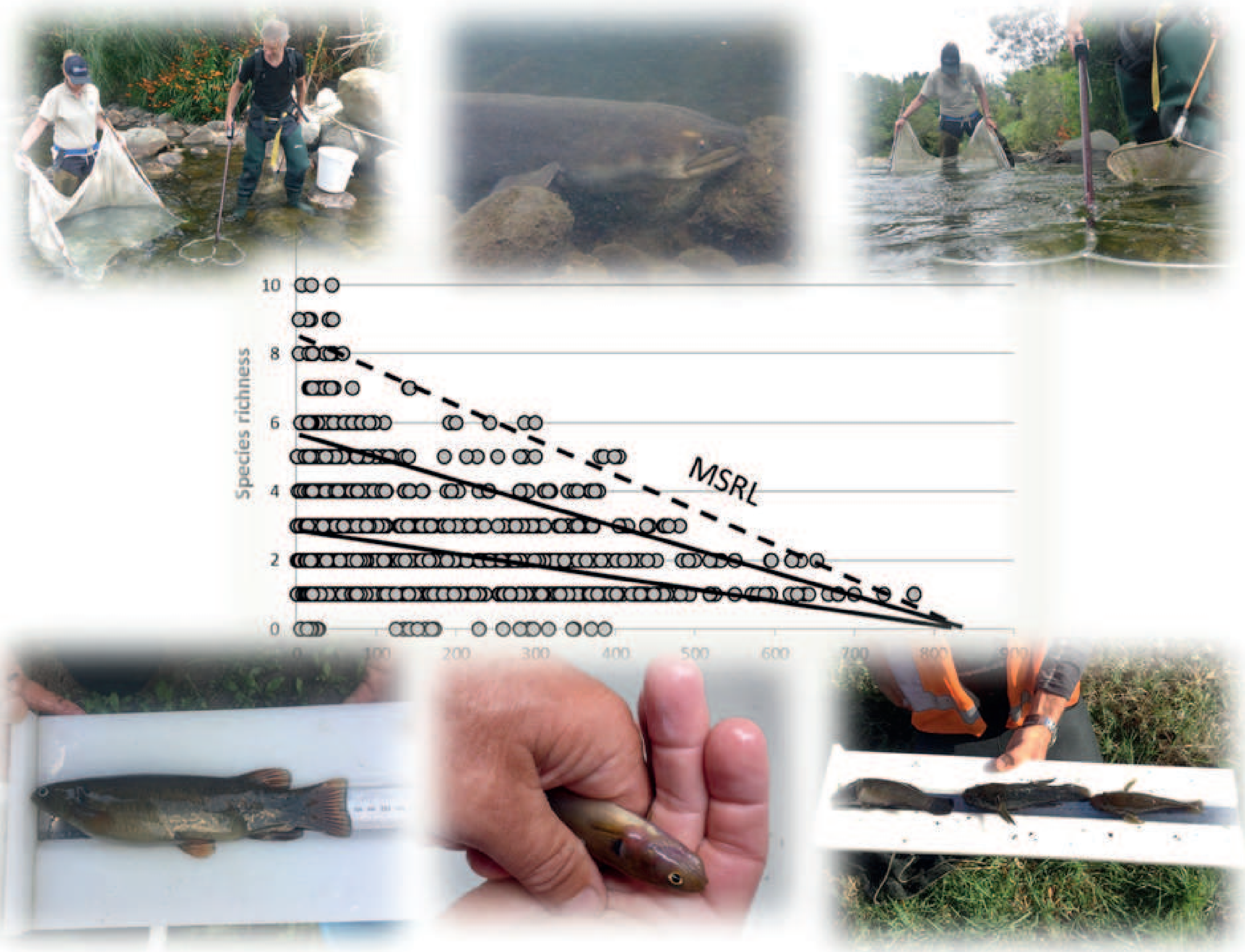
Development of a Fish Index of Biotic Integrity for the Bay of Plenty



Bay of Plenty Regional Council
Environmental Publication 2016/11

5 Quay Street
PO Box 364
Whakatāne 3158
NEW ZEALAND

ISSN: 1175-9372 (Print)
ISSN: 1179-9471 (Online)

BAY OF PLENTY
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Cover Photo:
Fisheries surveys throughout the Bay of Plenty, showing the typical reduction of fish species with altitude

Acknowledgements

Thanks to Mike Joy (Massey University) for review comments to this report. All fish data was extracted from the New Zealand Freshwater Fish Database (NZFFD), as well as being obtained from recent surveys conducted by Bay of Plenty Regional Council (BOPRC).

Executive summary

1 Fish are one of the most important ecological values of rivers and streams, and for centuries have sustained iwi, who developed close relationships with their natural life cycles. Following European settlement, trout have also been liberated throughout the Bay of Plenty, and these fish now form the basis of a hugely important recreational resource. Despite their importance, fish are being adversely affected by human activities such as removal of riparian vegetation, channel straightening and ongoing drain maintenance, water abstraction and inputs of nutrients and sediments. Hydroelectric dams, weirs, culverts and wetland drainage also have large impacts on native fish by blocking their free access to and from the sea.

2 Fish distribution patterns are strongly regulated by elevation and distance to sea, as many native fish are migratory and need access to and from the sea. Super imposed on these elevation and distance to sea gradients are factors such as hydrology, land cover and water quality that dictate the overall suitability of a site to particular fish. Smaller-scale factors such as riparian vegetation, stream habitat and cover, water flow and substrate size also influence the numbers of fish at a site. Presence of fish barriers is also a critically important in determining whether fish are found at a site.

3 Despite their importance, and relationships to environmental conditions, fish are not often used to indicate stream health. This is ironic, especially as many organisations such as BOPRC, National Institute of Water and Atmospheric Research Ltd (NIWA), Department of Conservation (DOC), and Fish and Game have conducted numerous surveys throughout the region. Indeed, there are 1942 records of fish surveys throughout the Bay of Plenty. This data is stored on the NZFFD, and was used to generate a Fish Index of Biotic Integrity (Fish IBI) specific to the Bay of Plenty. This index can be used to assess stream condition based on the presence of fish at a site.

4 Development of the Fish IBI was based on plotting individual metrics, describing aspects of the fish community against either elevation or distance to sea. Six metrics were chosen for this analysis including the number of: native species; riffle dwelling species, benthic pool species, pelagic pool species, intolerant species and the proportion of native species. Quantile regression analysis was used to create regression lines based on the percentage of sites below two regression lines, representing 33% and 66% of the data. Sites below the 33% line were scored 1, sites between 33 and 66% line scored 3 and sites above 66% line scored 5. These regressions were done for both distance to sea and elevation. The Fish IBI was calculated as the sum of all individual metrics.

5 Calculated Fish IBI values ranged from 11 (indicative of streams with poor fish community integrity) to 55 (indicative of streams with excellent fish community integrity). Fish were absent from 14 streams (Fish IBI = 0). Fish IBI values were highest in streams draining indigenous forest, intermediate in streams draining exotic plantation forest, and low in streams draining pasture. Values were also low (but highly variable) in streams draining urban catchments. Streams in the central and western parts of the region generally had lower Fish IBI scores than streams in the eastern part of the region.

6 Development of a Fish IBI for the Bay of Plenty is an important step in using fish as indicators of overall stream health throughout the region. The five narrative classes used to describe a stream's fish integrity may represent a very useful tool to policy and planning, in terms of setting desired states of various waterways, based on these clearly defined attribute bands. It is recommended that the Fish IBI be used throughout the region to further report on the status of freshwater fish communities.

Contents

Part 1: Introduction

1.1 Fish communities in the Bay of Plenty

One of the most important ecological values of rivers and streams for most people would undoubtedly be fish. For centuries, freshwater fish have sustained iwi, who have developed a very close relationship with the natural life cycle of many of New Zealand's native freshwater species to ensure they could harvest this bountiful supply (McDowall 2011). With the arrival of European settlers, introduced fish such as salmon and trout were liberated throughout the country, and these have now formed the basis of a hugely important recreational resource throughout the country (McDowall 1990). Unfortunately, other introduced fish such as mosquito fish, goldfish, and carp have also been introduced throughout the country, and these have often had dramatic negative effects on native fish communities and habitat conditions.

