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THE PRINCE EDWARD ISLANDS' LIFE-SUPPORT SYSTEM: RELATIVE IMPORTANCE OF LOCAL AND ADVECTED SOURCES

E.A. Pakhomov, S. Kaehler, R. Perissinotto

Abstract

Over the last 30 years, a number of mechanisms have been proposed to explain plankton dynamics as well as the supply of food to terrestrial top predators and inter-island bottom-dwelling communities around the Prince Edward Archipelago. Mechanisms include (a) the island's lee upwelling hypothesis, (b) the intrusion of upstream generated eddies, (c) the trapping of water and local phytoplankton blooms linked to water column stability and nutrient runoff, (d) the replenishment/depletion hypothesis and (e) the utilization of distant frontal systems and topographically generated eddies. It appears that the 'life-support system' of the Prince Edward Islands includes both water trapping and flow-through components. These are critically evaluated and their relative contributions assessed and linked to the variable oceanographic setting in the vicinity of the islands. Several recent stable isotope studies have quantified the importance of allochthonous and autochthonous (locally generated) sources of energy to various biotopes between the islands. The significance and spatial extent of kelp-derived carbon for the inter-island and downstream realms have largely been underestimated and are here assessed for the first time.

Key words: Prince Edward Archipelago, allochthonous and autochthonous sources of energy.

1. Life-support system of the Prince Edward Islands

Each open ocean island can only function as an attractive breeding ground for top predators if it possesses a successful life support system. The Prince Edward Islands' indigenous vertebrate fauna is well established, suggesting a mechanism in place that supports vertebrates during their reproduction and molting periods, both of which are energetically demanding. The vertebrate fauna includes twenty-five flying bird, four penguin and three seal species. Since eradication of feral cats in 1991, the only alien mammal species remaining has been the house mouse *Mus musculus* which is present only on Marion Island [1]. The overall biomass of this top predator community has been estimated to be approximately 10300 tons of wet mass. This is partitioned between truly offshore feeders, e. g. species foraging beyond the shelf region of the islands (seals, some penguins and petrels/albatrosses), and truly inshore feeders (most penguins as well as, gulls, terns and skuas) as 86% and ~14%, respectively. Species obtaining their food from the islands, e. g. mice, sheathbills and partially skuas, contribute very little (< 1%) to total land-based top predator biomass.

These estimates highlight the importance of the oceanic environment, not only in providing food for top predators but also in supplying nutrients to the islands' terrestrial ecosystems [2].

The success of the Prince Edward Islands' ecosystem is the result of a close marine-terrestrial interaction known as "life-support system", which provides food for the entire community of numerous top predators on the islands as well as a high density of benthic inter-island organisms, including fish. The life-support mechanism is thought to function as a combination of two components, an inshore (autochthonous) component, which is of crucial importance for only a few land-based top predators, and an offshore (allochthonous) component, which supports most of the top predators at the Prince Edward Islands [2]. A better understanding of the relative contribution of these two components is crucial not only for resolving ecological and biogeographic issues but also for enhancing our understanding of long-term changes at the islands. Over the past decades, numerous mechanisms have been proposed for the life-support system of the Prince Edward Islands, which include both inshore and offshore components. Before attempting to quantify local and offshore organic matter inputs, it is therefore necessary to critically review the mechanisms of the life-support system proposed to date.

2. Inshore component of the life-support system

2.1. Island's lee upwelling hypothesis. The island mass effect has often been proposed to explain the persistence of top predator biomass and production on oceanic islands [3]. After the earlier oceanographic studies conducted in the vicinity of the Prince Edward Islands in the 1970's, it was suggested that upwelling of deep Antarctic water masses in the lee of the islands, triggered by the strong north-westerly winds, may be a primary mechanism responsible for the productivity in the region [4]. This hypothesis was strongly supported by observations of cold, nutrient rich, upwelled water and increased phytoplankton productivity in the lee of Marion Island [5]. Furthermore, several copepods of Antarctic origin were associated with the upwelling region [4]. El-Sayed et al. [5] and Deacon [6], however, disputed this hypothesis on the basis of low silica concentrations near the surface. Upwelling events were only described from a single cruise and were never reconfirmed during subsequent surveys in the 1980-s, notwithstanding the occurrence of strong westerly winds during many of the cruises [7].

2.2. Water trapping and local phytoplankton blooms hypothesis. Since 1976, several studies conducted between November and May have noted regular occurrence of algal blooms in combination with trapped eddies over the Prince Edward Islands' inter-island shelf [7, 8], clearly suggesting that the archipelago does generate an island-mass effect. During these surveys, photosynthetic pigment (chlorophyll-*a*) concentrations often exceeded 1.5 $mg{\cdot}m^{-3}$, reaching at times 3.0 $mg{\cdot}m^{-3}$. Furthermore, algal concentrations, chiefly of the chain-forming diatom *Chaetoceros radicans*, which forms rapidly sinking, heavily silicified resting spores, were as high as $10^6 – 10^9$ cells [2, 9]. Regression analysis showed that water column stability and mixed-layer depth accounted for most of the variance associated with integrated productivity and photosynthetic capacity of the local algal community [10]. The mesoscale distribution of nutrients, in particular ammonia and urea, also showed a strong correlation with algal biomass and significantly contributed to its variability [11]. It was suggested that both water-column stratification and high nutrient concentrations entrained by the water circulation (a Taylor Column type of feature) represented the most important factors initiating and controlling algal blooms in the inter-island region of the Prince Edward Islands [8]. Attwood, however, questioned the evidence and theoretical basis that were used to predict the existence of a Taylor Column over the islands. He proposed that local phytoplankton blooms were simply a result of seeding by a dormant stock of diatom resting spores from the shallow sediments around the islands. Therefore, the island-mass effect of the Prince Edward Islands appears to be facilitated by interactions of the Antarctic Circumpolar Current with the local topography and by nutrient inputs from the islands as well as the existence of diatom resting spores in the shallow sediments [7, 12].

