WATERBIRDS IN
RICHARDSON BAY

Assessing Rafting Waterbird Usage in Richardson Bay-2026

Habitat Monitoring



Audubon CALIFORNIA

Waterbirds Rafting in Richardson Bay
Photo: Paige Fernandez

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Waterbirds Rafting in Richardson Bay
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Assessing Rafting Waterbirds in Richardson Bay

Audubon's Role

Richardson Bay Audubon Center & Sanctuary has been a part of the Marin County community since 1957. Staff are the stewards and protectors of a 900-acre subtidal waterbird sanctuary within the great waters of Richardson Bay. Furthermore, over the last 30 years, Audubon California's expertise in environmental engagement, habitat restoration, and waterbird conservation has helped protect countless acres throughout the greater San Francisco Bay.

Richardson Bay is critically important to tens of thousands of diving ducks, grebes and other waterbirds who rely on the bay for roosting and feeding each winter season. During the winter months, Richardson Bay teems with Bufflehead, Ruddy Ducks, Lesser and Greater Scaup, Western and Horned Grebes, Double-crested Cormorants and other wintering waterbirds. Richardson Bay is also well known for its annual herring runs that are an important local fishery providing important food for birds and people. There is growing concern that the long-term decline in bird numbers as well as herring in Richardson Bay and other parts of San Francisco Bay is linked to the decline in native eelgrass beds.

The purpose of this paper is to support Richardson Bay Regional Agency's Eelgrass Protection and Management Plan[1] as well as the Richardson Bay Regional Agency project: Collaboratively Restoring Eelgrass in Richardson Bay to Improve Water Quality through the synthesis of data gathered from November 2024 to March 2025 on the usage patterns of rafting waterbirds. All data is compared to previous years' studies conducted by Audubon California staff.

Goals

Audubon's primary goal of the drone surveys was to gather an additional year of seasonal data on rafting waterbird usage in Richardson Bay.

This data was added to previous sets collected during the 2020, 2021/22, 2022/23, 2023/24, and 2024/25 monitoring seasons. Subsequently, we are hoping this data can be used to learn where rafts of waterbirds are frequently observed and how this possibly relates to the location of the eelgrass beds. Finally, data gathered during the surveys will support the Richardson Bay Regional Agency project: Collaboratively Restoring Eelgrass in Richardson Bay to Improve Water Quality in addition to the continued support of the Eelgrass Protection Zone noted in Richardson Bay Regional Agency's Transition Plan[2].

As an Audubon Important Bird Area, Richardson Bay is critical habitat for wintering waterbirds and is home to the second largest eelgrass bed in San Francisco Bay. Therefore, gathering rafting waterbird data supports the overall conservation goals of Audubon California and the Richardson Bay Audubon Center & Sanctuary.

Study Methodologies

Study methodology was replicated from 2020 data collection process. Drone-based waterbird surveys were conducted by FAA Part 107 licensed Audubon staff six times during the wintering season. Survey dates were December 3, 2025; January 15, 2026; January 29, 2026; February 15, 2026; and March 11, 2026, and March 16, 2026. Captured photographs covered approximately 1,700 bay acres, resulting in just under 900 photographs per survey. These images were analyzed for the presence of rafting waterbirds. The shift in analysis methodology first performed during the 2023/2024 season was replicated again for the 2025/2026 season- all birds in all images were counted.

Paige Fernandez, Audubon California's San Francisco Bay Program Manager (based out of the Richardson Bay Audubon Center & Sanctuary) supervised all drone flights. Imagery analysis was performed by Kris Hung and Kate Brewster, Richardson Bay Audubon Center & Sanctuary's Community Conservation Fellows, and evaluated by Fernandez. Drone surveys complied with all FAA rules and regulations.

Results

Audubon staff manually analyzed just over 4,500 drone images taken across six surveys from December 2025 to March 2026.

Imagery from the 2025/2026 season contained many more images with rafts (254) when compared to the 2024/2025 season (171), the 2023/2024 season (150), and the 2022/2023 season (188). However, there were few very large rafts in the 2025/2026 season- with only two rafts containing over 1000 birds.

From a qualitative perspective, Audubon staff noted that during the 2025/2026 season, waterbirds were slower to populate in Richardson Bay compared to previous years. After speaking with colleagues in other parts of the Pacific Flyway, we believe this may have occurred due to delayed freezing of lakes along the northern portion of the migration routes. The freezing of lakes and interior bays along the Pacific Flyway is one cue for waterbirds to continue their migration south to stopovers and wintering areas like Richardson Bay. This change in arrival time could account for the shift in raft size, but the exact reason is unknown at this time.

Unlike previous years, images show that waterbird rafts were frequently observed in the western portion Richardson Bay, in addition to the northern and eastern shorelines (Figure 1). Aligning with raft locations, statistically calculated hotspots were most often observed along the western and northern shorelines with few occurring on the eastern shoreline (Figures 2a, 2b). The largest rafts were observed in western and southeastern corner of Richardson Bay- likely due to the capture of waterbird response to a herring run (Figures 3a, 3b). These trends become apparent when counts across all 2025/26 surveys are overlayed (Figure 3c) and can be compared to previous years in Figures 6c and 9c.

During the 2024/2025 season, images show waterbird rafts and associated statistically calculate hot spots were most frequently observed near the northern and eastern shorelines of Richardson Bay, within

Richardson Bay Audubon Center's sanctuary waters and less frequently observed utilizing the western portion of Richardson Bay (Figure 4, 5). In addition, several medium-sized rafts were also observed in the waters between Sausalito and Belvedere (Figures 6 a, 6b). These trends become apparent when counts across all 2024/25 surveys are overlayed (Figure 6c). During the 2024/2025 season, there was greater utilization of the western portion of Richardson Bay compared to the 2023/2024 season (Figure 9c) but not as much as 2025/2026 season (Figure 6c).

During the 2023/2024 season, waterbird rafts, and associated statistically calculated hot spots, were most frequently observed near the northern and eastern shorelines of Richardson Bay, within Richardson Bay Audubon Center's sanctuary waters (Figure 7, 8 a, 8b). Several rafts were also observed in the waters between Sausalito and Belvedere; these rafts contained the majority of the largest rafts of waterbirds (Figure 9a, 9b). Waterbirds were rarely photographed utilizing the western portion of Richardson Bay. These trends become apparent when counts across all 2023/24 surveys are overlayed (Figure 9c).

During the 2022/23 monitoring season, waterbird rafts were most frequently observed near the northern and eastern shorelines of Richardson Bay, within Richardson Bay Audubon Center's sanctuary waters. Few rafts of waterbirds were observed between Sausalito and Belvedere with the exception of the survey completed on 2/8/23 when it is believed that we captured imagery of a herring run (Figure 10). Waterbird rafts closer to the northern and eastern shorelines of Richardson Bay tended to contain a higher number of birds (Figure 11, 12).

