

Supplementary Material

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Supplement 1. Exploring multiple methods for quantifying colonization and extinction rates

S1.1. A description of the methods

Here we compare and contrast the efficacy of six methods for quantifying colonization and extinction rates for the fish community inhabiting ten offshore banks of the Scotian Shelf, NW Atlantic. The exploration was undertaken to facilitate the most effective methodology for evaluating the hypotheses framed in the main text.

Since the publication of MacArthur & Wilson’s (1967) Theory of Island Biogeography, multiple approaches to quantifying colonization and extinction events have been proposed. Assuming perfect detection of all resident species at sampling, colonization is deemed to have occurred when a species was observed during time t but not during time $t-1$. Similarly, an extinction is deemed to occur when a species was not observed during time t but was observed in time $t-1$. This approach (hereafter referred to as “naïve”, sensu Beck et al. 2018) was employed in analyses of colonization and extinction for many years (e.g., Brown et al. 2001). In reality, however, perfect detection of all species occupying a given habitat environment is virtually impossible even with exhaustive sampling. This is especially true in marine ecosystems and particularly with respect to fishes where sampling is essentially blind. Gear avoidance, species that exist at low densities, and the physical constraints on sampling the entire habitat under consideration often result in species being underrepresented or absent in the collections. Imperfect detectability of species, in turn, can confound estimates of species richness and of colonization and extinction rates.

Several approaches have been employed to account and correct estimates of incomplete detection. For example, Magnuson et al. (1994) removed species from their data sets that were known to exist but were too rarely sampled to elicit meaningful temporal trends in estimates of extinction and re-colonization. Others sought to correct estimates of turnover (cumulative colonizations and extinctions per species) for sampling error as estimated from either annual variation in turnover or through Monte Carlo simulations of species abundances (Arnott et al. 1999).

Others investigators sought to retain more species in their data set and to correct for potential detection errors, using criteria-based approaches to identifying colonization and extinction events. As the potential error lies in not detecting species that are actually present (not in detecting a species that was actually absent), the purpose of these criteria was to determine whether an absence could be recorded as an actual local extinction. Cisneros' (1993) employed three criteria, at least two must be met for a species absence to be classified as an extinction: 1) a significant decline in species abundance prior to the disappearance, 2) an increase in mean body size indicating an aging population, and 3) a significant decline in dispersion (number of samples within an area in which the species is found). Using these criteria, Cisneros (1993) and Arnott et al. (2006) demonstrated that estimated turnover rates were higher than those predicted by the naïve approach, but noted that these rates were still likely to be underestimated.

Several other approaches, including Bootstrap and Jackknife estimators have also been employed (Oksanen et al. 2017, Chao 1987, Heltshe & Forrester 1983, Smith & van Belle 1984, Nichols et al. 1998; Appendix A4). Nichols et al (1998) used the Jackknife approach and assumed that the probability of extinction was a function of the ratio of predicted (Jackknife) to observed species richness. However, this approach fails to explicitly account for variation in detection probabilities among species and is principally used to compare community states between two intervals in time. Acknowledging this shortcoming, Nichols et al. (1998) suggested that estimators based on probabilistic modelling would be more effective correcting for incomplete sampling. Following this logic, Kery et al. (2006) argued that maximum likelihood estimates derived from probabilities of detection could yield unbiased and effective estimators of species richness. Interest in probability-based modelling and maximum likelihood estimates of these vital rates intensified (MacKenzie et al. 2002, MacKenzie et al. 2003, Alonso et al. 2015) which led in turn to the development of a statistical package in R, *island* (Ontiveros et al. 2019; Table S1.1) designed to yield unbiased estimates of colonisation and extinction under conditions of incomplete sampling. This package follows the stochastic implementation of Wilson & Simberloff's (1969) model of time variant species richness (Eqn. S1.1) in which the species complexes present in a given habitat is related to the number of species arriving from the greater species pool minus the number of species lost. Alonso et al. (2015) expanded this model to include probabilities of species-specific transitions between time periods while relaxing the species neutrality (all species have same vital rates) assumption of the TIB (MacArthur & Wilson 1967), but maintaining species independence. “island” employs annual per-sample presence-absence data to estimate community- or group-level probabilities of transition between presence and absence states over a period of at least two sampling times using a maximum likelihood approach (MacKenzie et al. 2003).

$$island S_t = S_{t-1} + \left(\frac{(PC_{t,t+n} * (S_p - S_{t-1}))}{n} \right) - \left(\frac{(PE_{t,t+n} * (S_{t-1}))}{n} \right) \quad (\text{Eqn. S1.1})$$

where S is the number of species in sampling times t and $t-1$, PC probability of colonization (i.e., transitioning from absence to presence between sampling time t and $t+n$), PE is the probability of extinction (i.e., transitioning from presence to absence between sampling time t and $t+n$), S_p is the total number of species observed in a given area (such as an offshore bank) over the full sampling period, i.e., the species pool, and n is the number of sampling times over which the transition occurs.

These probabilities are used to estimate equilibrium species richness and the number of colonization and extinction events per unit time. All models employed subsequent to the initial rules-based approaches of Cisneros (1993) and Arnott et al. (2006), including *island* (2019), have assumed species independence as defined above (see their test of this assumption in Ontiveros et al.). Fidino et al. (2019) further developed a Multi-state Dynamic Occupancy Model based on pair-wise interactions of species and the probabilities of community state transitions. Still in development, this approach requires assumptions concerning the nature of species interaction, few of which are currently adequately quantified.

In our analysis, we first evaluated colonization and extinction events using the naïve approach (Table S1.1). We then developed and employed two rules-based approaches based on species presence/absence data (denoted as “PA2/3” and “PA3/5”; see Table S1.1). These approaches ensure that one year of absence preceded and followed by specified years of presence is not classified as a true local extinction. We next incorporated species abundance data into the PA3/5 rules-based approach (as suggested by Arnott et al. (2006)) by classifying a local extinction on the basis of a species’ reduction to 10% or less of its long-term maximum abundance for at least 3 out of 5 years (denoted as “F35” in Table S1.1). This approach was influenced by conservation literature’s definition of “functional extinction”, often resulting in failed population recovery even under conditions of reduced perturbation (Hutchings 2001, Hutchings & Reynolds 2004, Keith 2015). In this context several studies have found that even small reductions in population size can result in population growth rates (during recovery periods) that are different from zero (see McCauley et al. 2017). It is now widely acknowledged that the maximum abundance recorded for most populations of fish and other exploited animals from sampling in recent times is an accurate measure of its true historical maximum given that in most cases exploitation has been occurring for centuries Baum & Meyers 2004, Lotze & Worm 2009, Lotze et al. 2011). For this reason, using 10% or less of a population’s current maximum can be considered a reasonable approximation of functional extinction.

Finally, we compared the results of our naïve and rules-based approaches to those derived from two functions in the *island* R package (Ontiveros et al. 2019); Table S1.1). The *island* package contains functions “regular_sampling_scheme” (hereafter “islandNR5”), which predicts colonization and extinction probabilities under the assumption of perfect detection, and “sss_cedp” (hereafter “islandWD5”), which incorporates corrections for imperfect detection at the community level (Table 1). Both *island* methods assume species independence (the presence or absence of one species is independent of the presence or absence of another), and equal probabilities of detection among species. We calculated and compared estimates of colonization and extinction using all methods detailed in Table S1.1). For reasons detailed in the main text, only the results of the “PA3/5” and “islandWD5” assessments were employed in the analyses detailed there.

Table S1.1. Descriptions, pros and cons of each of the methods of quantifying colonization and extinction rates in this study.

Method	Description	Pros	Cons
Naïve	<ul style="list-style-type: none"> - Raw data - Presence after year of absence = colonization - Absence after year of presence = local extinction - Error from fit of linear model ($x = \text{year}$) 	<ul style="list-style-type: none"> - Quantifies short-term variability - Allows for identification of species involved in colonization/extinction dynamics 	<ul style="list-style-type: none"> - Incorrectly assumes perfect detectability - Assumes species are independent from one another - Temporal patterns are highly variable or noisy; reflects mainly sampling variability
PA2/3	<ul style="list-style-type: none"> - Colonization when year of presence followed by at least 1 other presence within a 3-year time block (2 total) - Extinction when year of absence followed by at least 1 other absence in 3 years - Error from fit of linear model ($x = \text{year}$) 	<ul style="list-style-type: none"> - Quantifies short-term variability - Partially accounts for detectability - Allows for identification of species involved in colonization/extinction dynamics 	<ul style="list-style-type: none"> - Incorrectly assumes equal detectability among species (same rules apply to all) - Assumes species are independent from one another - Temporal patterns are highly variable and somewhat noisy
PA3/5	<ul style="list-style-type: none"> - Colonization: when a year of a species presence is followed by at least 2 other presences within a 5-year window (3 in total) - Extinction: when a year of a species absence is followed by at least 2 other absences in a 5-year window - See Supplementary material for examples 	<ul style="list-style-type: none"> - Smoothed temporal trends (less noisy than raw data) - Partially accounts for detectability - A simple and accessible method - Allows for identification of species involved in colonization/extinction dynamics 	<ul style="list-style-type: none"> - Incorrectly assumes equal detectability among species (same rules apply to all) - Assumes species are independent from one another - Reduced temporal variability compared to naïve and PA2/3 approaches, but higher interannual variability compared to island methods - - may mask long-term trends

<p>F35</p>	<ul style="list-style-type: none"> -Colonization when abundance $\geq 10\%$ of the long-term maximum for that species on that bank and followed by at least 2 other years with abundance $\geq 10\%$ of maximum in a 5-year time block (3 total) - Absence = functional extinction when abundance $< 10\%$ of the maximum for 3 of 5 years - Colonizations given priority as in the Presence/Absence (3/5-year rule) approach - Error from fit of linear model ($x = \text{year}$) 	<ul style="list-style-type: none"> - Accounts for “functional extinction”, when abundance is extremely low, which can have consequences for trophic and competitive species interactions - Smoothed temporal trends (less noisy) - Partially accounts for detectability issues - Allows for identification of species involved in colonization/extinction dynamics 	<ul style="list-style-type: none"> - Incorrectly assumes equal detectability among species (same rules apply to all) - Assumes species are independent from one another
<p><i>islandNR5</i> (perfect detection/ no rules)</p>	<p>Function “regular_sampling_scheme” in <i>island</i> R package (Ontiveros et al. 2019)</p> <ul style="list-style-type: none"> - Presence after year of absence = colonization - Absence after year of presence = local extinction - Calculates vital rates and probabilities across multiple sampling times (at least two) assuming perfect detectability within sampling times, but uses a maximum likelihood approach to estimating transition probabilities 	<ul style="list-style-type: none"> - Estimated from the original stochastic implementation of equations of TIB - Maximum likelihood approach allows for estimation of confidence intervals - Requires only presence/absence data by sampling time (does not require replicate samples) 	<ul style="list-style-type: none"> - Assumes species are independent from one another - Probabilities must be estimated over time periods of at least two years; can estimate annual colonizations and extinctions from these average probabilities - Assumes perfect detection of species within sampling times (does not consider variation in detection by using replicate samples as in <i>islandWD5</i>)

<p><i>islandWD5</i> (imperfect detection, i.e., with detection correction); referred to as “<i>island</i>” in the main text</p>	<ul style="list-style-type: none"> - Function “<i>sss_cedp</i>” in <i>island</i> R package (Ontiveros et al. 2019) - Based on MacKenzie’s (2003) likelihood function to estimate site occupancy, colonization and local extinction when species are detected imperfectly - Relies on replicate observations (trawl sets within banks each year): here, calculated probabilities for 5-year sliding windows - Rates, and therefore transition probabilities, are estimated heuristically from the sum of probabilities of all possible detection histories (between consecutive sampling periods) 	<ul style="list-style-type: none"> - Estimated from the original stochastic implementation of equations of TIB - Rates based on probabilities of all presence/absence combinations - Less interannual variability than raw data or PA3/5 approach (clear, smoothed temporal trends). 	<ul style="list-style-type: none"> - Assumes species are independent from one another - Low replication (sites, number of transects) prevents species-specific characterization of vital rates and detectability.
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Before conducting these analyses, we edited the dataset to retain only records identified to the species level (the one exception being Redfish which are comprised of two, largely indistinguishable species) and species whose annual presence/absence history resulted in the assessment of at least one colonization event under the PA3/5 rule (Table 2, main text). Table S1.2 details the bank specific number of species retained in the edited data set (considered the “species pool” from which colonization of the banks occurred, Eqn. S1.5) and the number of species and family-/genus-level records contained in the unfiltered dataset.

