BOPRC – DOC Collaboration: 2022/23 State of environment assessment on Australasian bittern/Matuku (*Botaurus poiciloptilus*).

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Cover photo: Australasian bittern. Adult stalking fish in lake fringe vegetation. Waitangi wetland, Napier, April 2015. Image © Adam Clarke by Adam Clarke

DOC-7417895

Contents

1. Acknowledgements:

Ngā mihi nui ki a koe Lisa Bevan (BOPRC) for your considerable mahi putting out devices during the survey period. This involved a lot of time driving around the Bay of Plenty for which we are grateful for. Shay Dean (BOPRC), thank you for continuing to grow the relationships within the region and support the annual wetland forums. Thank you to the landowners, rūnanga, and district council for access to certain recorder locations and continued management of these wetland spaces.

2. Introduction:

In 2016 the status of Australasian bittern/Matuku-hūrepo (Botaurus poiciloptilus) was raised to Nationally Critical[1] and is now listed as a priority species for management within the New Zealand Threatened species strategy[2].

Matuku-hūrepo are apex predators in our wetland habitats which means they are important indicators of wetland health. Wetlands, including RAMSAR sites, hold many public interests for conservation and restoration efforts and matuku play a much-needed role as a flagship/iconic species for these sites of great importance. Although matuku also occur in Australia, they have declined by >90% there in recent years[3], and New Zealand may now be the stronghold for the species. In addition, virtually nothing is known about their ecology in Australia.

Unfortunately, there are data deficient areas that require further research: the ecology, causes of decline, or how to manage and/or recover bittern populations[4,5]. Preliminary research thus far has focused on developing methods to find and monitor these highly elusive birds[6,7,8,9,10]. The continuing threats to matuku include wetland loss and degradation (sedimentation, flooding and nitrates), starvation, predation, and human forcing (e.g. power lines, vehicles and roads, urbanisation)[11].

The critical issue for bittern conservation is lack of knowledge of which techniques (management prescriptions) to use to recover populations effectively and secure the species from extinction. Nevertheless, the consistent use of fit-for-purpose monitoring is essential to achieving effective conservation management[12]. Thus, our long-term assessment of male Matuku activity across wetland sites is important in understanding the state of change within our breeding populations at known hot spots.

Collaborations help us achieve additional goals beyond the direct focus of Arawai Kākāriki site restoration funding streams. Nevertheless, AK funds help provide direct advice for on-going monitoring strategies, new monitoring proposals and supervision, and indirect assistance in the form of equipment and field-based resources. This monitoring programme has been a collaborative effort between DOC (Arawai Kākāriki) and Bay of Plenty Regional Council (BOPRC). BOPRC staff have undertaken the fieldwork for the project while DOC staff have undertaken the data analysis and reporting components. With the third year of collaboration surveys completed with the BOPRC, a thorough foundation of male bittern activity across broad range of wetland habitats has been gathered. With the inventory monitoring of matuku-hūrepo completed for many sites the long-term strategy is now underway. Over the coming years we should be able to observe male activity trends within and among wetlands in the Bay of Plenty.

1. **Aims/outcomes for matuku-hūrepo monitoring in BOP:**

   Continue wide-reaching monitoring strategy to observe long-term male bittern activity levels among and within BOP wetlands.

   Maintain logistical output for perpetuity of monitoring strategy.

   Continue inventory monitoring of new sites to increase resolution of bittern activity within region where possible with aim to add active sites to long-term strategy.

   Maintain relationships between agencies and community to safeguard future of matuku-hūrepo data stream. Engaging and communicating outcomes of taonga species with region.

4. Methods:

1. Equipment:

Approximately 30 automatic Acoustic Recording Devices
1 x 8GB SD card per recording unit
4 x AA batteries per recording unit
Wooden stakes or metal waratahs used for mounting ARD's to if no appropriate tree branches are available to deploy devices on

2. How the recorder works:

a) Setup:

The ARD will wake up automatically at the scheduled preset 'Start Time' every day and will continuously record for the preset 'Duration Time'. The recorder will be asleep and not draw much power when outside of the scheduled preset recording times.
When the ARD is prepped for deployment, it is fixed to a stake, waratah, or suitable tree at the designated 'listening station' coordinates. The duration of deployment varies according to desired listening periods prescribed for the monitoring effort. During this investigation deployments ranged from a couple days-couple weeks (snap-shot events) to more than a month (known bittern sites). Full procedure for setting up ARDs can be found in **Appendix 1** of *O'Donnell & Williams 2015: Protocols for the inventory and monitoring of populations of the endangered Australasian bittern in New Zealand*[7].

