## Supplement

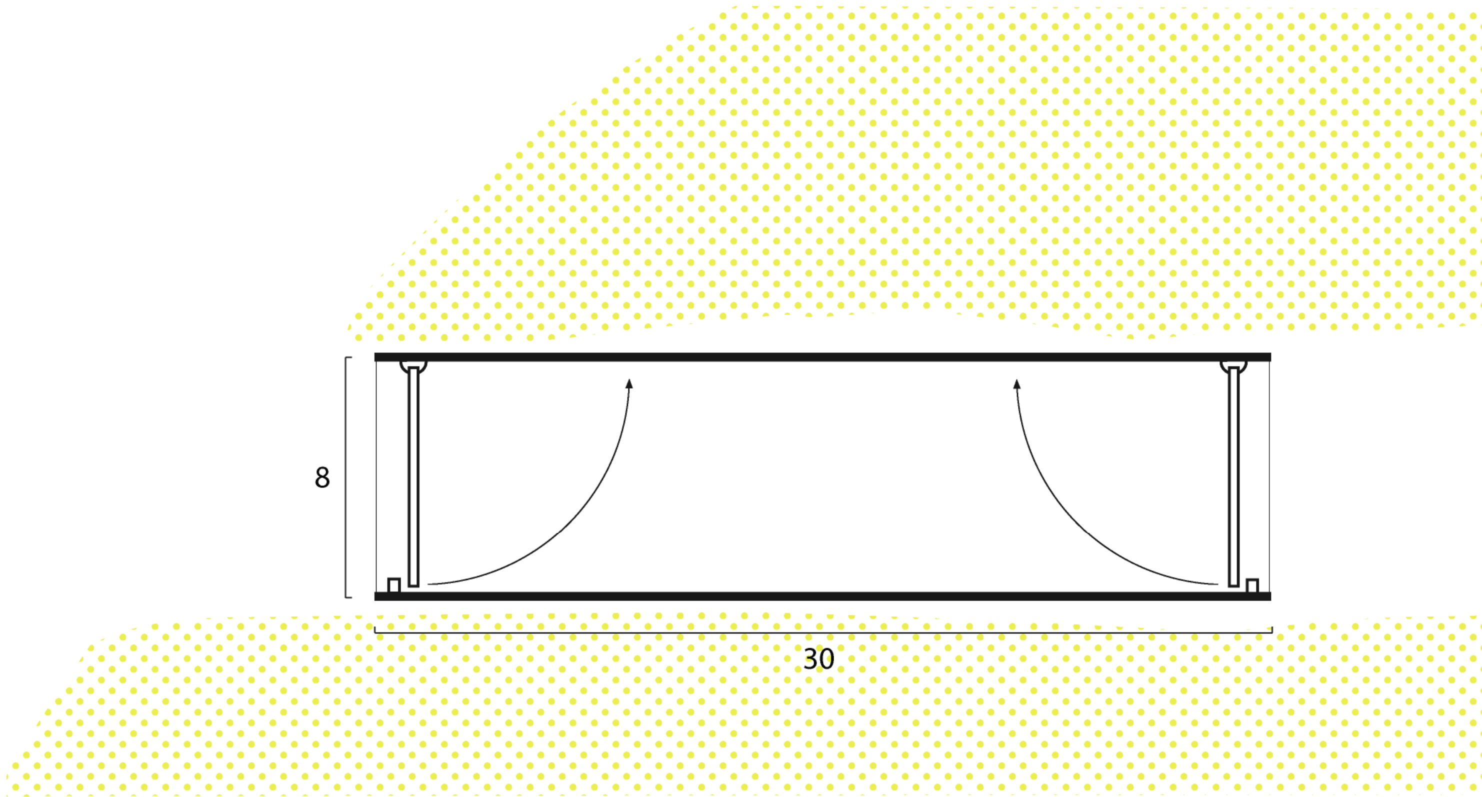


**Fig. S1.** Custom-made burrow trap to (re)capture tagged Whenua Hou Diving Petrels as they enter/exit their burrow. Dimensions are in cm. The main body of the trap consisted of a polyvinyl chloride (PVC) piping, while the one-way doors were made of acrylic. Hinges were constructed out of braided stainless-steel wire.