Zooplankton grazing during bloom conditions is responsible for removal of only a small (< 20%) proportion of primary production [13]. Unexploited organic matter may be horizontally dispersed but mainly sinks into deeper water (Fig. 1) [14], providing a plentiful food source for the benthic community. As a result, the benthic community of the Prince Edward Islands is diverse (~550 species), rich in biomass (up to 6000 g wet mass m^{-2}) and dominated by animals (bryozoans, cnidarians and sponges) that feed upon suspended organic particles and small plankton [15, 16]. Beside mass sedimentation of algal cells and spores after blooms over the island shelf, on the shallow parts of the shelf benthic animals may directly consume algal cells [14]. Furthermore, late larval stages of the benthic shrimp *Nauticaris marionis*, which are abundant over the island's shelf, undertake marked diel vertical migrations and are also able to utilize algae directly [17]. Both bottom-dwelling fish and the shrimp *N. marionis* consume mainly benthic animals, providing an important link between benthic production and top predators on the islands [17–20] (Fig. 1).

3. Offshore component of the life-support system

3.1. The replenishing hypothesis. During several surveys conducted in the vicinity of the Prince Edward Islands (e. g. April/May 1989, 1997–2000), through-flow regimes were observed to dominate the water dynamics in the inter-island region [11, 21]. This resulted in no water trapping and low chlorophyll-*a* concentrations (< 0.5 $mg \cdot m^{-3}$) within the inter-island region. During such situations, the advection of zooplankton from the upstream region of the islands was postulated to be able to supply much of the food necessary for the survival of the land-based offshore feeding predators (Fig. 2, *a*) [22]. Preliminary estimates showed that approximately 310 tons of myctophid (pelagic) fish and 3200 tons of zooplankton could be replenished between the Prince Edward Islands every 24 h through advection. It was furthermore calculated that nocturnal advection of allochthonous zooplankton alone may exceed local algal production twofold [23]. The advected plankton is likely to be trapped by the island's shallow topography (Fig. 3, see p. 113), depleted between the islands during the day by visual predators and replenished by advection from upstream during the following night [22, 24]. The importance of the advected mesozooplankton for the benthic food web can be illustrated by the direct observation of enormous quantities of calanoid copepods in the stomachs of bottom dwelling, near-shore fish *Notothenia macrocephala* [25].

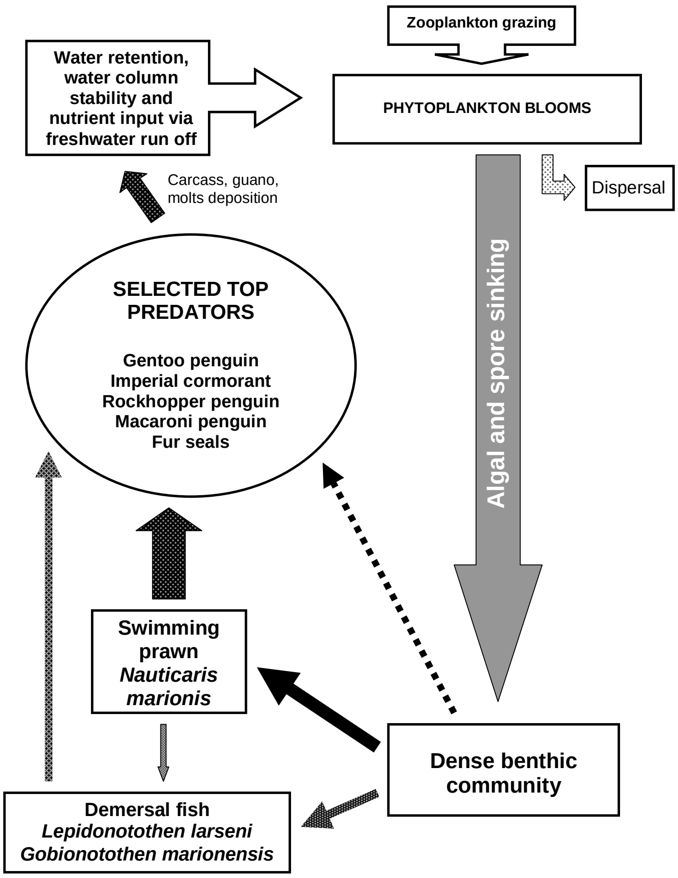

Fig. 1. Diagram illustrating the autochthonous component of the life-support system of the Prince Edward Islands. Updated from [2], reprinted with permission from the University of Chicago Press

Being strictly a benthic feeder, *N. macrocephala* does not have adaptations for filter feeding [26]. It is therefore apparent that this species encounters plankton in such vast concentrations near the bottom that filtering is not necessary [25].

Predators on the archipelago, excluding bottom-dwelling fish, may consume daily as much as 900 tons of crustaceans and up to 1770 tons of myctophid fish [22]. Thus, advection supplies all zooplankton (dietary) needs of top predators, but is inadequate in supporting the larger myctophid-feeding predators.

The latter predators would therefore have to forage in the deeper offshore waters, a hypothesis which was confirmed during foraging studies of king penguins [27]. Both myctophid fish and large pelagic crustaceans generally avoid advection to the inter-island region and are largely diverted around the islands, forming a belt of elevated concentrations in the close proximity to the outer island shelf, particularly in the lee of the islands (Fig. 2, *b*) [24, 28]. These areas thus represent important foraging grounds for many land-based predators. This is indirectly supported by the distributional pattern of all the major penguin colonies, e. g. king, rockhopper and macaroni penguins, which are concentrated on the eastward side of the Prince Edward Islands [29–31], and by the foraging trip patterns of some albatrosses from the Crozet Islands [32].