Table S1.2. Number of species and family- and genus-level records included in the full, raw dataset obtained through DFO compared to those species-level records retained in the truncated dataset for the purpose of comparing methods.

	Bc	Bq	Bw	Em	LH	Md	Mi	Rw	Sb	Ws
Total (raw dataset)	37	61	50	34	33	45	64	37	66	54
Truncated	21	28	29	21	15	26	23	17	32	29
<i>Number of “species” removed</i>	<i>16</i>	<i>33</i>	<i>21</i>	<i>13</i>	<i>18</i>	<i>19</i>	<i>41</i>	<i>20</i>	<i>34</i>	<i>25</i>
<i>% raw records removed</i>	<i>43</i>	<i>54</i>	<i>42</i>	<i>38</i>	<i>55</i>	<i>42</i>	<i>64</i>	<i>54</i>	<i>52</i>	<i>46</i>

We identified colonization and extinction events using the naïve, PA2/3, PA3/5 and F35 methods according to the rules described in Table S1.1. Annual species richness was then derived using Equation S1.2 and turnover was calculated from Equation S1.3. Colonization and extinction rates were expressed as the slope of the linear relationship between cumulative colonizations ($S_{t-1} + C_t$) and extinctions ($S_{t-1} - E_t$) and year (see main text). Confidence intervals associated with colonization and extinction rates were derived from the standard error of the fitted slope.

$$\text{Species richness } (S_t) = S_{t-1} + C_t - E_t \quad (\text{Eqn. S1.2})$$

$$\text{Turnover (T)} = (C_t + E_t) / (S_{t-1} + S_t) \quad (\text{Eqn. S1.3})$$

where S is the number of species, C is the number of colonizations and E is the number of extinctions.

Annual species richness derived using the *islandNR5* and *islandWD5* methods was calculated from the probabilities of colonization (CP) and extinction (EP) given by the above noted functions (Table S1.1; Eqn. S1.5). Colonization and extinction rates were then derived from the slope of the linear relationship between cumulative colonizations/extinctions and year. In this calculation we used generalized least squares regression, accounting for temporal autocorrelation ($r \sim 0.82$) at lag = 1 year) as

$$\text{island } S_t = S_{t-1} + \left(\frac{(PC_{t,t+4} * (S_p - S_{t-1}))}{1} \right) - \left(\frac{(PE_{t,t+4} * (S_{t-1}))}{1} \right) \quad (\text{Eqn. S1.5})$$

where S is the number of species, PC is the average probability of colonization (for 5-year sliding window), PE is the average probability of extinction (for 5-year sliding window) and S_p is the total number of species observed on the bank over the full sampling period (1970-2017), i.e., the species pool.

S1.2. Comparison of methods

a) Species Richness

From the analyses detailed above we constructed time series of annual species richness, colonizations, extinctions and the annual ratio of colonization to extinction event for each of the ten offshore banks of the Scotian Shelf. We then evaluated the similarity of method-specific time series, using Pearson correlation coefficients (r). Finally, we assessed the extent to which the time series reflected the ecosystem regime shift that resulted from the sudden and near total top predator collapse that occurred in the early 1990s, a perturbation that resulted in compositional

change in community structure from large-bodied piscivore dominated system to one dominated by smaller bodied planktivorous and mesopredator species.

The time series of species richness derived from the resulting estimates of colonization and extinction events exhibited similar temporal trends, the naïve and PA2/3 time series exhibited the greatest interannual variability (Fig. S1.1). All methods yielded species richness time series that exhibited an increase in the early 1990s on eight of the ten the banks, the exceptions being Emerald and Western (Fig. S1.1). The resulting temporal series were also, with a few exceptions, strongly and positively correlated one with another (Table S1.3). *islandNR5* and *islandWD5* produced time series virtually identical one to another (Pearson correlation coefficients ranging 0.79-1.00; Table S1.3). Time series derived from the PA3/5 and F35 rules-based methods were also nearly identical (Pearson correlation coefficients ranging 0.77-0.98; Table S1.3).

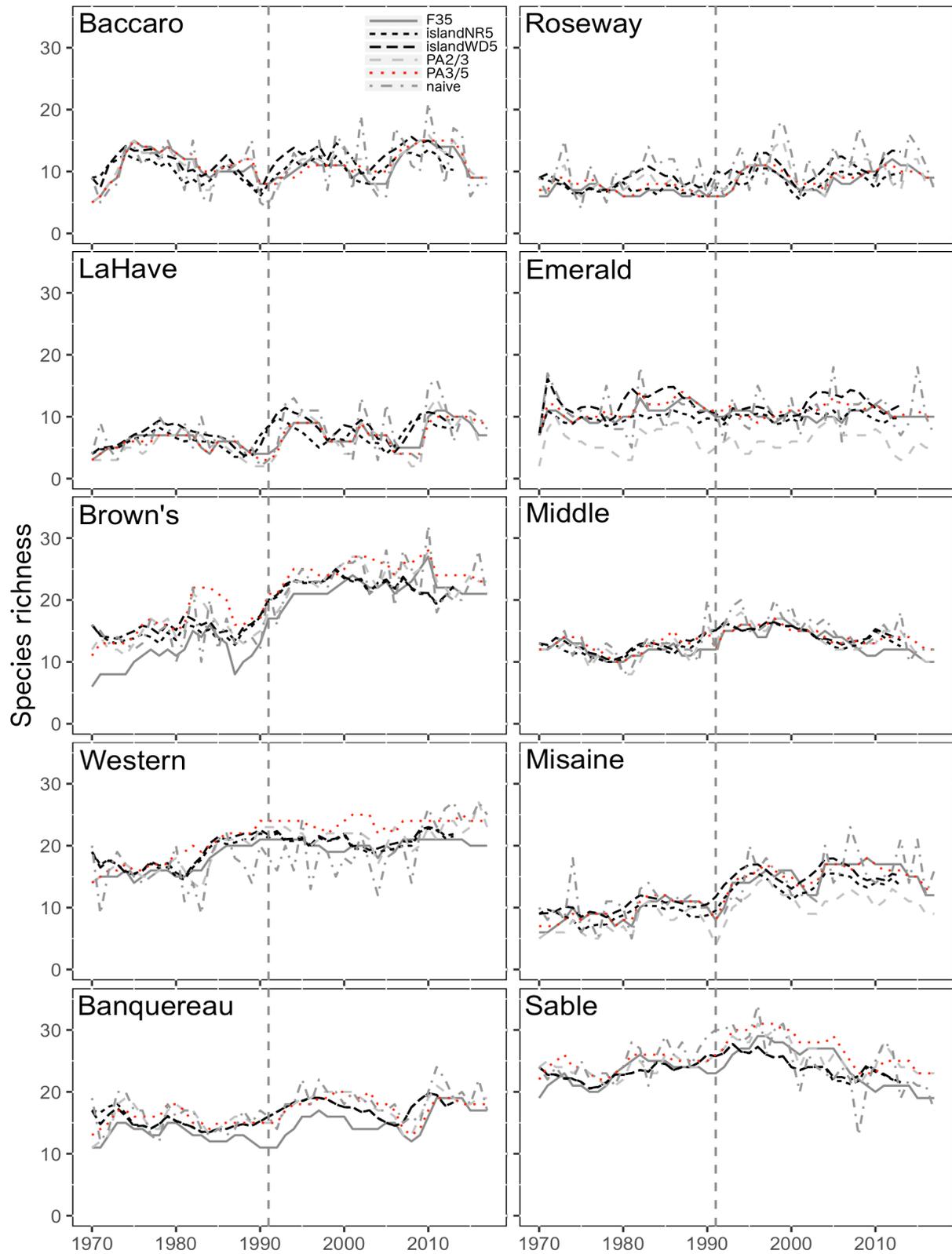


Fig. S1.1. Bank specific species richness time series for each of the 6 methods evaluated (listed from smallest bank (top left) to largest (bottom right))

Table S1.3. Pearson correlation (r) of time series (1970-2017) of annual species richness among the six methods considered for each of the ten banks, including correlation of these values with year, reflecting the long-term trends in species richness

a) Baccaro (Bc), 534 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.57	1				
<i>islandWD5</i>	0.63	0.92	1			
<i>PA2/3</i>	0.88	0.61	0.67	1		
<i>PA3/5</i>	0.95	0.49	0.57	0.87	1	
<i>Naïve</i>	0.62	0.49	0.46	0.77	0.62	1
b) Roseway (Rw), 551 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.63	1				
<i>islandWD5</i>	0.61	0.84	1			
<i>PA2/3</i>	0.63	0.56	0.49	1		
<i>PA3/5</i>	0.93	0.63	0.58	0.71	1	
<i>Naïve</i>	0.38	0.41	0.37	0.75	0.45	1
c) LaHave (LH), 908 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.34	1				
<i>islandWD5</i>	0.66	0.81	1			
<i>PA2/3</i>	0.90	0.24	0.63	1		
<i>PA3/5</i>	0.95	0.23	0.62	0.89	1	

<i>Naïve</i>	0.75	0.17	0.53	0.85	0.76	1
d) Emerald (Em), 1 034 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.49	1				
<i>islandWD5</i>	0.41	0.79	1			
<i>PA2/3</i>	0.50	0.53	0.58	1		
<i>PA3/5</i>	0.77	0.54	0.59	0.76	1	
<i>Naïve</i>	0.42	0.43	0.27	0.57	0.46	1
e) Brown's (Bw), 2 243 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.90	1				
<i>islandWD5</i>	0.91	1.00	1			
<i>PA2/3</i>	0.96	0.87	0.88	1		
<i>PA3/5</i>	0.97	0.85	0.86	0.95	1	
<i>Naïve</i>	0.84	0.84	0.84	0.87	0.81	1
f) Middle (Md), 2 253 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.71	1				
<i>islandWD5</i>	0.71	0.98	1			
<i>PA2/3</i>	0.80	0.80	0.80	1		
<i>PA3/5</i>	0.83	0.74	0.78	0.87	1	
<i>Naïve</i>	0.72	0.69	0.68	0.84	0.74	1
g) Western (Ws), 4 442 km ²						

	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.87	1				
<i>islandWD5</i>	0.90	0.99	1			
<i>PA2/3</i>	0.86	0.79	0.80	1		
<i>PA3/5</i>	0.94	0.77	0.80	0.84	1	
<i>Naïve</i>	0.52	0.55	0.54	0.69	0.48	1
h) Misaine (Mi), 4 513 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.85	1				
<i>islandWD5</i>	0.85	0.98	1			
<i>PA2/3</i>	0.88	0.81	0.79	1		
<i>PA3/5</i>	0.98	0.90	0.90	0.90	1	
<i>Naïve</i>	0.75	0.73	0.70	0.79	0.73	1
i) Banquereau (Bq), 10 496 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.55	1				
<i>islandWD5</i>	0.59	0.98	1			
<i>PA2/3</i>	0.80	0.55	0.61	1		
<i>PA3/5</i>	0.78	0.47	0.52	0.88	1	
<i>Naïve</i>	0.46	0.74	0.56	0.56	0.78	0.68
j) Sable (Sb), 10 537 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>

<i>F35</i>	1					
<i>islandNR5</i>	0.62	1				
<i>islandWD5</i>	0.63	0.99	1			
<i>PA2/3</i>	0.68	0.70	0.70	1		
<i>PA3/5</i>	0.91	0.66	0.67	0.85	1	
<i>Naïve</i>	0.52	0.73	0.70	0.76	0.57	1

b) Colonization and Extinctions

Time series of cumulative colonizations (Fig. S1.2) and extinctions (Fig. S1.3) derived from each of the methods were next assessed. The naïve approach yielded a considerably greater number of colonization and extinction events (more than 200 in some cases) over the course of the 1970-2017 time series (Fig. S1.2-3) than any of other methods considered.

