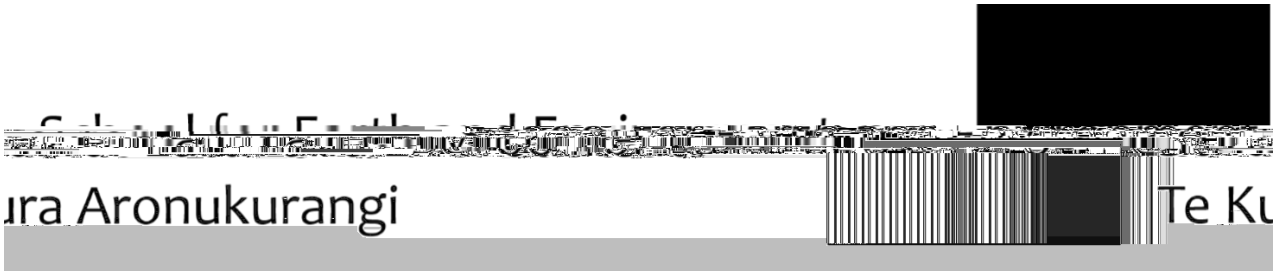
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Bar-tailed godwits (*Limosa lapponica baueri*) are native shorebirds that migrate

This report begins with a review of relevant literature focused on factors that may affect juvenile godwit settlement. The methods of the report are then explained, followed by the results and discussion. Limitations, recommendations, and future research focus areas are then identified, followed by a conclusion.

Literature around human disturbance, water quality, and climate change was reviewed. These findings highlight the importance of assessing the effects of human disturbance and environmental quality, as these are likely key drivers affecting juvenile godwit settlement at the estuary.

Adult godwit migration is a key variable that directly influences identification of juvenile godwits at the estuary. As there is no long-term dataset that focuses on the Avon-Heathcote Estuary, understanding how and when adults migrate relies on studies that focus on other estuaries around New Zealand (Battley et al., 2020).

Juvenile godwits reside in New Zealand until they reach adulthood (2 ς 4+ years old). After this, they migrate in March ς April each year to the Yellow Sea, where they stop to refuel before continuing on to Alaska (Battley et al., 2012; Choi et al., 202000088177.18 Tm0 g0 G[( )] TJETQq0.000

Flight initiation distance (FID) refers to the distance at which a bird begins escaping from disturbance (Navedo & Herrera, 2012). Glover et al. (2011) looked at 28 shorebird species in Victoria, Australia, and found they often have increased FIDs when in larger flocks, possibly because disturbance is detected earlier. Heavier shorebirds had greater FIDs (Glover et al., 2011), suggesting godwits may be more readily disturbed than smaller species. Flock composition can also affect FID. Both knots (*Calidris* spp.) and plovers (*Charadrius* spp.) 8(r)-4( )-2(al. 1 3. Darwin, Australia, had greater FIDs in single species flocks compared to mixed s na2[6(e)-4(in)5(c)6(r)-4(eas

sedimentation patterns and estuary biota (Zeldis et al., 2011). This raises concerns about the impacts on godwits, other organisms, and vegetation in the estuary.

Overall, pollutants and excess nutrients can affect sediment and water quality, negatively impacting ecosystems (Lau, 2000; Ren et al., 2014). Water and sediment quality are relevant to juvenile godwit settlement patterns as they can affect the quality and availability of food sources for godwits. Therefore, they were considered in this project as factors that could

present at the Avon-Heathcote Estuary. The survey only includes juveniles as it is conducted in winter when the adults are overseas (Battley et al., 2011).

Figure 2: Trends in juvenile bar-tailed godwit numbers over winter at the Avon-Heathcote Estuary between 2000-2021. Data obtained from the Ornithological Society of New Zealand.