During the 2021/2022 monitoring season, waterbird rafts were most frequently observed near the northern and eastern shorelines of Richardson Bay, within Richardson Bay Audubon Center's sanctuary waters. Very few rafts of waterbirds were observed between Sausalito and Belvedere (Figure 13). Waterbird rafts closer to the edges of the bay tended to contain a higher number of birds compared to rafts closer to the middle of the bay (Figures 14, 15).

During the first season of monitoring in 2020, waterbirds consistently gathered near the coastline along the northeastern most edge of Richardson Bay (Figure 16). Rafts were frequently observed in the waters between Sausalito and Belvedere where it was not uncommon to observe rafts around boats anchored out. Waterbird rafts closer to the middle of the bay tended to contain a higher number of birds compared to rafts closer to the coast (Figure 17).

Major Takeaways and Limitations

The primary goal of these surveys are to display the locations within Richardson Bay that are most frequently used by waterbirds. This was done by combining data collected over 5 surveys in 2020 and 6 surveys during 2021/2022, 2022/2023, 2023/2024, 2024/25, and 2025/26 monitoring seasons. The overall goal is not to assess population trends.

As a side note for this particular season of monitoring, during the middle of the season, we abruptly and unexpectedly lost access to the launch area used to survey the southern portion of Richardson Bay. We were able to quickly locate an alternate launch area that would still capture the majority of the bay imaged from the previous launch location. Despite losing images from a very small area of the bay that is no longer covered, that location rarely, if ever, hosted rafts of waterbirds in any of the previous surveys. As a result of this necessary survey location change, flight plans after 01/29/2026 are different when compared to previous years. This is shown by comparing the dots on the heat maps in Figure 2a to 2b, which indicate all image locations.

Additionally, exceptionally persistent bad weather this winter resulted in the cancellation of many of our scheduled surveys, especially in early winter. As a result, the partial survey flown on 01/29/2026 was included in the analysis and image locations are exemplified in Figure 2a. This should be considered when analyzing figures and comparing data from this year to previous years. Had we not included this survey, the next possible date to survey would have been flown in mid to late-April, which is after the vast majority of the waterbirds had already begun their migration north.

Overall, waterbirds continued to be frequently observed in the shallow waters along the northern and eastern shorelines of Richardson Bay. These locations tend to have calmer waters where birds can rest out of the wind and waves. Occasions when rafts were observed in the middle and deeper waters of Richardson Bay were likely instances where the birds were responding to fish spawning events. These rafts of waterbirds also often tend to contain the largest number of birds. Fish entering Richardson Bay would naturally flow along the central spine of the Bay, eventually ending up within the eelgrass beds. Birds were less frequently observed in the western and central portion of Richardson Bay. As an important note, waterbird surveys are scheduled weeks in advance and are not reactively surveyed when Pacific Herring (or other fish species) are actively spawning in Richardson Bay. Differences between years can be partially explained by the fact that surveys conducted within a monitoring year may, by chance, capture more or fewer bird responses to herring spawns than surveys conducted in other years. It is also possible the 2025/2026 surveys captured fewer bird responses to herring spawn events compared to the previous year's resulting in a smaller number of very large rafts observed.

The methodological shift that took place during the 2023/2024 season analysis was repeated for the 2025/2026 analysis. More data was extracted from images collected by including counts of all waterbirds in all images instead of only images that contained rafts. This shift provided an additional layer of data when compared to previous years and produced more meaningful heatmaps of waterbirds rafting across Richardson Bay. Care should be taken when comparing this year's data to data collected prior to the 2023/2024 seasons due to the differing methodology used to create the heat maps and the concentric circle count maps.

The figures on the following pages highlight locations of rafting waterbirds at a moment in time. They are not indicative of comprehensive waterbird populations or usage of Richardson Bay across a single day or season. Due to the fact each survey can take up to 8 hours to complete, it must be assumed waterbirds are moving locations throughout the survey window. Therefore, it is difficult to completely count or photograph all locations waterbirds are rafting or prevent recounts of the same bird on each survey date.

References

1. Lesberg, R.S. 2021. Richardson Bay Regional Agency: Richardson's Bay Eelgrass Protection and Management Plan. Coastal Policy Solutions (Document No. 0721). Vallejo, CA
2. Richardson Bay Regional Agency: Transition Plan. Adopted June 11, 2020