The *islandNR5* method, which contained no correction for detectability issues, exhibited the next highest cumulative colonization (Fig. S1.2) and extinction counts (Fig. S1.3). Cumulative colonization and extinction frequencies derived from the detection-corrected *islandWD5* method were mid-range. The *PA3/5* and *F35* methods produced the most conservative (lowest) estimates of colonization and extinction events (Fig. S1.2-3).

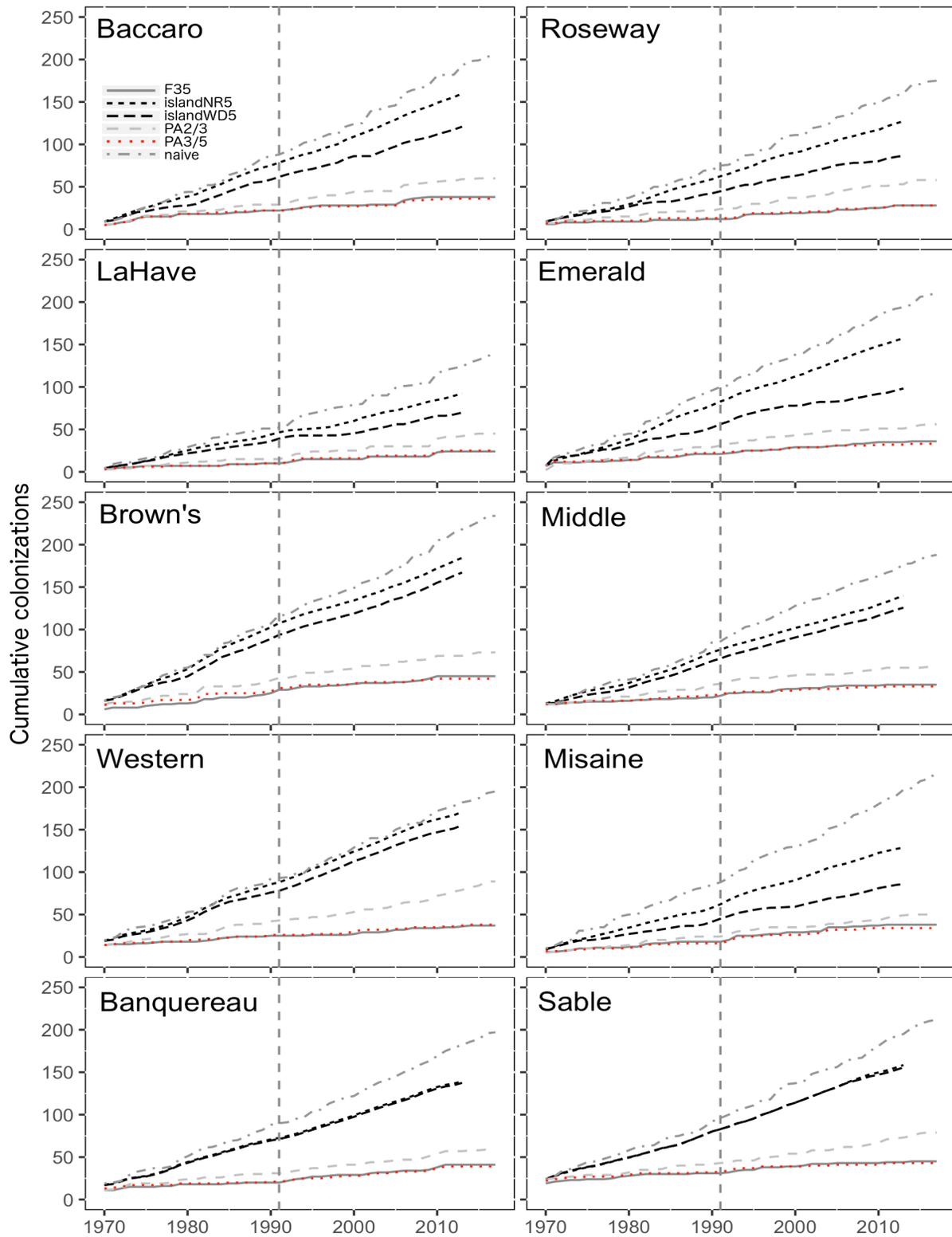


Fig. S1.2. Cumulative colonization events over the 1970–2017 time period for each bank listed from smallest (top left) to largest (bottom right), for each of the six methods of estimation.

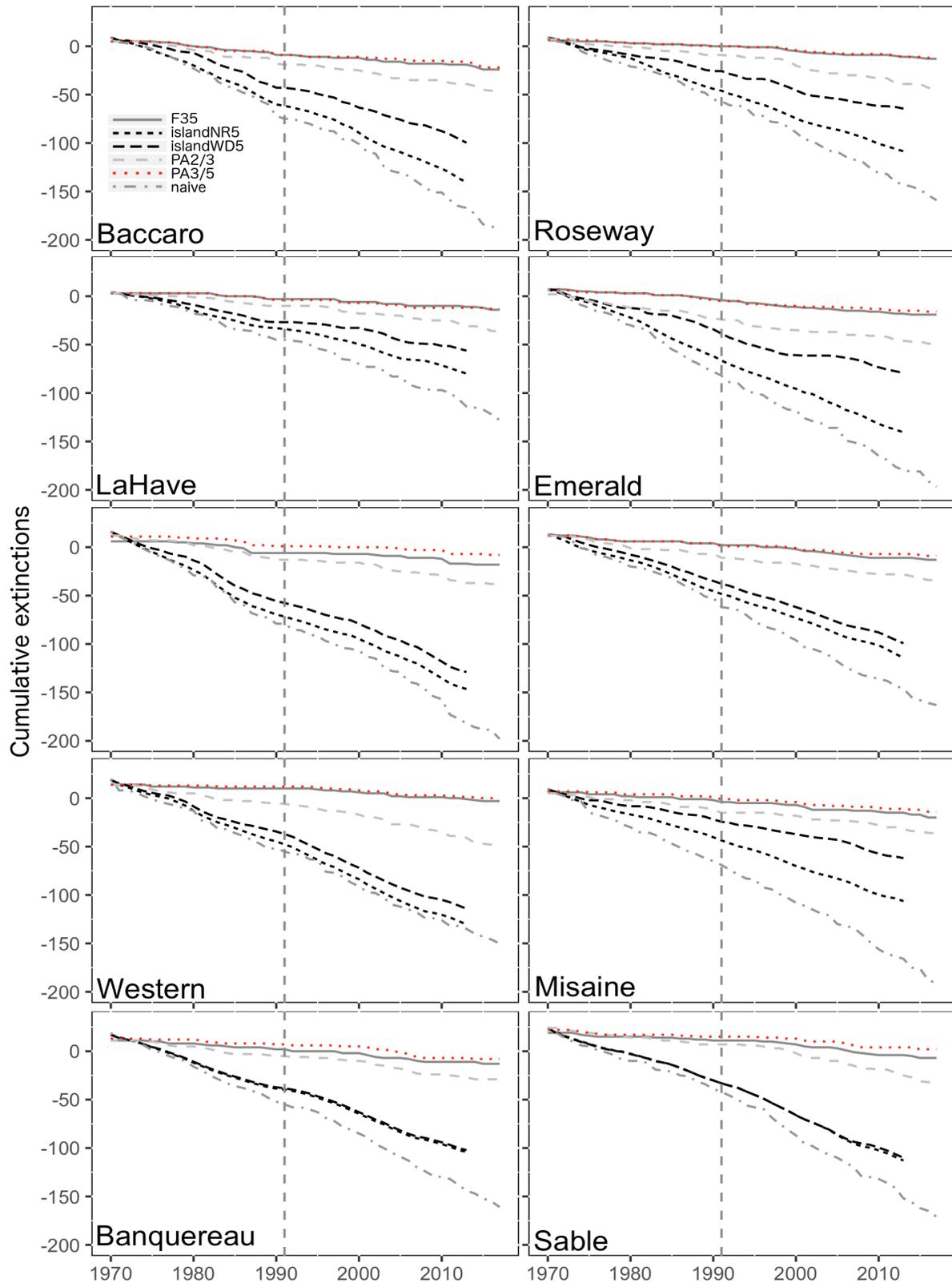


Fig. S1.3. Cumulative extinction events over the 1970–2017 time period for each bank listed from smallest (top left) to largest (bottom right), for each of the six methods of estimation.

