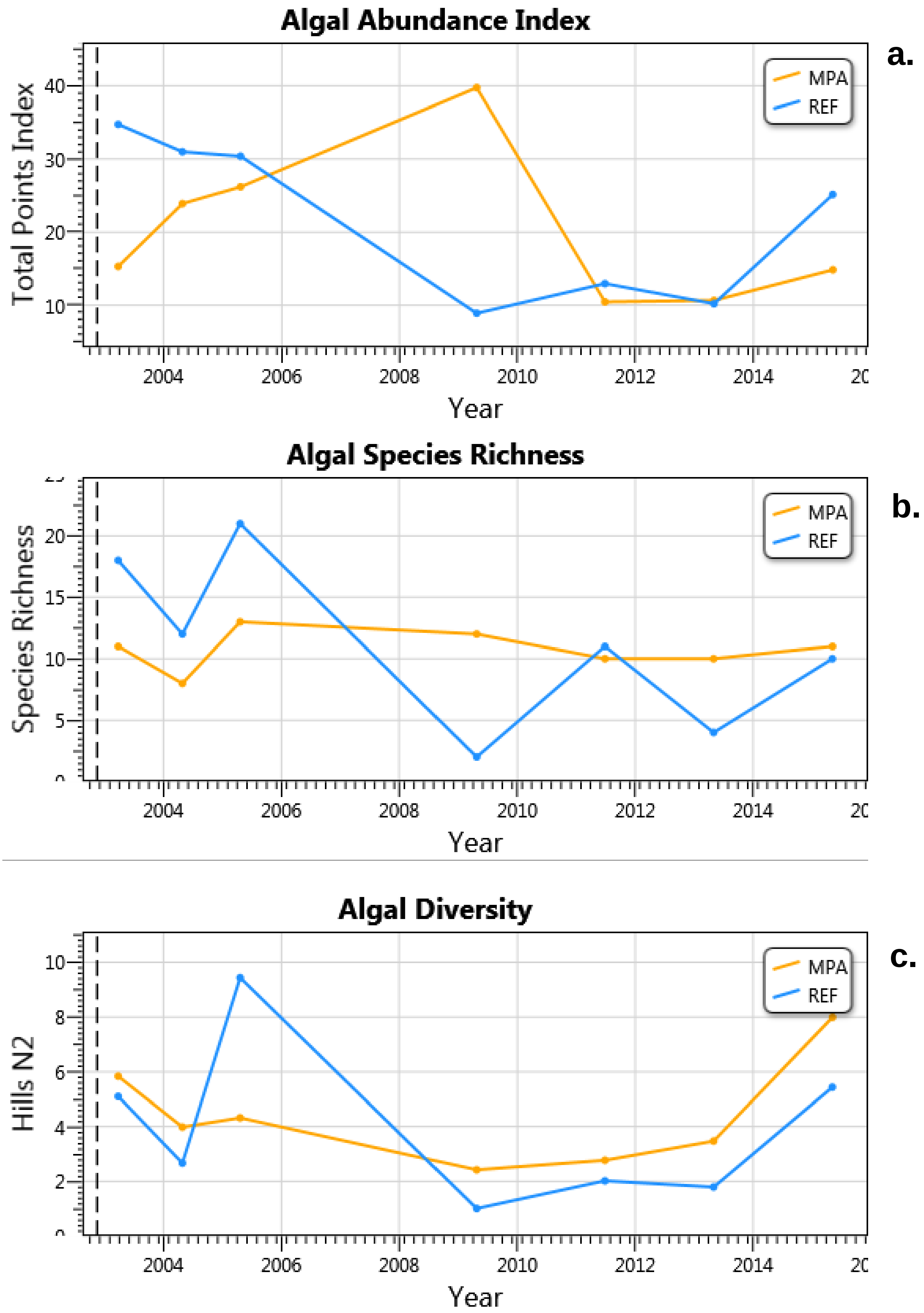


Figure 3.3. Algal species diversity indicators at Point Cooke MS.

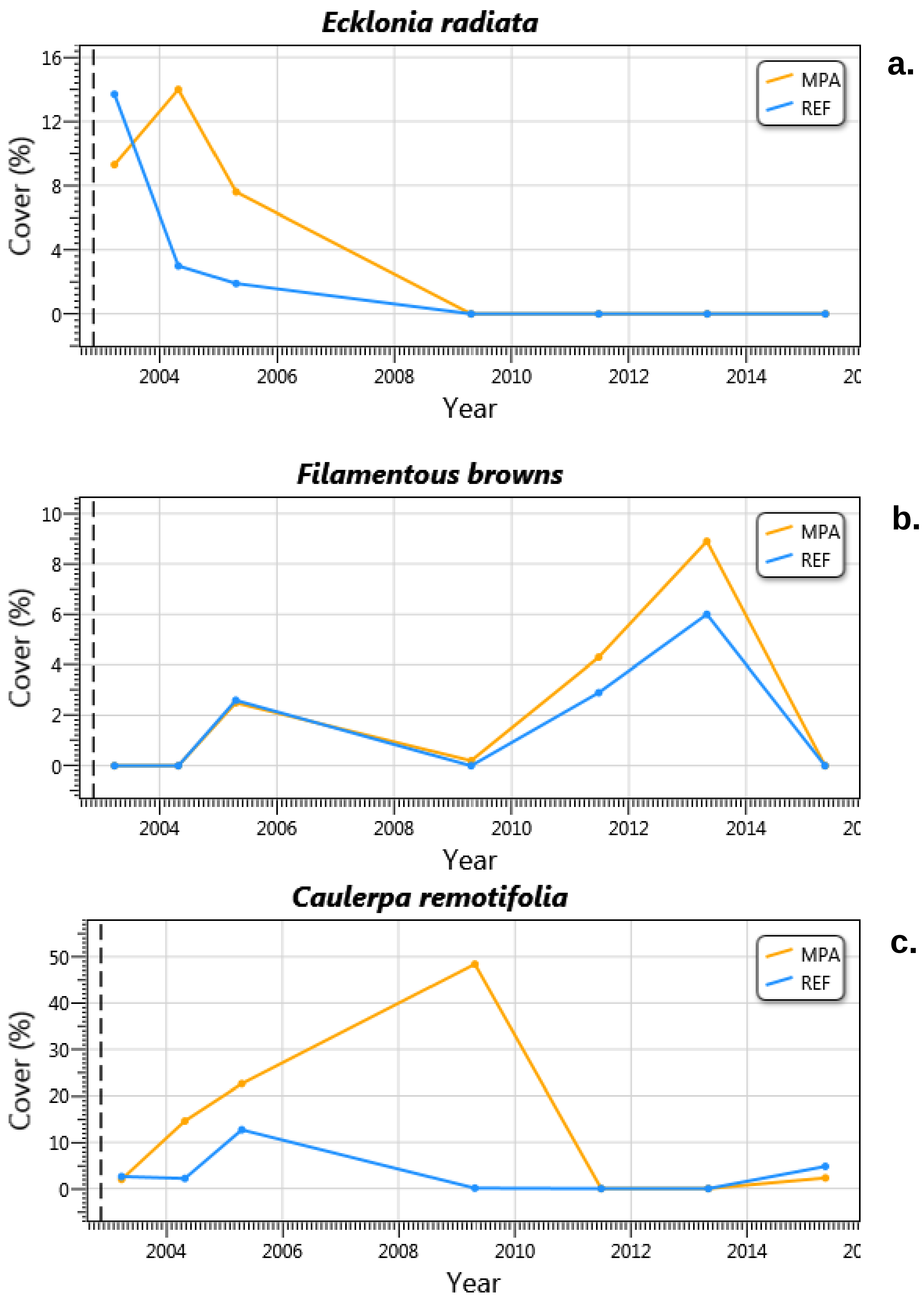


Figure 3.4. Percent cover of common algal species inside and outside the Point Cooke MS.

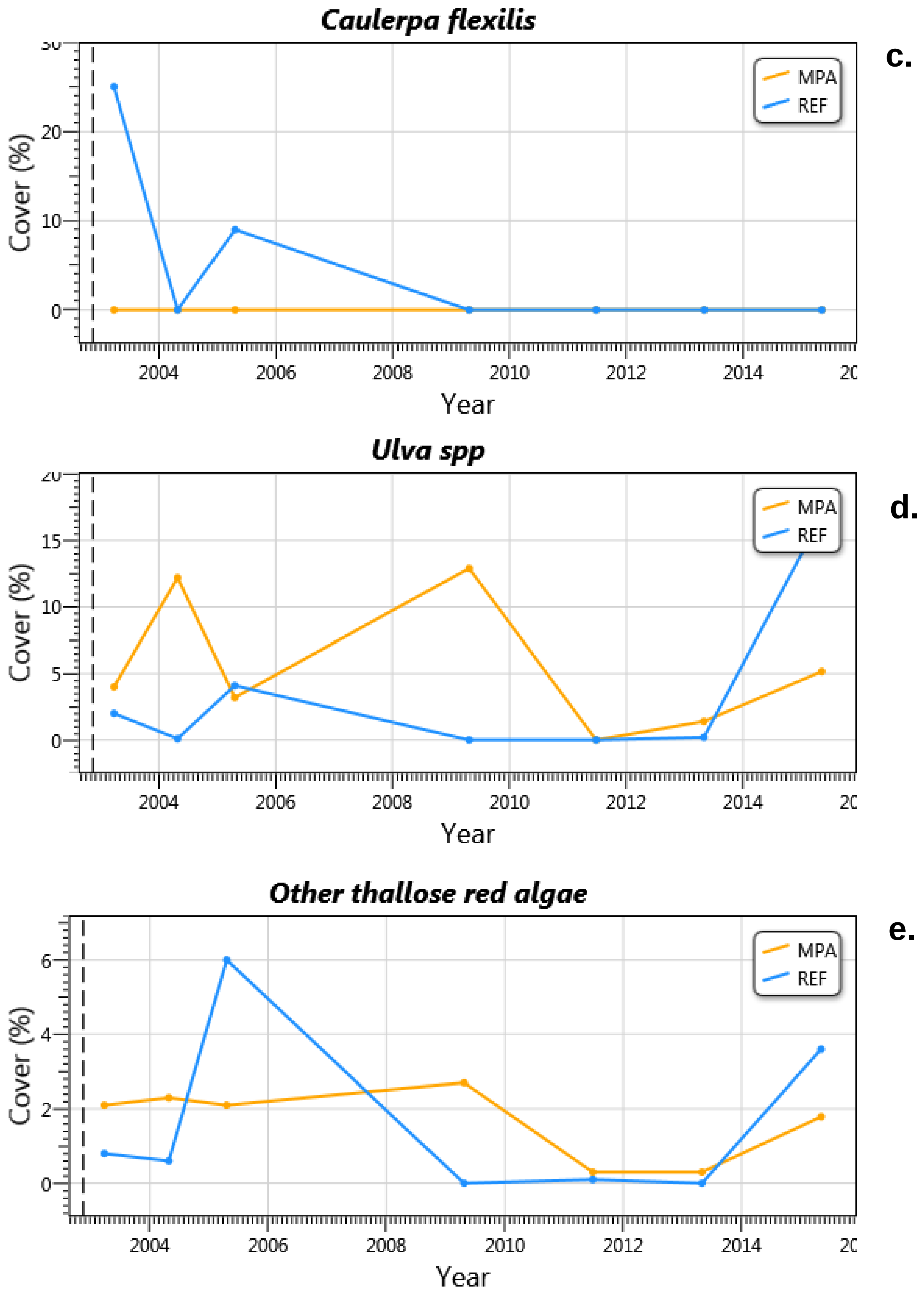


Figure 3.4 (continued). Percent cover of common algal species inside and outside the Point Cooke MS.