b) Sound files:

Recordings are stored on the device memory card as single channel .wav files in a folder labelled 'survey'. Each file is 15 minutes long and each is named with the current date and time (6 digits _6 digits, respectively). Files are stamped with the respective date and time in File Explorer. (e.g., 260210_212406.wav = 26/02/10 at 21:24:06PM).

c) Sound file Analysis:

Upon ARD deployment completion, devices were collected and the data from the SD card transferred to a computer and an external hard drive by the BOPRC (back-ups highly recommended as this data can corrupt easily). Sound files were then checked for corruption and to determine if the ARD has correctly stored the files. It can become clear

if the device has had some sort of fault or has been deployed incorrectly according to start/end times of listening periods and listening period durations by checking files.

Once all sound files had been transferred and checked they were distributed to three research assistants who visually analysed them using RavenLite or RavenPro 1.4 software (other related software can be used but Raven is recommended). Methods on how to use this software for the purpose of analysing bittern sound files can be found in **Appendix 5** of *O'Donnell & Williams 2015: Protocols for the inventory and monitoring of populations of the endangered Australasian bittern in New Zealand*[7].

All research assistants were issued the same sampling method for analysing sound files. For years 2021 & 2022 population monitoring was performed, pre-2021 inventory was completed. For inventory monitoring staff were instructed to analyse 1*dawn and 1*dusk 15-minute recording for each day of ARD deployment. Population monitoring is the analysis of 6 files per device per round, consisting of 3*dawn and 3*dusk files from good weather days. Data is entered into an excel spreadsheet template that is fitted with a macro system for entering meta-data to ensure consistency in terms, weather, disturbances, and location data. This spreadsheet is formatted in preparation for statistical analysis in R[14]. Continued years of population monitoring will be presented as a long-term trend. This early instance of data will be presented in a spreadsheet.

3. 2022 ARD Deployment Timeframes:

Lake Rotopotaka –	7-28th September
Kaituna Wetland –	7th October – 9th November
Matatā –	7th October – 9th November
Braemar Spring –	10th October – 12th November
Awaiti –	12th October – 22nd November
Bregman –	9th November – 14th December
Athenree –	4th November – 6th December
Lake Aniwaniwa –	11th November – 21st December
Maketu Estuary –	8th October – 8th November
Matua Reserve –	4th November – 13th December
Ohiwa Harbour –	11th November – 21st December
Tarawera Cut –	9th November – 2nd December
Waihi Estuary –	12th October – 28th November
Waiotahe Estuary –	11th November – 21st December
Yatton Park –	4th November – 13th December

5. Results:

1. **2022 failed/missing data collection:**

   Ohiwa Harbour 1 and 3 did not have data present for analysis.

2. **2022 considerable disturbance sites:**

   Waiotahe Estuary, Lake Aniwaniwa, Rotopotaka.

3. **2018-2022 table summaries:**

   Since 2018 a total of 9175 sound files have been analysed for matuku-hūrepo call activity from 28 sites (Table 1) consisting of 54 listening stations (Table 2). Of all sites only four have been monitored every year; Athenree, Kaituna Wetland, Waihi Estuary, and Yatton Park. The number of sites monitored each year varied from 8, 18, 16, and 15 for 2018, 2020, 2021 and 2022 respectively (Table 1).

   Matuku-hūrepo have been observed at 21 of the 28 sites (Table 3) and 35 of 54 listening stations (Table 2). By station the highest bittern activity levels in 2018 were recorded at Kaituna 4, 2020 at Awaiti 2, 2021 at Matatā 2, and 2022 at Waihi 1 (Table 2). By site the highest bittern activity levels in 2018 were recorded at Waihi Estuary, 2020 at Awaiti, 2021 at Awaiti, and 2022 at Waihi Estuary (Table 3).

Table 2. All sound files analysed for matuku-hūrepo sequences from 2018 to 2022 for all sites. Stations grouped into sites for table summary.

n	2018	2020	2021	2022
Athenree	159	92	153	12
Awaiti		85	24	12
Braemar Spring		35	13	6
Bregman WMR		68	65	6
Herema Road		4		
Hiwarau		5		
Jess Road		20	175	
Kaituna Wetland	1782	533	300	30
Lake Aniwaniwa				80
Lake Tamurenui		14		
Maketu Estuary		37	24	12
Matakana Island	1252			
Matata		168	24	12
Matua				78
Mary Jackson Reserve		2		
Ohiwa Harbour		336	60	24
Opotiki		120	146	
Rotopotaka				84
Sanctuary Point	159			
Tahuwhakatiki	184			
Tarawera Cut		66	81	6
Thornton Lagoon			64	
Toatoa Beach			288	
Waihi Estuary	847	142	367	24
Waiotahe Estuary		16		80
Whakapoukorero	316			
Whakatane Estuary			54	
Yatton Park	296	66	61	6
∑	4995	1809	1899	472

Table 1. Matuku-hūrepo call index (calls/15min) for all listening stations deployed between 2018 to 2022. Annual average displayed at the base.