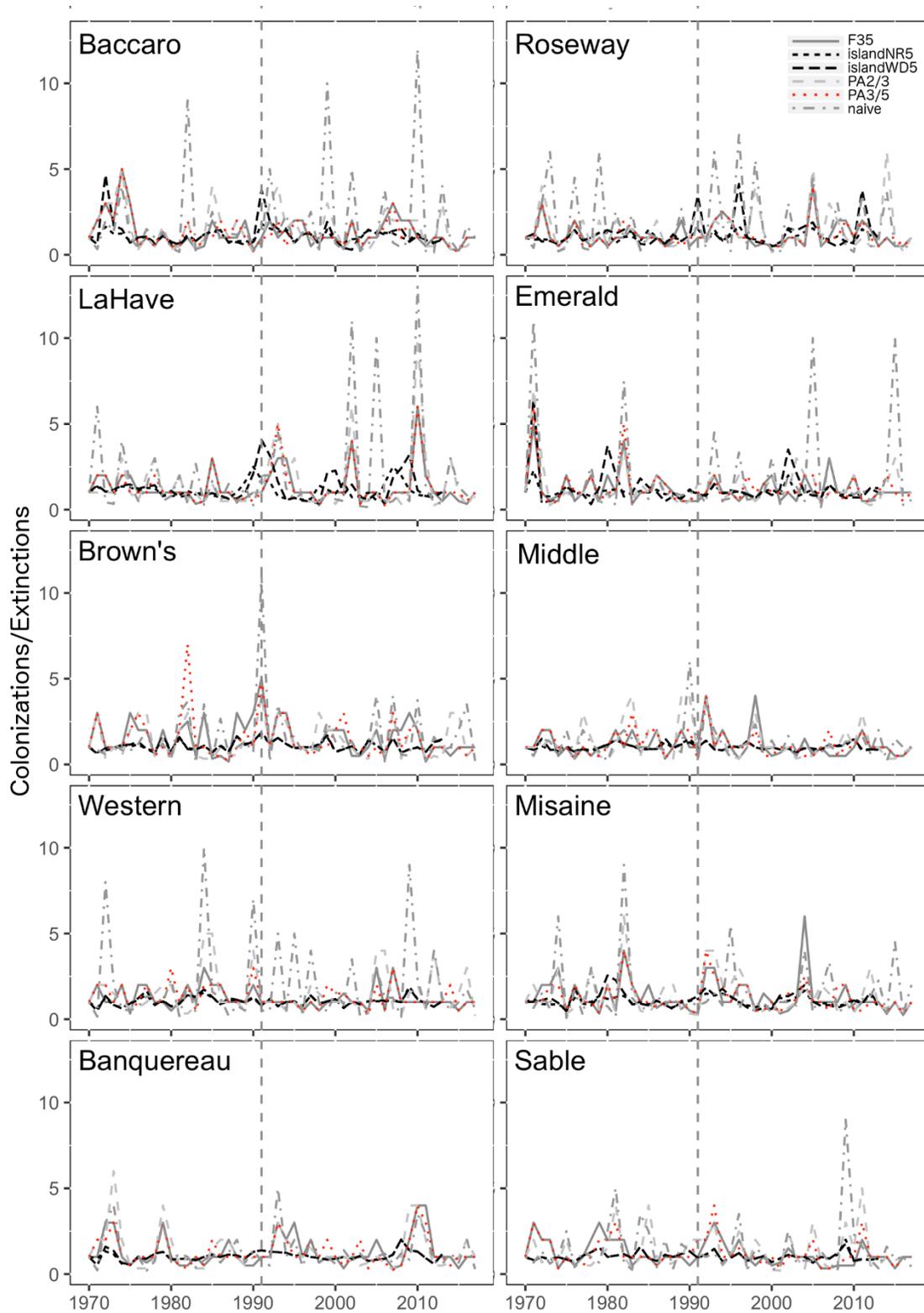


Fig. S1.4. Annual ratio of colonization to extinction events over the 1970–2017 time period for each bank listed from smallest (top left) to largest (bottom right), for each of the six methods of estimation.

Time series of the ratio of colonizations to extinctions derived from the methods evaluated were generally similar, exhibiting peaks (more colonizations relative to extinctions) in the early 1990s and late 2000s (Fig. S1.4). However, the peaks expressed in the naïve and rules-based outputs were more pronounced relative to those expressed in the *islandNR5* and *islandWD5* outputs (Fig. S1.4), and the naïve exhibited the highest degree of interannual variability and the most prominent occurrence of extreme years (Fig. S1.4). The rules-based approaches yielded time series that were quite similar to one another but were less well correlated with the *island*-derived series. The PA3/5- and F35-derived series were virtually identical over time and also across banks, with a few exceptions (Table. S1.4).

Table S1.4. Pearson correlation (r) of annual (1970-2017) ratio of colonization to extinction events (number of species) from each of the five methods for each bank (a-j).

a) Baccaro (Bc), 534 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.31	1				
<i>islandWD5</i>	0.27	0.77	1			
<i>PA2/3</i>	0.68	0.46	0.33	1		
<i>PA3/5</i>	0.87	0.26	0.25	0.66	1	
<i>Naïve</i>	0.16	0.36	0.12	0.43	0.16	1
b) Roseway (Rw), 551 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.29	1				
<i>islandWD5</i>	0.15	0.72	1			
<i>PA2/3</i>	0.47	0.24	0.12	1		
<i>PA3/5</i>	0.89	0.32	0.20	0.53	1	
<i>Naïve</i>	0.38	0.52	0.40	0.52	0.36	1
c) LaHave (LH), 908 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					

<i>islandNR5</i>	-0.19	1				
<i>islandWD5</i>	0.09	0.50	1			
<i>PA2/3</i>	0.85	-0.17	0.09	1		
<i>PA3/5</i>	0.93	-0.23	0.10	0.88	1	
<i>Naïve</i>	0.71	-0.22	0.06	0.76	0.71	1
d) Emerald (Em), 1 034 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.58	1				
<i>islandWD5</i>	0.51	0.80	1			
<i>PA2/3</i>	0.70	0.52	0.57	1		
<i>PA3/5</i>	0.86	0.51	0.49	0.79	1	
<i>Naïve</i>	0.58	0.58	0.45	0.74	0.65	1
e) Brown's (Bw), 2 243 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.50	1				
<i>islandWD5</i>	0.49	0.99	1			
<i>PA2/3</i>	0.58	0.36	0.35	1		
<i>PA3/5</i>	0.67	0.24	0.22	0.69	1	
<i>Naïve</i>	0.59	0.53	0.52	0.55	0.56	1
f) Middle (Md), 2 253 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.19	1				
<i>islandWD5</i>	0.23	0.91	1			

<i>PA2/3</i>	0.60	0.32	0.19	1		
<i>PA3/5</i>	0.77	0.30	0.29	0.71	1	
<i>Naïve</i>	0.36	0.46	0.32	0.63	0.48	1
g) Western (Ws), 4 442 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.26	1				
<i>islandWD5</i>	0.27	0.97	1			
<i>PA2/3</i>	0.36	0.22	0.24	1		
<i>PA3/5</i>	0.67	0.12	0.10	0.29	1	
<i>Naïve</i>	0.26	0.55	0.53	0.52	0.28	1
h) Misaine (Mi), 4 513 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.34	1				
<i>islandWD5</i>	0.32	0.81	1			
<i>PA2/3</i>	0.61	0.37	0.23	1		
<i>PA3/5</i>	0.78	0.36	0.40	0.74	1	
<i>Naïve</i>	0.51	0.24	0.12	0.59	0.40	1
j) Banquereau (Bq), 10 496 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.24	1				
<i>islandWD5</i>	0.30	0.96	1			
<i>PA2/3</i>	0.71	0.33	0.35	1		
<i>PA3/5</i>	0.82	0.26	0.26	0.76	1	

<i>Naïve</i>	0.76	0.33	0.42	0.69	0.71	1
k) Sable (Sb), 10 537 km ²						
	<i>F35</i>	<i>islandNR5</i>	<i>islandWD5</i>	<i>PA2/3</i>	<i>PA3/5</i>	<i>Naïve</i>
<i>F35</i>	1					
<i>islandNR5</i>	0.20	1				
<i>islandWD5</i>	0.24	0.99	1			
<i>PA2/3</i>	0.33	0.18	0.17	1		
<i>PA3/5</i>	0.79	0.11	0.13	0.62	1	
<i>Naïve</i>	0.01	0.62	0.55	0.53	0.15	1

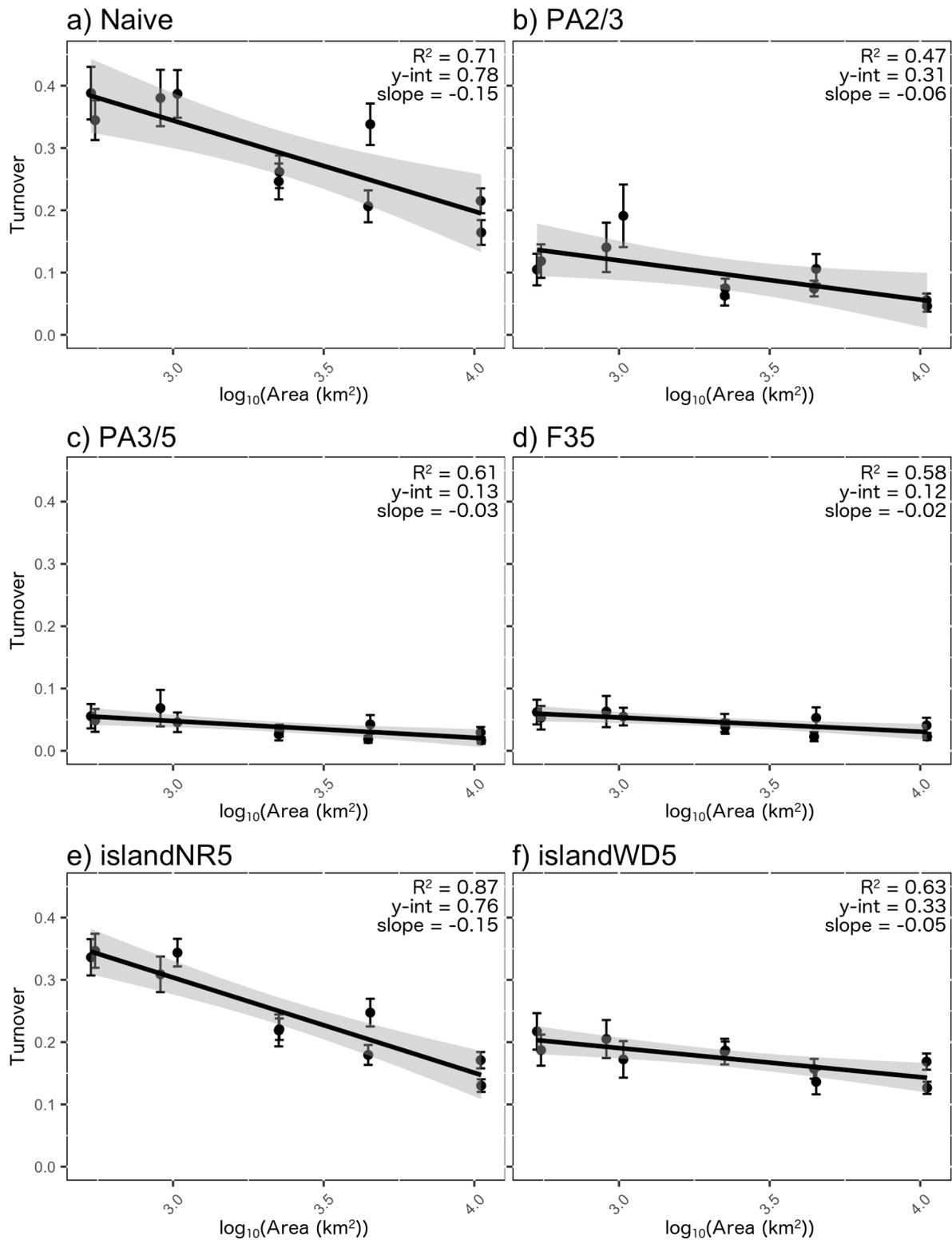


Fig. S1.5. Relationship between mean (and associated 95% CWE for time series ($n = 48$)) of turnover (Eqn. S1.3) and bank area (\log_{10} -transformed) for each of the six methods.

Average long-term (1970-2017) estimates of turnover per bank as derived from all six methods assessed were strongly and negatively correlated with bank area (Fig. S1.5), being on the order of 2-3 times higher on the largest (Sable) relative to the smallest bank (Baccaro) (Fig. S1.5). However, consistent with previous outcomes, the magnitude of turnover as estimated using the naïve approach was higher than that derived using rules-based and *island* methods (Fig. S1.5) as were the confidence intervals about these estimates.