Maps

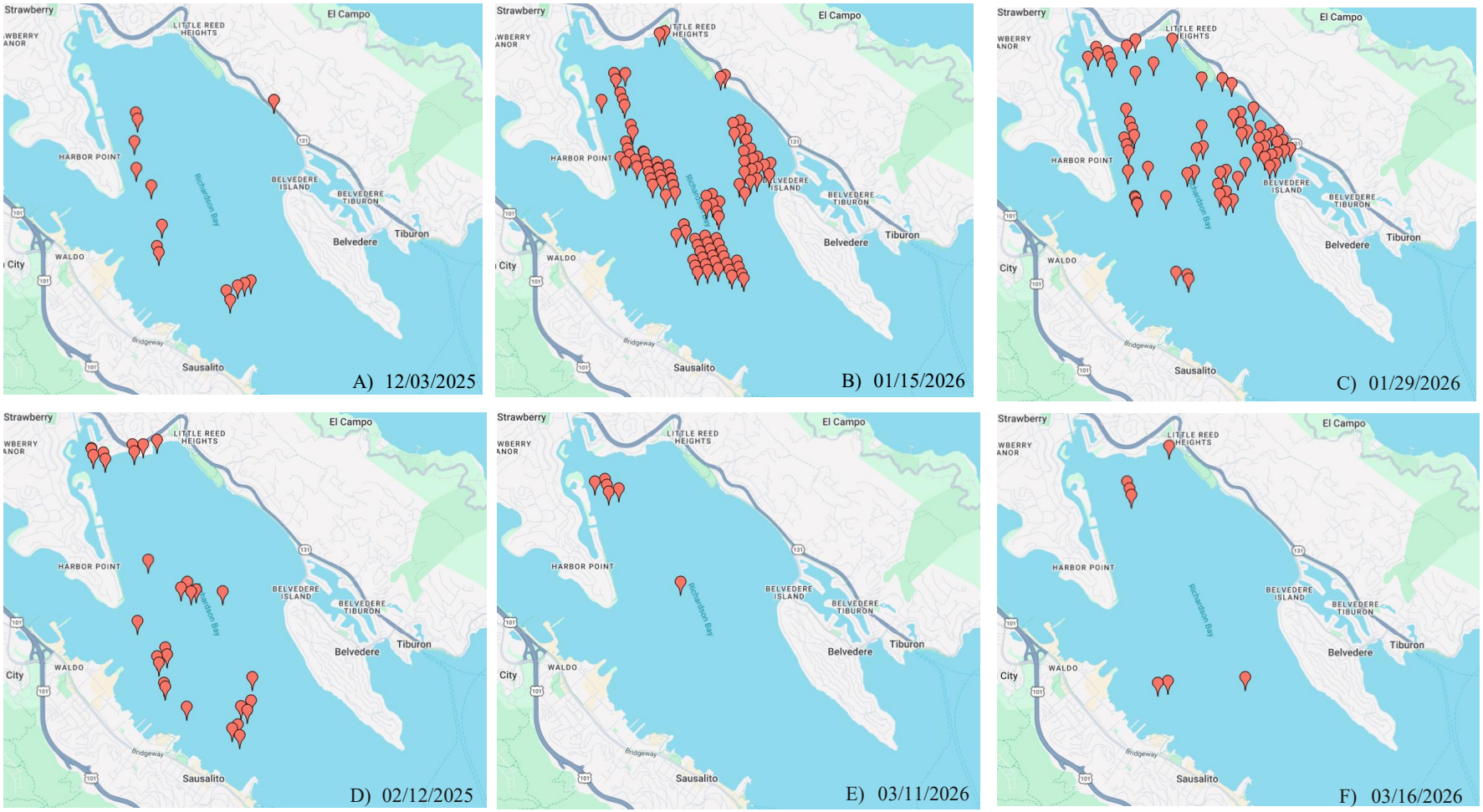


Figure 1. Locations of rafting waterbirds in Richardson Bay from December 2025 to March 2026. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.) Take note that the survey completed on 01/29/26 was partially flown.

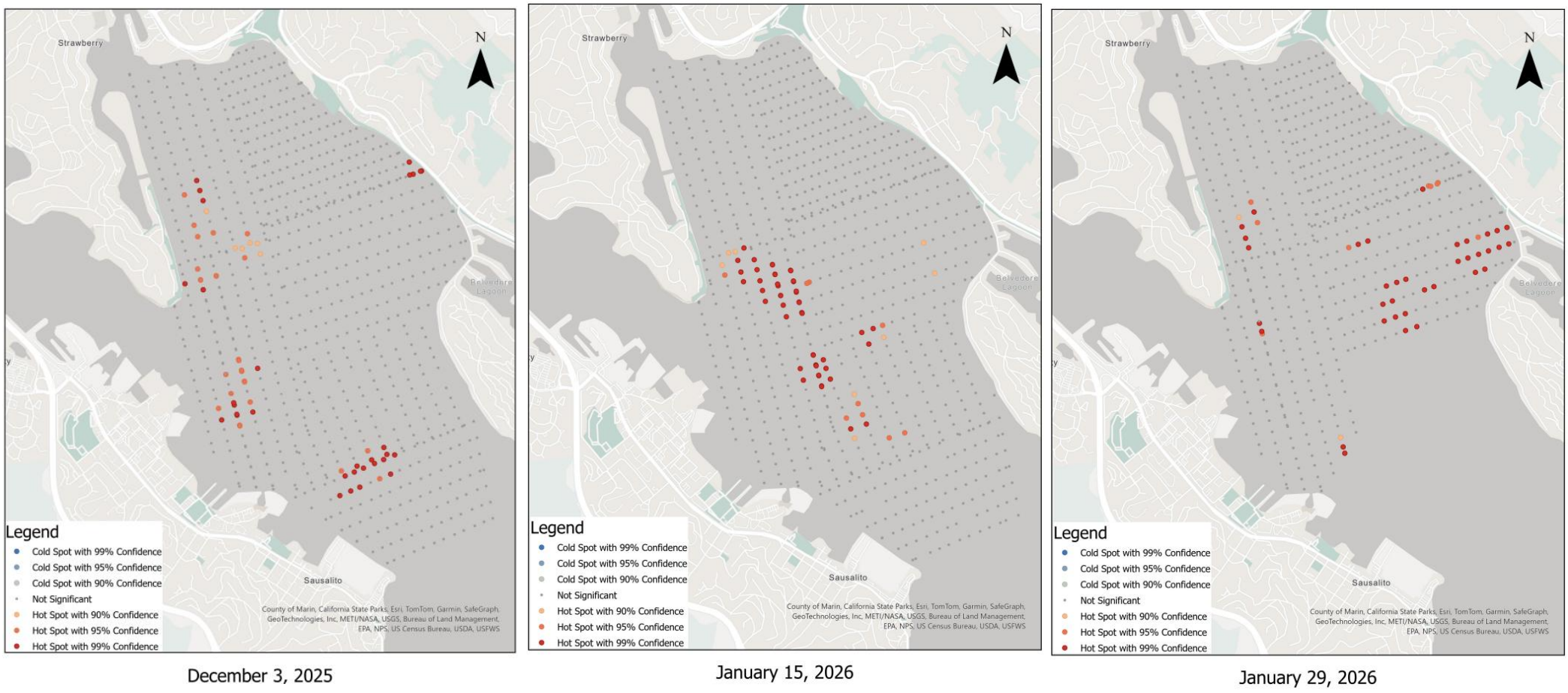


Figure 2a: Rafting waterbird heat maps of Richardson Bay across 2025-2026 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds. Take note that the survey completed on 01/29/26 was partially flown.