3.2 Invertebrates

The megafaunal invertebrates at the two Point Cooke sites were dominated by high abundances of the sea urchin *Heliocidaris erythrogramma*. Other common species were blacklip abalone *Haliotis rubra* and seastars *Tosia australis*, *Petricia vernicina* and *Coscinasterias muricata*.

The MDS plot indicated there were differences in algal assemblage structure between the two monitoring sites throughout the monitoring program, however the trajectories of change were similar (Figure 3.5). The control charts indicated the greatest periods of change were up to 2009, 2013 and 2015, with the conditions in 2013 and 2015 being the most different to the conditions surveyed at the start of the monitoring program (Figure 3.6).

The abundance of blacklip abalone *Haliotis rubra* was highest at both sites during the first years of monitoring, however there was a declining trend between 2003 and 2009. Abundances remained low at both sites from 2009 to 2015 (Figure 3.8a).

The abundance of common sea urchins *Heliocidaris erythrogramma* was much higher at the reference site than at Point Cook MS for most of the monitoring period, with exceptionally high densities occurring in 2009 and 2011 of 6-700 individuals per 50 m^2 (Figure 3.8b). Following the peak in 2009, there was a gradual decline in abundance to lowest observed levels in 2015, in the order of 40 per 50 m^2. The sea urchin density at Point Cooke peaked in 2013 with 240 per 50 m^2 and a slight decrease to 2015 (Figure 3.8b).

The abundances of eleven-armed seastars *Coscinasterias muricata* were also initially lower from 2003 to 2005 with a subsequent peak occurring at both sites in 2009 (Figure 3.8c).

Other seastars, including *Tosia australis, Petricia vernicina* and *Meridiastra gunnii* tended to have highest abundances in 2003-2004 and lowest abundances in 2013-2015 (Figures 3.8d to 3.8f).

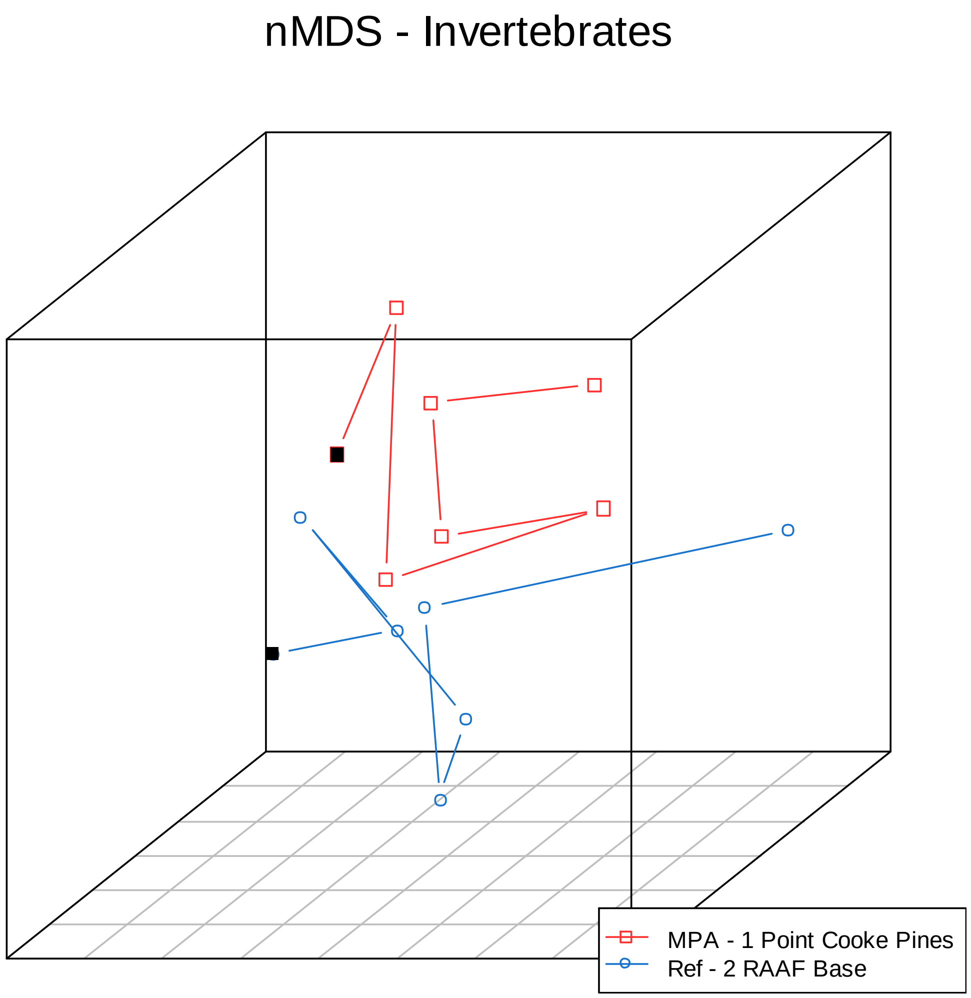


Figure 3.5. Three-dimensional nMDS plot of invertebrate assemblage structure at Point Cooke MS. Black, filled shapes denote the first survey time. Kruskal stress = 0.07.

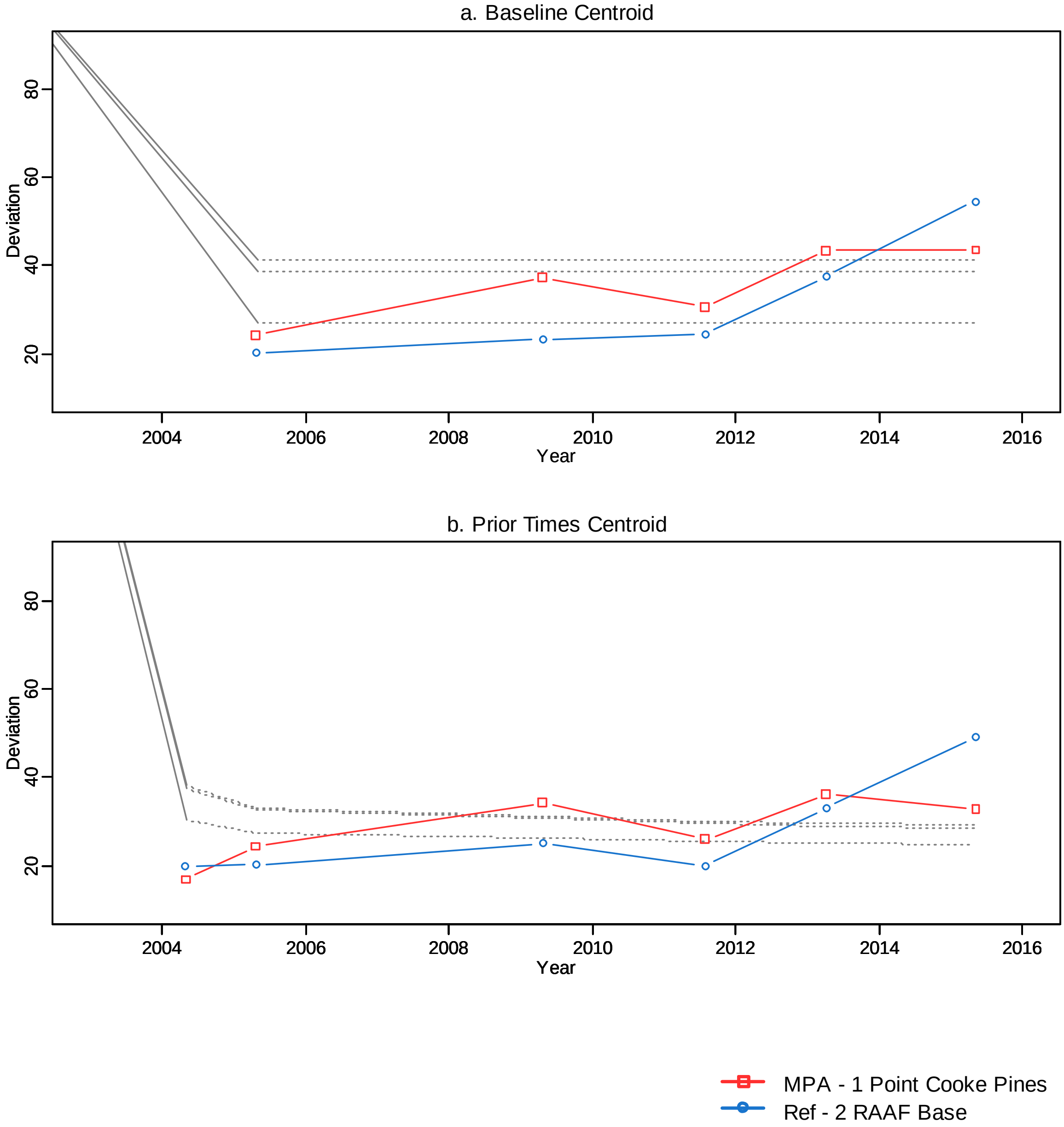


Figure 3.6. Control charts of invertebrate assemblage structure at Point Cooke MS.