S1.3 Choosing methods

The rules-based approaches we developed were intended to correct for incorrect assignment of an extinction event due to a detection failure of a species from samples in a given year. Reduced interannual variability in species richness associated with methods that contained corrections for probability of detection (PA2/3, PA3/5, F35, *island*WD5) relative to those that did not (naïve, *island*NR5) provide strong evidence of incomplete detection in the database and the need for corrections in the methods ultimately employed. The species richness, and vital rates derived from these methods were generally strongly correlated with one another (Tables S1.3-4). The least conservative rules-based method, PA2/3, produced more short-term variability than the more conservative rules-based method, PA3/5 (Fig. S1.1, Fig. S1.4), implying lesser ability to correct for detection errors. The abundance-based approach (F35) produced results that were nearly identical to those derived from the adjacent presence/absence-based method, PA3/5 (Tables S1.3-4); for the purpose of simplicity and accessibility of methods (e.g., application in other regions where abundance data are not available) only the PA3/5 method was considered further. The two *island* methods also produced time series that were highly correlated (Tables S1.3-4), but higher variability and magnitude of colonization and extinction events more similar to the naïve approach led us to consider *island*NR5 no further.

Ultimately, given the strong similarity between the outputs of the PA3/5 and *island*WD5 (referred to simply as “*island*” in the main text), our decision was to consider and report only the outcomes of the *island*WD5 model in our analysis of bank specific community dynamics in the main text. We retained and evaluated the output of the PA3/5 analyses to assess the colonization/extinction dynamics of individual species within trophic groups; the *island* method being structured as it is, functions only at the community level.

The differences in bank-specific average annual species richness estimates between the PA3/5 and *island*WD5 methods were never higher than 2 species (main text Table 3), but *island*WD5 estimates tended to be higher on the smaller banks (Fig. S1.6), possibly due to the higher frequencies of rare species occurrences, and hence lower detectability there being accounted for in the *island*WD5 function. The opposite was true on the larger banks (Fig. S1.6), where the frequency of occurrence of rare species was lower. While not statistically meaningful, this observation does suggest that the *island*WD5 method is more effective in correcting for detectability.

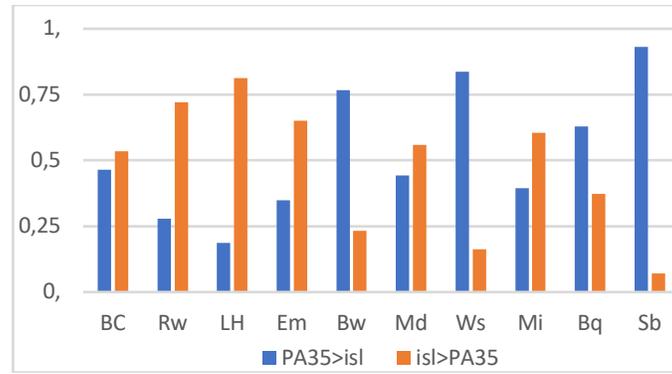


Fig. S1.6. Proportion of years (48 total) during which the PA3/5 estimate of species richness was higher than that of *island* (blue), and vice versa (orange). Banks arranged small (left) to large (right).

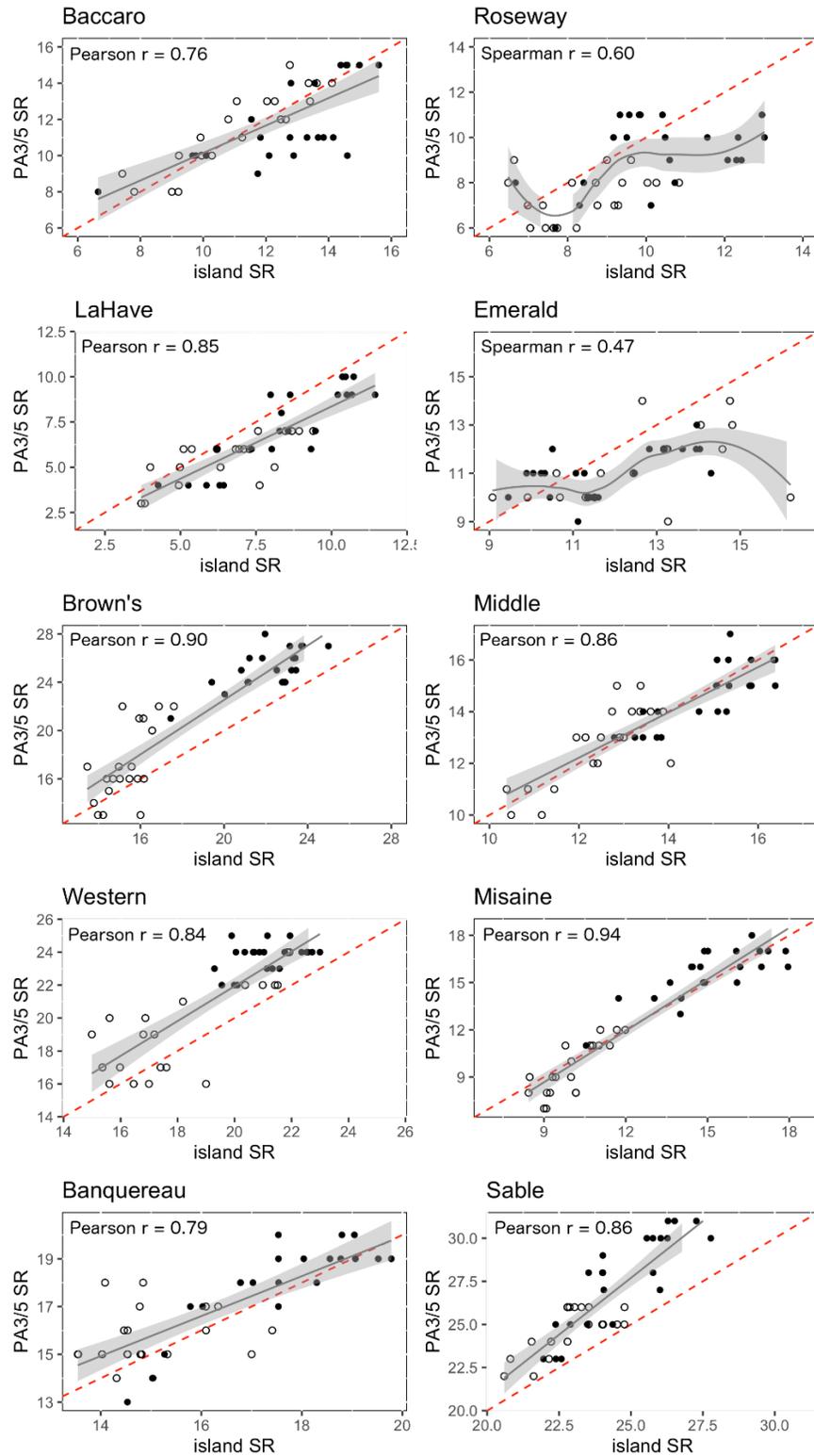


Fig. S1.8. Linear relationships (coefficients provided in upper left) between annual estimates of species richness derived from the PA3/5 method (PA3/5 SR) and the islandWD5 method (island SR, lagged by 2 years). The red dashed line represents a theoretical 1:1 relationship. Pre-collapse values are shown as open circles, post-collapse values are shown as closed circles.

Supplement 2. Characterizing colonization and extinction events using a rules-based approach

For our assessment of individual species' colonization/extinction dynamics on the banks, in order to determine the trophic identity of those most responsible for observed temporal changes in overall turnover, we employed the PA3/5 method. Being structured as it is, the *island* method, which was employed for all other analyses in the main text, functions only at the community level. The PA3/5 method produced community-level time series of species richness and vital rates (evaluated in Supplement 1) most similar to the *island* method (referred to as “*island*WD5” in Supplement 1) compared to the other 4 methods evaluated (Supplement 1).

Number of colonizations (COL) and extinctions (EXT) per year, resulting species richness (SR, Eqn. S2.1), cumulative colonizations (CC, Eqn. S2.2), cumulative extinctions (CE, Eqn. S2.3) and turnover (TOV, Eqn. S2.2) are provided for each of three trophic groups, for top predators (PRED), for meso-predators (MESO) and for prey (PREY). Species-specific colonization and extinction dynamics for each bank, as defined by the PA3/5 rules (see Table S1.1), are shown in Tables S2.1-S2.10, where colonizations are highlighted in blue (periods of persistence, as defined by the PA3/5 rules, maintaining blue highlighting), and extinctions are highlighted in red (periods of persistent absence, as defined by the PA3/5 rules, maintaining red highlighting). These events are summarized for each bank in Table S2.11 (excluding species that are always present).

$$PA3/5 S_t = S_{t-1} + C_t - E_t \quad (\text{Eqn. S2.1})$$

where S is species richness in times t and $t-1$, C is the number of colonizations and E is the number of extinctions

$$PA3/5 CC = S_{t-1} + C_t \quad (\text{Eqn. S2.2})$$

$$PA3/5 CE = S_{t-1} - E_t \quad (\text{Eqn. S2.3})$$

where CC is cumulative colonizations (species added without subtracting extinctions) and CE is cumulative extinction (species lost without adding colonists).

$$\text{Turnover (T)} = (C_t + E_t) / (S_{t-1} + S_t) \quad (\text{Eqn. S2.4})$$

where S is species richness in times t and $t-1$, C is the number of colonizations and E is the number of extinctions.

Table S2.5. Average standardized abundance (per tow) for each fish species (divided into trophic groups: top predators (PRED), prey (PREY) and meso-predators (MESO)) per year on Brown's Bank. Using the PA3/5 criteria, described in Table S1.1, true colonizations are highlighted in blue and true local extinctions are highlighted in red. Number of colonizations (COL) and extinctions (EXT) per year, resulting species richness (SR), cumulative colonizations (CC), cumulative extinctions (CE) and turnover (TOV) are also provided.