Figure 3 shows the different locations of juvenile godwits sightings at the estuary between 1997-2019 and in June-August 2021. Sightings have a higher density around three broad areas of the estuary. One cluster is located to the south-east of the estuary, at the tip of Southshore Spit (Figure 3). A second cluster is found at the north of the estuary, around

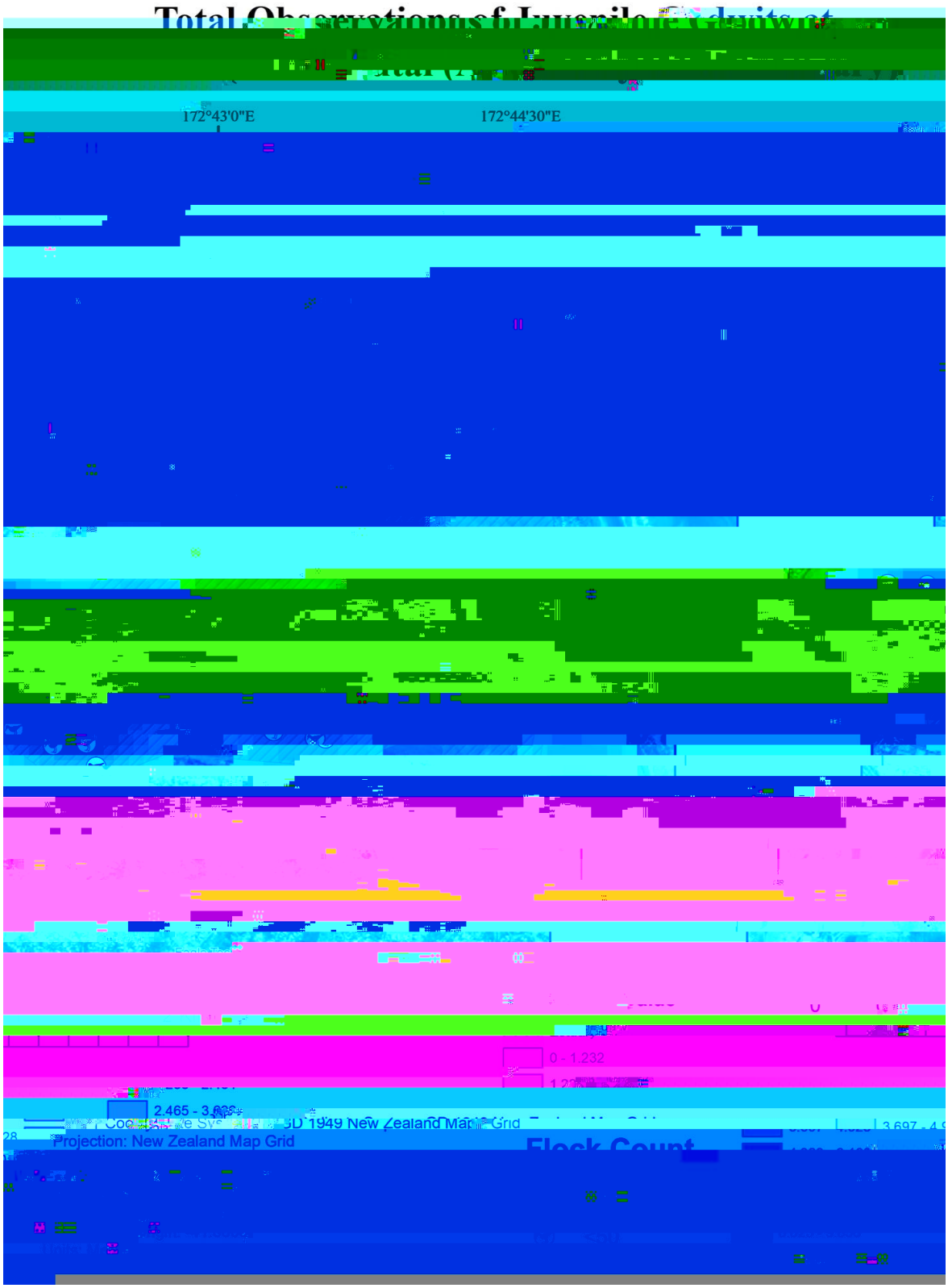

Figure 3: A kernel density map of juvenile bar-tailed godwit observations at the Avon-Heathcote Estuary, based on primary observations and secondary data obtained from eBird.

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