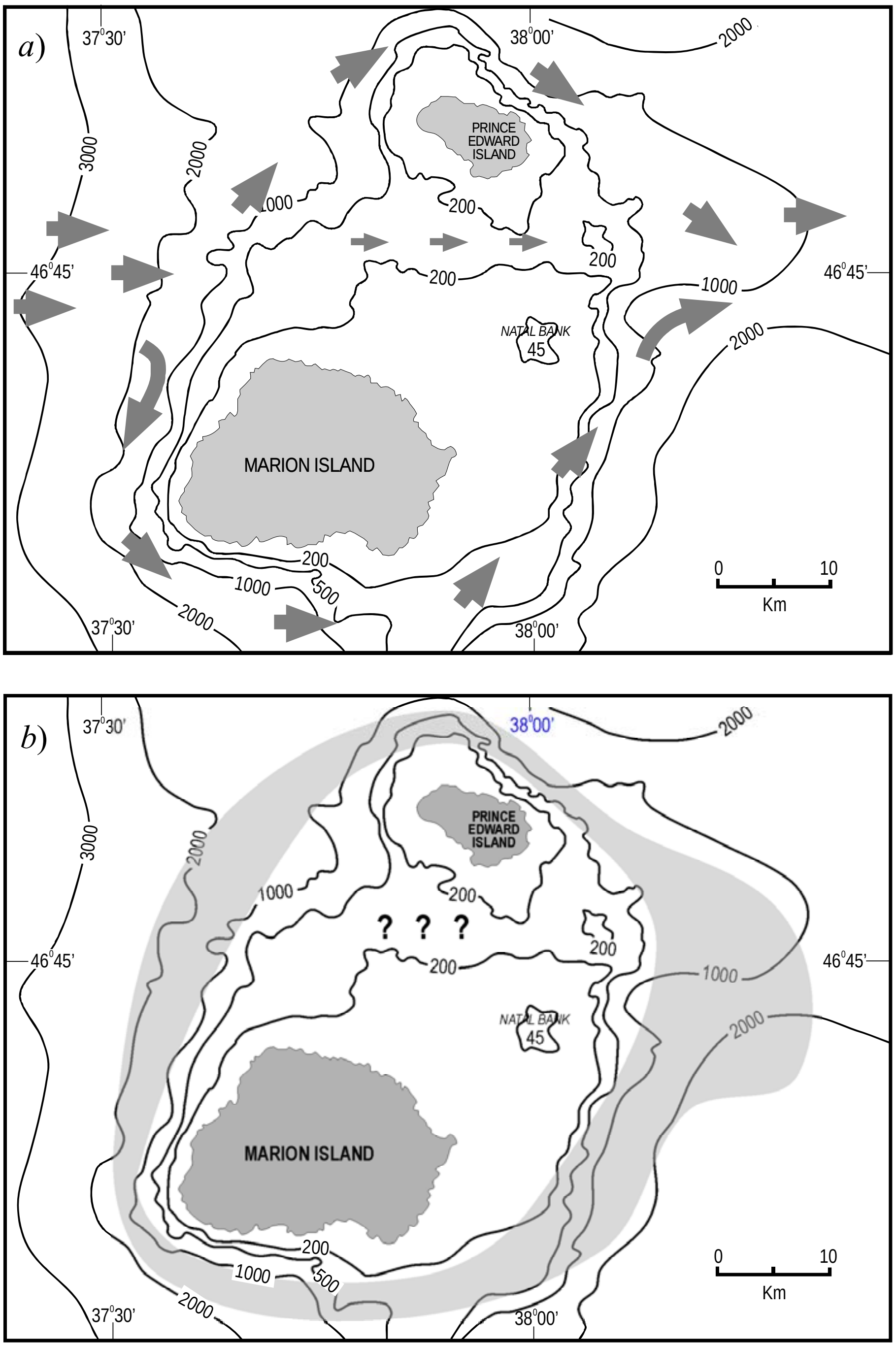

Fig. 2. Diagram illustrating the allochthonous component of the life-support system of the Prince Edward Islands. From [2], reprinted with permission from the University of Chicago Press. *a*) Generalized current system around the Prince Edward Islands. Size of arrows shows major flow pattern of water indicating that most of the water moves around the island shelf and only limited portion flows between the islands. *b*) Diagram showing elevated concentrations of large zooplankton and micronekton (shaded area) around the islands. Question marks indicate that very limited amounts of macroplankton/micronekton may be washed over the inter-island trench region. For further explanation see the text

3.2. The pulse hypothesis. It has previously been mentioned that relatively high acoustic signals (plankton concentrations) were observed within the deepest channel between the islands [33]. Currently, little data is available on the potential through-flow capacity of the inter-island saddle. It was, however, demonstrated that even during a through-flow regime pronounced water pulses might occur across the inter-island region of the Prince Edward Islands [34]. The location of the Subantarctic Front (SAF) to the north of the island plateau appeared to determine water dynamics (trapping or advection) at different time scales in the trench between the islands. The biological consequences of water pulses observed within the inter-island trench with regard to the food supply to top predators were, however, found to be minimal [34]. The frequency of water pulses and their importance as potential carriers of plankton and fish stocks over the inter-island saddle, as well as the effect of the SAF on the inter-island environment, should be investigated further, with special emphasis on the fine-scale aspect of these events.