Index by Station	2018	2020	2021	2022
Athenree 1	0.629	0.296	0.000	0.000
Athenree 2		0.000	0.000	1.333
Awaiti1			4.667	2.167
Awaiti 2		1.247	0.417	0.667
Braemar Spring 1		0.886	3.000	4.167
Bregman WMR 1		0.044	0.769	0.000
Herema Road 1		0.000		
Hiwarau		0.000		
Jess Road 1		0.150	0.000	
Kaituna 1	0.000	0.427	0.312	1.667
Kaituna 2	3.033	0.785	3.563	7.167
Kaituna 3	1.097	0.288	1.153	3.500
Kaituna 4	5.631	0.032	0.250	0.000
Kaituna 5		0.000	1.083	4.000
Kaituna 6	3.573			
Kaituna 7	0.929			
Lake Aniwaniwa 1				0.163
Lake Tamurenui 1		0.000		
Maketu 1		0.000	0.000	0.000
Maketu 2		0.000	0.000	0.000
Matakana 1	1.429			
Matakana 4	0.539			
Matakana 5	0.008			
Matakana 6	0.193			
Matakana 7	0.000			
Matata 1		0.000	0.000	0.000
Matata 2		1.702	5.417	0.167
Matua 1				1.385
MJ1		0.000		
Ohiwa 1		0.000	0.000	0.000
Ohiwa 2		0.000	0.000	0.000
Ohiwa 3		0.000	0.000	
Ohiwa 4		0.000	0.000	0.000
Ohiwa 5		0.000	0.000	0.000
Opotiki 1		0.017	0.000	
Opotiki 2		0.000	0.000	
Rotopotaka 1				0.024
Rotopotaka 2				0.167
Sanctuary Point	0.786			
Tahuwhakatiki West 1	1.190			
Tarawera Cut 1		0.015	0.000	0.000
Thornton Lagoon 1			0.000	
Thornton Lagoon 2			0.000	
Toatoa Beach 1			0.000	
Toatoa Beach 2			0.000	
Waihi 1	5.060		1.071	13.833
Waihi 2	2.059	0.414	0.287	2.167
Waihi 3	2.255	0.000	0.904	0.000
Waihi 4		0.329	1.734	5.667
Waihi 5	1.943			
Waiotahe Estuary		0.000		0.013
Whakapoukorero South 1	0.108			
Whakatane Estuary 1			0.000	
Yatton Park 1	1.882	0.061	0.000	0.000
Average	1.836	0.284	0.578	0.867

Table 3. Matuku-hūrepo call index (calls/15min) for all listening stations grouped by site, 2018 to 2022. Annual average displayed at the base. Standard errors displayed for each site. Annual average and standard error displayed at base.

Index by Site	2018	SE	2020	SE	2021	SE	2022	SE
Athenree	0.629	0.172	0.148	0.197	0.000	0.000	0.667	0.667
Awaiti			1.247	0.359	2.407	0.836	1.417	0.543
Braemar Spring			0.886	0.301	1.560	1.086	4.167	0.477
Bregman WMR			0.044	0.033	0.580	0.237	0.000	0.000
Herema Road			0.000	0.000				
Hiwarau			0.000	0.000				
Jess Road			0.150	0.082	0.000	0.000		
Kaituna Wetland	2.377	0.101	0.307	0.082	0.947	0.166	3.267	0.777
Lake Aniwaniwa							0.163	0.065
Lake Tamurenui			0.000	0.000				
Maketu Estuary			0.000	0.000	0.000	0.000	0.000	0.000
Matakana Island	0.434	0.113						
Matata			0.851	0.164	0.985	1.239	0.083	0.083
Matua							1.385	0.268
Mary Jackson Reserve			0.000	0.000				
Ohiwa Harbour			0.000	0.000	0.000	0.000	0.000	0.000
Opotiki			0.008		0.000	0.000		
Rotopotaka							0.095	0.036
Sanctuary Point	0.786	0.172						
Tahuwhakatiki	1.190	0.197						
Tarawera Cut			0.015	0.237	0.000	0.000	0.000	0.000
Thornton Lagoon					0.000	0.000		
Toatoa Beach					0.000	0.000		
Waihi Estuary	2.829	0.176	0.248	0.154	0.895	0.135	5.417	1.499
Waiotahe Estuary			0.000	0.000			0.013	0.013
Whakapoukorero	0.108	0.045						
Whakatane Estuary					0.000	0.000		
Yatton Park	1.882	0.267	0.061	0.237	0.000	0.000	0.000	0.000
Average	1.836	0.059	0.284	0.043	0.578	0.042	0.867	0.122