Despite their importance, many fish (both native and introduced) are being adversely affected by human activities throughout New Zealand. In particular, activities associated with agricultural development such as removal of riparian vegetation, channel straightening and ongoing drain maintenance, water abstraction and inputs of nutrients and sediments are having demonstrable negative effects on fish communities throughout the country. Furthermore, large hydroelectric dams have affected the ability of native fish to successfully complete their life cycle, as they have blocked free access to and from the sea. Finally, many native New Zealand fish have been displaced by the larger and more aggressive introduced trout and salmon. Other pest species such as mosquito fish can also displace native fish due to their aggressive behaviour, and other fish such as tench, catfish and carp can dramatically degrade aquatic habitats through their foraging behaviour as they uproot aquatic plants.

Many organisations such as BOPRC, NIWA, DOC and Fish and Game have conducted numerous freshwater fish surveys throughout the region. Additional surveys have been conducted by individual consultancies as part of consent applications or compliance monitoring. Most fish data collected from the Bay of Plenty has been uploaded into the New Zealand FFDB, maintained by NIWA. The FFDB contains over 30,000 records of freshwater fish observations throughout the country, and represents a nationally significant database. Of these records, 1,354 are from the Bay of Plenty. Bay of Plenty Regional Council has also conducted fish surveys at 138 sites throughout the region (not yet added to the FFDB, giving a total of 1,942 records from the region (Figure 1). A total of 29 fish species have been recorded from these surveys (Table 1). The most commonly collected fish in the region were longfin and shortfin eels (found at 51% and 34% of sites respectively), followed rainbow trout (28%), redfin and common bully (25% and 23% of sites respectively) as well as inanga, smelt and redfin bully (collected at 24% of sites). Introduced fish such as mosquito fish were found at 14% of the sites sampled.

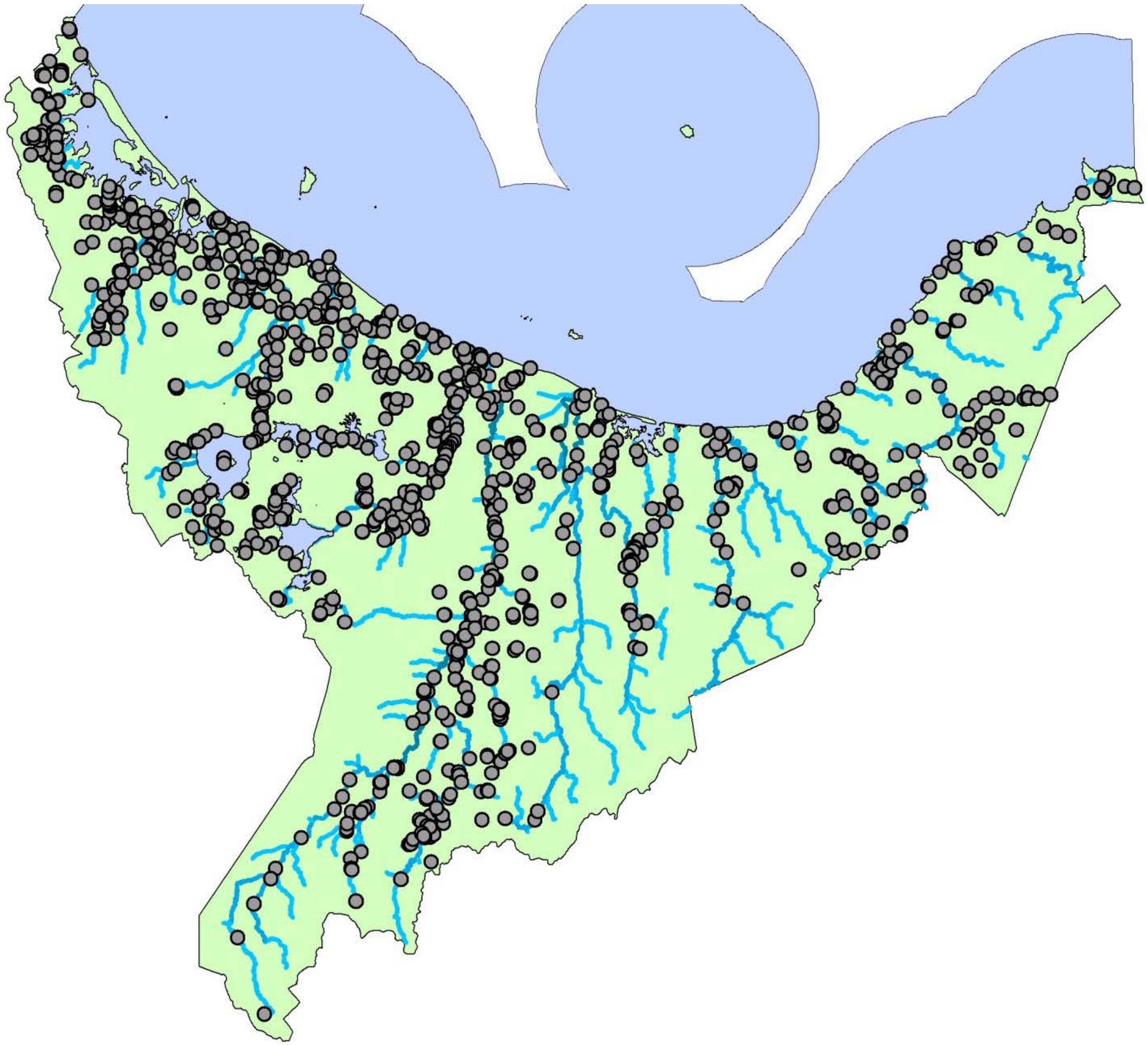

Figure 1 Location of the 1942 sites where fish surveys have been conducted throughout the Bay of Plenty region.

*Table 1 List of all fish species found in the Bay of Plenty, showing the number of sites where each species is present, as well as the percentage of sites out of the 1942 surveyed. * = introduced fish.*

Common name	Scientific name	No. of sites	Percentage
Longfin eels	*Anguilla dieffenbachii*	765	51.3
Shortfin eels	*Anguilla australis*	500	33.5
Rainbow trout*	*Oncorhynchus mykiss*	425	28.5
Redfin bully	*Gobiomorphus huttoni*	373	25.0
Common bully	*Gobiomorphus cotidianus*	335	22.5
Inanga	*Galaxias maculatus*	281	18.8
Brown trout*	*Salmo trutta*	223	14.9
Smelt	*Retropinna retropinna*	187	12.5
Banded kokopu	*Galaxias fasciatus*	178	11.9
Torrentfish	*Cheimarrichthys fosteri*	175	11.7
Unidentified eel	*Anguilla sp*	174	11.7
Koaro	*Galaxias brevipinnis*	98	6.6
Bluegill bully	*Gobiomorphus hubbsi*	96	6.4
Mosquito fish*	*Gambusia affinis*	83	5.6
Giant bully	*Gobiomorphus gobioides*	79	5.3
Giant kokopu	*Galaxias argenteus*	62	4.2
Gold fish	*Carassius auratus*	48	3.2
Shortjaw kokopu	*Galaxias postvectis*	33	2.2
Unidentified bully	*Gobiomorphus*	32	2.1
Unidentified Galaxiid	*Galaxias sp*	22	1.5
Yelloweye mullet	*Aldrichetta forsteri*	21	1.4
Grey Mullet	*Mugil cephalus*	15	1.0
Crans bully	*Gobiomorphus basalis*	13	0.9
Lamprey	*Geotria australis*	12	0.8
Dwarf galaxias	*Galaxias divergens*	9	0.6
Yellowbelly flounder	*Rhombosolea retiaria*	8	0.5
Cockabully	*Grahamina*	5	0.3
Grass carp*	*Ctenopharyngodon idella*	4	0.3
Brook char*	*Salvelinus fontinalis*	2	0.1
Tench*	*Tinca tinca*	2	0.1
European carp*	*Cyprinus carpio*	1	0.1

The average species richness per site was three, although most sites contained only one or two species. Twenty-three sites supported eight or more species (Figure 2). The number of fish found at any particular site is a reflection of many different factors. For example, fish communities are strongly regulated by elevation and distance inland (e.g., Figure 3) as many New Zealand native freshwater fish are migratory and need access to and from the sea. Superimposed on this land use, elevation gradients are other factors that operate at different spatial and temporal scales. Large-scale factors such as stream hydrology, land cover and water quality often dictate the overall suitability of sites to particular fish species, while small-scale factors such as presence of riparian vegetation, stream habitat and cover, water flow and substrate size can dictate numbers of fish found at a particular site. Given the highly migratory nature of many native species, the presence or absence of fish barriers is also of critical importance in determining whether fish are found at a site. Even the most suitable stream will support no fish if, for example, a large hanging culvert blocks migration above this culvert.