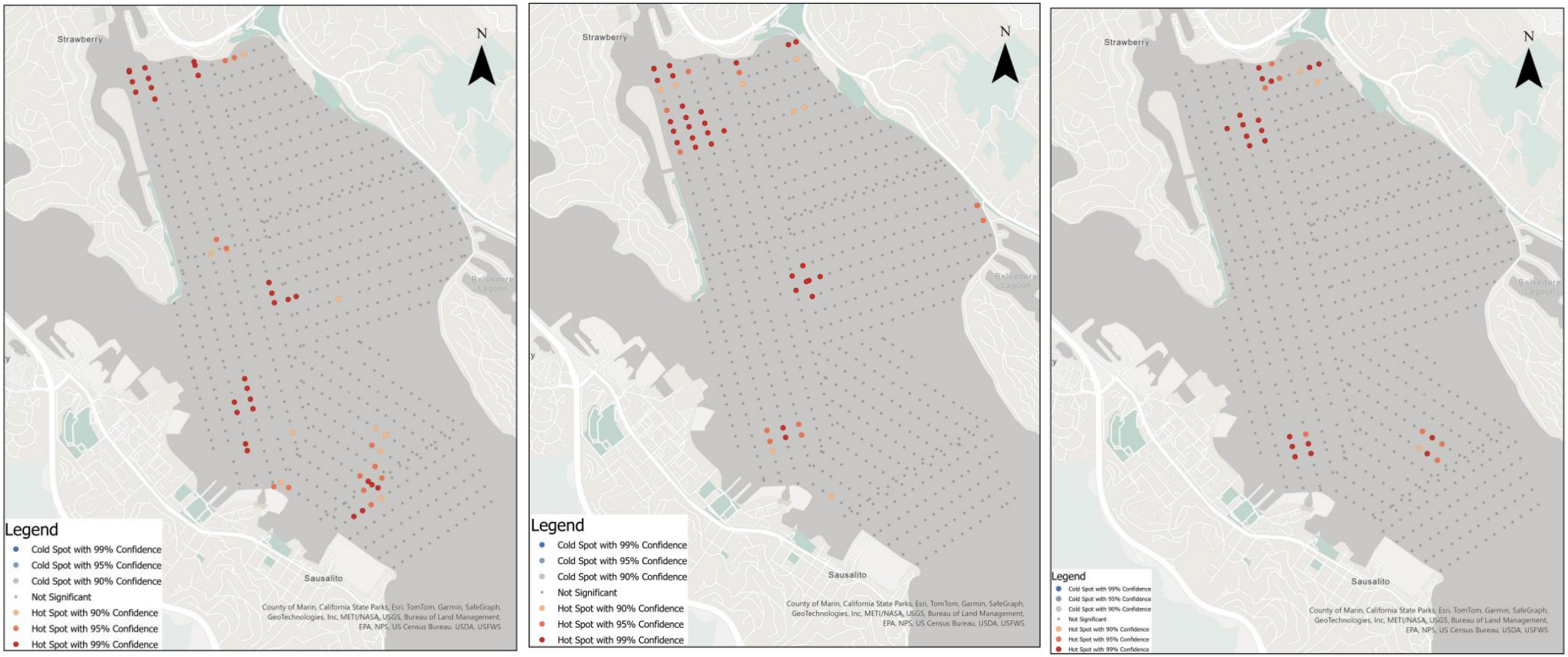


Figure 2b: Rafting waterbird heat maps of Richardson Bay across 2025-2026 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds. Take note of altered flight path after 01/29/26 survey.

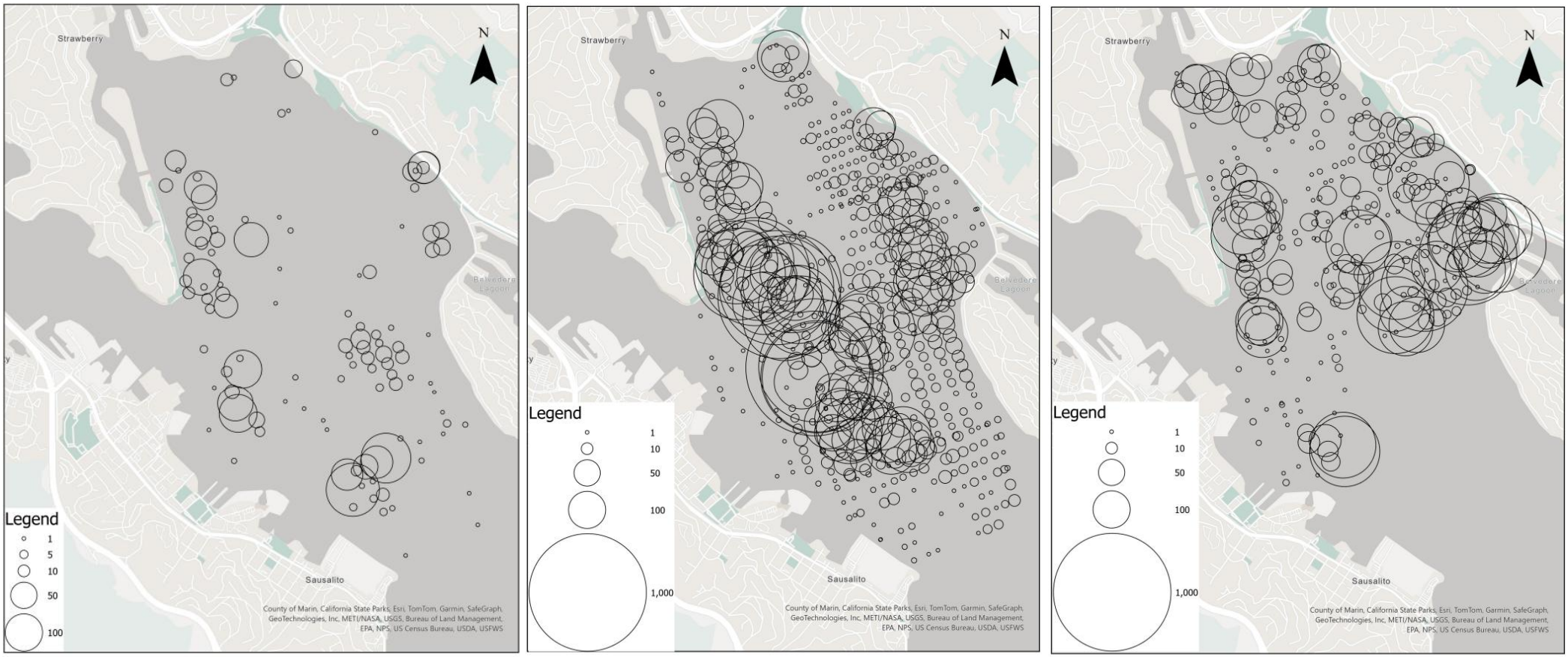


Figure 3a: Rafting waterbirds in Richardson Bay across 2025-2026 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed. Take note that the survey completed on 01/29/26 was partially flown.



Figure 3b: Rafting waterbirds in Richardson Bay across 2025-2026 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.



Figure 3c: Rafting waterbirds in Richardson Bay across all 2025-2026 surveys. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.



Figure 4. Locations of rafting waterbirds in Richardson Bay from November 2024 to March 2025. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.)