**Text S1.** Equations of movement models used in the net squared displacement (NSD) modelling in *MigrateR* (1.1.0; DB Spitz et al. unpublished), which allowed us to objectively identify presence and quantify timing in migratory movements in Whenua Hou Diving Petrels:

1. Residency model:
   $NSD = \gamma \times [1 - \exp(K \times t)]$,
   in which $\gamma$ is the mean NSD of all locations, $K$ is the logarithm of the rate constant, and $t$ is the time from start.
2. Nomadic model:
   $NSD = \beta \times t$,
   in which $\beta$ is a linear constant.
3. Dispersal model:
   $NSD = \frac{\delta}{1 + \exp\left(\frac{\theta_1 - t}{\varphi_1}\right)}$,
   in which $\delta$ is the distance between the two seasonal distributions, $\theta_1$ is the midpoint of the outbound migration, and $\varphi_1$ is the time required to complete 50-75% of the outbound migration.
4. Migration model:
   $NSD = \frac{\delta}{1 + \exp\left(\frac{\theta_1 - t}{\varphi_1}\right)} + \frac{-\delta}{1 + \exp\left(\frac{\theta_2 - t}{\varphi_2}\right)}$,
   in which $\theta_2$ is the midpoint of the homebound migration and $\varphi_2$ is the time required to complete 50-75% of the homebound migration.
5. Mixed-migration model:
   $NSD = \frac{\delta}{1 + \exp\left(\frac{\theta_1 - t}{\varphi_1}\right)} + \frac{-\delta \times \zeta}{1 + \exp\left(\frac{\theta_2 - t}{\varphi_2}\right)}$,
   in which $\zeta$ is a factor allowing an individual to return to a breeding distribution different than the original one.
6. Multi-range migration model:
   $NSD = \sum_{i=1}^{n} \frac{\delta_i}{1 + \exp\left(\frac{\theta_i - t}{\varphi_i}\right)}$,
   in which $n$ is the number of range transitions, $\delta_i$ is the distance between $i$ seasonal distributions, $\theta_i$ is the midpoint of migration $i$, and $\varphi_i$ is the time required to complete 50-75% of migration $i$. The number of range transitions for each individual was determined based on the number of peaks in the moving mean (window width = 3 days) of |ΔNSD| that exceeded the global mean by more than one standard deviation (DB Spitz et al. unpublished).

To delineate phenophases, we defined the onset of migratory movements when an individual was predicted to exceed 5% of the total distance travelled ($\delta_i$) and the conclusion of migratory movements when an individual was predicted to exceed 95% of the total distance ($\delta_i$).

**Table S1.** Estimates of intercepts ($\hat{\alpha}$ ± SE) and changes in the fixed-effects slopes ($\hat{\beta}$ ± SE) of Whenua Hou Diving Petrel movements. Intercepts and slopes are reported on the link scale. **Bold** indicates that $\beta$ ± 2 × SE does not intersect 0.

| Movement variable | Intercept | Breeding success | Sex | Year |
|---|---|---|---|---|
| Departure breeding distribution | $\hat{\alpha}$ = -1.89 ± 0.34 | **$\widehat{\beta_{success}}$ = 1.61 ± 0.22** | $\widehat{\beta_{female}}$ = -0.31 ± 0.20 | **$\widehat{\beta_{2018}}$ = 1.07 ± 0.32**<br>**$\widehat{\beta_{2019}}$ = 1.29 ± 0.35** |
| Arrival non-breeding distribution | $\hat{\alpha}$ = -1.62 ± 0.36 | **$\widehat{\beta_{success}}$ = 1.61 ± 0.23** | $\widehat{\beta_{female}}$= -0.20 ± 0.21 | $\widehat{\beta_{2018}}$ = 0.68 ± 0.35<br>**$\widehat{\beta_{2019}}$ = 0.87 ± 0.37** |
| Departure non-breeding distribution | $\hat{\alpha}$ = 0.08 ± 0.55 | $\widehat{\beta_{success}}$ = 0.16 ± 0.35 | $\widehat{\beta_{female}}$= 0.49 ± 0.32 | $\widehat{\beta_{2018}}$ = -0.56 ± 0.53<br>$\widehat{\beta_{2019}}$ = -0.44 ± 0.56 |
| Arrival breeding distribution | $\hat{\alpha}$ = -0.50 ± 0.56 | $\widehat{\beta_{success}}$ = 0.30 ± 0.36 | $\widehat{\beta_{female}}$= -0.05 ± 0.33 | $\widehat{\beta_{2018}}$ = 0.31 ± 0.54<br>$\widehat{\beta_{2019}}$ = 0.45 ± 0.58 |
| Length outbound migration | $\hat{\alpha}$ = 1.18 ± 0.50 | $\widehat{\beta_{success}}$ = 0.001 ± 0.33 | $\widehat{\beta_{female}}$= 0.36 ± 0.30 | **$\widehat{\beta_{2018}}$ = -1.58 ± 0.48**<br>**$\widehat{\beta_{2019}}$ = -1.52 ± 0.52** |
| Length of stay at non-breeding distribution | $\hat{\alpha}$ = -1.31 ± 0.42 | **$\widehat{\beta_{success}}$ = -1.27 ± 0.28** | $\widehat{\beta_{female}}$= 0.42 ± 0.27 | **$\widehat{\beta_{2018}}$ = -0.75 ± 0.37**<br>**$\widehat{\beta_{2019}}$ = -0.91 ± 0.41** |
| Length of homebound migration | $\hat{\alpha}$ = -0.43 ± 0.53 | $\widehat{\beta_{success}}$ = -0.01 ± 0.34 | **$\widehat{\beta_{female}}$= -0.66 ± 0.32** | $\widehat{\beta_{2018}}$ = 0.92 ± 0.49<br>$\widehat{\beta_{2019}}$ = 0.88 ± 0.53 |