4. 2018-2022 chart summaries:

Male bittern activity index in 2018 averaged 1.836 calls/15min in 2018 (±0.06, n=4995) (Figure 1; Table 3). When surveys restarted at an increased number of sites this activity index in 2020 averaged 0.284 calls/15min (±0.04, n=1809) rising to 0.578 (±0.04, n=1899) in 2021 again to 0.867 calls/15min (±0.12, n=472) in 2022 (Figure 1; Table 3). A chart of all wetland sites surveyed 2018-2022 is provided as an appendix at the end of the document (Figure 5).

Additional charts shown illustrate some changes at select wetlands that have identified significant male activity each year. Figure 2 shows 2018 to 2022 data for Kaituna Wildlife Management Reserve and Waihi Estuary. Sites show similar levels

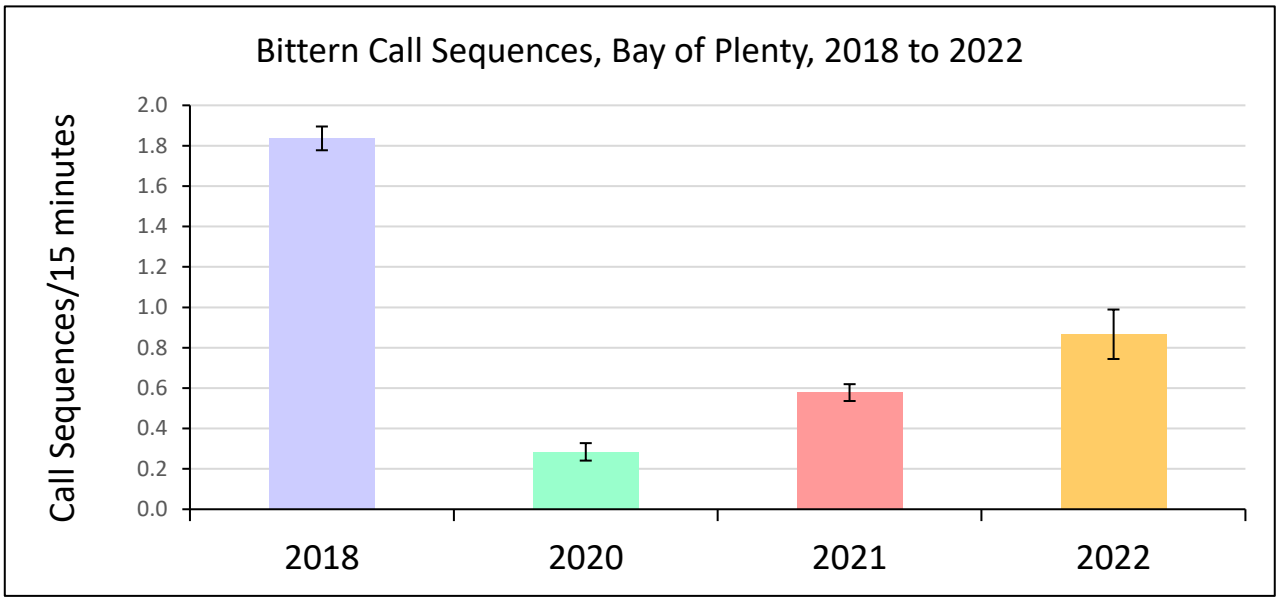

Figure 1. All data shown from Bay of Plenty Region between 2018 & 2022. Sequences per 15 minutes shown against year with standard error of the mean.