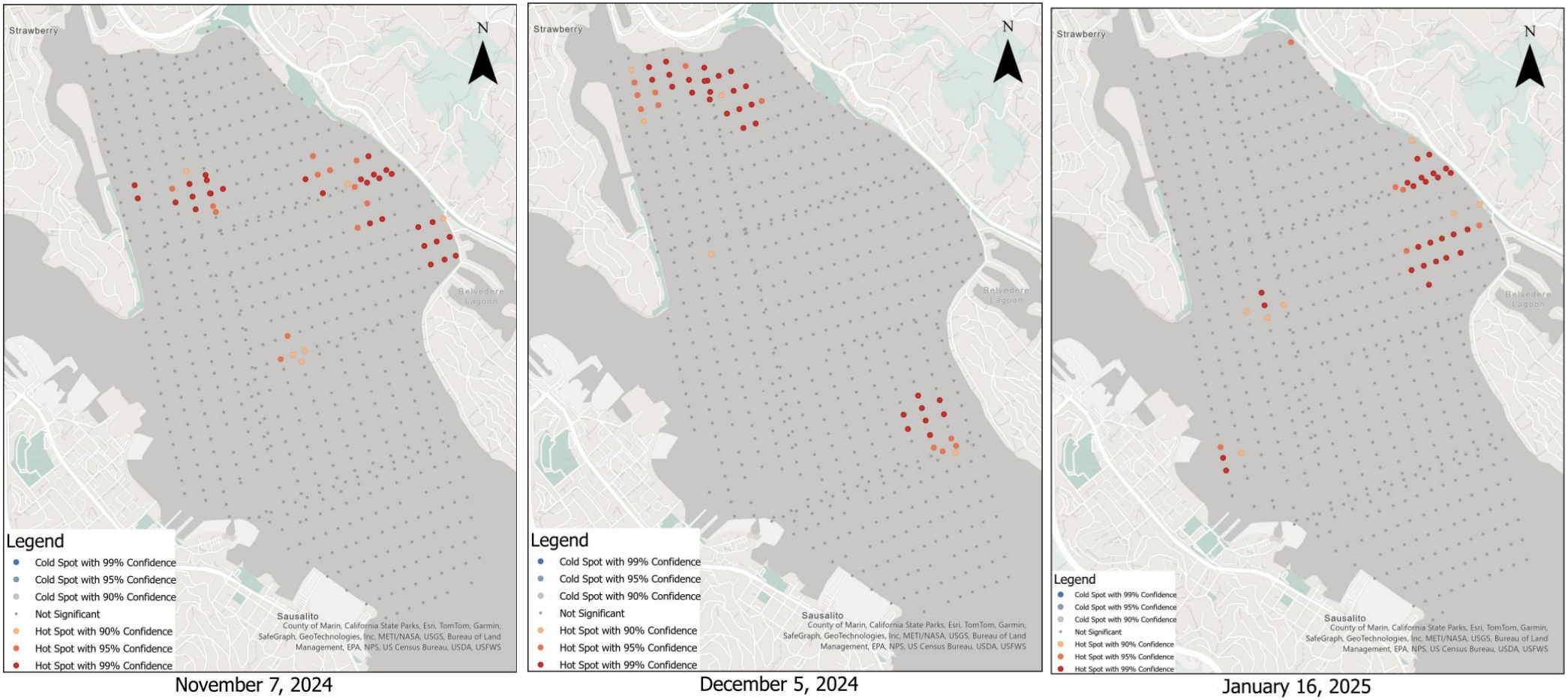


Figure 5a: Rafting waterbird heat maps of Richardson Bay across 2024-2025 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.

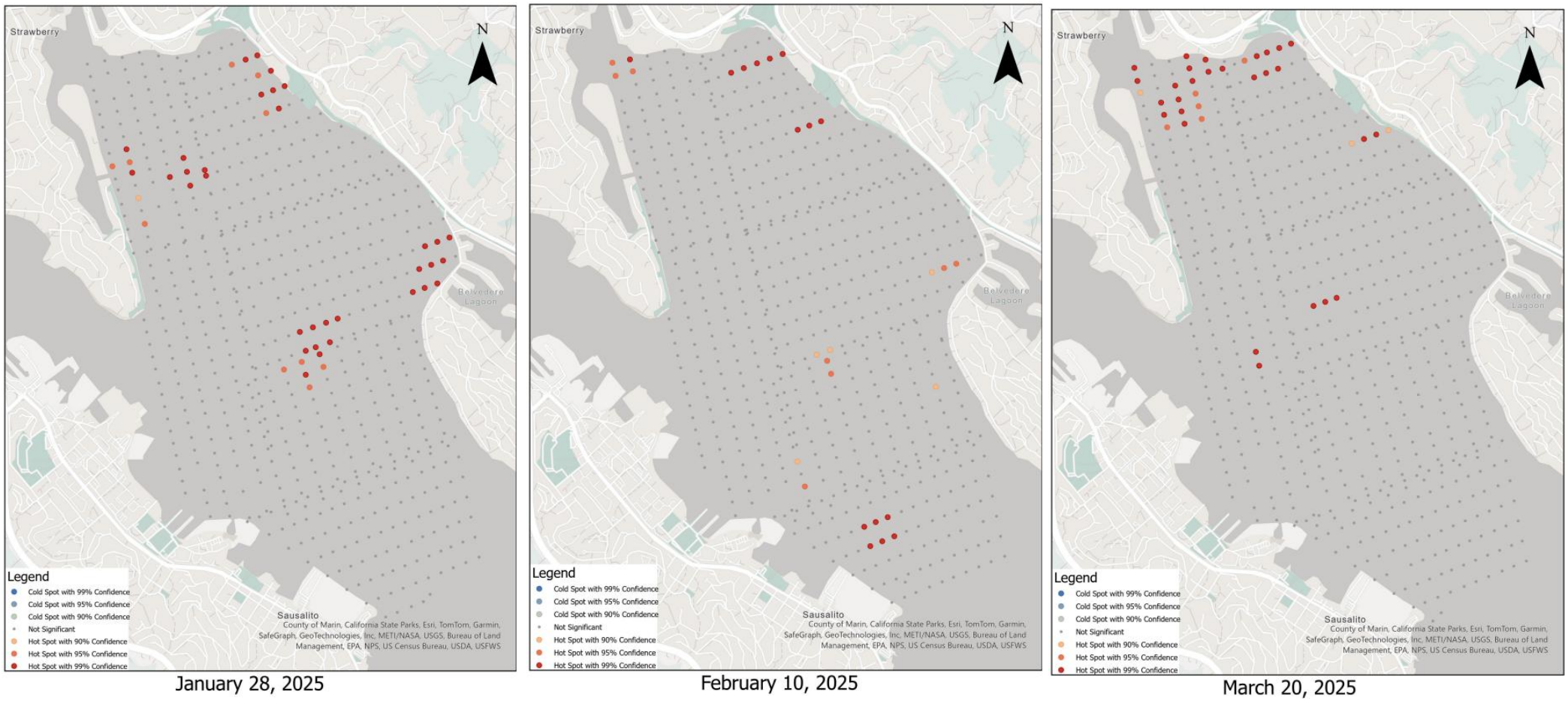


Figure 5b: Rafting waterbird heat maps of Richardson Bay across 2024-2025 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.