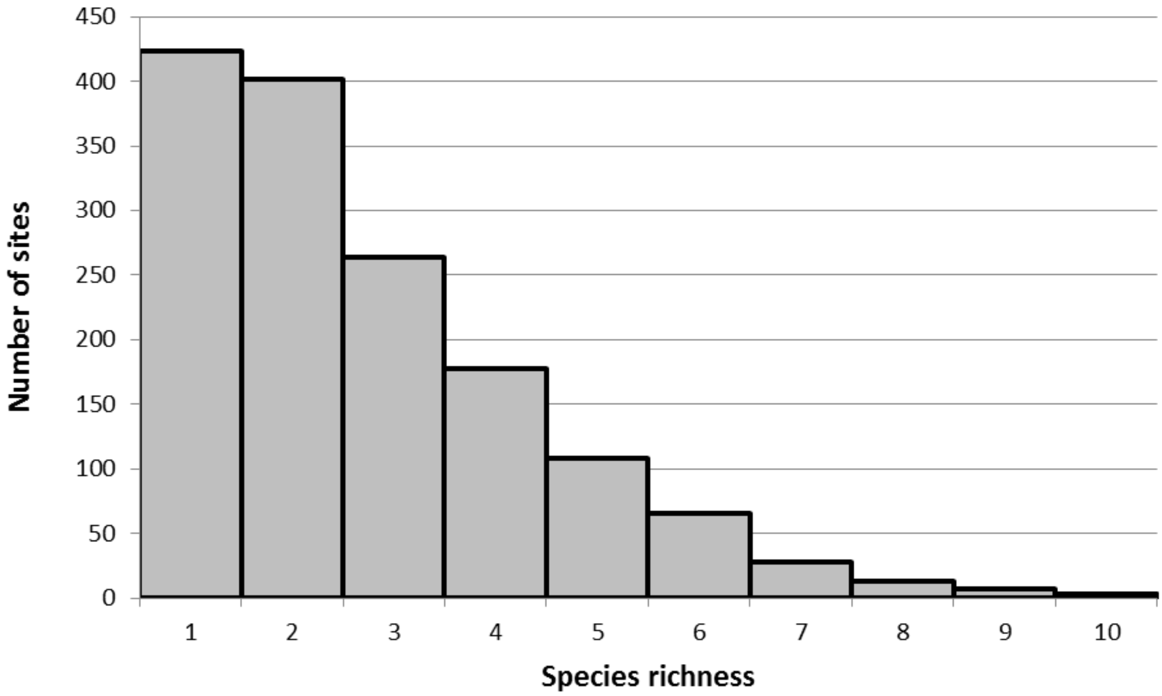

Figure 2 Bar chart showing the number of sites that supported different species richness across the Bay of Plenty.

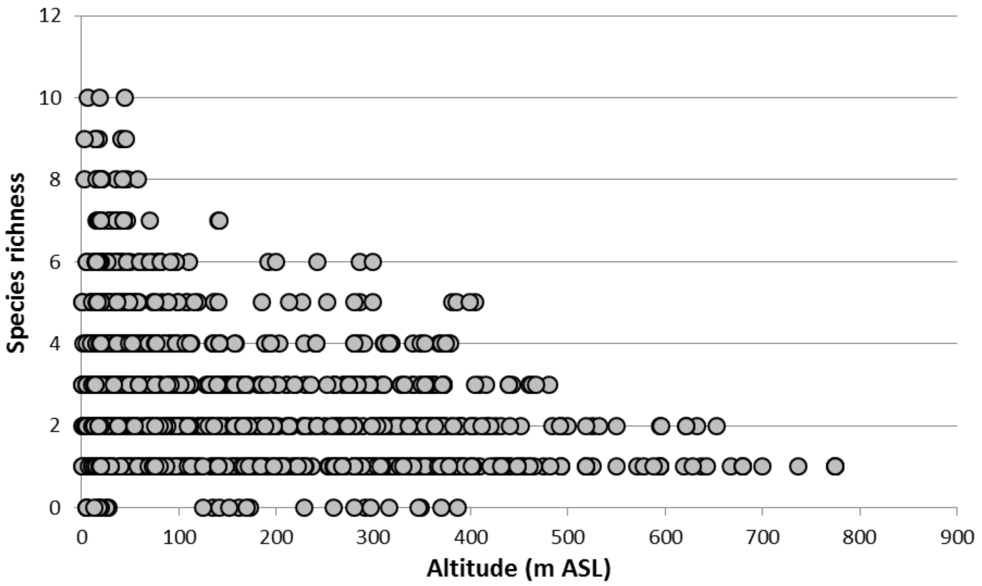

Figure 3 *Relationship between species richness and distance to sea from 1,942 sites in the Bay of Plenty.*

1.2 Metrics to assess stream health using fish

Monitoring fish communities in streams is one way of determining the overall health of a waterway. Given the strong influence of distance to sea and altitude, more fish species would be expected at lowland sites closer to the coast, and fewer species in higher elevation sites further inland. However, as discussed, other factors will also influence the suitability of a particular site to fish, so a particular site with poor habitat or water quality may support fewer fish, than a site in a similar location with better habitat and water quality conditions. The challenge faced by ecologists is to develop simple and robust ways to summarise the overall fish community composition and to determine whether it is indicative of a stream in good or poor condition for streams at a similar location.

One way of doing this is to develop biological indices: numbers that are used to describe various ecological parameters, that give an indication as to the overall "health" of a particular stream, or the communities within a stream. Within New Zealand, the Macroinvertebrate Community Index (MCI) is a widely used biotic index of water quality in stony streams (Stark 1985; Stark 1993). This index assesses stream health on the basis of the different types of freshwater invertebrates found at a site. Four water quality classes have been developed based on this index, such that scores > 120 represent streams in “excellent” condition, and scores < 80 indicate highly degraded streams. This index has been very useful throughout New Zealand, in allowing organisations such as Regional Councils and Ministry for the Environment, to report on the overall ecological condition of waterways throughout the country.

Joy and Death (2004) developed a biotic index to assess the integrity of fish communities in New Zealand. This index was a modification of an earlier index of biotic integrity developed for fish communities in the USA (Karr 1981). This original index was based on scoring 12 attributes that reflected fish species richness and composition at a site, as well as the number and abundance of specific indicator species, their different trophic levels, reproductive behaviour, abundance and condition (e.g., presence or absence of disease). This index was based on analysis of a large number of sites throughout America which included both minimally impacted, and heavily impacted sites. The resultant IBI could describe changes to the fish assemblages as the ecosystem became more impaired.

Joy and Death (2004) highlighted that New Zealand's fish fauna is very different to that overseas. For example, the fish fauna only has a small number of species, and a single trophic guild (predators). Fish diseases are also virtually absent in wild populations. Joy and Death subsequently chose six metrics that described fish communities that were based on measures of taxonomic richness over a number of different habitat types. They also used the ratio of native to exotic species as an additional metric. Because elevation and distance to the sea has such a large effect on fish communities, the six metrics are assessed on the basis of both elevation and distance to sea. This meant that the total Fish IBI was based on the sum of 12 individual metrics.