3.4. Mesoscale anomalies and eddies hypothesis. The possibility of trapping of the upstream frontal spinout or vagrant eddies over the Prince Edward Islands' shallow topography was first hypothesized by Boden & Parker [42], after they noticed remarkable temporal differences in the zooplankton community structure in the vicinity of the islands. It was suggested that these eddies may carry biogeographically unique communities and may contain enhanced plankton standing stocks [36, 42]. More recent studies have shown that many flying birds and seals have strong associations with upstream mesoscale oceanographic anomalies/eddies during their foraging trips [43, 44]. It is now established that such anomalies are created as the Antarctic Circumpolar Current crosses the South-West Indian Ridge upstream of the Prince Edward Islands [39]. Eddies, drifting mainly in a northeastern direction, closer to the Prince Edward Islands, dissipate entirely by 47°E longitude [45]. Indeed, preliminary measurements conducted during the DEIMEC* II cruise showed that the biomass of micronekton and macroplankton within freshly created eddies is significantly higher than in the aged, somehow weakened eddies recorded closer to the Prince Edward Islands. Therefore, upstream eddies appear to be more significant foraging grounds for land-based top predators when they are located close to the point of their formation and may thus contribute substantially to the offshore component of the Prince Edward Islands' life-support system [44].

4. Concluding remarks on the life support system

Even an approximate contribution of both inshore and offshore components to the life support system of the Prince Edward Islands is not presently quantified. It can, however, be speculated *a priori* that the offshore component should be of critical importance, because the island terrestrial ecosystem and the inshore component itself significantly depend, be it directly or indirectly, on the amount of nutrients delivered to the islands in the form of dead bodies, molts and guano [2]. Providing energy and nutrients to the islands, offshore feeders should be recognized as central to the dynamics of the island ecosystems. The inherent domination of offshore foragers

* DEIMEC: Dynamics of Eddy Impacts on Marion's Ecosystem Study.

indeed reflects the prevalence of the offshore component in the islands' life-support system [2]. However, the proportion of inshore and offshore feeders on the islands is seemingly not only directly related to the allochthonous nutrient supply but may also be closely linked to terrestrial rate processes. The importance of the inshore components should not therefore be ignored and will be discussed below. It is noteworthy that an increasing contribution to the islands' life-support system by one of the components, particularly if related to climate change on the islands, may be critical to understanding long-term variability in the offshore- and inshore-feeding top predators of the Prince Edward Archipelago [2].

Until recently, the inshore component of the life-support system has been largely attributed to the island mass effect, e. g. to the periodic occurrence of autochthonous diatom blooms over the islands' shelf [2]. However, in addition to autochthonous phytoplankton blooms, extensive kelp beds surround the Prince Edward Islands. In the infralittoral fringe, the kelp *Durvillaea antarctica* may reach densities of 28 to 161 kg wet mass m^{-2}, while at depths exceeding 5 m the endemic kelp *Macrocystis laevis* predominates reaching biomass levels of ~12 $kg \cdot m^{-2}$ [46–48]. It has been estimated that macroalgal productivity per unit of area may be 2–3.5 times that of the phytoplankton [48]. Nevertheless, macroalgal productivity was assumed to be overall unimportant for the Prince Edward Islands' marine food web during both water trapping and throughflow regimes, because it was most likely localized within the nearshore realm and mostly washed ashore or transported out of the islands' ecosystem by ocean currents [48]. Only recently, with the advent of stable isotope techniques in trophic ecology, has it became possible to trace the flow of organic matter from different sources through consumers, and to uncover the relative trophic importance of allochthonous and autochthonous dietary sources within the Prince Edward Islands' ecosystems [49, 50].

5. Trophic structure of the marine food webs at the Prince Edward Islands

The first network analysis of the Prince Edward Islands marine ecosystem was undertaken by Perissinotto [51]. A conceptual model representing these interactions during a water retention scenario (Fig. 4, *a*) shows coastal runoff as an important source of guano-generated nutrients, and thereby as one of the main sources of energy fueling the inter-island pelagic and benthic subsystems. This would provide nutrients to both benthic macroalgae and phytoplankton, which through water retention would in turn be consumed by the local grazing food chains, both pelagic and benthic, and finally passed to the top predators on the islands (Fig. 4, *a*). Despite a reasonably good understanding gained of the major pathways of energy flow within the inter-island ecosystem, these have been only partially quantified (Fig. 4, *b*). According to Perissinotto [51], the majority of food requirements of the islands' predator community appear to be met by input of allochthonous sources (Fig. 4, *b*).

In a preliminary study using lipid content and fatty acid composition as biomarkers, Attwood & Hearshaw [52] postulated that herbivory was the major feeding mode of the inter-island zooplankton at the Prince Edward Islands, suggesting that a "simple" and short food chain, primary production → zooplankton → top predators, linked the marine and terrestrial systems of the islands. Only very recently have the origins (autochthonus or allochthonous) and pathways of organic matter been studied in more detail, using stable-isotope analysis in various marine communities in the