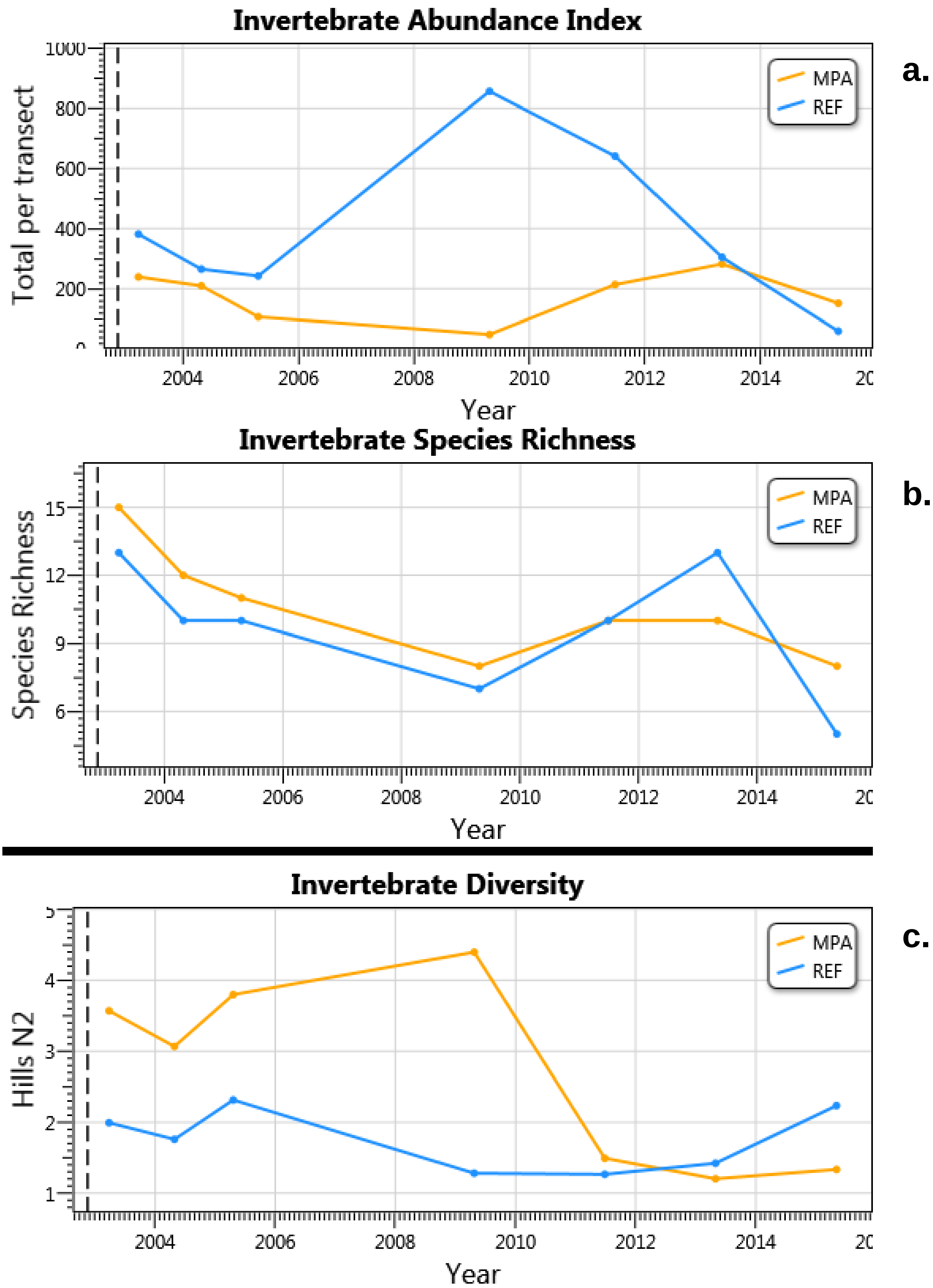


Figure 3.7. Invertebrate species diversity indicators at Point Cooke MS.

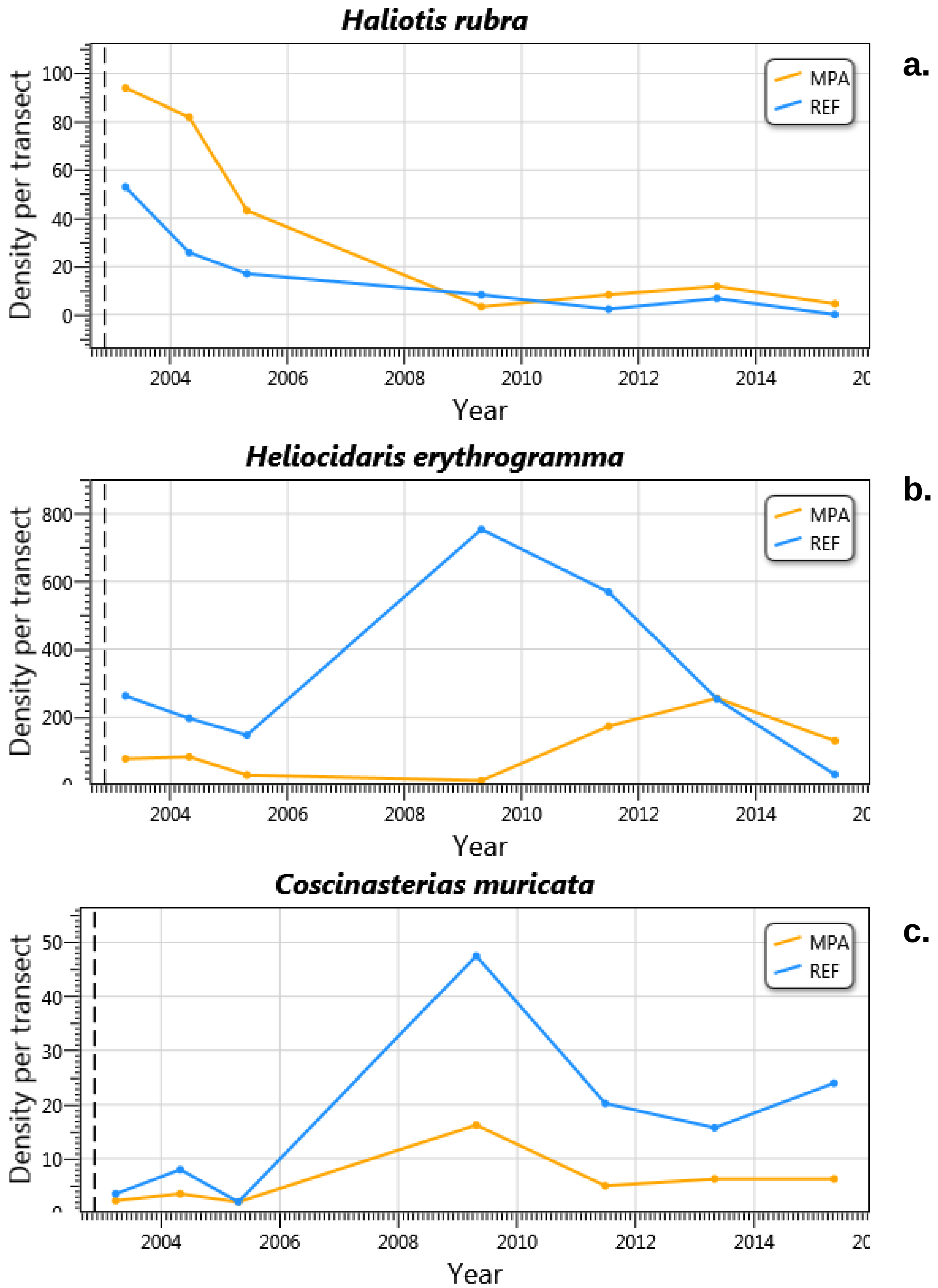


Figure 3.8. Density of invertebrate species at Point Cooke MS.

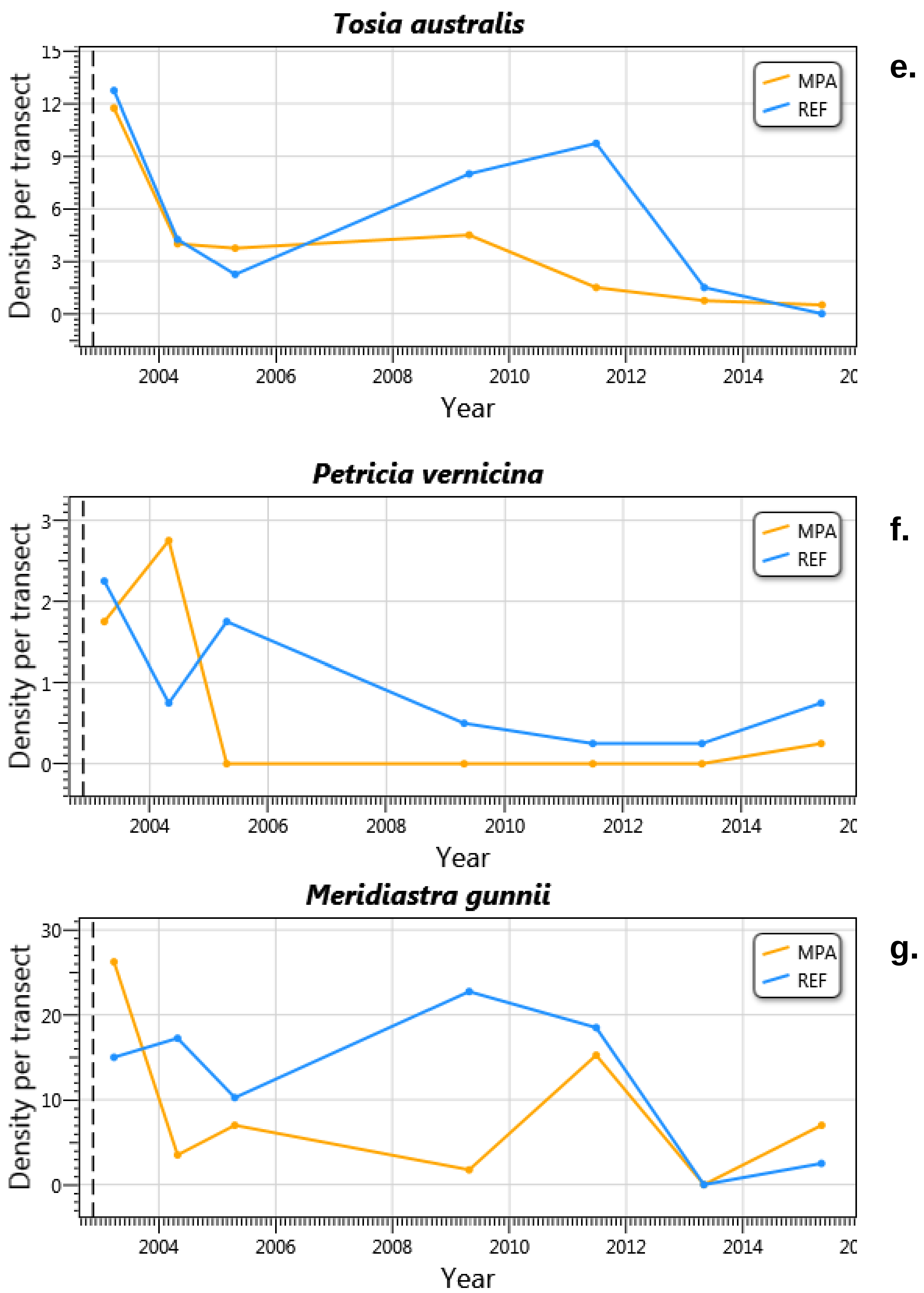


Figure 3.8 (continued). Density of invertebrate species at Point Cooke MS.