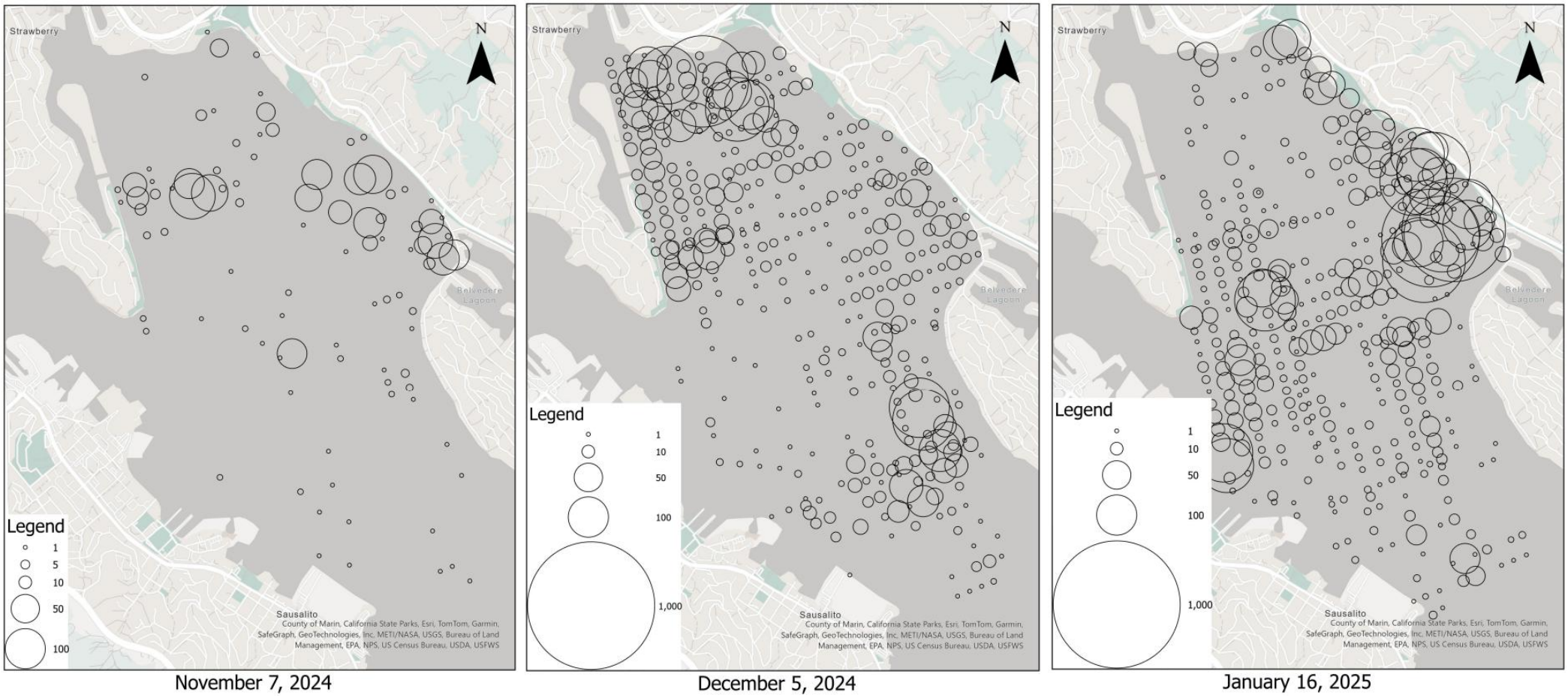


Figure 6a: Rafting waterbirds in Richardson Bay across 2023-2024 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.

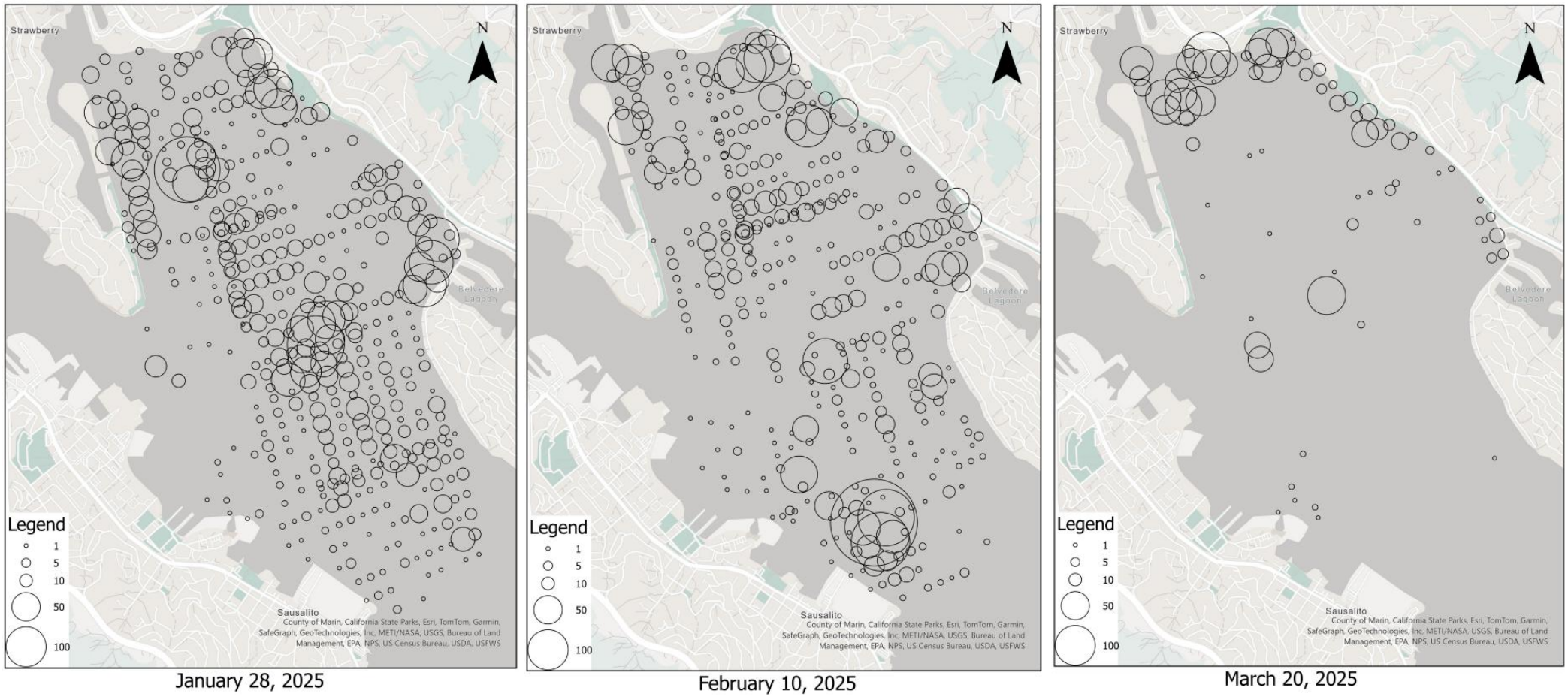


Figure 6b: Rafting waterbirds in Richardson Bay across 2023-2024 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.