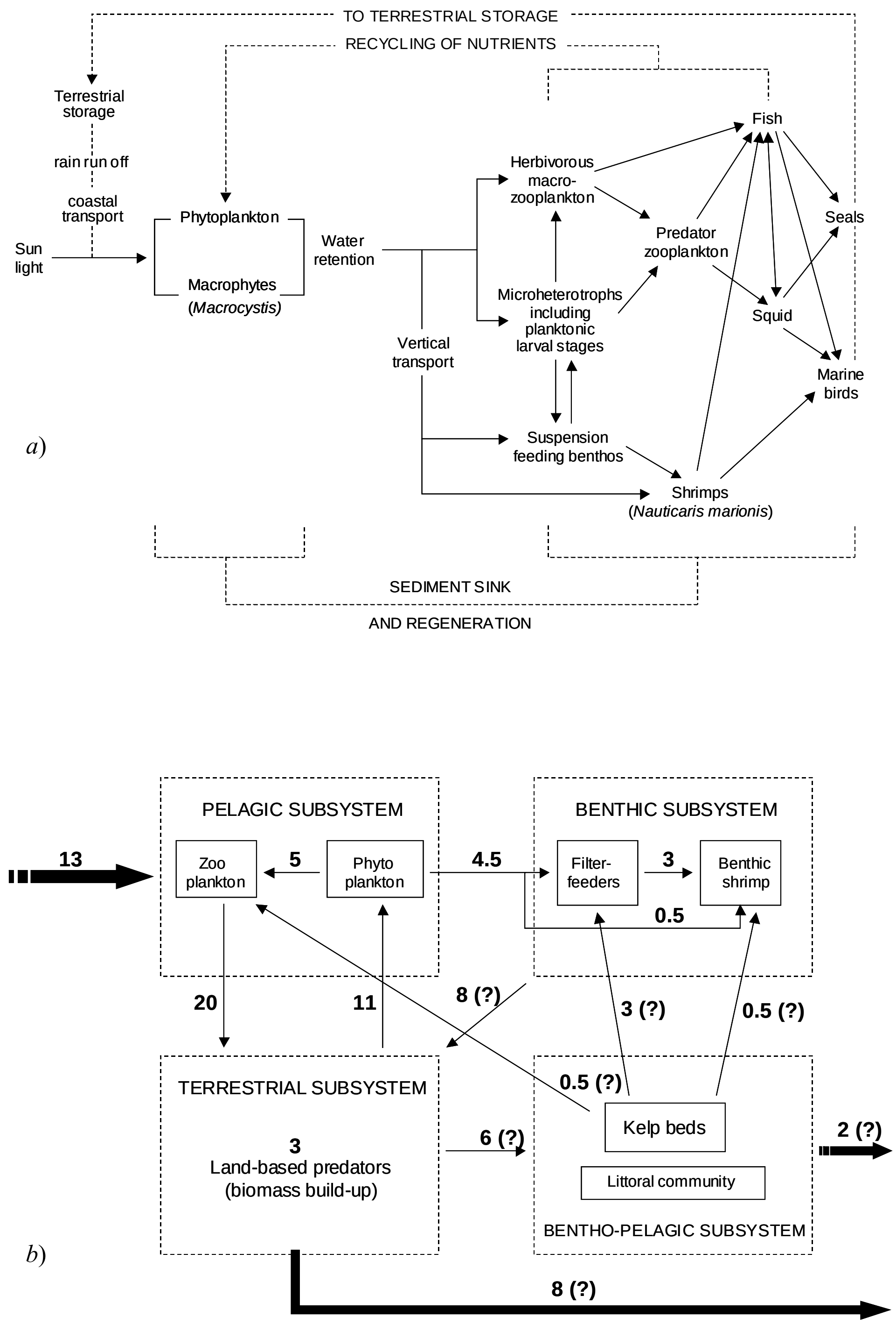

Fig. 4. Principal components and their interaction within the Prince Edward Archipelago marine ecosystem (*a*) and the schematic representation of daily nitrogen flux ($t \cdot N \cdot d^{-1}$) through the pelagic, benthic, bentho-pelagic and terrestrial subsystems of the Prince Edward Islands (*b*). Redrawn and updated from [51]. The bentho-pelagic subsystem has been added using data from [49, 50]

vicinity of the Prince Edward Islands [49]. Studies of stable isotopes provide information on the origins and pathways of organic matter because the isotopic composition of consumers closely reflects that of their diet [53, 54]. Carbon and nitrogen stable isotope signatures of consumers usually become predictably enriched as related to their prey allowing for the determination of both the consumer's diet and its trophic position within the food web [55–57].

Stable isotope signatures of organisms from four major assemblages comprising zooplankton, kelp-associated species, inter-island and near-shore benthos were investigated in the vicinity of the Prince Edward Islands and related to stable isotopes of offshore (small phytoplankton) and inshore (diatom bloom, kelps) producers [49].

While within the zooplankton community three distinct trophic levels of consumers were observed, both the benthic and kelp bed communities exhibited trophic continua [49]. Carbon stable isotope values of consumers varied greatly between communities, suggesting different dietary sources and origins of organic matter. Unlike the zooplankton community, inter-island benthic organisms were diet flexible, as indicated by their high variability in stable isotope signatures [49]. Two main types of primary producers were identified in the vicinity of the Prince Edward Islands. These included kelp ($\delta^{13}C \sim -14.4‰$) and mixed upstream phytoplankton ($\delta^{13}C \sim -24.8‰$). In addition, carbon stable isotope signatures of the micro size-fraction of the particulate organic matter (POM), mainly diatoms, were ~–23.6 (Fig. 5).

Basing on a simple mixing model for a two-source system [58], it was found that both pelagic (zooplankton) and benthic inter-island communities ultimately derived most of their energy from pelagic production. In contrast, both kelp-associated animals and near-shore communities derived a high proportion of their energy (70–100% and > 40% respectively) from kelp-originated matter. The above findings showed for the first time that autochthonous sources of organic matter (both inter-island blooms and kelp-derived) are important components of the diet of all but the zooplankton community at the Prince Edward Islands [49]. Unlike previously suggested by Beckley & Branch [48], not all kelp material is washed ashore or transported away from the islands but is rather incorporated, either directly or indirectly, into the diet of a large number of inter-islands species [20, 49, 50]. Depending on the length of their foraging trips, it is not inconceivable, therefore, that many of the land-based top predators also indirectly consume organic matter that ultimately originates from kelps. Detailed stable-isotope analyses of the top predators (currently in progress) are required to shed more light on the importance of the coupling of the land-based and near-shore marine systems.