The Fish IBI scores differed significantly amongst different geological areas, and between streams draining different dominant land cover. Joy and Death concluded that their Fish IBI had a large potential to be used to assess river condition at large spatial scales throughout the country, in the absence of specially selected reference sites.

1.3 Development of the Fish IBI

The original Joy and Death (2004) method was based on plotting individual metrics against either elevation or distance to sea, and drawing an upper line by eye to include approximately 95% of the sites (Figure 4). This line is called the maximum species richness line (MSRL), which shows the upper band for species richness against (in this case) elevation. The area under this line is then divided into three segments to produce specific site scores which are related to elevation (Figure 5). The three lines are then used to allocate a score for each metric based on the elevation of a particular site. If the observed species richness at a given site is below the lower line, it scores 1, if it is between the two lower lines it scores 3, and if it is above the second line it scores 5 (Figure 6).

This process is repeated for each of the six metrics when plotted against both elevation and distance to sea. The final Fish IBI is simply the sum of all the individual scores for each metric, when plotted against elevation and distance to sea.

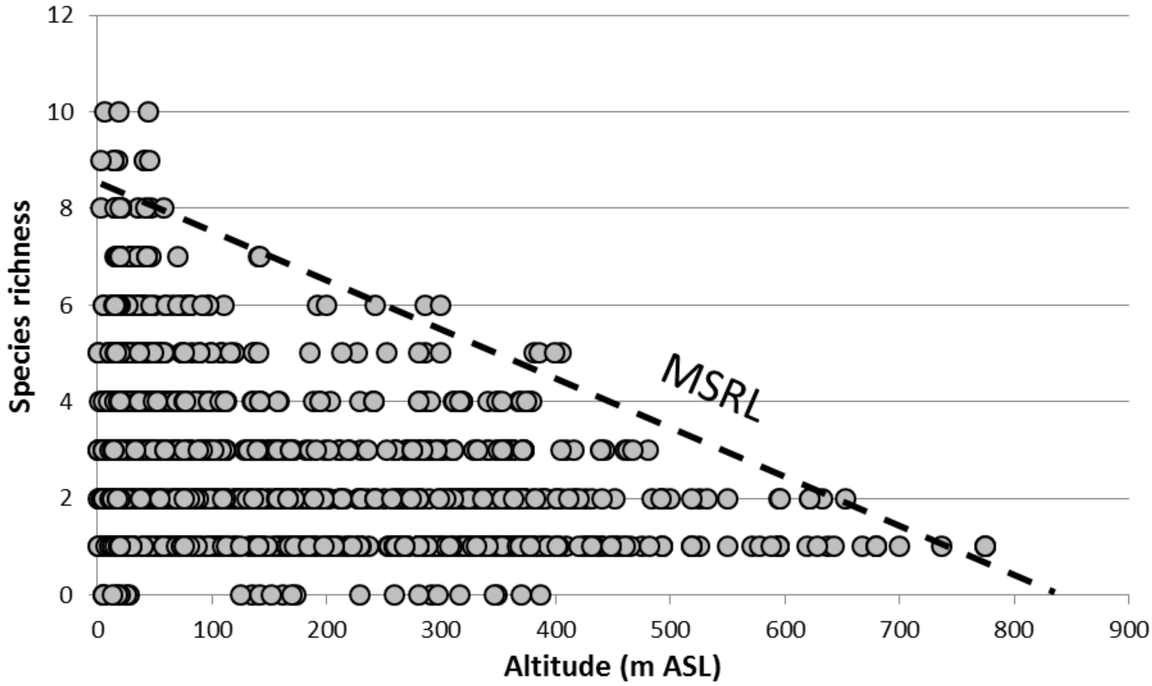

Figure 4 *Fitting the maximum species richness line (MSRL) by eye such that 95% of sites are below the line.*

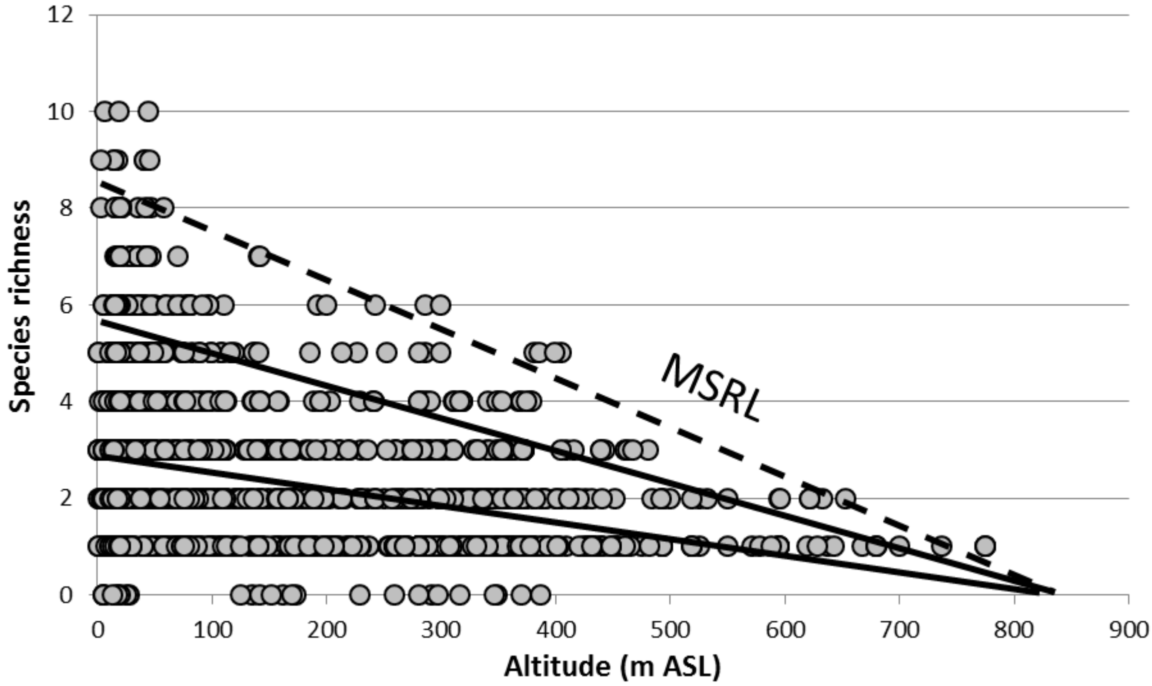

Figure 5 *The area below the MSRL is divided into three to give the scoring lines relative to altitude.*