3.3 Fishes

The density and number of fish species was very low at both the Point Cook and RAAF Base sites. The assemblage structure was primarily described by shoals of southern hulafish *Trachinops caudimaculatus*, which varied greatly in abundance between surveys (Figures 3.9 to 3.12). Other species present included little rock whiting *Neoodax balteatus*, globefish *Diodon nichthemerus* and scalyfin *Parma victoriae*. There was a peak in abundance of *Neoodax balteatus* in 2004 and 2005 (Figure 3.12b).

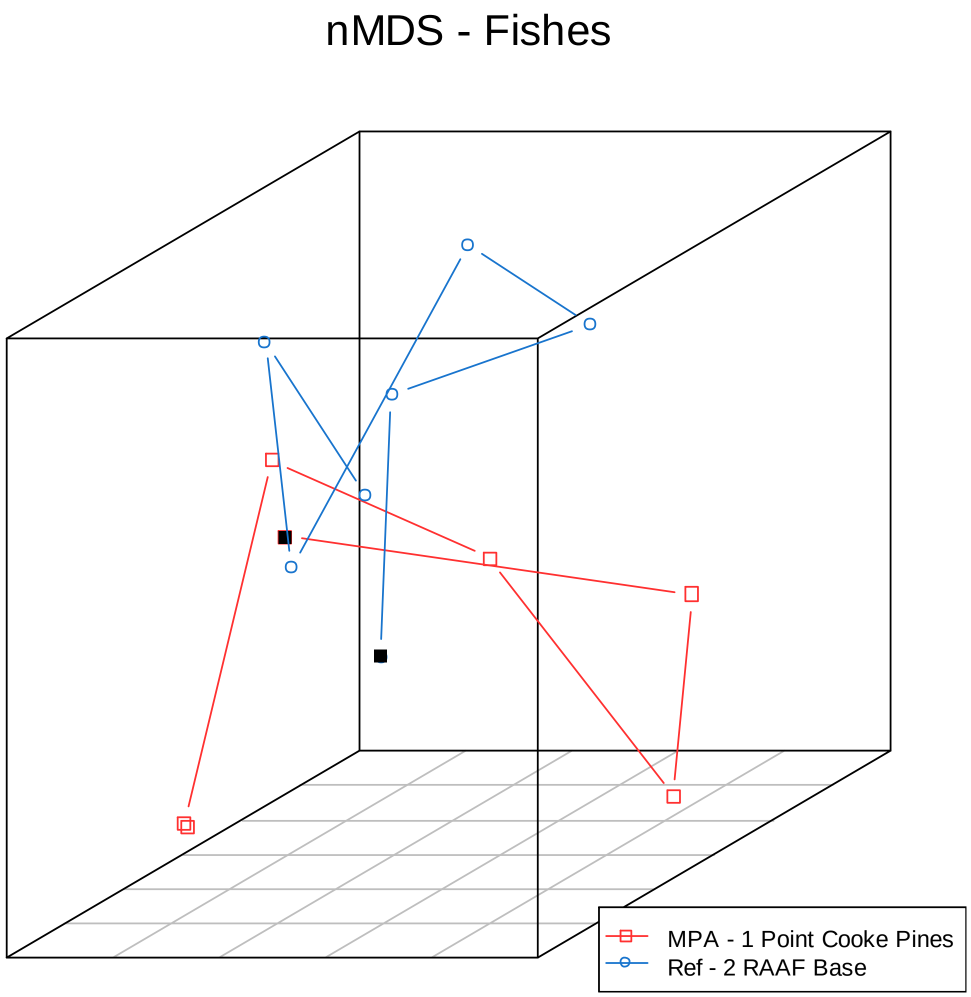


Figure 3.9. Three-dimensional nMDS plot of fish assemblage structure at Point Cooke MS. Black, filled shapes denote the first survey time. Kruskal stress = 0.04.

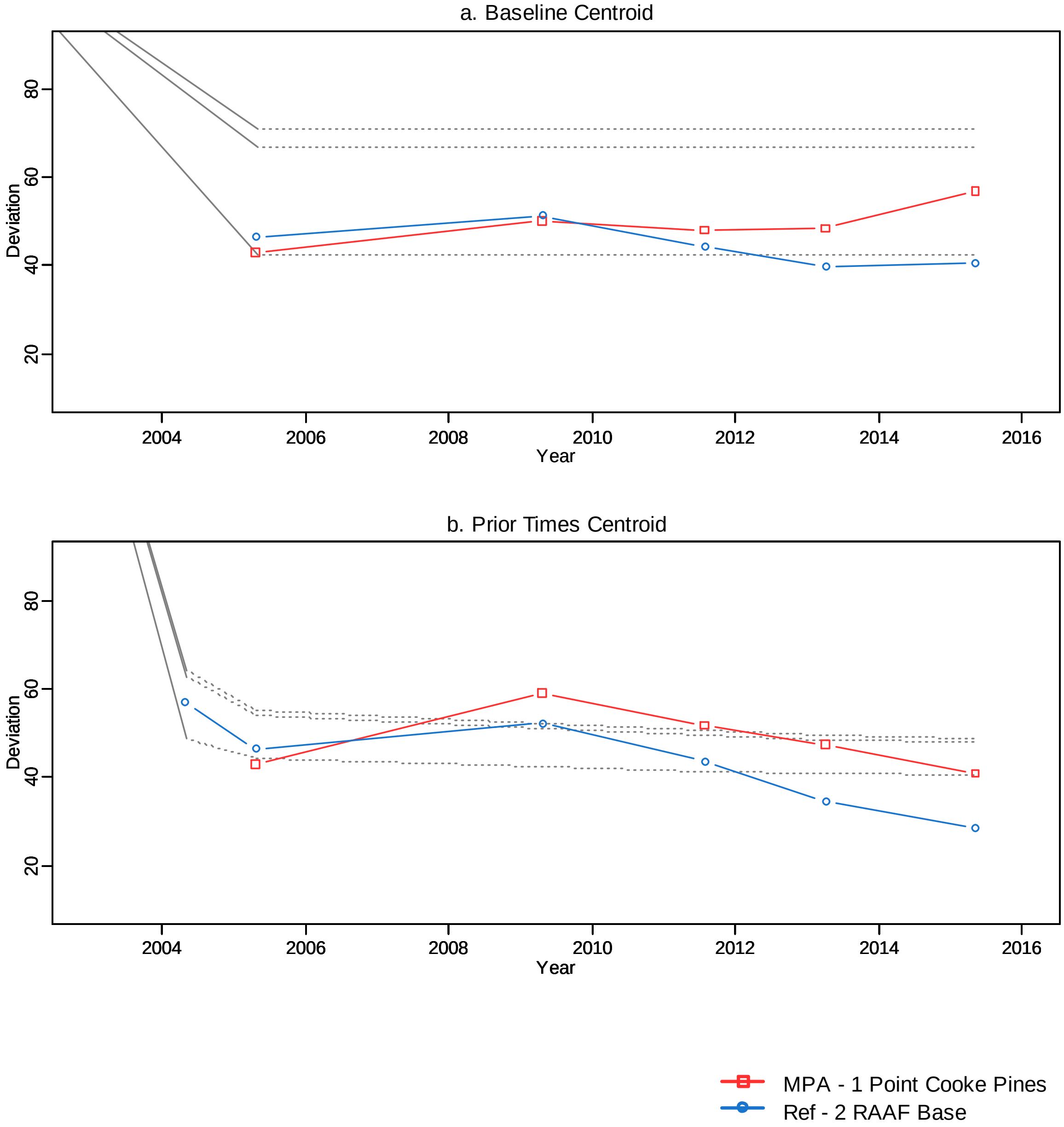


Figure 3.10. Control charts of fish assemblage structure at Point Cooke MS.

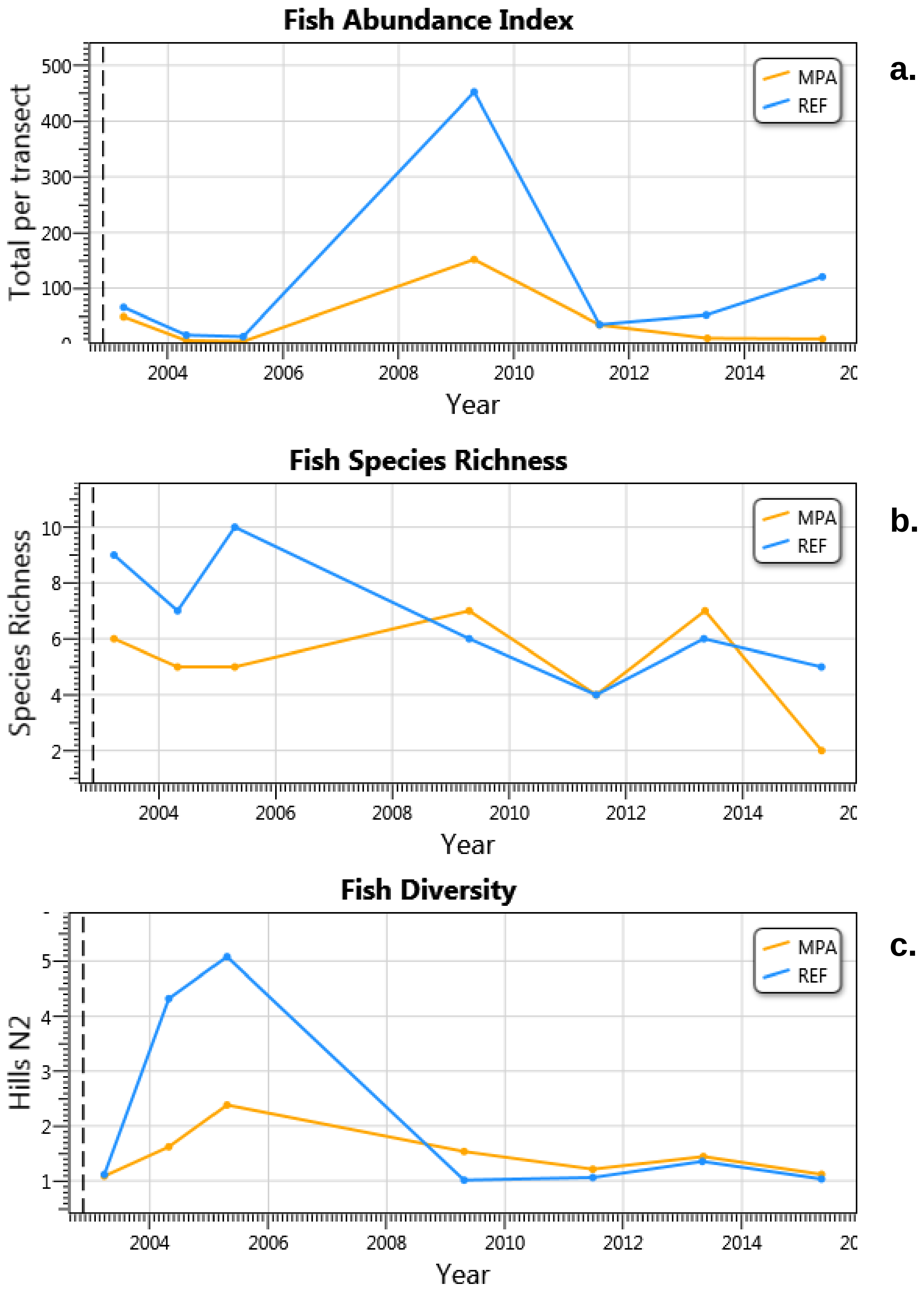


Figure 3.11. Fish species diversity indicators at Point Cooke MS.