6. Trophic importance of kelp-derived matter in the through-flow Prince Edward Islands' system

It is currently established that, while most pelagic consumers ultimately derive their organic carbon from phytoplankton production, the diet of many of the Prince Edward Islands' shelf and coastal consumers is heavily subsidized by macroalgal-derived matter [49]. There is now mounting evidence that the importance and spatial extent of macroalgal- and especially kelp-derived matter in coastal and island ecosystems has been considerably underestimated worldwide [58, 59]. Until very recently, we knew little about the spatial and temporal extent of the influence of kelp derived matter in the vicinity of the Prince Edward Islands.

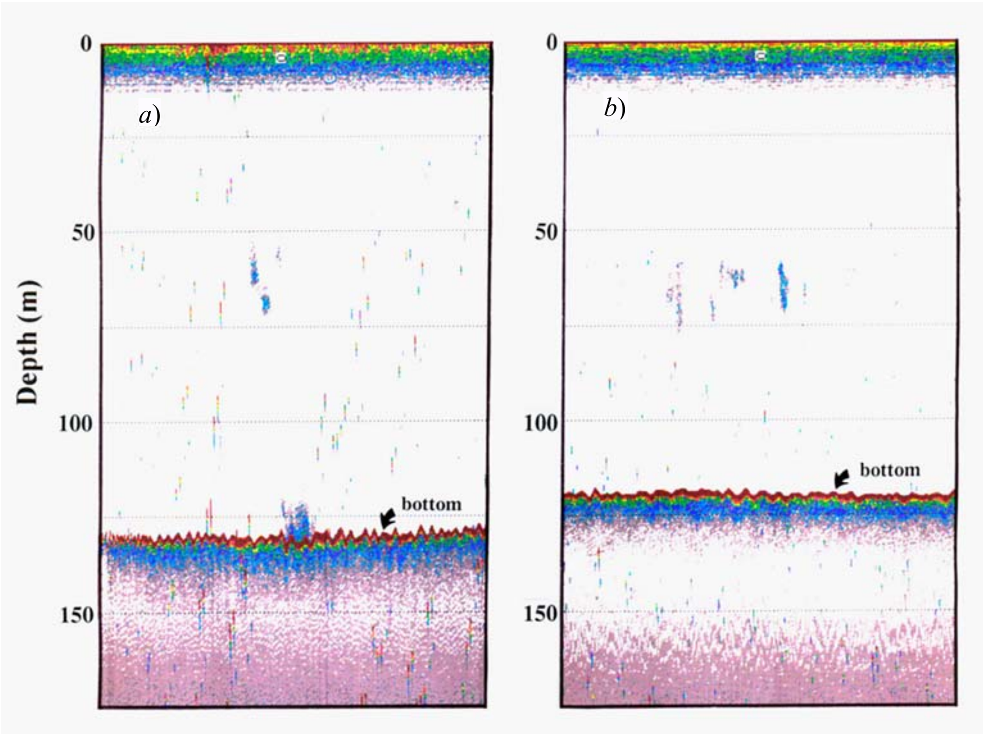

Fig. 3. Echo charts (EK 500 Simrad, 120 kHz) showing swarms of mesozooplankton at dawn (local time 05:40 to 05:55 hrs) on 4 May 1997 (*a*) and at sunrise (06:35 to 06:50 hrs) on 23 May 1997 (*b*) between the Prince Edward Islands

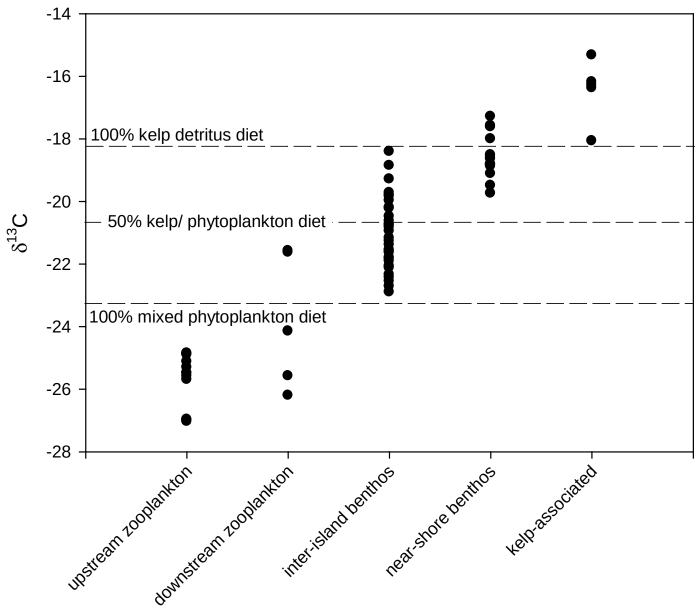

Fig. 5. Carbon stable isotope signatures of primary consumers (or suspension-feeding organisms) in different communities of the Prince Edward Islands' ecosystem. Data taken from [20, 49, 50 and Kaehler & Pakhomov, unpublished data]