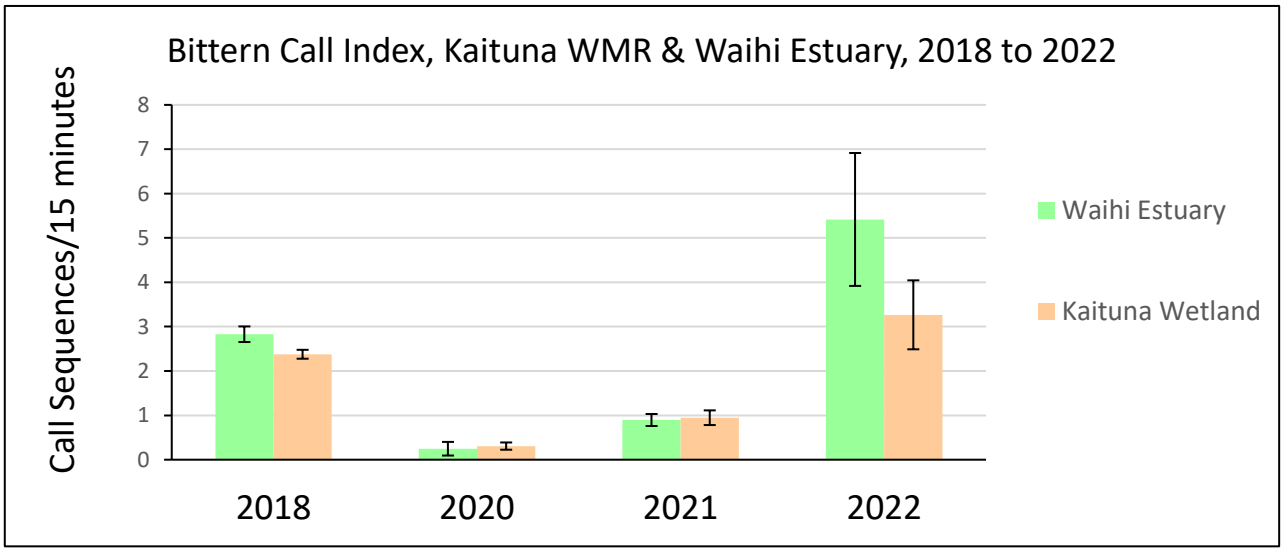

Figure 2. Summarised data from 2018 to 2022 for Kaituna Wetland Management Reserve and Waihi Estuary. Sequences per 15 minutes shown against year with standard error of the mean.

of activity varying by 0.452, 0.059, and 0.052 for years 2018, 2020, and 2021 respectively (Figure 2; Table 3). In 2022 activity at Waihi Estuary was on average 2.15 calls/15min higher than Kaituna WMR (Figure 2) which is near double the previous highest observation of bittern activity at Waihi Estuary in 2018.

Three new sites from the Tarawera River plain added in 2020, Bregman Wildlife Management Reserve, Braemar Spring (Tumerau), and Awaiti Wildlife Management

Reserve all observed active bittern. All stations from these sites, except Bregman WMR 1, observed an average index of at least 1 call/15mins during a survey season since 2020 (Figure 3). Awaiti 1 and Braemar Spring 1 each observed successive years with an average of ≥2 calls/15mins (Figure 3). There was an increase in activity at Braemar Spring (Tumerau) from 2018 to 2022 and a decrease in activity at Awaiti WMR in respective years (Figure 3).

Matatā is a site of two listening stations initiated in 2020 similarly located in the Tarawera River plain. Male bittern activity has only been observed at Matatā 1 with a peak index of 5.417 calls/15min (±1.964, n=12) in 2021 (Figure 4).