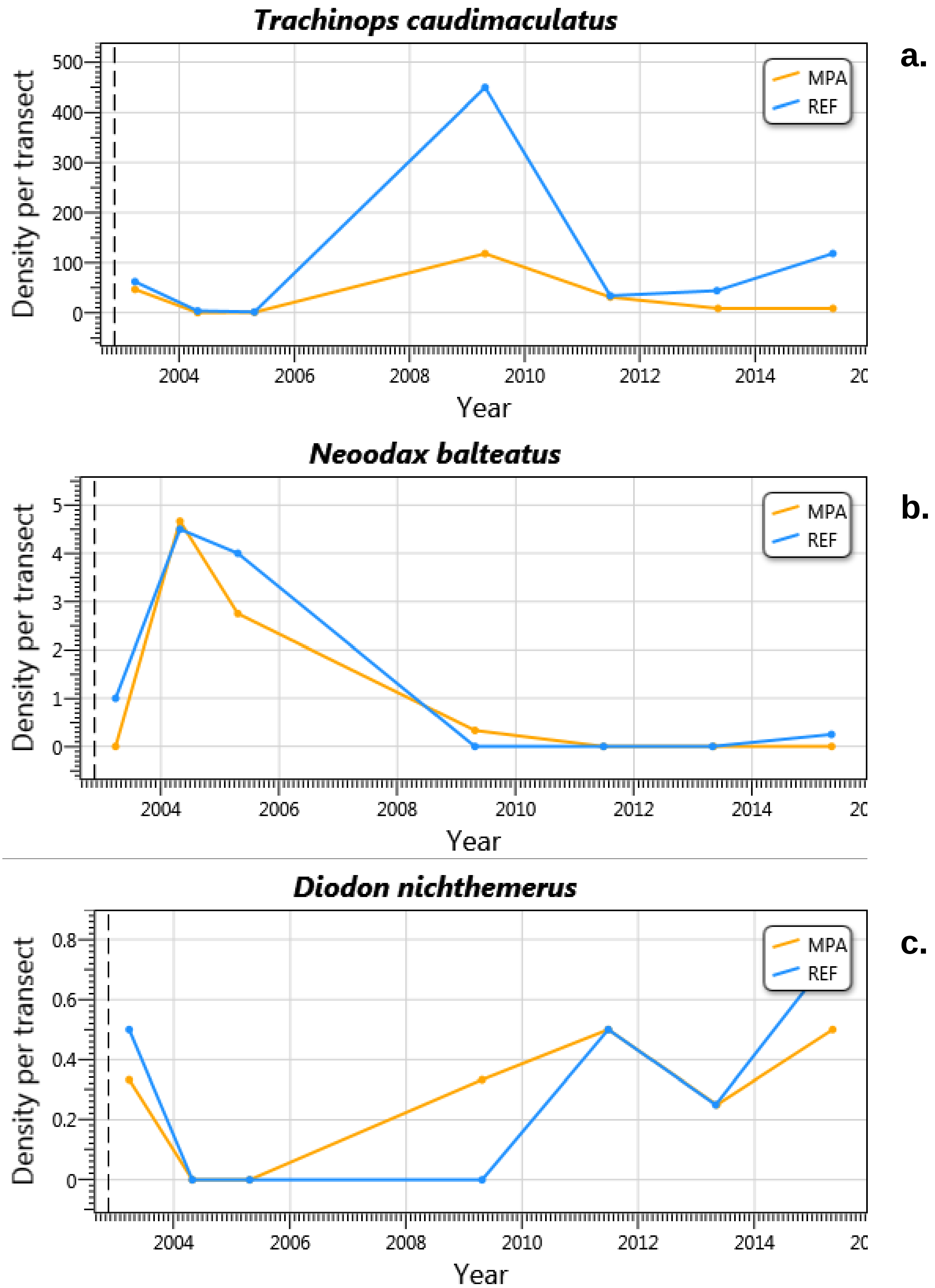


Figure 3.12. Density of fish species at Point Cooke MS.

3.4 Ecosystem Functional Components

3.4.1 Habitat and Production

There was shift in biogenic habitat consisting of *Ecklonia radiata* and *Caulerpa* mats in 2003-2004 toward essentially sea urchin barrens habitat with crustose coralline algae and finer thallose red algae from 2009 to 2013 (Figure 3.13). There was a shift back towards a seaweed dominant assemblage in 2015.

3.4.2 Sediment Cover

Much of the reefs are low profile bedrock outcrops interspersed by rubble and sand. The sediment cover varied substantially during the monitoring period. At Point Cooke, the cover was initially 40 %, declining to < 10 % in 2009, increasing to 40 % again in 2015 (Figure 3.14). The sediment cover at RAAF base was highest in 2015.

3.4.3 Invertebrate Groups

The predominant invertebrate groups were grazers, reflecting the abundances of common sea urchin *Heliocidaris erythrogramma* and blacklip abalone *Haliotis rubra* (Figure 3.15). There were peaks in seastar abundance in 2003 and 2009 (Figure 3.15d).

3.4.4 Fish Groups

The dominant fish group was planktivores, represented by the southern hulafish *Trachinops caudimaculatus* (Figure 3.16).

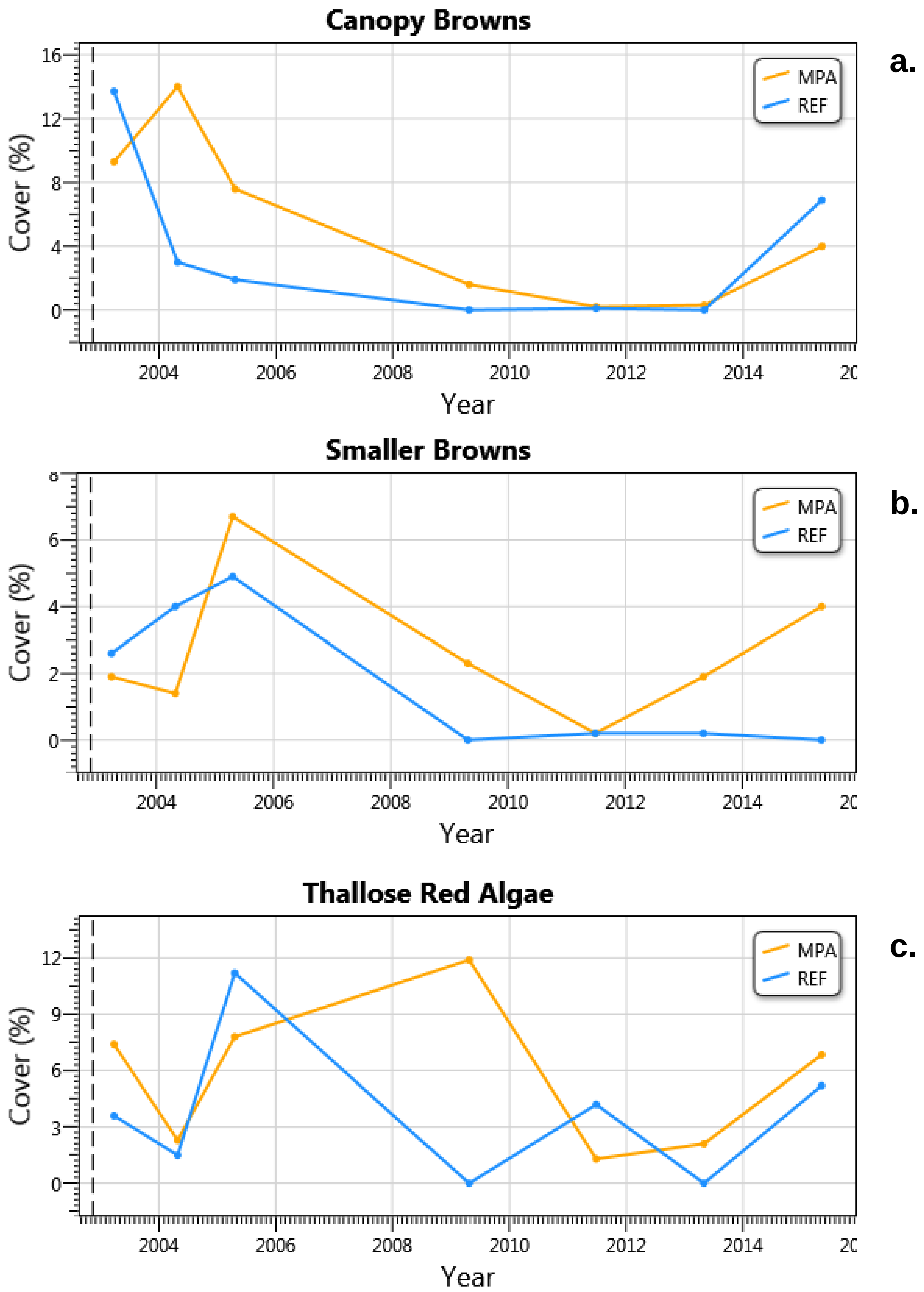
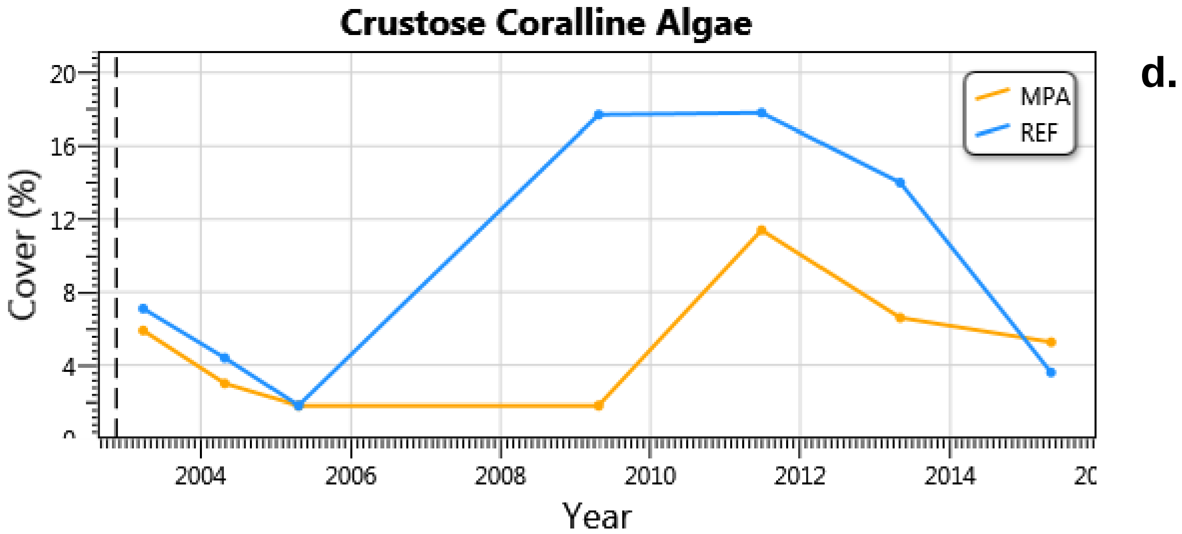


Figure 3.13. Percent cover of macrophyte functional groups at Point Cooke MS.