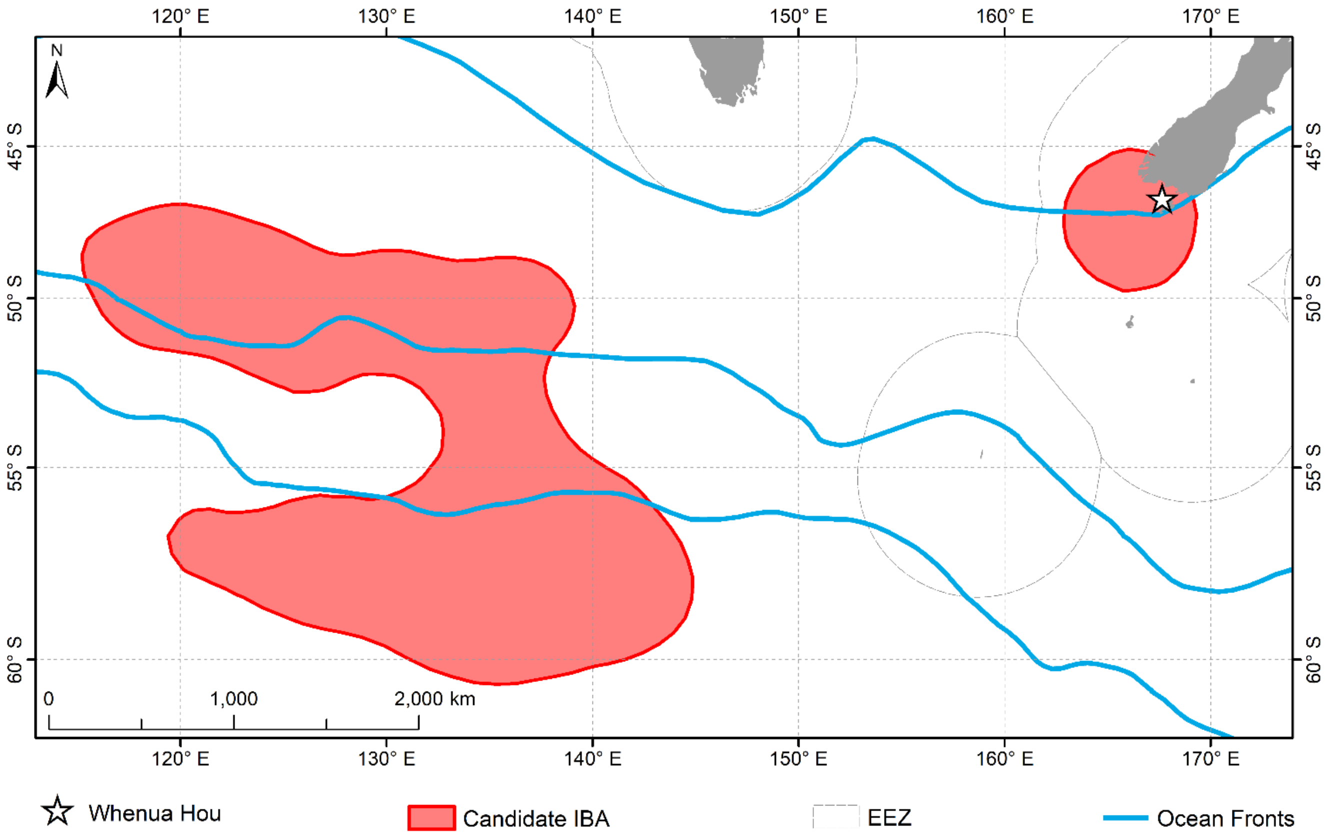


**Fig. S2.** Candidate marine Important Bird and Biodiversity Areas (IBAs) based on criteria A1 and A4ii triggered by breeding/non-breeding 50% utilization distribution isopleths of Whenua Hou Diving Petrels (based on tracking of 2.6, 9.7, and 7.0% of the world population in 2015/16, 2017/18, and 2018/19, respectively). Approximate location of Ocean Fronts based on Harris & Orsi (2006).