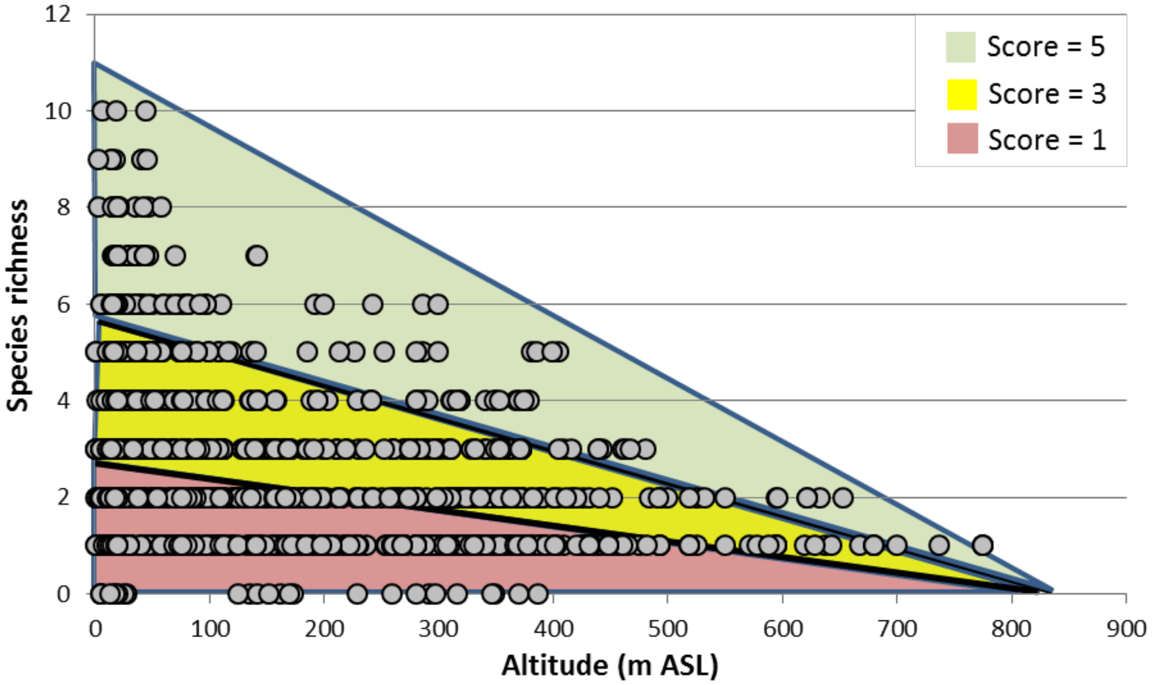

Figure 6 *Example showing how specific sites are scored according to the relationship between species richness and altitude gradient. For a given altitude, a site is scored 1, 3 or 5 depending on which polygon it is found in.*

The Joy and Death approach fitted the scoring lines of each metric against altitude or distance to sea by eye. This, however, may have been inaccurate as it was not possible to tell how many sites were represented by a single dot on a plot. To overcome this, Joy (2007) used Quantile regression to better fit lines that would separate out the lower 33% of sites, and the upper 66% of sites. Use of quantile regression was thus regarded as much more robust than the original fitting by eye approach. This was called the QIBI.

The aim of this report was to develop a Fish IBI for the Bay of Plenty, based on a similar Quantile regression approach as used by Joy (2007). This was done using data extracted from the NZFFD and from surveys conducted by BOPRC, as it was felt that the modelled relationships between species richness and distance to sea or elevation in the Bay of Plenty may have differed somewhat to those used in Waikato. Moreover, some of the invasive fish encountered in other regions such as koi carp, catfish, and rudd are not found in the Bay of Plenty, so relationships developed for regions where the species were found may not be relevant in the Bay of Plenty.

Part 2: Methods

The Joy and Death IBI relied on calculation of six metrics and their relationship to elevation and distance to sea. These are described below:

1 **Number of native species -** This metric describes the number of native and trout species found at each site. Native species are generally regarded as being sensitive to environmental degradation, and also rely on free access to the sea. Their presence in a stream thus suggests relatively good habitat and water quality conditions, and absence of significant fish barriers. Trout have been included in this metric as these fish are also generally sensitive to habitat degradation and poor water quality.

2 **Number of native benthic riffle species -** This metric is based on how many fast-water riffle dwelling species are found. This metric is important as riffles can often become choked with sediment, reducing their habitat value to many native fish. Riffles also commonly dry during periods of low flow, so riffle dwelling species may be less common in streams subject to extreme low flow events.

3 **Number of native benthic pool species -** This metric was chosen to make the index sensitive to changes in stream geomorphology resulting from the effects of channelisation and dams on habitats required by these fish. This metric may also be sensitive to sedimentation and loss of instream habitat such as debris jams and overhanging banks and vegetation.

4 **Number of pelagic (= swimming) pool species -** This metric measures the number of native fish which are commonly found swimming in deep, slow flowing pools in streams. Only native species are considered here because many introduced pelagic species are indicative of habitat degradation.

5 **Number of intolerant native species -** Native freshwater fish were assessed as being intolerant of environmental degradation such as water quality, temperature, sediment and ammonia (Richardson et al. 1994; 2001; Richardson 1997) as well as intolerant to migration barriers (McDowall 1990; Joy and Death 2001).

6 **Proportion of native to alien species -** This metric measures the extent to which the fish assemblage is composed of invasive introduced species. The presence of non-native species (not including trout) usually reflects loss of habitat and water quality conditions, as these species are often more tolerant of degraded conditions then native species.

All fish found within the Bay of Plenty were allocated to each of the six metrics (Table 2) as per Joy (2007). Note that these metrics were non-exclusive, such that some species were scored using multiple metrics. Of the 31 species, most (11) were used in either one or three metrics; only two species (shortjaw kokopu and banded kokopu) were used in four metrics. The number of fish species allocated to each of the six metrics differed greatly. The number of native species (plus trout) had the highest number of fish species (25), whilst the number of benthic riffle species and number of invasive species had only nine and six species respectively.

Table 2 Table of the fish species found in the Bay of Plenty showing their allocation to each of the six metrics used to create the Fish IBI (From Joy 2007).

Taxa	Common Name	NZ Native	Benthic riffle	Benthic Pool	Pelagic Pool	Intolerant	Invasive	No. of metrics
Aldrichetta forsteri	Yelloweye mullet	*			*			2
Anguilla australis	Shortfin eels	*		*				2
Anguilla dieffenbachia	Longfin eels	*	*	*				3
Carassius auratus	Gold fish						*	1
Cheimarrichthys fosteri	Torrentfish	*	*					2
Ctenopharyngodon idella	Grass carp						*	1
Cyprinus carpio	European carp						*	1
Galaxias argenteus	Giant kokopu	*			*	*		3
Galaxias brevipinnis	Koaro	*	*			*		3
Galaxias divergens	Dwarf galaxias	*	*			*		3
Galaxias fasciatus	Banded kokopu	*		*	*	*		4
Galaxias maculatus	Inanga	*			*			2
Galaxias postvectis	Shortjaw kokopu	*		*	*	*		4
Gambusia affinis	Mosquito fish						*	1
Geotria australis	Lamprey	*		*				2
Gobiomorphus basalis	Crans bully	*		*				2
Gobiomorphus cotidianus	Common bully	*		*				2
Gobiomorphus gobioides	Giant bully	*		*		*		3

Taxa	Common Name	NZ Native	Benthic riffle	Benthic Pool	Pelagic Pool	Intolerant	Invasive	No. of metrics
Gobiomorphus hubbsi	Bluegill bully	*	*			*		3
Gobiomorphus huttoni	Redfin bully	*	*			*		3
Grahamina	Cockabully	*						1
Mugil	Mullet	*			*			2
Mugil cephalus	Grey mullet	*			*			2
Oncorhynchus mykiss	Rainbow trout				*			1
Retropinna retropinna	Smelt	*						1
Rhombosolea	Flounder	*		*		*		3
Rhombosolea retiaria	Yellowbelly flounder	*		*		*		3
Salmo trutta	Brown trout				*			1
Salvelinus fontinalis	Brook char				*			1
Scardinius erythrophthalmus	Rudd						*	1
Tinca tinca	Tench						*	1

The number of species for each of the six metrics was plotted against both distance to sea and elevation, and Quantile regression analysis used to create lines representing 33% and 66% of the MSRL. This analysis was done using the Blossom Statistical Software (Cade and Richards 2005).

Part 3: Results

Quantile regression analysis was done on the six derived metrics against both distance to sea and elevation. This analysis calculated the 33% and 66% regression lines. Good relationships were seen for the number of New Zealand native fish, as well as the number of benthic riffle, and benthic pool fish when plotted against both distance to sea and elevation (e.g., Figure 7).