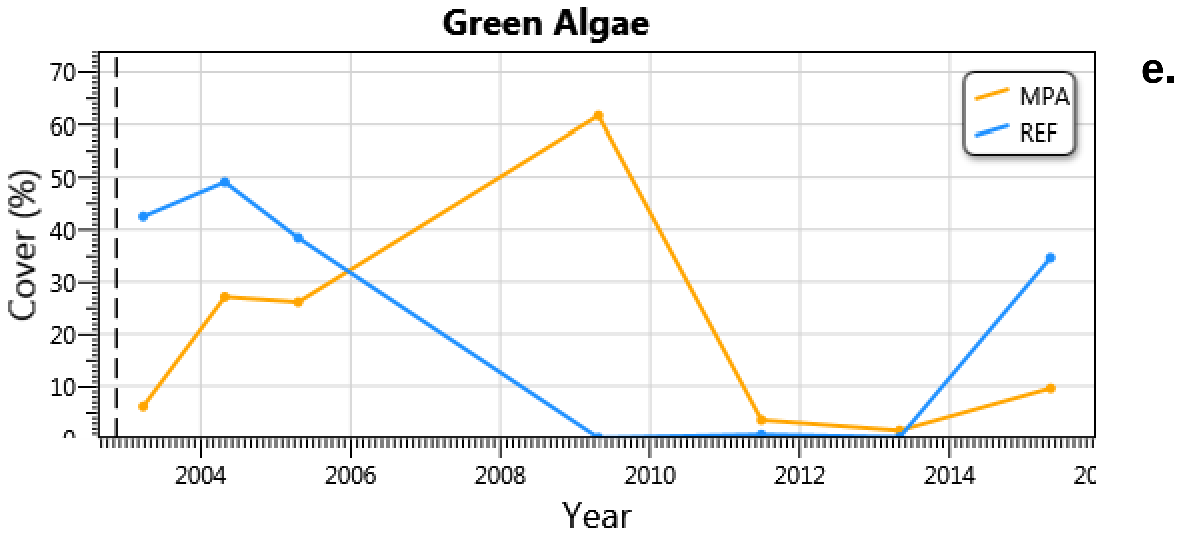


Figure 3.13 (continued). Percent cover of macrophyte functional groups at Point Cooke MS.

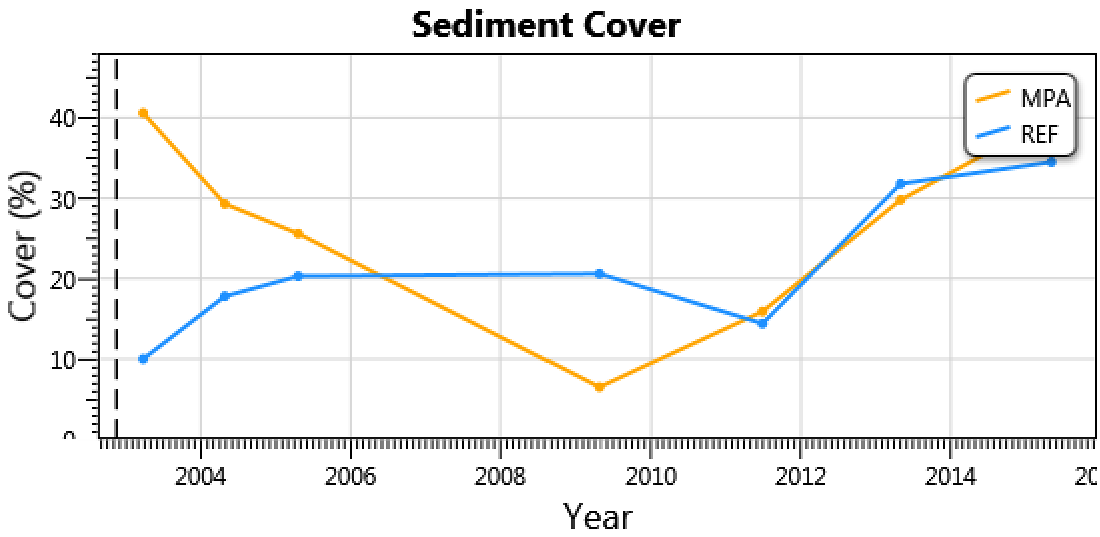


Figure 3.14. Sediment functional group percent cover at Point Cooke MS.

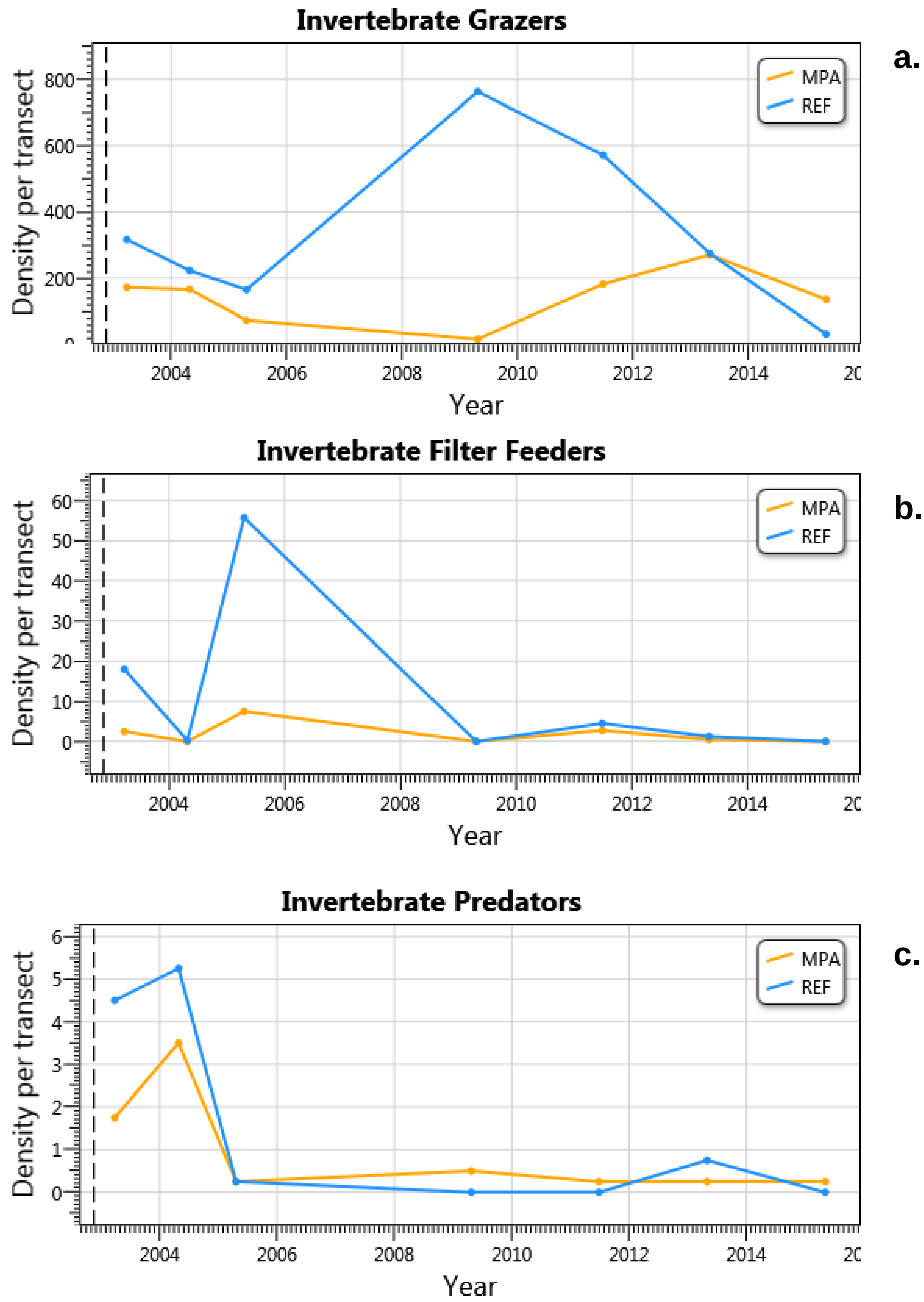


Figure 3.15. Invertebrate functional group densities at Point Cooke MS.