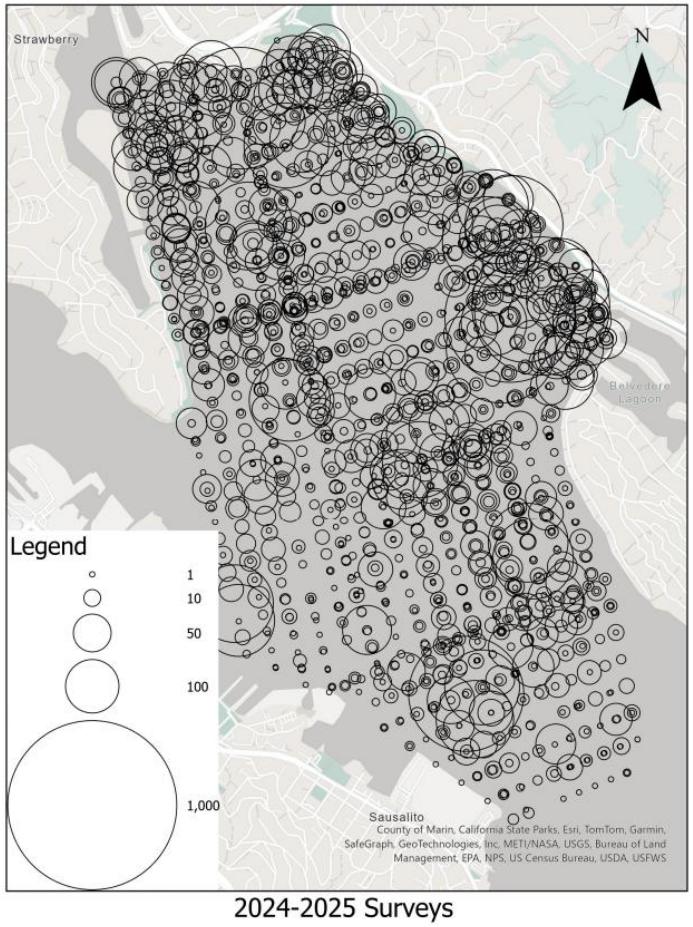


Figure 6c: Rafting waterbirds in Richardson Bay across all 2024-2025 surveys. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.



Figure 7. Locations of rafting waterbirds in Richardson Bay from November 2023 to April 2024. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.)

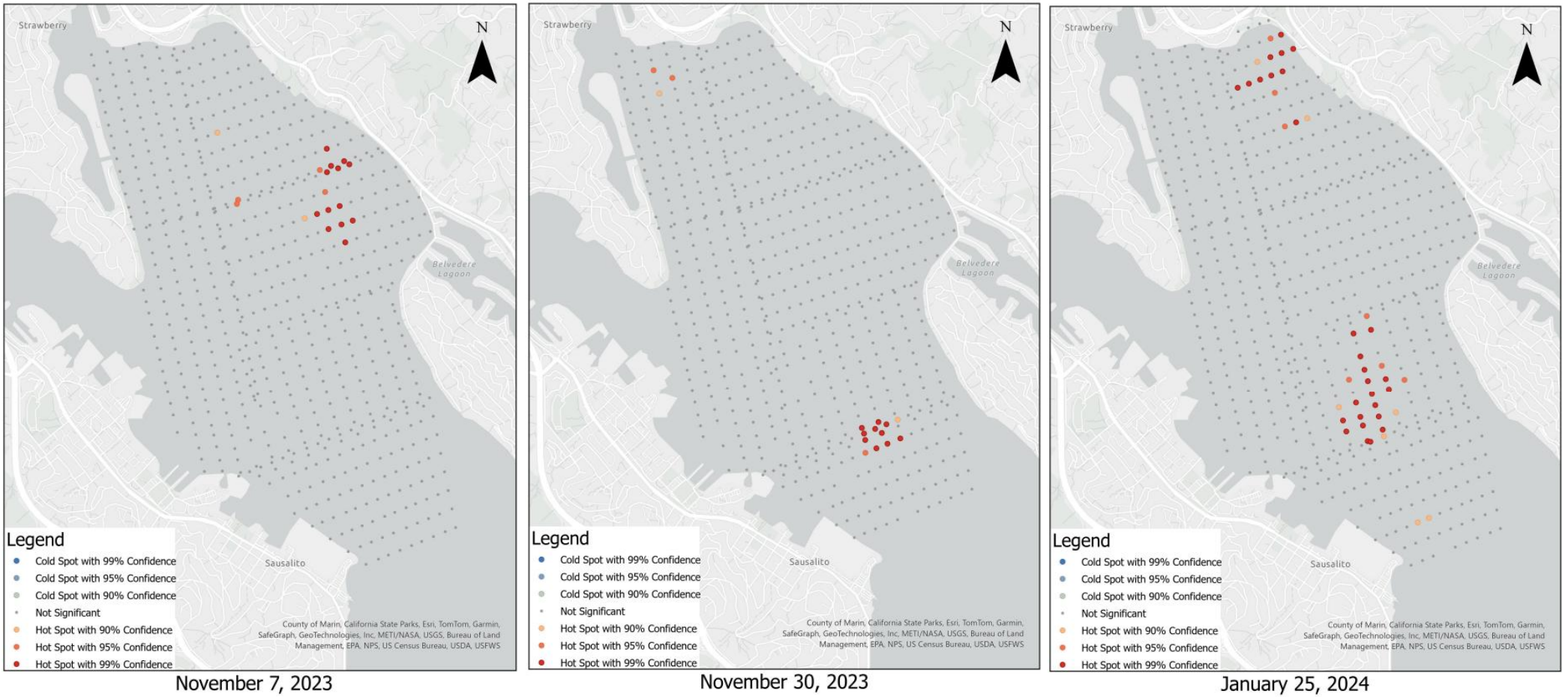


Figure 8a: Rafting waterbird heat maps of Richardson Bay across 2023-2024 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.