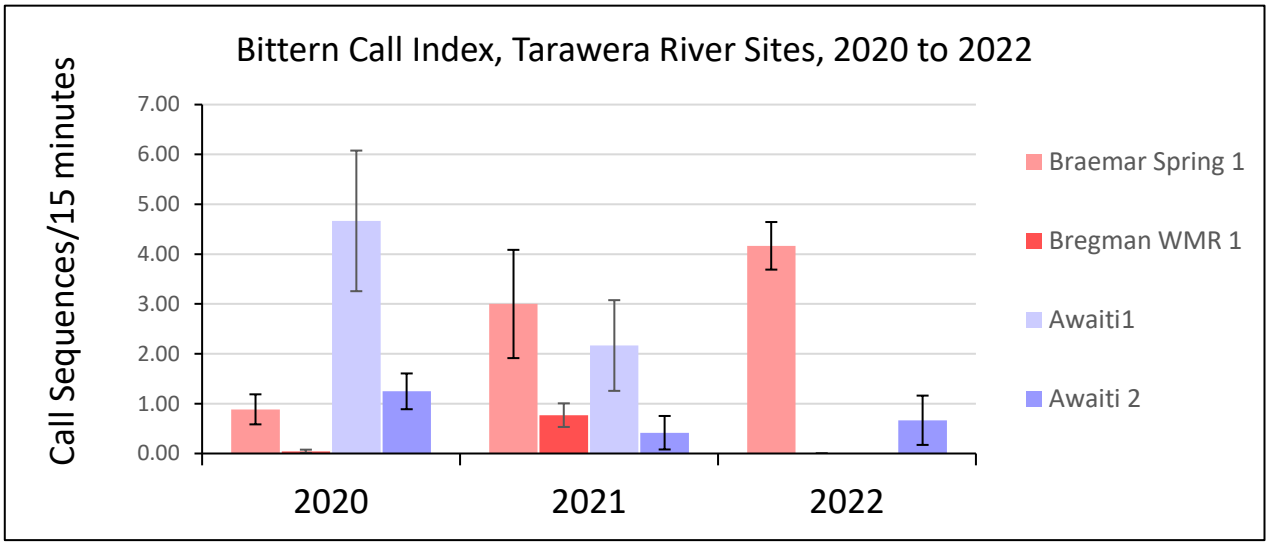

Figure 3. Summarised data from 2020 to 2022 for Braemar Spring (Tumerau), Bregman Wildlife Management Reserve, and Awaiti Wildlife Management Reserve sites. Sequences per 15 minutes shown against year with standard error of the mean.

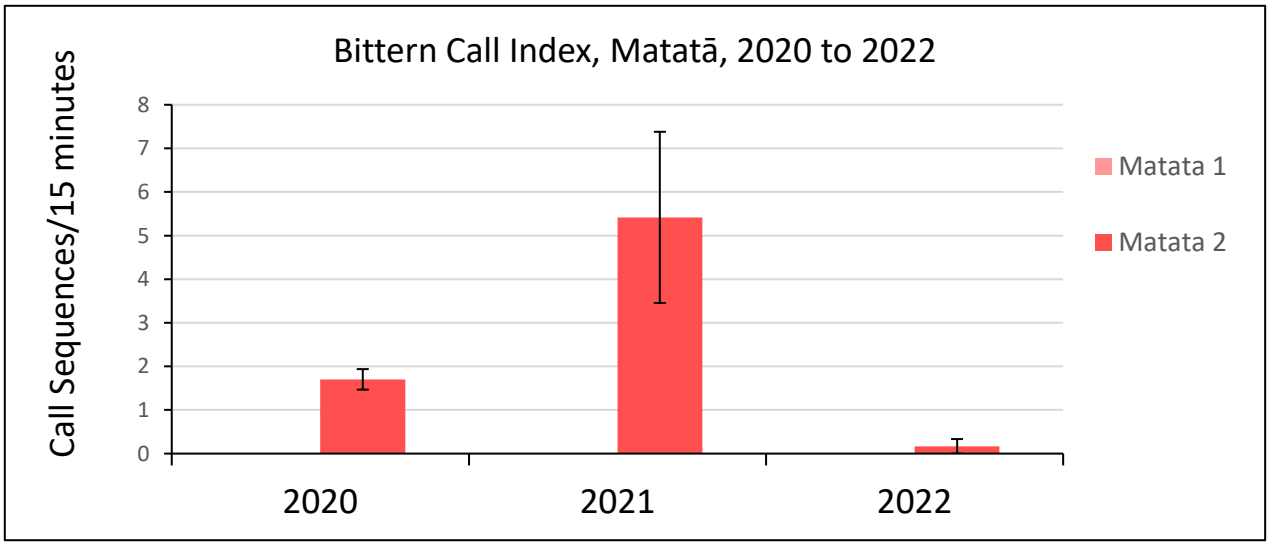

Figure 4. Summarised data from 2020 to 2022 for Matatā. Sequences per 15 minutes shown against year with standard error of the mean.

6. Discussion:

1. Summary:

Year three of region-wide surveys in the Bay of Plenty ended with a continuing upward trend in male matuku-hūrepo activity in the breeding season (Figure 1). The 2018 data should be considered carefully. Activity levels averaging 1.836 calls/15min result from eight monitored sites, of which two are some of the regions busiest for matuku calls (Table 2). Successive years have included the addition of inventory surveys to investigate new sites that within the wetland landscape matuku are possibly frequenting. An increase from 8 to 15 sites, 2018 to 2022, has revealed a wide wetland complex that matuku-hūrepo are utilising across the breadth of BOP. In 2020 11 of 18 sites observed matuku, in 2021 6 of 16, and 2022 10 of 15 (Table 3).