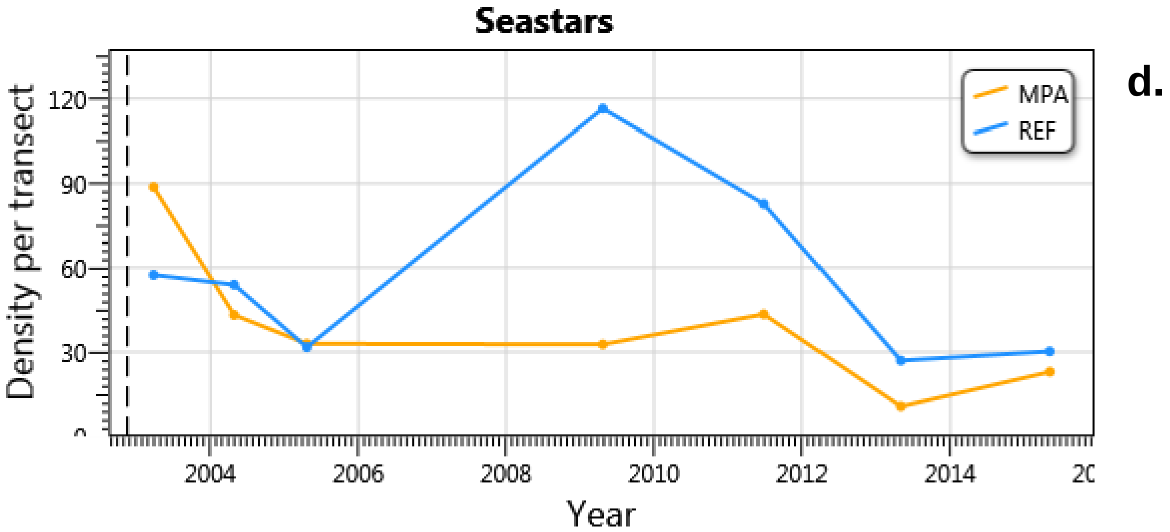


Figure 3.15. (continued). Invertebrate functional group densities at Point Cooke MS.

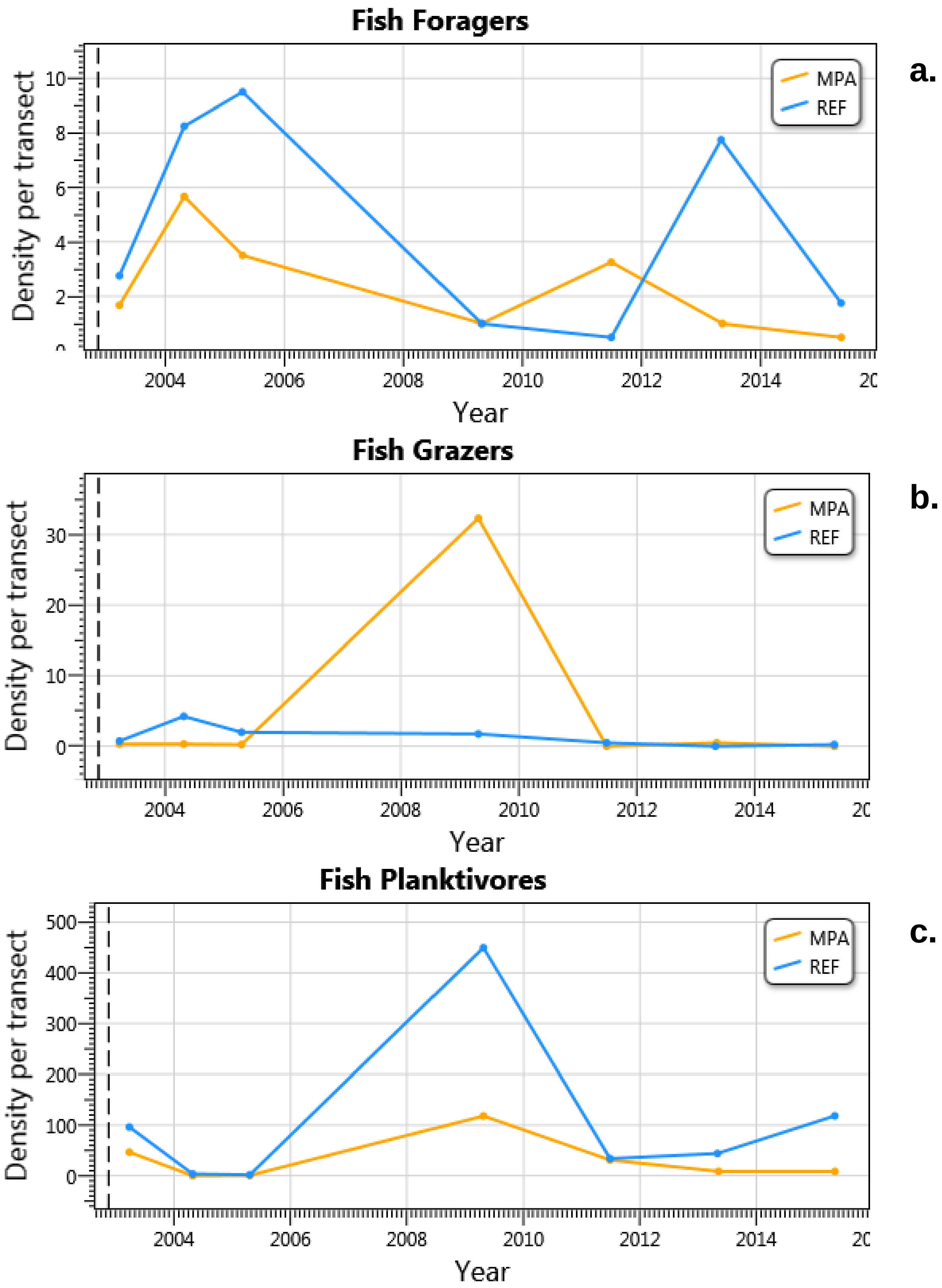


Figure 3.16. Fish functional group density at Point Cooke MS.

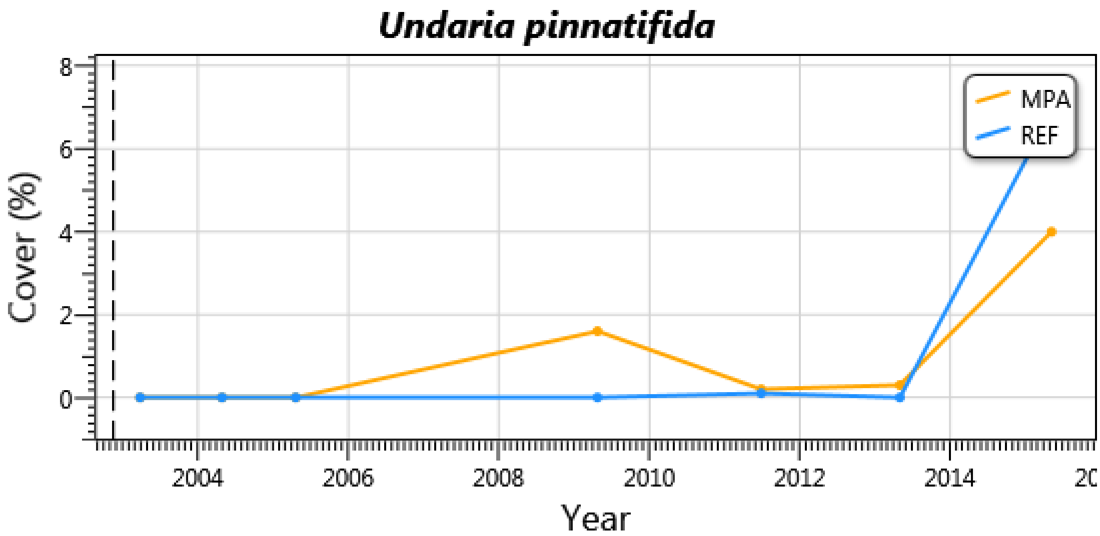


Figure 3.17. Abundance of the introduced Japanese wakame kelp *Undaria pinnatifida* at Point Cooke MS – note surveys are during the pre-seasonal growth period (April-May).

3.5 Introduced Species

The introduced pest Mediterranean fanworm *Sabella spallanzanii* was observed sporadically at both sites in relatively low abundance. The introduced Japanese kelp *Undaria pinnatifida* was also observed at the Point Cooke sites, however it should be noted that this species has a seasonal growth form with the larger sporophyte form usually predominant from late winter to spring. Although the survey periods were outside the most appropriate period for determining *U. pinnatifida* abundance, highest abundances were recorded in 2015, indicating recruitment of the sporophyte phase commenced earlier than usual (Figure 3.17). The Northern Pacific seastar Asterias amurensis was observed sporadically on the sediments adjacent to the Point Cooke patch reefs. *Asterias amurensis* was counted in the transects at both sites for the first time in 2015.

3.6 Climate Change

3.6.1 Species composition

There were no distinct changes in species composition reflecting a shift towards warmer water species (*e.g.* Figures 3.18 and 3.19).

3.6.2 Macrocystis pyrifera

The giant string kelp *Macrocystis pyrifera* did not occur at Point Cooke.

3.6.3 Durvillaea potatorum

The bull kelp *Durvillaea potatorum* is not present at the monitoring sites, being sheltered habitats.

3.6.4 Centrostephanus rodgersii

The long-spined sea urchin *Centrostephanus rodgersii* is an eastern, warmer-water species. Its incursion westward not only indicates changes in climate, but also presents threats in terms of grazing and creating urchin-barren habitat. No *C. rodgersii* was observed during any of the Point Cooke surveys.