PRED		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017							
ANARHICUS LUPUS		0.83	2.16	2.41	1.68	7.78	14.6	4.11	8.88	1.94	0.95	1.81	3.68	6.18	0	2.69	0.92	0.92	0	2.06	0.92	0	2.81	2.43	0.97	0	15.8	19.9	17.4	3.4	3.42	1.31	6.78	5.56	4.13	2.56	2.48	3.31	2.51	1.98	2.98	2.9	0	1.01	0	1	1.46	0.98	0.99							
DIFTURIUS LAEVIS		0.8	0	0	0	0	0	0	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.094	0	0	1	2.97	0	0.94	0.97	0	1.01	0.99	0	2.68	2	0	0	1	1.19	1.78	0.98								
GADUS MORHUA		7.57	16.1	9.21	12.9	5.1	9.52	10.3	30.8	11.4	13.9	18.1	14.7	3.81	20.9	10.9	4.23	15.7	16	28.6	12.8	13.5	10.1	15.9	6	9.99	29.8	20.9	23.6	6.86	9.87	14	15.8	12.6	5.14	3.45	6.1	3.89	6.53	6.9	10.8	9.63	7.24	3.18	80.1	3.04	10.5	3.51	1.19							
HIPPOGLOSSUS HIPPOGLOSSUS		1.87	7.13	3.09	2.21	2.49	5.47	6.72	18.6	4.62	3.81	3.47	4.61	1.03	0	1.96	2.53	2.65	1.06	1.61	6.23	3.95	1.46	0	3.38	2.03	4.05	1.99	2.87	5.24	1.58	1.93	3.32	1.67	1.78	2.79	4.23	1.69	3.02	2.74	1.92	9.18	7.05	4.41	5.14	2.26	4.53	6.16	1.74							
LEUCORAJA OCELLATA		0.97	0	11.5	0	1.09	2.61	0	3.75	8.75	7.18	0	0	2.22	0	1	0	0.92	0	3.31	7.83	0	7.13	2.92	5.52	2.49	3.82	5.47	4.13	3.26	2.05	0	6.49	1.85	2.13	12.5	7.33	3.43	2.53	7.58	14.4	5.83	4.26	6.5	11.8	2.83	20.6	25.2	4.52							
POLLACIUS VIRENS		1.94	1.03	0.76	0.92	0	0	0.92	34.8	1.09	0	1.46	0	2.06	5.83	0	2.46	6.5	29.3	0.88	1.89	3.6	3.65	6.22	3.74	3.58	6.15	4.1	3.09	2	2.14	2.68	1	1.01	3.98	0	0	1.01	0	1.80	1.93	1.24	4.21	1.52	10.5	1.65	1.66	1.91								
SQUALUS ACANTHIAS		8.56	40.8	0	0	0	0	0	3.75	0	1.03	707	2.76	20.8	1111	3.92	832	12.4	6.18	487	11.1	0	0	0	0	0	0	1.03	882	2.18	0	2.46	0	109	0.97	1	124	43	0.97	0.98	307	261	91.6	50.4	0	1.01	0	15.1	91.9	0.99	35.8	0.98				
UROPHYCUS TENUIS		0.65	0	0	1.09	0	0	0	0	0.98	1.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.94	0	0	0	1	0	0.97	0	0	0	1.01	1.02	0	0.99	0	0	0	0	0	0	0	0	0					
YEAR		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017							
COL		5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
EXT		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
SR		5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				
CR		5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				
ER		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5			
TOV		0	0	0	0	0	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0.09	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PREY		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017							
AMMODYTES DUBIUS		0	0	0	0	0	0	0	0	0	0	0	0	0.92	0.92	1.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
ASPIDOPIRIDIUS MONOPTERYGIUS		0	0	0	0	4.86	0	0	0	0	0	0	0	0	7.21	1.03	0	4.61	0	0	0	0	0	0	0	1.03	1.33	2.33	1.74	0	4.12	5.04	9.5	1.52	1.98	0	0.94	1.05	1.02	6.03	3.45	0	14.2	0	0	0	0	0	0	0	0	2.87	0			
CLUPEA HARENUS		0	0	0	9.33	0	0	0	0	0	0	0	0	0	0	0	0	9.26	0	0	0	0	0	0	13.1	1.94	9.38	73	62	8.23	50.3	15.5	12.8	29.3	3.7	82.9	35.7	124	55.9	0	44.9	5.28	62.4	12.3	16	42.6	80.2	5.65	4.59	13.87	15.9					
PEPILUS TRIACANTHUS		0	0	0	0	0	0	0	0	0	0	0	0	0.92	1.03	0	2.06	0	0	0	0	0	0	0	1.03	1.01	0	0	1.03	1.96	0.98	0	0.95	0.97	0	1.01	0	0	1.03	0	1.2	0	1.02	6.51	0.98	1.59	1.57									
SCOMBER SCOMBRUS		0	0	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
TRIGLOPS MURRAYI		0	1.85	0	0	7.78	0	0	0	0	0	0	0	22.2	0	3.09	0	24.9	0	0	0	0	0	0	19.8	2.71	12.4	1.03	10.4	20.3	2.12	7.74	3.84	10.8	2.04	6.34	0	1	1.03	0	30.7	15.8	0	18.9	0	0	0	0	0	0	0	0	0.96	0		
YEAR		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017							
COL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
EXT		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SR		0	0	0	0	0	0	0	0	0	0	0	0	1	4	4	3	3	3	0	0	0	0	0	2	2	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
CR		0	0	0	0	0	0	0	0	0	0	0	0	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
ER		0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
TOV		0	0	0	0	0	0	0	0	0	0	0	0	1	0.6	0	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MESO		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017							
AMBLYRAJA RADIATA		2.42	4.04	3.31	4.78	3.93	19	5.66	5.8	3.59	3.81	2.13	4.12	1.68	0.97	0.99	1.84	0.98	1.03	1.03	1.44	0	0.94	1.48	0.92	0	1.33	0.99	1.93	0	0.96	1.97	2.01	1.32	0	2.06	0	2.01	0.98	0.99																

Table S2.10. Average standardized abundance (per tow) for each fish species (divided into trophic groups: top predators (PRED), prey (PREY) and meso-predators (MESO)) per year on Sable Island Bank. Using the PA3/5 criteria, described in Table S1.1, true colonizations are highlighted in blue and true local extinctions are highlighted in red. Number of colonizations (COL) and extinctions (EXT) per year, resulting species richness (SR), cumulative colonizations (CC), cumulative extinctions (CE) and turnover (TOV) are also provided.

PRED																						
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
ANARHICHAS LUPUS	1.09	2.19	0.00	0.00	0.00	3.38	0.96	1.21	1.94	0.00	2.19	1.09	1.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00	1.00	0.00
GADUS MORHUA	10.17	12.31	18.99	32.61	94.41	34.02	44.40	47.21	33.32	124.06	34.28	88.23	94.79	449.89	12.01	12.03	22.08	47.31	23.95	198.61	178.15	57.82
HIPPOGLOSSUS HIPPOGLOSSUS	0.00	0.00	0.92	1.20	2.58	1.41	0.92	1.25	0.90	1.17	1.75	1.94	1.02	0.00	1.00	0.97	1.76	1.89	2.03	1.00	0.00	1.03
LEUCORAJA OCELLATA	6.13	2.58	2.14	4.59	4.82	8.58	1.69	4.51	47.64	32.58	2.30	8.72	8.39	5.09	9.24	7.40	5.28	2.75	5.32	2.43	8.81	12.10
POLLACHIUS VIRENS	1.94	1.09	0.00	0.92	0.00	0.00	0.00	2.06	0.00	0.00	0.00	2.06	5.69	1.41	5.94	11.67	1.03	1.96	14.19	1.05	3.69	31.85
SQUALUS ACANTHIAS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.89	0.00	0.00	0.00	0.97	0.00	0.00
UROPHYCIS TENUIS	0.88	0.00	0.80	7.66	0.89	2.78	0.92	0.92	1.32	0.00	1.75	3.30	0.00	15.56	5.41	1.94	6.62	1.39	0.00	3.84	1.00	2.06
COL	4	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
EXT	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR	4	4	5	5	4	5	5	5	5	5	5	6	6	6	6	6	5	5	5	5	5	5
CC	4	4	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7
CE	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2
TOV	0	0	0.11	0	0.11	0.11	0	0	0	0	0	0.09	0	0	0	0	0.09	0	0	0	0	0
PREY																						
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AMMODYTES DUBIUS	4474.45	0.00	29.58	1.75	0.88	18.38	0.00	227.88	0.00	0.00	13.82	0.73	7.03	0.00	0.00	1.03	44.26	9.72	1.25	0.97	37.46	1.09
ASPIDOPHOROIDES MONOPTERYGIUS	2.16	0.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CLUPEA HARENGUS	23.63	1.75	8.38	3.28	0.00	17.46	1.84	0.00	0.00	0.00	0.00	1.17	19.36	7.95	10.94	9.72	3.60	705.89	4.21	26.86	8.62	1.03
EUMICROTREMUS SPINOSUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00
PEPRILUS TRIACANTHUS	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	231.62	1.03	0.00	0.00	0.97	0.00	
SCOMBER SCOMBRUS	0.88	0.00	2.50	1.53	0.00	1.84	0.83	1.83	13.07	2.63	6.36	1.67	3.50	0.97	45.19	20.62	6.18	70.49	0.00	29.38	48.36	20.70
TRIGLOPS MURRAYI	2.44	0.88	0.83	0.00	4.00	3.50	0.00	0.00	0.00	1.17	5.10	1.86	0.98	0.00	0.00	1.03	1.03	1.25	0.97	4.81	1.03	
MALLOTUS VILLOSUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	660.00	0.00	12.24	0.00
SCOPHTHALMUS AQUOSUS	0.00	1.00	0.00	0.00	0.97	3.18	0.00	4.12	3.82	1.67	0.80	1.03	49.82	0.00	12.21	1.03	0.00	1.00	1.03	0.00	0.97	1.37
TAUTOGOLABRUS ADSPERSUS	0.00	4.38	3.68	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.22	0.00	0.00
COL	4	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
EXT	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR	4	6	6	6	5	5	4	3	3	3	4	5	5	5	5	5	5	5	6	6	6	6
CC	4	6	6	6	6	6	6	6	6	6	7	8	8	8	8	8	8	8	9	9	9	9
CE	4	4	4	4	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TOV	0	0.2	0	0	0.09	0	0.11	0.14	0	0	0.14	0.11	0	0	0	0	0	0	0.09	0	0	0
MESO																						
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AMBLYRAJA RADIATA	4.95	5.67	4.14	7.28	4.41	6.77	10.22	6.51	31.97	15.57	4.24	5.36	5.53	7.80	2.61	3.30	3.30	13.41	3.31	2.23	2.47	1.93
GLYPTOCEPHALUS CYNOGLOSSUS	1.30	3.22	1.28	3.43	1.71	8.36	2.85	5.62	6.75	3.60	5.81	8.47	2.98	1.93	3.76	2.00	5.36	7.53	2.22	2.25	1.45	4.31
HEMITRIPTERUS AMERICANUS	1.90	2.04	3.33	5.02	3.40	5.46	2.20	2.82	2.18	1.37	2.50	2.50	1.73	1.50	3.89	2.38	2.31	1.43	1.21	1.61	2.88	2.99
HIPPOGLOSSOIDES PLATISSOIDES	59.08	34.26	31.78	15.39	38.77	31.23	18.95	22.79	64.23	98.91	10.39	27.27	25.39	31.90	10.32	18.62	10.08	26.33	8.39	30.01	58.44	16.35
LEUCORAJA ERINACEA	0.97	0.00	0.95	0.00	1.75	0.00	0.83	0.00	15.56	0.00	10.81	9.64	0.00	8.75	1.68	0.00	2.27	0.00	0.00	0.00	9.53	1.78
LIMANDA FERRUGINEA	188.23	151.28	104.74	102.73	107.40	199.96	142.98	87.61	127.00	131.59	66.24	160.25	225.15	89.93	143.92	101.87	156.15	191.06	88.14	129.24	216.84	286.88
LOPHIUS AMERICANUS	1.64	1.30	1.20	0.81	1.21	2.15	2.05	1.77	2.01	0.88	1.41	3.16	1.07	2.41	1.79	1.47	2.04	2.07	1.06	0.00	0.96	1.06
MALACORAJA SENTA	1.34	1.47	0.90	2.79	2.13	1.81	1.72	2.82	2.71	8.42	2.81	1.29	1.32	1.00	1.01	1.56	1.54	2.11	1.09	0.00	0.92	1.10
MELANOGRAMMUS AEGLEFINUS	17.29	87.97	6.55	6.64	10.03	7.44	29.83	55.32	84.60	194.76	88.57	254.75	100.85	362.90	370.90	168.07	264.81	186.95	548.29	316.13	320.64	565.33
MERLUCCIIUS BILINEARIS	13.28	3.82	1.08	17.46	18.28	6.16	4.19	9.51	11.50	19.31	3.58	234.80	187.27	232.55	518.89	787.48	188.73	61.94	27.04	157.77	249.83	212.99
MYOXOCEPHALUS OCTODECEMSPINOSUS	58.73	40.16	12.93	48.69	19.81	54.13	16.71	21.74	16.27	29.33	4.53	14.22	17.65	7.66	25.88	6.30	20.44	13.00	25.08	29.35	37.20	43.09
PSEUDOPLEURONECTES AMERICANUS	19.60	12.82	25.95	23.08	31.88	11.42	4.38	5.12	3.64	4.14	6.63	2.91	6.48	2.79	20.91	20.02	14.05	17.77	11.29	17.69	40.34	46.51
SEBASTES SP.	0.00	0.00	0.00	19.78	20.13	7.12	2.92	1.84	0.00	3.09	0.00	0.00	1.03	0.00	0.00	11.67	24.71	2.57	0.00	0.00	0.00	9.84
UROPHYCIS CHUSS	1.05	0.88	0.00	0.00	0.88	0.00	0.00	0.00	0.00	82.35	4.96	3.28	1.77	8.75	5.32	4.50	12.94	3.91	3.68	3.09	5.41	3.36
ZOARCES AMERICANUS	3.92	1.36	2.46	4.56	2.24	3.77	1.72	2.31	4.67	1.09	2.02	4.04	1.36	0.00	1.49	0.97	2.74	4.23	3.09	2.75	1.84	2.08
COL	14	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
EXT	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SR	14	14	14	15	15	14	14	14	14	15	15	15	15	15	15	15	15	15	15	14	14	15
CC	14	14	14	15	15	15	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16	17
CE	14	14	14	14	14	13	13	13	13	13	13	13	13	13	13	13	13	13	13	12	12	12
TOV	0	0	0	0.03	0	0.03	0	0	0	0.03	0	0	0	0	0	0	0	0	0.03	0	0	0.03

Table S2.10. Continued...