Environmental factors can influence and sometimes force matuku to change the temporal and spatial relationships with habitat. The timing in which birds initiate the breeding season can be delayed by heavy rain, as witnessed spring/summer 2022 by at least one month due to inundation of wetlands. Conversely, if a wetland is drier than average the birds will seek more desirable habitat to form territories within. It is possible that these shifts between sites are observed within this data set.

2. Water Levels and Bittern Movements:

In Figure 3 & 4 we see high levels of call activity at Awaiti, Braemar Spring and Matata 2 for 2020 & 2021. These sites sit in the Tarawera River floodplain close to the coast. For the 2021 breeding season this stretch of river peaked 1.535m in September in the peak-booming period, descending to 0.942m mid-December and then rising rapidly to 1.784m two weeks later[15]. These water levels appear sufficient to encourage increased matuku activity during this period on the river plain (Figure 3; Figure 4).

In 2022 an extreme weather event occurs in the North Island resulting in the Tarawera River water level surpassing 1.1m indefinitely, peaking to 2.414m in early-October[15]. This weather event is likely responsible for causing a dramatic loss in bittern activity for this region of survey sites near the coastline.

Braemar Spring Tumerau is a larger wetland space further upstream with considerable vegetated habitat. This is suited to matuku and likely acted as a refuge for breeding bittern even within these extreme weather events (Figure 3). Awaiti 2 also appears to indicate a

part of Awaiti that is similarly resistant to an extreme water event likely due to sitting ~2km from the river channel.

These instances of habitat-resilience are reminders of the environmental services that wetlands provide. Importantly for matuku, acting as refugia for breeding within a limited landscape of suitable habitat when extreme weather events occur.

Kaituna Wildlife Management Reserve and Waihi Estuary appeared to benefit from the additional rainfall events in 2022 (Figure 2). Average depth of the Kaituna River October 2021 was 0.608m peaking 1.376m whilst in 2022 the average was 2.945m and peaked 6.948m for October[15]. This extreme difference could have resulted in more preferable water depths across Kaituna WMR and Waihi Estuary for matuku-hūrepo breeding attempts in November/December.

3. Review of Sites:

There are several sites that remain free of consistent matuku-hūrepo observation over a two- to three-year period: Ōhiwa Harbour, Ōpōtiki Harbour, Tarawera Cut and Maketu Estuary. It could be that device locations are not quite appropriate for observing bittern at these sites or that bittern are much less frequent than previously expected, anecdotally or otherwise. The Maketu Estuary for example, is in-between Kaituna WMR and Waihi Estuary and exhibits a habitat much like the latter. Ohiwa Harbour is especially large as a site compared to most and modification of approach needs to be considered.

The four sites sitting along the Tarawera River continue to consistently observe encouraging male activity. When experiencing a landscape scale extreme weather event, the local population are able vary their habitat use and adapt to the conditions. There is a site reliance within this flood plain that should be maintained if not expanded upon. Listening station Matatā 1 continues to be quiet of matuku observations suggesting that the western end of Matatā lagoon is not attractive.

In 2022 two new inventory sites were assessed and observed matuku-hūrepo ~50km inland from Whakatane. Lake Aniwaniwa observed a handful of sequences across November and December. It is possible that the timing of male occupancy differed to the coastal sites, or the device location needs to be modified to better observe the site where bittern are located. Rotopotaka, a regenerative lake site ~2km NW of Kawerau, observed a similar

activity index to Lake Aniwaniwa (Table 2; 3). 2022 weather event considered; these sites may experience increased bittern activity in successive years. These sites should be repeated for a second year.

7. Recommendations:

1. **Adaptive Surveys:**

   Some spatial and temporal relationships between matuku and hydrological factors can be hypothesised early into this investigation. Such as along the Tarawera River sites, observing considerably changes in male matuku activity among sites during extreme river height changes. Successive years investigating matuku-hūrepo in this region should further a focus on these relationships. Impactful weather events are predicted to become more likely. Preparing an adapted methodology to ensure the tracking of bittern activity through these events should be considered. Example; delaying the deployment of devices if a weather event is predicted during spring like in 2022 (this happened to be the case for this investigation where 321 of 466 files analysed were within November & December).

   Conversely if weather events are not predicted, peak bittern booming should be expected during October. Surveys should be implemented as best possible to reflect this.