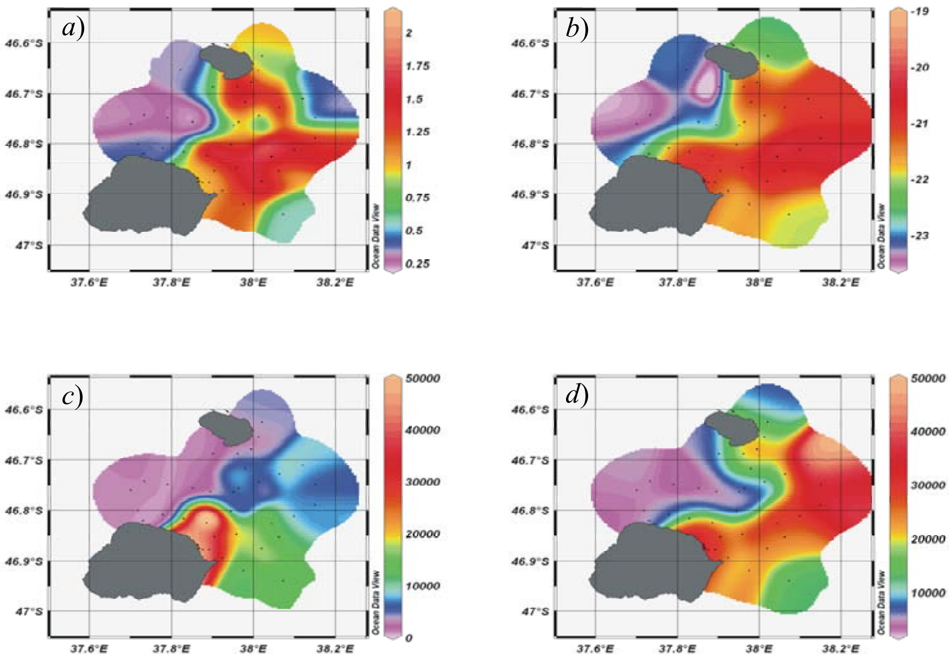

Fig. 6. Surface water composition in the vicinity of the Prince Edward Islands during April 2003 [50], reprinted with permission from Springer: *a*) chlorophyll-*a* concentration of the micro size-fraction (μg l^{-1}); *b*) $\delta^{13}C$ signature of surface POM (‰); *c*) diatom densities (cells l^{-1}); *d*) density of suspended rectangular detritus fragments (particles l^{-1})

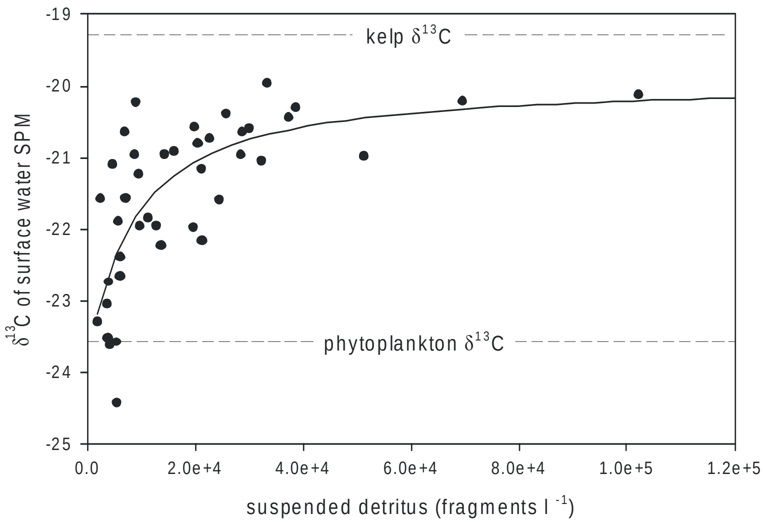

Fig. 7. Relationship between density of suspended detritus fragments and $\delta^{13}C$ signatures of surface water POM during April 2003 in the vicinity of the Prince Edward Islands. In samples with high densities of detrital fragments, carbon isotope signatures draw close to those of kelp. Data from [49, 50], reprinted with permission from Springer

During the April/May 2003 survey in the inter-island region of the Prince Edward Islands, high chlorophyll-*a* values and diatom concentrations of surface water were not related (Fig. 6) [50]. At the same time, the distribution of large angular detrital fragments closely resembled that of chlorophyll-*a* and their densities were significantly and positively correlated with micro size-fraction chlorophyll-*a* concentrations. Due to their large size (3 to 10 times that of the diatoms), their origin could not be planktonic, and a microscopic investigation concluded that many of the least decomposed particles were fragments of the kelp *Macrocystis laevis*. Stable isotope data provided further support for this suggestion [50].

In the lee of the islands, surface POM stable isotope signatures were of intermediate values, suggesting a mixture of 50 to 80% kelp-derived matter and 20 to 50% of phytoplankton (Fig. 7). During previous studies of marine food webs at the Prince Edward Islands, it was postulated that inter-island communities are less strongly subsidized by the kelp-derived carbon compared to kelp-associated and nearshore benthic assemblages, because macroalgal detritus was not likely to occur in abundance at great distances from the kelp beds [49].

The new findings challenged this suggestion. Not only did kelp particles appear to be a major component of the POM up to 30 km downstream of the islands (the spatial extent of the current study), but also larger decomposing kelp-matter was found to be abundant in all benthic dredges, independent of distance from the islands. It is likely that the contribution of kelp to various consumers was yet underestimated in the previous study, as primarily fresh kelp and some detrital kelp from the shore was used for stable isotope analysis [49].

While most recent findings are changing our perception of the importance of kelp-derived organic matter within the inter-island realm of the Prince Edward Islands, it is still not fully understood by which mechanism the suspended kelp particles are derived.