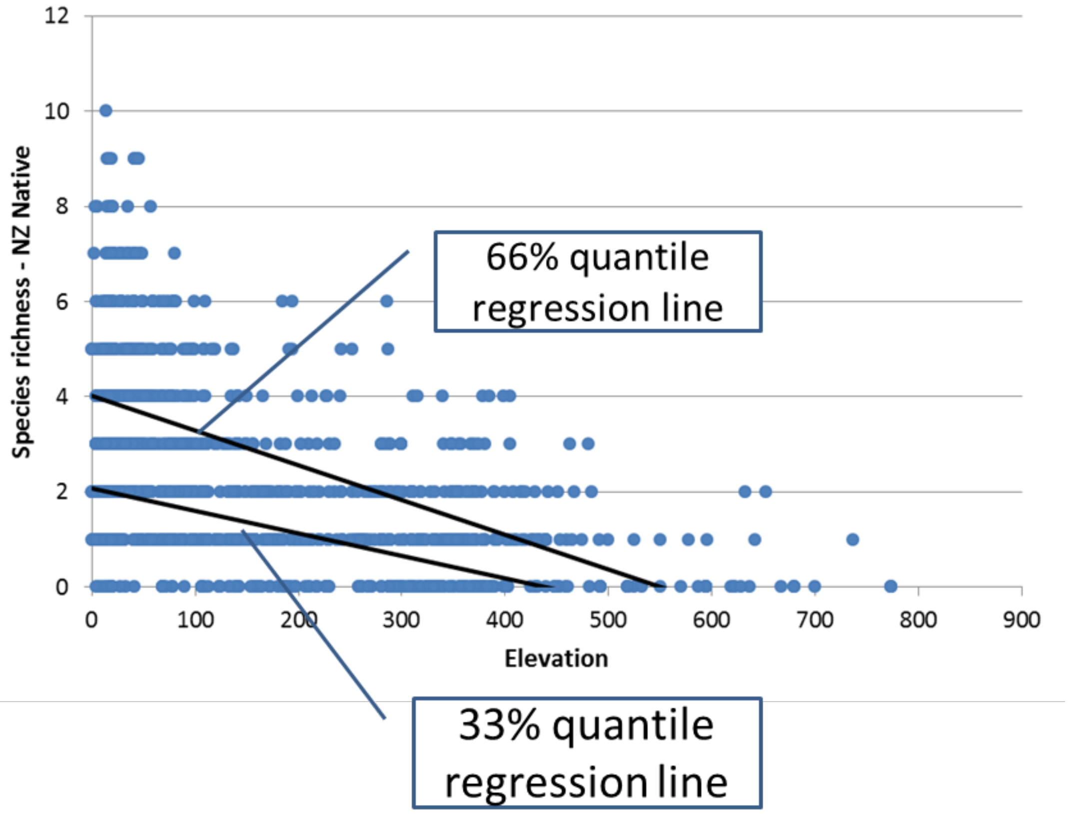

Figure 7 *Plot showing quantiles calculated for the native species richness metric showing the 33% and 66% Quantile regression lines.*

Relationships between number of pelagic species and distance to sea or elevation were not as clear cut (Figure 8). Quantile regression analysis for the number of pelagic species showed a positive trend with both elevation and distance to sea for the 33% data line. However, the *P* value for this regression line was relatively weak ($P = 0.025$). In contrast, quantile regression for the 66% data line showed a highly significant regression line ($P = 0.0004$) with a minimal slope (-1.11E-19) and Y intercept of 1. Because of this, it was decided to use a species richness >=1 (i.e., the 66% line) to represent sites with a high score (5) for this metric, while sites with no pelagic species were scored a 1 for this metric.

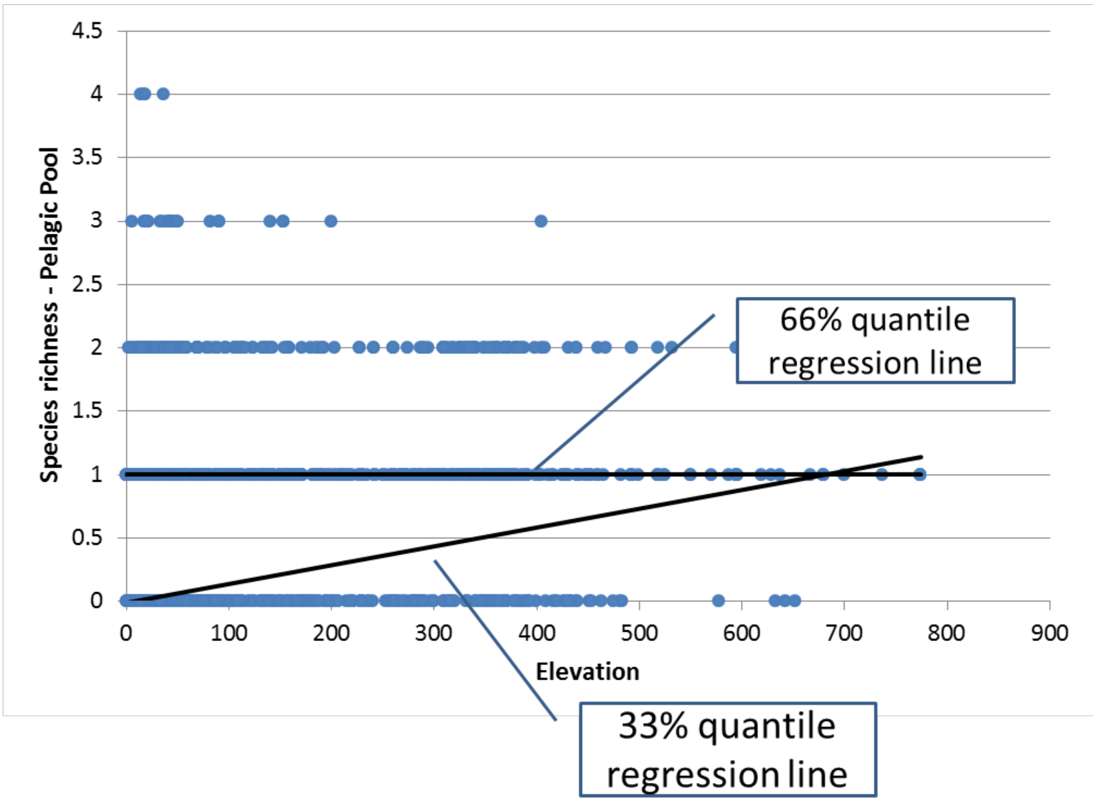

Figure 8 *Plot showing quantiles calculated for the number of pelagic pool species against elevation metric showing the 33% and 66% Quantile regression lines.*

No significant Quantile regression was generated from the 33% regression line for the richness of intolerant species against both elevation and distance to sea. Instead, only a highly significant relationship was seen for the 66% regression line, which significantly declined with increasing elevation (Figure 9). Because of this, this metric was scored on the basis of sites having more or less than the 66% MSRL. Sites with > 66% scored 5, while sites with less than this scored 1.

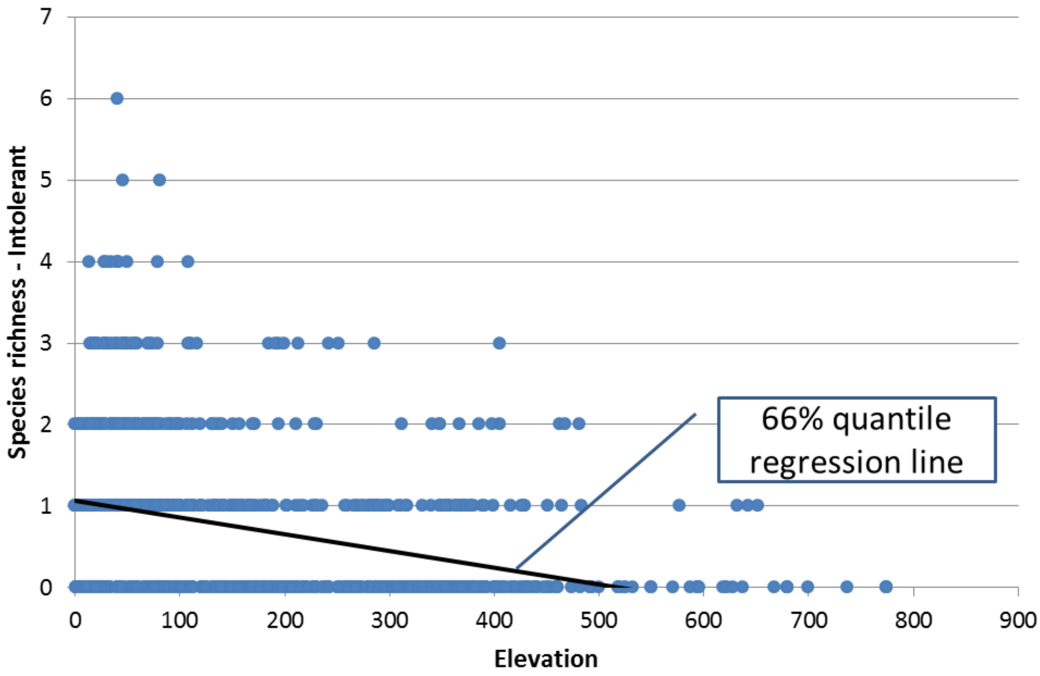

Figure 9 *Plot showing the 66% Quantile calculated for the number of intolerant species against elevation. There was no significant regression line for the 33% line.*

Scores for each of the six metrics were assigned to each sampling site based on relationships between each metric and distance to sea or elevation (Table 3). Each metric was summed to give the Fish IBI for each sampling site. Potential scores for the Fish IBI range from 0 to 60.