PREO																										
1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
0.00	0.00	0.00	0.00	7.62	0.00	7.16	1.00	0.99	0.00	0.00	0.00	0.00	2.87	1.04	1.01	0.00	0.00	0.00	0.00	0.00	1.49	1.01	0.00	0.00	0.00	
209.84	113.01	39.32	53.54	25.11	14.89	32.02	76.13	11.98	99.91	17.34	10.99	21.43	13.95	20.87	27.95	1.66	159.76	22.74	38.41	3.90	3.21	2.18	1.83	2.97	2.46	
0.97	0.89	2.04	0.97	1.01	0.00	0.00	0.96	0.99	0.00	0.95	1.00	1.02	1.01	1.98	0.99	0.00	1.00	1.00	3.00	2.26	1.71	0.99	1.73	1.01	1.65	
4.60	8.94	21.97	4.82	1.66	6.12	9.34	6.65	1.01	0.99	3.91	3.13	0.94	1.67	0.00	0.00	1.02	2.00	0.00	0.00	1.24	0.00	0.00	3.07	8.82	1.01	
2.62	3.95	3.23	10.30	3.75	3.42	4.50	3.94	1.48	6.03	136.69	2.35	1.94	0.00	1.01	0.96	0.00	7.41	3.00	0.98	4.25	11.30	1.53	54.40	1.67	0.99	
0.00	0.98	0.95	0.99	0.00	0.00	0.00	1.02	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.97	1.97	1.17	0.00	0.99	0.97	1.01	8.09	5.47	0.00	1.87	0.99	0.00	0.00	1.00	5.77	0.00	1.70	1.51	1.99	1.01	0.00	1.02	0.99	0.00	0.00	
0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
5	6	6	6	6	6	6	6	6	5	5	5	5	6	6	6	5	5	5	5	5	5	5	5	5	5	
7	8	8	8	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	
2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
0	0.09	0	0	17	0	0	0	0	0.09	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	
MESO																										
1.94	44.28	12.52	13.51	5.00	0.97	5.91	100.83	77.84	189.11	713.14	161.63	121.55	83.11	15.77	315.11	89.29	4.64	20.98	31.25	204.75	24.40	22.90	11.11	97.39	53.64	
0.97	1.48	0.00	0.00	38.36	45.19	4.89	6.50	1.24	2.46	1.90	0.00	1.88	3.53	7.96	1.83	0.00	1.28	10.98	1.32	3.59	0.99	1.97	1.98	0.97	0.00	
1.62	0.97	1641.06	21.54	7.71	150.51	114.64	1207.12	228.49	161.77	81.79	93.18	1320.37	270.82	374.74	133.24	68.87	45.54	366.92	237.87	256.63	692.32	527.28	200.06	17.69	0.00	
0.00	0.96	0.00	0.97	2.84	0.00	0.00	1.32	0.00	0.00	0.99	0.00	0.99	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.00	0.00	0.00	0.00	152.26	0.00	0.00	0.98	1.93	1.01	0.93	43.27	0.00	0.00	1.32	0.00	0.00	1.06	2.00	0.98	0.00	2.06	0.00	27.04	0.00	1.01	
45.69	2.73	25.82	16.29	25.55	13.22	0.00	15.73	17.63	23.47	7.39	5.59	98.82	0.00	202.00	0.00	0.00	0.00	0.00	3.32	5.67	7.20	0.00	0.99	0.99	0.99	
0.97	1.77	0.96	1.94	54.31	13.79	13.16	35.50	2.50	4.92	2.88	12.04	4.97	12.89	30.44	1.93	16.75	1.01	8.13	1.99	2.04	0.00	2.00	0.99	3.94	0.99	
23.33	223.05	39.74	282.05	268.00	74.04	0.00	3.00	0.00	0.00	11.93	0.00	606.47	0.00	694.91	0.00	694.91	0.00	64.27	42.75	2.51	0.00	0.00	102.82	0.00	0.00	
0.97	0.98	0.00	1.06	1.98	0.00	1.00	0.00	0.00	0.00	0.97	11.93	3.74	1.49	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	2.05	2.94	0.00	
0.00	4.25	0.00	0.00	7.78	0.00	2.00	8.85	0.00	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	
0	0	0	0	0	0	0	1	0	0	1	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	
7	8	8	8	9	9	9	8	8	8	8	8	8	8	8	6	5	4	4	4	6	6	6	6	6	6	
10	11	11	11	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	15	15	15	15	15	15	
1	1	1	1	1	1	1	0	0	0	-1	-1	-1	-1	-3	-4	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	
0.08	0.13	0	0	0.05	0	0	0.05	0	0	0.11	0	0	0	0.13	0.08	0.09	0	0	0.17	0	0	0	0	0	0	
PREY																										
2.47	0.97	2.06	3.93	1.00	1.47	1.52	2.56	0.00	0.00	1.96	0.00	2.98	0.00	0.96	0.00	0.00	0.00	1.02	1.01	0.00	0.00	0.00	0.99	0.00	0.00	
1.94	1.59	2.40	2.94	2.65	3.44	6.28	3.50	2.96	2.14	2.85	5.77	1.34	4.34	9.35	2.52	1.50	7.63	4.28	4.24	3.00	1.45	7.08	3.79	14.02	2.43	
3.03	2.64	2.01	1.56	1.27	2.92	5.14	1.98	1.71	1.19	4.58	2.12	2.18	5.03	2.73	1.52	3.03	3.16	2.02	2.60	1.84	1.29	3.16	1.08	0.99	1.11	
22.01	10.21	8.92	9.98	17.98	9.53	17.62	20.44	10.04	5.92	7.92	8.99	34.07	33.67	13.77	6.25	11.99	20.12	27.34	6.51	15.34	5.72	8.48	14.86	6.43	4.21	
0.00	12.20	5.00	8.28	4.47	4.88	0.00	0.99	3.81	0.00	2.89	0.99	2.81	5.03	1.01	1.03	0.00	0.00	0.97	1.98	1.50	1.93	2.03	0.00	0.00	0.00	
197.25	117.28	101.39	51.99	124.02	111.15	84.93	52.76	62.07	31.04	61.62	44.75	30.06	51.63	41.69	102.56	23.18	92.41	138.96	72.28	117.34	69.19	141.49	45.29	70.47	53.10	
0.97	0.99	1.46	1.33	1.50	0.99	0.00	1.00	1.51	0.00	0.00	0.00	0.00	0.00	2.06	1.02	2.01	1.04	1.52	1.01	1.00	0.00	1.00	0.98	0.98	0.98	
1.94	0.00	1.03	0.97	0.97	0.00	2.05	2.98	0.99	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	1.00	0.99	0.00	0.00	0.00	0.00	0.00	
214.02	210.14	193.97	78.49	337.03	199.48	401.75	733.70	830.06	743.95	441.21	543.89	674.11	459.83	314.13	708.38	226.94	477.36	135.27	94.25	181.37	541.00	115.97	767.95	176.09	54.21	
76.99	565.80	157.76	220.77	849.34	181.04	384.20	64.88	72.95	192.78	90.16	104.20	489.09	65.54	78.80	104.18	8.64	298.13	438.04	704.69	884.92	55.43	808.74	60.29	323.64	147.55	
44.20	15.44	21.97	54.51	14.15	15.44	14.31	118.40	8.77	10.85	15.85	20.85	18.20	18.12	9.48	4.36	26.64	27.48	89.18	15.12	29.27	40.80	18.79	10.26	20.24	24.17	
19.21	60.91	21.55	11.26	22.32	19.26	303.56	16.10	10.71	12.00	9.38	7.54	16.84	11.45	11.70	18.38	3.22	16.76	16.93	13.11	15.26	15.15	20.11	5.78	6.91	14.48	
0.00	1.61	0.00	1.01	108.78	0.00	154.53	47.54	0.00	1.01	0.00	1.99	2.98	1.91	3.62	1.01	0.00	8.55	1.48	0.99	0.00	0.00	1.97	4.30	0.98	0.00	
5.35	2.35	2.09	9.55	2.56	2.15	1.50	13.42	1.02	1.01	0.95	5.49	4.07	5.60	1.38	1.52	1.01	6.74	3.10	12.51	4.72	1.49	18.36	4.38	5.47	3.26	
0.97	0.00	1.54	1.31	1.04	2.43	2.51	2.51	3.98	1.01	0.00	1.24	3.06	0.96	0.00	1.01	0.00	1.58	1.50	2.50	0.99	0.00	3.09	0.00	0.00	0.00	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0
15	15	15	15	15	15	15	15	15	14	14	14	14	14	14	13	13	13	13	13	13	13	13	11	11	11	
17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
12	12	12	12	12	12	12	12	12	11	11	11	11	11	11	10	10	10	10	10	10	10	10	8	8	8	
0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0.08	0	0	

Table S2.11. Details of predator, meso-predator and prey species that underwent colonizations (red with year of colonization), extinctions (dark blue with year of extinction), repetitively went extinct and recolonized (orange, with number of extinctions and/or recolonizations provided) or remained present without colonization or extinction dynamics (light blue). Species that that were light blue on all banks were not included in this table.