2. **Site Removal/Adjustments:**

   A discussion needs to be held as soon as possible to determine the effectiveness of stations in Ōhiwa and Ōpōtiki Harbours, Maketu Estuary, and Tarawera Cut. Maketu Estuary exhibits similar habitat to Waihi Estuary so it is anticipated that matuku would frequent it, reducing the site to one device may suffice or moving a device to the regeneration sites further to the west of the estuary area. Tarawera Cut site can be removed considering much of the river plain is surveyed nearby. Ōhiwa Harbour is a large site with up to five devices deployed in a season, this is possibly un-attainable for the long-term in its current format.

8. References:

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9. Appendix:

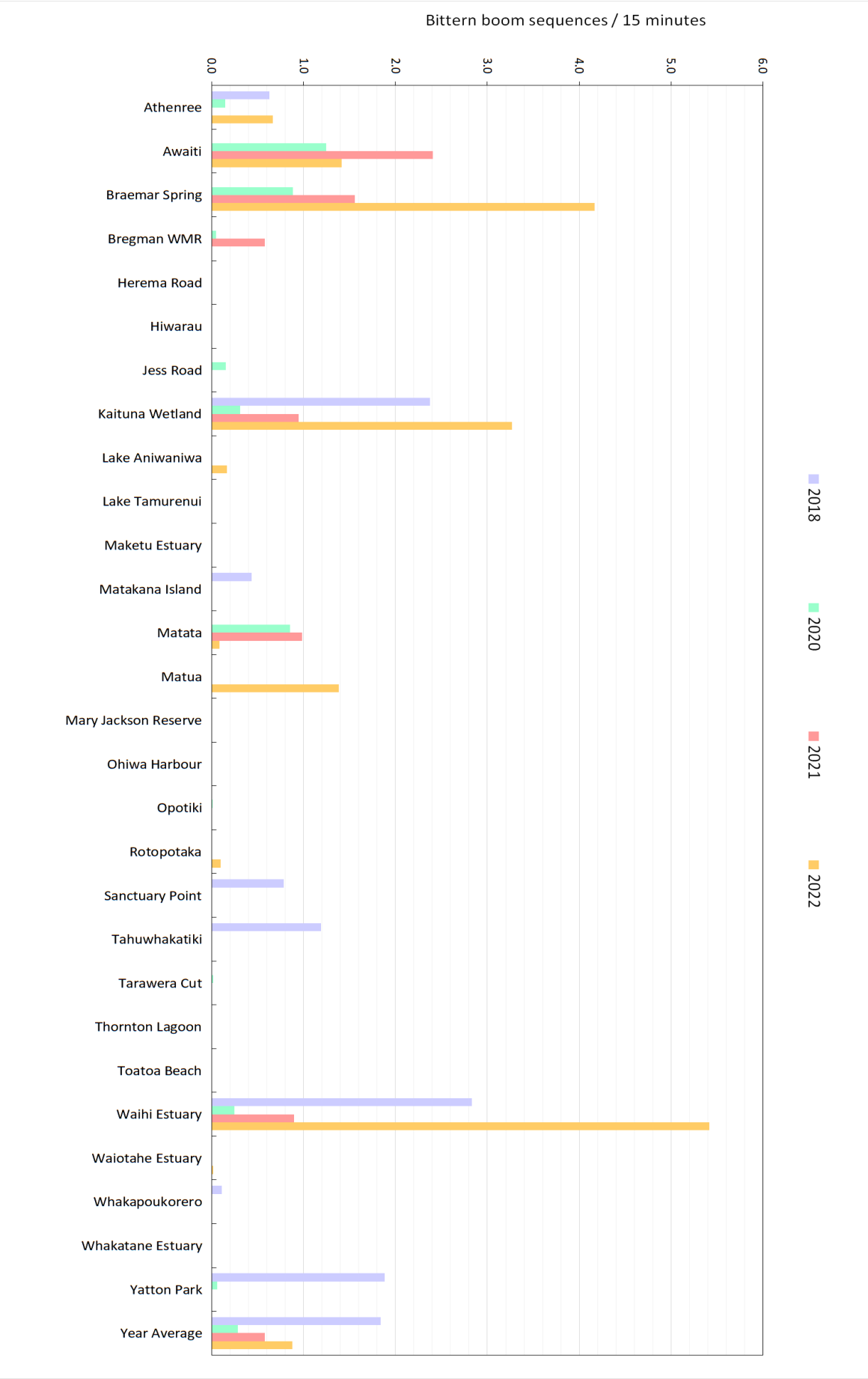

Figure 5. All wetland sites surveyed in Bay of Plenty from 2018 to 2022. Male matuku-hūrepo activity index shown as sequences/15minutes.