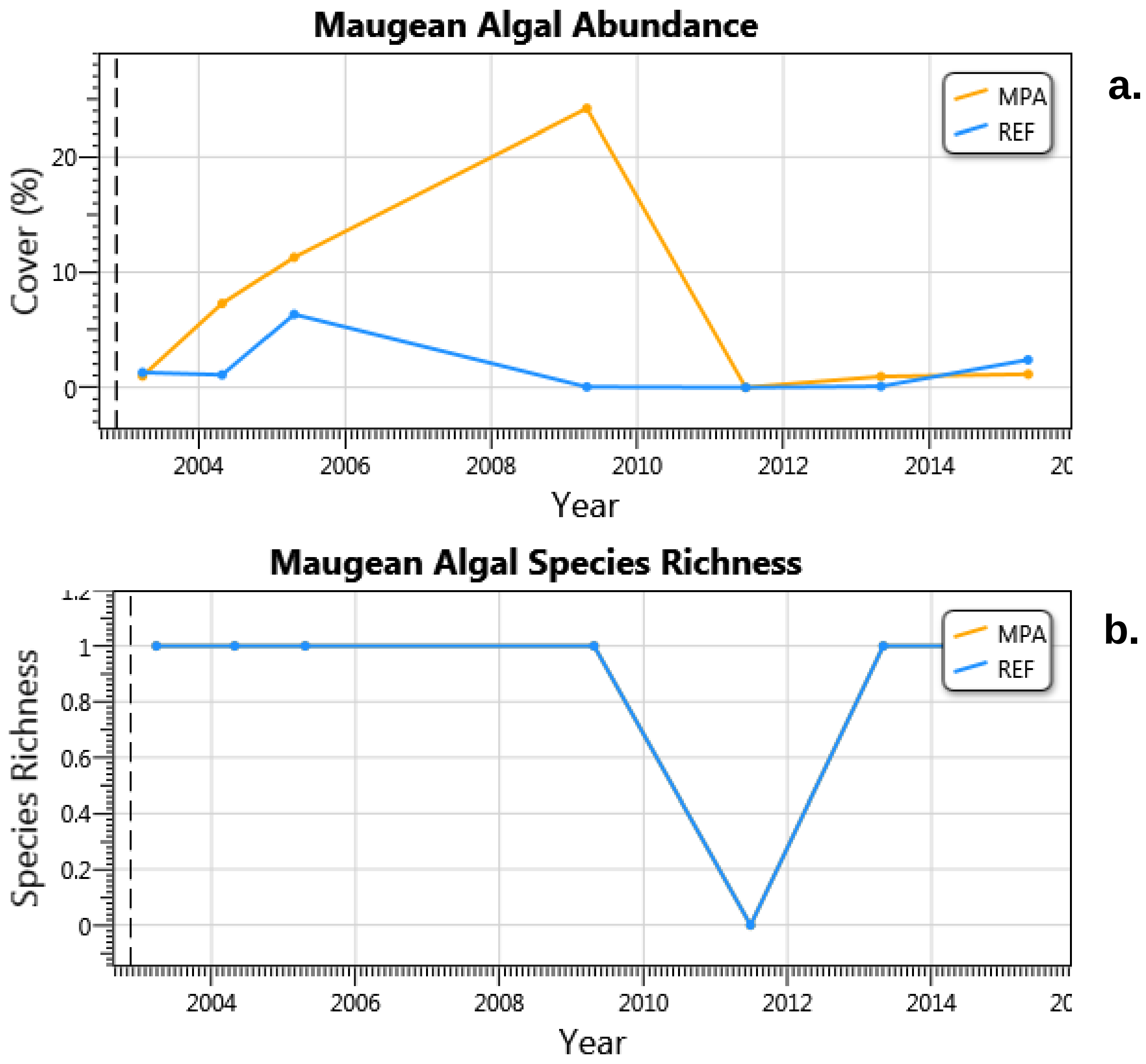


Figure 3.18. Abundance and species richness of cold water, Maugean algal species at Point Cooke MS.

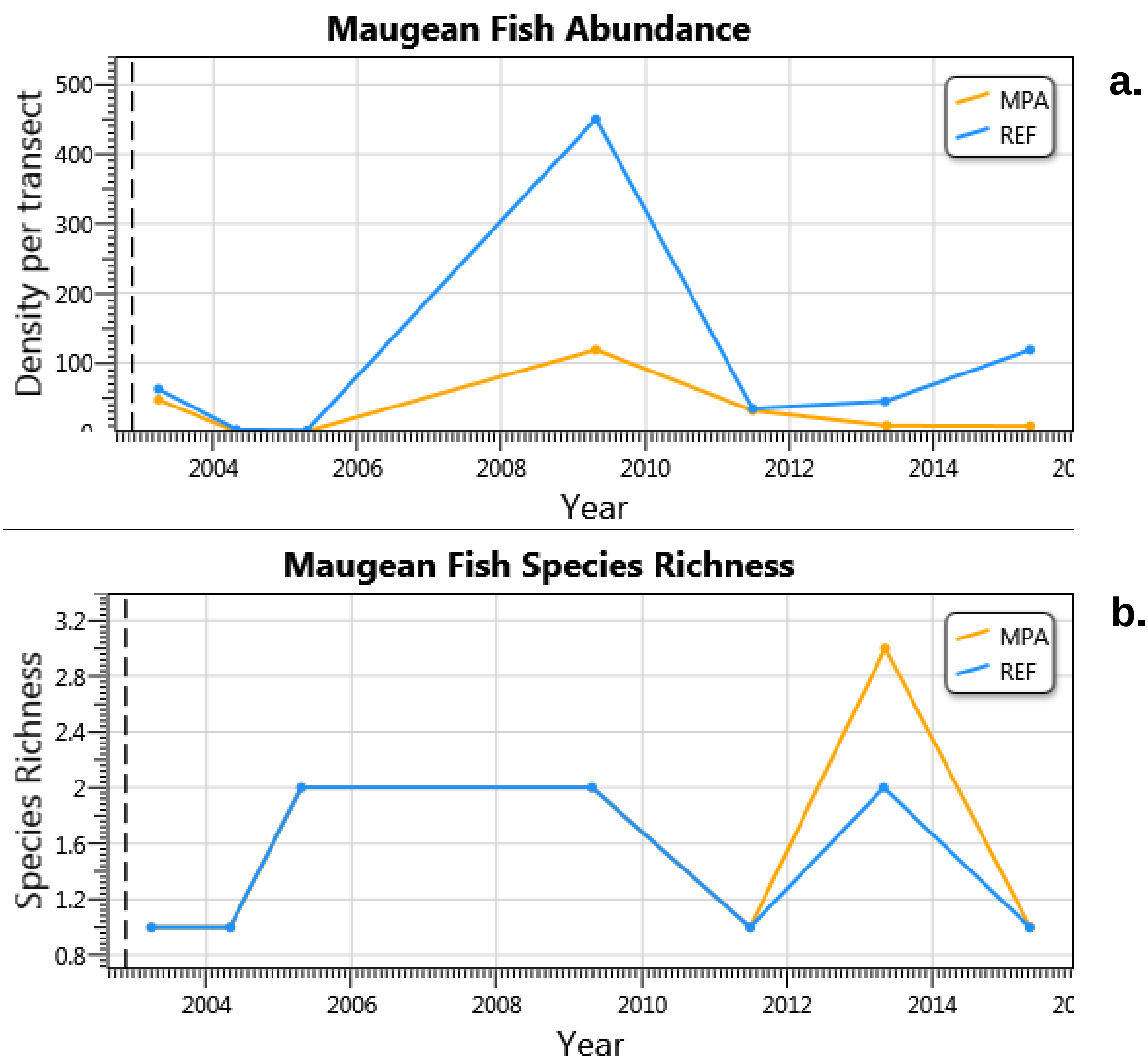


Figure 3.19. Abundance and species richness of cold water, Maugean fish species at Point Cooke MS.

3.7 Fishing

3.7.1 Abalone

There was a decline in abundance of blacklip abalone *Haliotis rubra* at the Point Cooke MS and RAAF Base sites from 2003 to 2009 with low abundances thereafter. Although the numbers of measured individuals were low from 2009, there was no trend evident in abalone size (Figure 3.20).

3.7.2 Fishes

The biomass of commonly fished fishes, resident on the reefs, was very low at both sites (Figure 3.21). The high dominance of small *Trachinops caudimaculatus* meant the size spectrum analysis was not a useful monitoring indicator at these sites.

3.8 Manufactured Debris

The 2015 survey was the first year to include manufactured debris at the Point Cooke monitoring sites. A sheet of plastic was observed at the RAAF Base site and an aluminium alcohol can was observed at the Point Cook MS site.

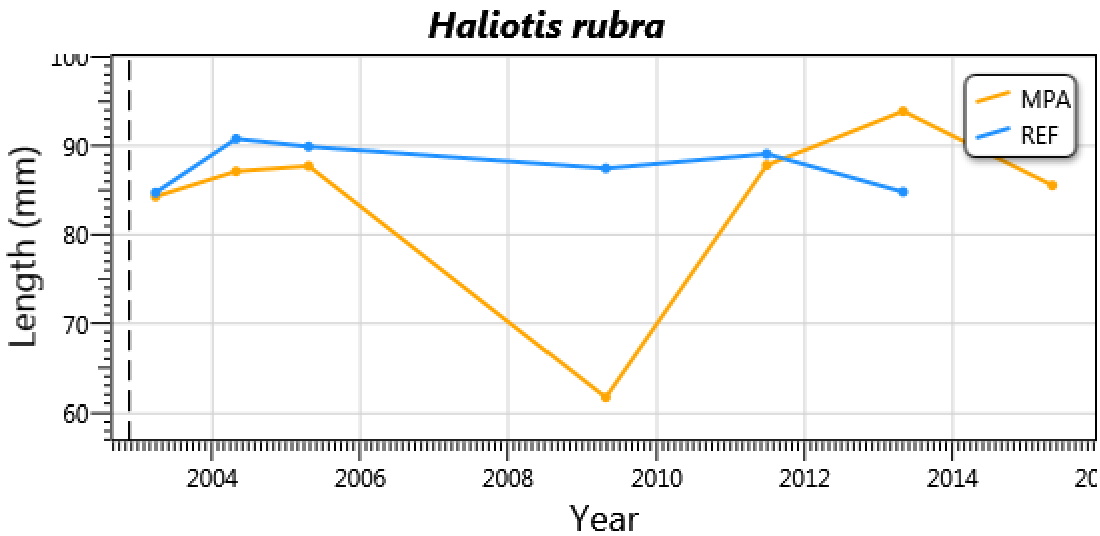


Figure 3.20. Blacklip abalone *Haliotis rubra* mean size at Point Cooke MS.

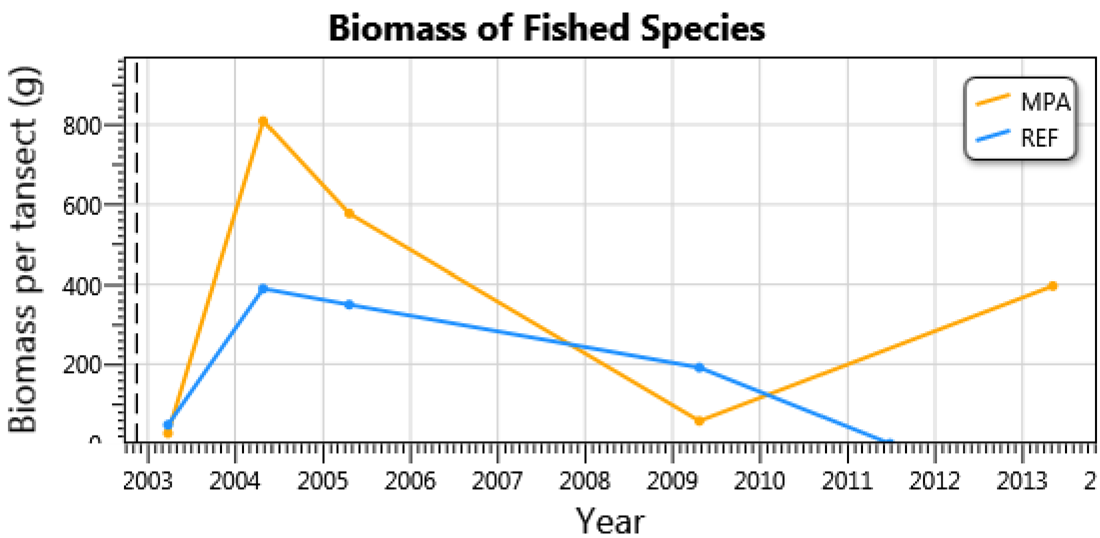


Figure 3.21. Total estimated biomass of fished species and estimated biomass of fished species over 200 mm inside and outside Point Cooke MS.

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