Group	Species	Bc	Rw	LH	Em	Bw	Md	Ws	Mi	Bq	Sb
Predator	A. lupus	2015	1999	2	1989		2	1996			3
	H. hippoglossus		2	1983	2		1979			2011	
	H. platessoides	2									
	L. ocellata	1979			4		2		1986	2004	
	P. virens		3	4		2	2			4	2
	S. acanthias	1990	3	2		2		2			2
	U. tenuis					2	4			1982	
Meso-predator	A. radiata	1993	1989	1989	1983		2004				2007
	B. brosme	1978				1986					
	G. cynoglossus	4	2	2010	4	1985	3		4		
	H. americanus	2	4	3	2				2		
	H. platessoides			2	3						
	L. americanus	3			3		1976			1975	
	L. erinacea							3			2015
	L. ferruginea		4						2		
	M. aeglefinus								2	2	
	M. bilinearis	2007	2011		1991				2	3	
	M. octodecemspinosus	3	3	6	4				4		
	M. senta	1983	4				3	2011		4	2001
	P. americanus						2	1980			
	Sebastes spp.	1993	1993	5	5	3		1990	3	4	
	U. chuss				4	1991	2011	1980			2
	Z. americanus					2		4			2015
	Prey	A. dubius					4	1985	1999	2	
A. monopterygius		2		2		4	1992	3	3	1993	1992
C. arctifrons					2014			2013			
C. harengus		1993	3	1993	2	1991	3	1985	2002	3	2
E. spinosus							2		3	1992	2
L. atlanticus										2	
L. decagonus									4	2	
L. lumpretaeformis									4		
L. maculatus									1997	2	
L. vahlii									4		
M. scorpius							2007			4	
M. villosus							2		2	2	3
P. triacanthus						5		3			1996
S. aquosus											3
S. scombrus						3		6		1990	2
T. adpersus											3
T. murrayi		7	4	5	2	4	2	5			2

Supplement 3. Evaluating bank-specific time series of community similarity

The consequence of increases in colonization and extinction events on the largest banks in the post-collapse regime was a weakening of the relationship between average annual turnover and bank area as assessed over the 10 banks examined (main text Fig. 6c). Notwithstanding this shift, the most rapid turnover dynamics, reflecting high interannual variability in species richness (main text Fig. 3), persisted on the smallest banks in the post-collapse time period. We therefore employed the *vegdist* function in the package “vegan” in R (Oksanen et al. 2017) using the Bray-Curtis Index of community similarity (BCSI, Bray & Curtis 1957) to evaluate annual community similarity of bank-specific fish communities relative to the year 1971. The resulting outputs suggest that the fish community structure on the smaller banks was both temporally more variable and exhibited larger deviations from the 1971 starting year than was the case for larger banks. (Fig. S3.1), consistent with the predictions of TIB and metacommunity theory. A subsequent multivariate linear model of the Bray Curtis Similarity Index (BCSI) as a function of year and bank area (R Core Team 2019), explained 45% of variance in annual BCSI (relative to 1971). Bank area was significantly ($p < 0.001$) and positively (coefficient 0.17) related to bank specific BCSI. Viewed from a temporal perspective, year was significantly ($p < 0.001$) and negatively (coefficient -0.003) related to bank-specific BCSI. In summary, larger banks had more consistent community similarity on average, and, while all banks exhibited a slight decline in BCSI over time ($\sim 0.003 \text{ yr}^{-1}$), the smallest banks underwent greater changes in community structure overall.

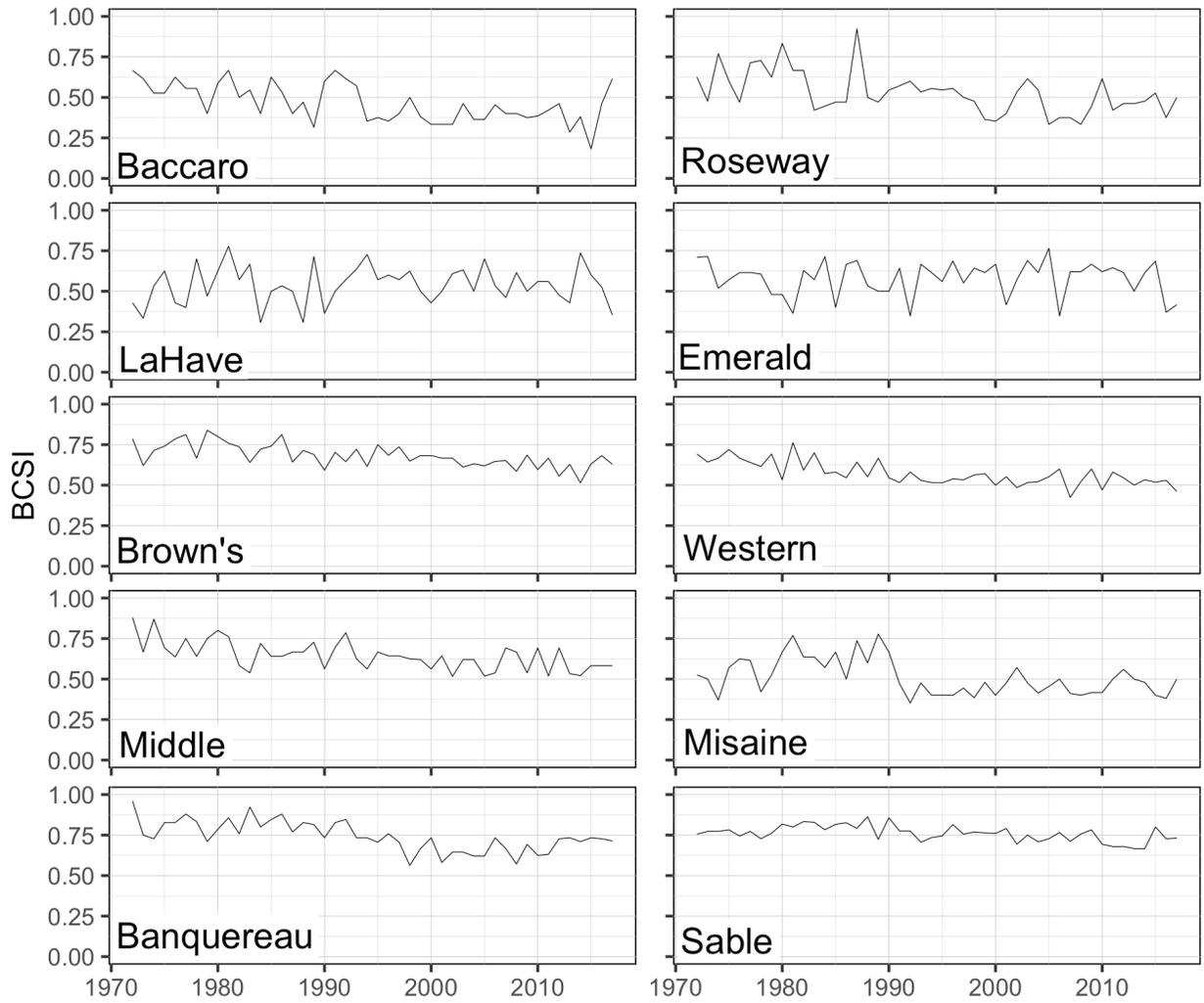


Fig. S3.1. Time series of fish community similarity (Bray-Curtis) relative to the year 1971 on each of the ten banks listed from smallest (top left) to largest (bottom right).

Literature Cited

- Alonso D, Pinyol-Gallemí A, Alcoverro T, Arthur R (2015) Fish community reassembly after a coral mass mortality: higher trophic groups are subject to increased rates of extinction. *Ecology letters* 18(5): 451-461
- Arnott SE, Magnuson JJ, Dodson S, Colby A (2006) Lakes as islands: Biodiversity, Invasion, and Extinction, pp. 67-88. In: Magnuson JJ, Kratz TK, Benson BJ (eds.) *Lakes in the Landscape: Insights and Concepts from the North Temperate Lakes LTER from 1981-2000*. Oxford, UK: Oxford University Press.
- Arnott SE, Yan ND, Magnuson JJ, Frost TM (1999) Interannual variability and species turnover of crustacean zooplankton in Shield lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 56(1): 162-172
- Baum JK, Ourers RA (2004) Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. *Ecology Letters* 7(2): 135-145
- Bray JR, Curtis JT (1957) An ordination of upland forest communities of southern Wisconsin. *Ecological Monographs* 27: 325-349
- Brown JH, Ernest SM, Parody JM, Haskell JP (2001) Regulation of diversity: maintenance of species richness in changing environments. *Oecologia* 126(3): 321-332
- Beck JJ, Larget B, Waller DM (2018) Phantom species: adjusting estimates of colonization and extinction for pseudo-turnover. *Oikos* 127(11): 1605-1618
- Chao A (1987) Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* 43(4): 783-791
- Cisneros RO (1993) Detection of cryptic invasions and local extinctions of fishes using a long-term database. University of Wisconsin--Madison.
- DFO (Fisheries and Oceans Canada) (2017) 2016 Maritimes research vessel survey trends on the Scotian Shelf and Bay of Fundy. DFO Canadian Science Advisory Secretariat Science Response 2017/011. DFO, Ottawa
- Fidino M, Simonis JL, Magle SB (2019) A multistate dynamic occupancy model to estimate local colonization–extinction rates and patterns of co-occurrence between two or more interacting species. *Methods in Ecology and Evolution* 10(2): 233-244
- Heltshel JF, Forrester NE (1983) Estimating species richness using the jackknife procedure. *Biometrics* 39(1): 1-11
- Hutchings JA (2001) Influence of population decline, fishing, and spawner variability on the recovery of marine fishes. *Journal of Fish Biology* 59: 306-322
- Hutchings JA, Reynolds JD (2004) Marine fish population collapses: consequences for recovery and extinction risk. *BioScience* 54(4): 297-309
- Keith DA (2015) Assessing and managing risks to ecosystem biodiversity. *Austral Ecology* 40(4): 337-346
- Kery M, Spillmann JH, Truong C, Holderegger R (2006) How biased are estimates of extinction probability in revisitation studies?. *Journal of Ecology* 94(5) 980-986
- Lotze HK, Worm B (2009) Historical baselines for large marine animals. *Trends in ecology & evolution* 24(5): 254-262
- Lotze HK, Coll M, Magera AM, Ward-Paige C, Airoidwe L (2011) Recovery of marine animal populations and ecosystems. *Trends in ecology & evolution* 26(11): 595-605
- MacArthur RH, Wilson EO (1967) *The theory of island biogeography*. Princeton University Press, Princeton, NJ

- MacKenzie DI, Nichols JD, Lachman GB, Droege S, Andrew Royle J, Langtimm CA (2002) Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83(8): 2248-2255
- MacKenzie DI, Nichols JD, Hines JE, Knutson MG, Franklin AB (2003) Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology* 84(8): 2200-2207
- Magnuson JJ, Benson BJ, McLain AS (1994) Insights on species richness and turnover from long-term ecological research: fishes in north temperate lakes. *American Zoologist* 34(3): 437-451
- McCauley DJ, Hardesty-Moore M, Halpern BS, Young HS (2017) A mammoth undertaking: harnessing insight from functional ecology to shape de-extinction priority setting. *Functional Ecology* 31(5): 1003-1011
- Nichols JD, Boulinier T, Hines JE, Pollock KH, Sauer JR (1998) Estimating rates of local species extinction, colonization, and turnover in animal communities. *Ecological applications* 8(4): 1213-1225
- Oksanen J, Blanchet FG, Friendly M et al. (2017) *Vegan: Community Ecology Package*. R package version 2.4-2. < <https://CRAN.R-project.org/package=vegan> >
- Ontiveros VJ, Capitán JA, Arthur R, Casamayor EO, Alonso D (2019) Colonization and extinction rates estimated from temporal dynamics of ecological communities: The island r package. *Methods in Ecology and Evolution* 10(7): 1108-1117
- Simberloff DS (1969) Experimental zoogeography of islands: a model for insular colonization. *Ecology* 50(2): 296-314
- Shackell NL, Frank KT (2007) Compensation in exploited marine fish communities on the Scotian Shelf, Canada. *Marine Ecology Progress Series* 336: 235-247
- Shackell NL, Frank KT, Fisher JA, Petrie B, Leggett WC (2009). Decline in top predator body size and changing climate alter trophic structure in an oceanic ecosystem. *Proceedings of the Royal Society B: Biological Sciences* 277(1686): 1353-1360
- Smith EP, van Belle G (1984) Nonparametric estimation of species richness. *Biometrics* 40: 119-129
- Stortini CH, Frank KT, Leggett WC, Shackell NL, Boyce DG (2018) Support for the trophic theory of island biogeography across submarine banks in a predator-depleted large marine ecosystem. *Marine Ecology Progress Series* 607: 155-169