Table 3 *Summary of scoring criteria used for each of the six metrics and the relationship to the MSRL. Note that the Quantile regression analysis showed no significant regression line for the 33% data for either number of pelagic species or intolerant species.*

	Scoring criteria		
Metric	5	3	1
Number of native species (including trout)	>67% MSRL	>33 - 67% MSRL	< 33% MSRL
Number of riffle dwelling species	>67% MSRL	>33 - 67% MSRL	< 33% MSRL
Number of benthic pool species	>67% MSRL	>33 - 67% MSRL	< 33% MSRL
Number of pelagic species	>1	Na	No species
Number of intolerant species	>67% MSRL	Na	< 67% MSRL
Proportion of native species	>67%	>33 - 67%	< 33%

Joy (2007) produced a series of five bands for the Fish IBI to assist with interpreting final scores, based on the percentile distribution of sites scores throughout the Waikato region. A similar approach was employed in the Bay of Plenty to produce a five banded scoring system for the Bay of Plenty Fish IBI (Table 4). As with Joy (2007), these bands were based on the percentile distributions of sites throughout the Bay of Plenty. Note that there was a very high degree of similarity between the scoring bands.

Table 4 Fish IBI scores and potential integrity classes for the Bay of Plenty, based on percentile distributions of the calculated Fish IBI score. Also shown are the IBI scores Joy (2007) developed for the Waikato region. Note the high degree of similarity between the different bands between the regions.

BoP Fish IBI score	**Waikato Fish IBI score**	**Integrity class**	**Attributes**
46 – 60	47 – 60	Excellent	Equivalent to the best situations without human disturbance; all species expected in the stream given its location are present. Site is above the seventy fifth percentile of streams.
36 – 45	36 – 46	Good	Site is above the fiftieth percentile of streams, but species richness and habitat or migratory access reduced. Shows some signs of stress.
24 – 35	24 – 35	Moderate	Site is above the twenty fifth percentile. Species richness is reduced. Habitat and/or access is impaired.
6 – 23	6 – 26	Poor	Side is impacted or migratory access almost non-existent.
0	0	No fish	Site is grossly impacted or access the system

Examination of the frequency of occurrence of the 1492 sites when allocated to the different attribute bands shows that the highest numbers of sites were graded as either poor or moderate: only 14 sites supported no fish.

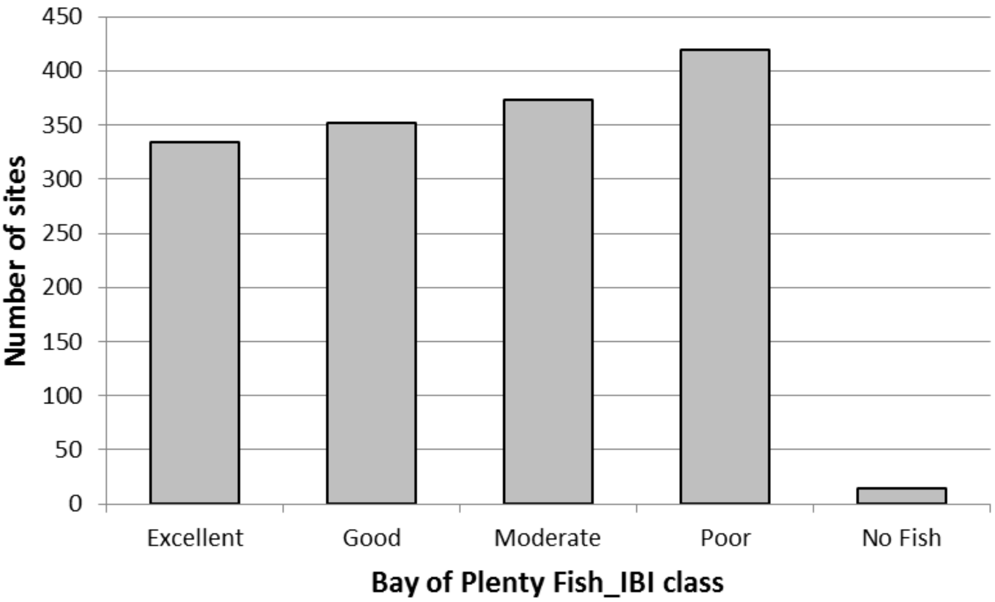

Figure 10 Number of sites allocated to each Fish IBI attribute class based on the 1492 sites throughout the Bay of Plenty used to calibrate the Fish IBI.

Analysis of Variance (ANOVA) showed significant differences to calculated Fish IBI scores in streams draining different land use classes (Figure 11). Scores were highest in streams draining indigenous forest, intermediate in streams draining exotic forest, and lowest in streams draining catchments dominated by pasture and urban development. Fish IBI scores were particularly variable in urban streams (Figure 11).

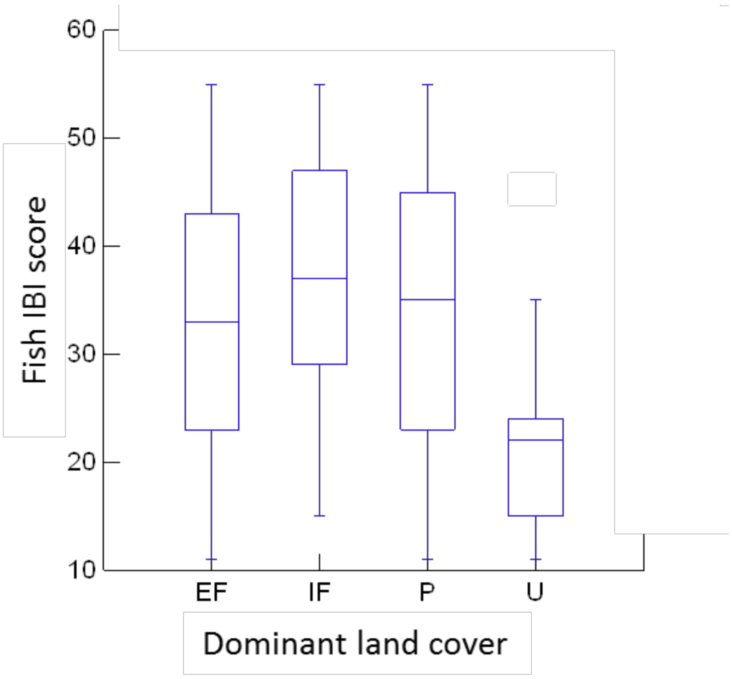

Figure 11 *Box plot of Fish IBI values in streams draining exotic forest (EF), indigenous forest (IDF), or pasture (P) and urban catchments (U). Median value = horizontal bar; twenty fifth and seventy fifth percentiles bounded by the box; whiskers = range of values.*

Examination of the spatial distribution of sites when allocated to one of the five scoring bands showed little pattern to the data, except for the fact that more sites appeared in either poor or moderate condition in the central and western parts of the region, with fewer sites in the eastern part of the region scored as poor. An ANOVA of the Fish IBI against the different Water Management Areas (WMAs) confirm this trend, with streams in Ohiwa/Waiotahi, East Cape, Waioeka/Otara and Whakatāne/Tauranga WMAs having higher scores than streams in the Rangitaiki, Tarawera, Kaituna/Maketu and Rotorua lakes WMAs. Streams in the Tauranga Harbour WMA had an average Fish IBI intermediate between those of Whakatāne/Tauranga and the Rangitaiki WMA.