The shape and size of the rectangular particles seem to preclude their microbial origin from dissolved organic carbon. Furthermore, due to their relatively small size, it is unlikely that suspended particles are a direct product of kelp frond senescence or fragmentation. More likely, they are the product of: (a) generation of suspended particulate matter through the re-suspension of previously degraded kelp matter from the benthos; and/or (b) the continual cell sloughing from parent plants. Considering that the occurrence of kelp fragments' abundance and size coincided with that of the chlorophyll-a distribution, it seems reasonable to suggest that the suspended kelp detritus was relatively fresh and still contained viable chlorophyll-a. This postulates that cell sloughing may be the primary source of particle formation. This suggestion is also supported by the occurrence of freshly produced kelp fragments in extremely high numbers (> 100000 particles l^{-1}) at several stations within the kelp beds (Kaehler, personal observation). These findings, however, cannot exclude the possibility that kelp fragments in the lee of the islands are populated by photosynthetic epiphytes, thus enhancing chlorophyll-a concentrations in areas of low phytoplankton / high kelp particle densities. Further investigations are clearly required to explain the mechanisms by which detrital POM is derived and to determine the fine scales of formation and residence of kelp-derived matter in the water column.

Whatever the source of kelp-derived POM, suspension feeders downstream of the islands exhibited isotopic signatures that could only be explained by the incorporation of a mixture of phytoplankton and kelp detritus. Both carbon and nitrogen signatures of the suspension-feeding brachiopod *Magellania kerguelenensis* were very close to that of the downstream "mixed" suspended particulate matter and were too enriched to be explained by the consumption of phytoplankton alone [50]. It was estimated that on average 40–45% of suspension feeders diet (in terms of both carbon and nitrogen), originated from kelp-derived matter [50]. This strongly suggests that the dietary subsidy of both kelp-derived carbon and nitrogen appears to be far more widespread than previously anticipated and not limited to the vicinity of kelp beds (Fig. 5). It may further be postulated that due to the suspended nature of the macroalgal matter and the strong unidirectional nature of the circumpolar current, dispersal of detritus may be greatly enhanced. It is possible that future investigations may show that this detrital matter contributes also to the diet of downstream plankton and benthic communities.

7. Conclusion and final remarks

Since the 1971 overview book edited by Van Zinderen Bakker, we have learned a great deal on how the ecosystem of the Prince Edward Islands may operate and is supported. It is increasingly clear that the offshore mechanism is one of the key processes allowing the island system to thrive. Nutrient input via top predators not only enhances terrestrial productivity but also fuels algal and phytoplankton production in the marine intertidal, nearshore and offshore waters in the vicinity of the Prince Edward Islands. This in turn enhances input from these habitats to the terrestrial ecosystem. We have shown that the contribution of autochthonous energy sources has been dramatically underestimated in the past. Nevertheless, our knowledge of the details of how certain mechanisms work and how much they contribute towards the life-support system of the Prince Edward Islands is still hampered by the lack of seasonal research efforts in the offshore region, and particularly by the absence of modeling efforts. A generic relationship between marine energy input into a terrestrial subsystem predicts that on an archipelago of the size of the Prince Edward Islands marine input would account for ~10% of total terrestrial production [60]. This contribution could, however, be higher due to decreased rates of terrestrial production, depressed by the adverse environment and slow nutrient release during the mineralization of organic reserves [2]. Modeling efforts should, therefore, bring together the nutrient fluxes of both terrestrial and marine ecosystems. The stable isotope techniques available now are very helpful in uncovering complex trophic dynamics and differential contribution of inshore and offshore components. Hence, future research based upon available knowledge should concentrate on creating an integrated model of the Prince Edward Islands, including its surrounding ocean environments. This would go a long way towards addressing long-term and conservational issues for the islands.

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Резюме

Е.А. Пахомов, С. Келлер, Р. Периссинотто. Система жизнеобеспечения островов Принца Эдуарда: важность локальных и внешних источников энергии.

За последние 30 лет было описано несколько механизмов объясняющих динамику планктона, а также обеспечение пищей островных хищников и донных сообществ в районе островов Принца Эдуарда. Предложенные механизмы включают: (а) гипотезу апвеллинга с подветренной стороны островной системы, (б) вторжение меандров образованных выше по течению на островной шельф, (в) формирование условий для цветения фитопланктона на островном шельфе, (г) гипотеза «конвейера» доставляющего планктон на шельф островов, и (д) утилизация хищниками фронтальных систем и топографически генерируемых круговоротов выше по течению или в непосредственной близости к островам. Предполагается, что «система жизнеобеспечения» островов Принца Эдуарда включает в себя все перечисленные выше компоненты. Их важность критически рассмотрена и оценена в связи с изменчивостью внешней среды вокруг островов. Базируясь на недавних исследованиях с использованием стабильных изотопов, количественно оценена важность аллохтонных (внешних) и автохтонных (локальных) источников энергии в различных экосистемах островов Принца Эдуарда. В частности, впервые для экосистемы островов показана важность органики поступающей от прибрежных бурых водорослей ламинарий.

Ключевые слова: экосистемы островов Принца Эдуарда, аллохтонные и автохтонные источники энергии.

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Пахомов Евгений Александрович – кандидат биологических наук, профессор кафедры исследования земли и океана университета Британской Колумбии, Канада.

E-mail: *epakhomov@eos.ubc.ca*

Келлер Свен – доктор, директор лаборатории стабильных изотопов, кафедра ботаники Университета Родса, Южная Африка.

E-mail: *s.kaehler@ru.ac.za*

Периссинотто Рензо – доктор, профессор школы биологии и охраны окружающей среды Университета Квазулу-Натал, Южная Африка.

E-mail: *perissinottor@ukzn.ac.za*

Pakhomov Evgeny Alexandrovich – Associate Professor (PhD) of Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, Canada.
E-mail: *epakhomov@eos.ubc.ca*

Kaehler Sven – Director (PhD) of Environmental Isotope Facility, Department of Botany, Rhodes University, Grahamstown, South Africa.
E-mail: *s.kaehler@ru.ac.za*

Perissinotto Renzo – Professor (PhD) of School of Biological and Conservation Sciences, University of KwaZulu-Natal, Durban, South Africa.
E-mail: *perissinottor@ukzn.ac.za*