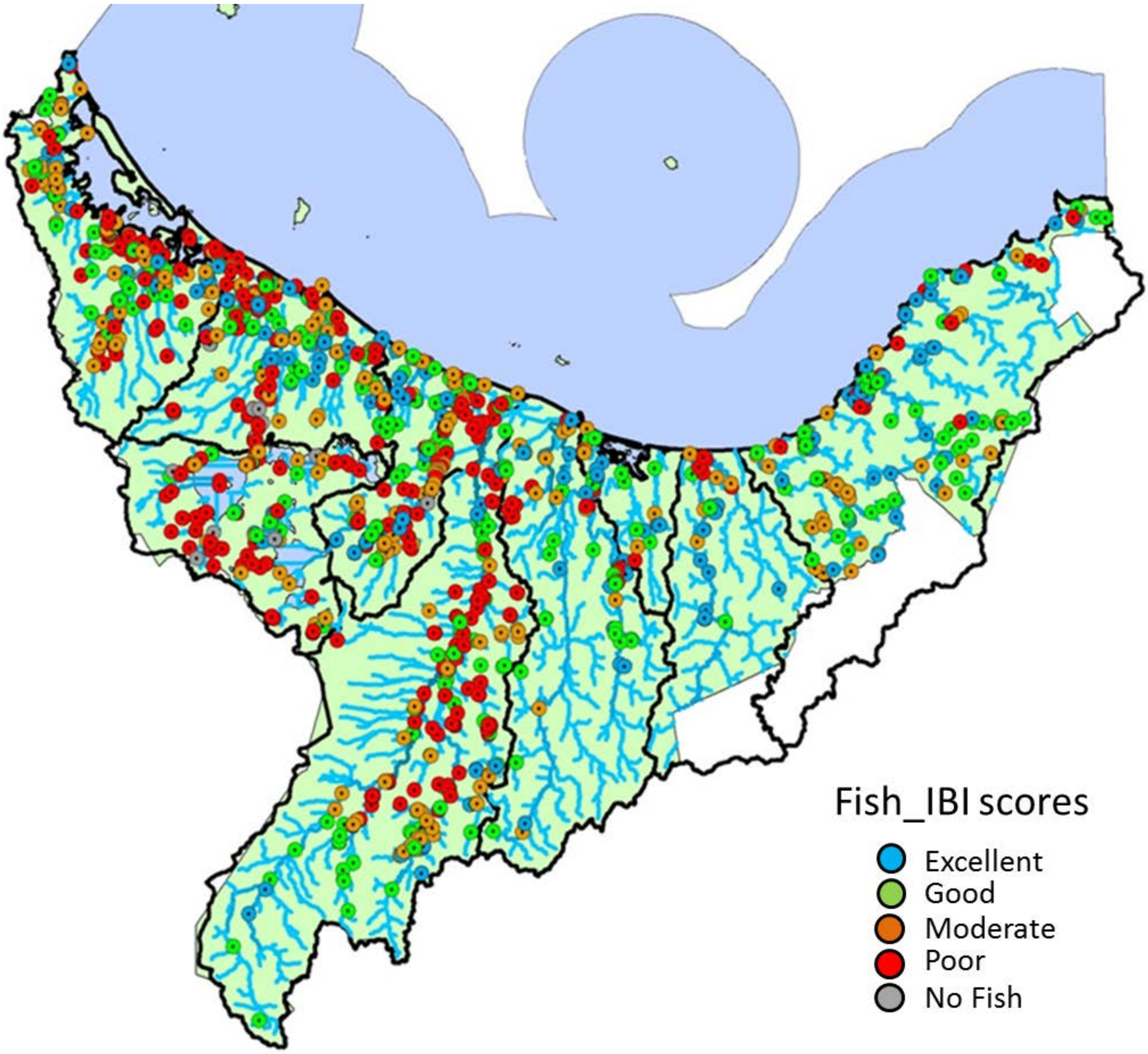

Figure 12 Match showing calculated Fish IBI scores for all sites in the Bay of Plenty region when allocated according to one of the five classes.

Part 4: Discussion

Development of a Fish IBI for the Bay of Plenty is an important step in using fish as indicators of overall stream health throughout the region. This work was based on the initial development of the Fish IBI by Joy and Death (2004), which highlighted the great potential to use freshwater fish to assess river condition at large spatial scales throughout the country. Joy and Death noted that the Fish IBI allows comparison of stream biotic conditions across a large spatial and temporal range of river types. They also acknowledged that further testing about the accuracy of the Fish IBI in relation to other river assessment systems (e.g. predictive modelling using Fish, or the use of single indices such as the MCI that measure stream condition in using invertebrates) may provide further useful information about the ability of the Fish IBI, to respond to human pressures within natural environmental gradients. Bay of Plenty Regional Council currently holds invertebrate community data from approximately 450 sites throughout the region, giving us the ability to quantify stream health, in the sites using invertebrate indices such as the MCI and QMCI. This may provide valuable information to see whether both fish and invertebrate communities are responding in a similar manner to environmental factors. It may also highlight significant differences between using these two ecosystem components. For example, the Fish IBI is likely to be strongly affected by the presence of downstream barriers to fish migration, whereas such barriers would have little direct effect on invertebrate communities.

Development of the Fish IBI is based on the response of fish communities (and the subsequent metrics that describe these communities) against elevation and distance to sea gradients. These responses may vary throughout the country, so it is arguably more robust to develop models at a regional level rather than rely on national models. This has successfully been done in the Waikato region (Joy 2007). Analysing the Bay of Plenty fish data highlighted a number of subtle differences between the regions. For example, eight invasive species were recorded in the Waikato region, whereas only six invasive species have been recorded in the Bay of Plenty. Thus, koi carp, perch and guppies have not been recorded in rivers in the Bay of Plenty, although there has been a recent incursion of catfish into Lake Rotoiti (Hamish Lass, pers comm). In contrast, there are no records of tench or European carp in the Waikato, yet these species have been found at two and one site, respectively in the Bay of Plenty. Furthermore, there were differences in the behaviour of individual metrics against distance to sea and altitude between the two regions. In particular, we found that the number of pelagic-pool species in the Bay of Plenty did not respond strongly to these gradients. The Quantile regression analysis instead showed that the data appeared to simply be divided into two classes: those with pelagic pool species and those without. Scores for these metrics were subsequently altered to reflect this. Because of these differences, development of a specific Fish IBI for the Bay of Plenty may provide a more robust assessment than using nationally derived models.

Despite the slightly different fish fauna between Waikato and Bay of Plenty, and the slightly different criteria used to score the different metrics then used by Joy and Death (2004), we found only very slight differences in the bands used in the five classes that described fish community integrity. These five classes were developed by dividing the calculated Fish IBI data into percentiles, so it appears as if the slight differences in our scoring criteria had little effect on the overall banding structure. The five narrative class bands used to describe a stream's fish integrity, are likely to represent a very useful tool to policy and planning in terms of setting desired states of various waterways, based on these clearly defined attribute bands. These narrative bands can also be used as part of consent or compliance conditions to ensure that, for example, the Fish IBI shall not be reduced, or only be reduced by a certain percentage, by a specific activity. This is a very powerful tool, as it gives a clearly definable numeric value to the observed fish communities at a site. Prior to the development of the Fish IBI, this information did not exist.

It is thus recommended that the Fish IBI be used throughout the region to further report on the status of the freshwater fish communities.

Part 5: References

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