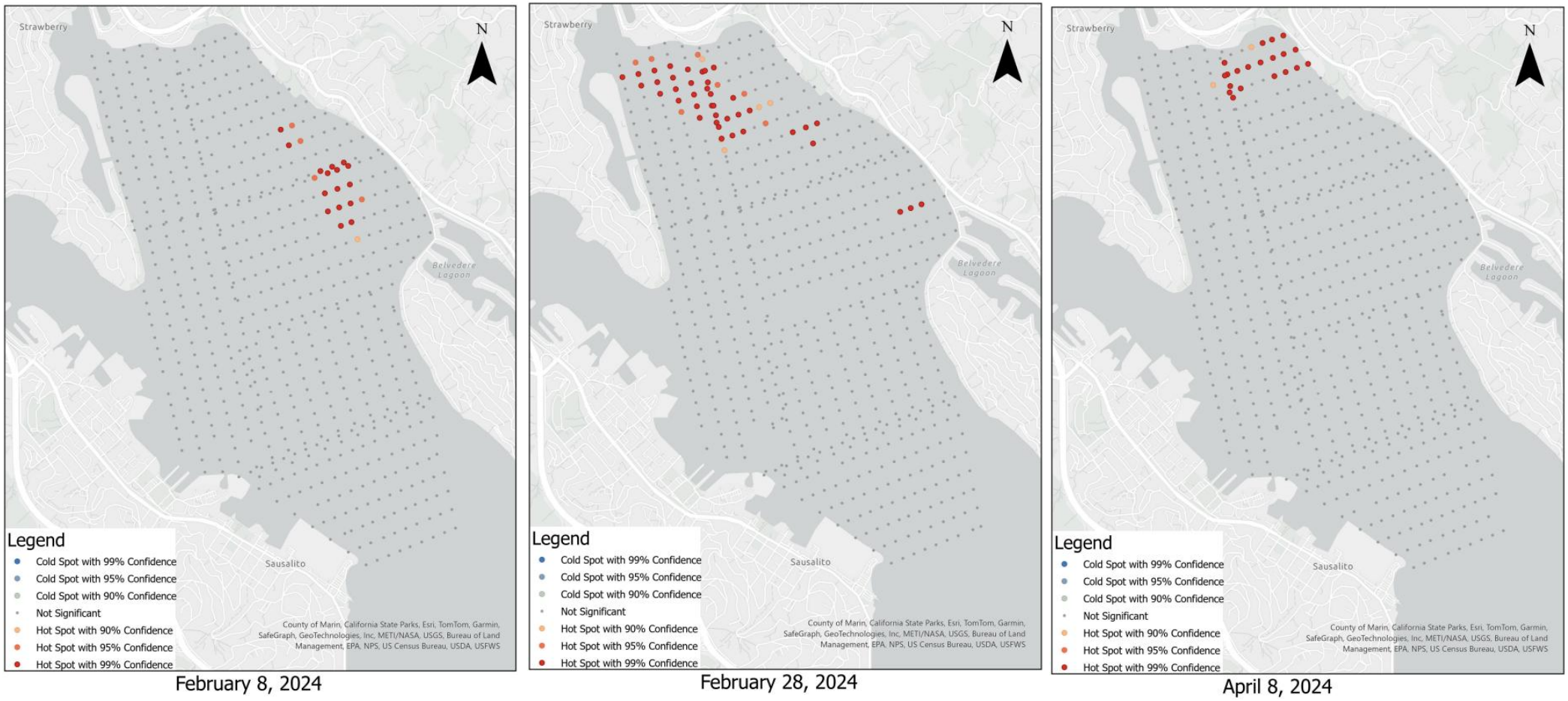


Figure 8b: Rafting waterbird heat maps of Richardson Bay across 2023-2024 survey period. Dots indicate individual images taken during surveys. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.

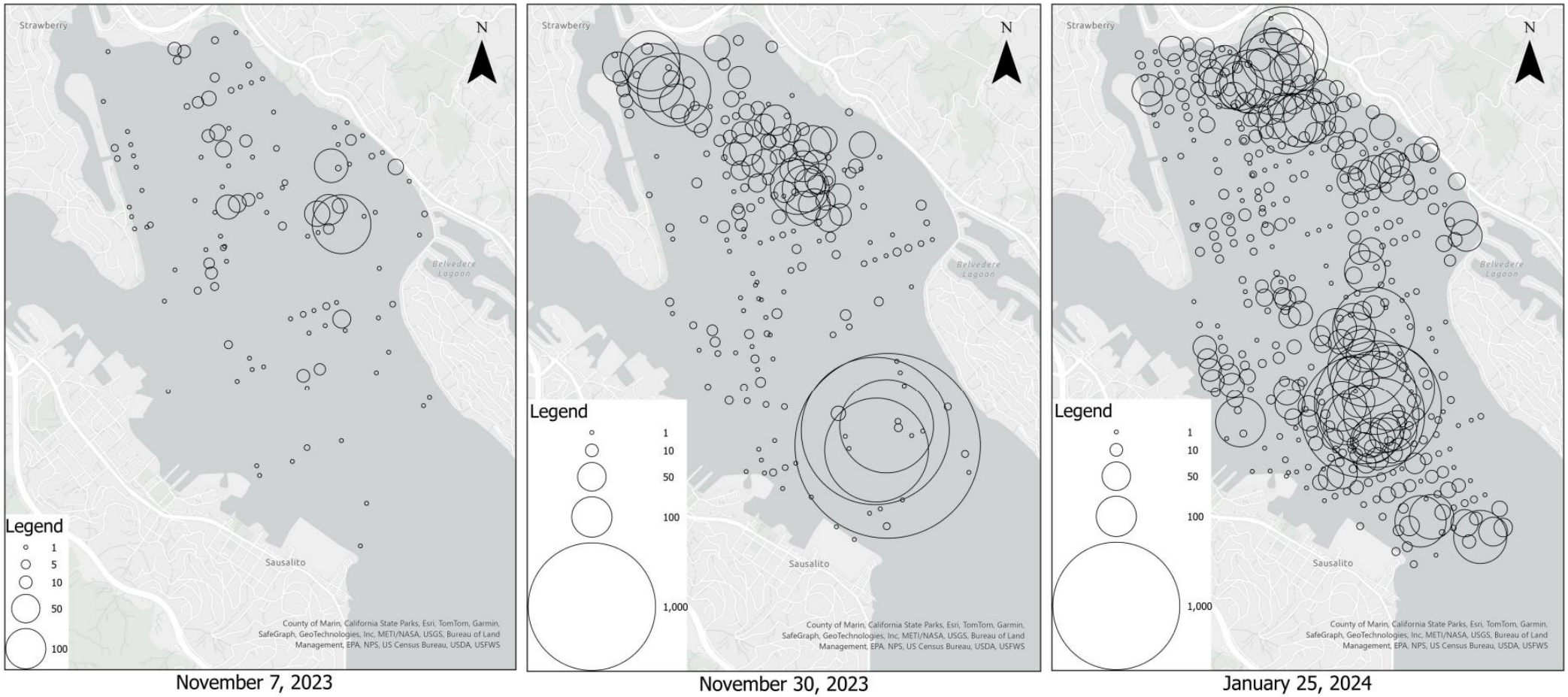


Figure 9a: Rafting waterbirds in Richardson Bay across 2023-2024 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.

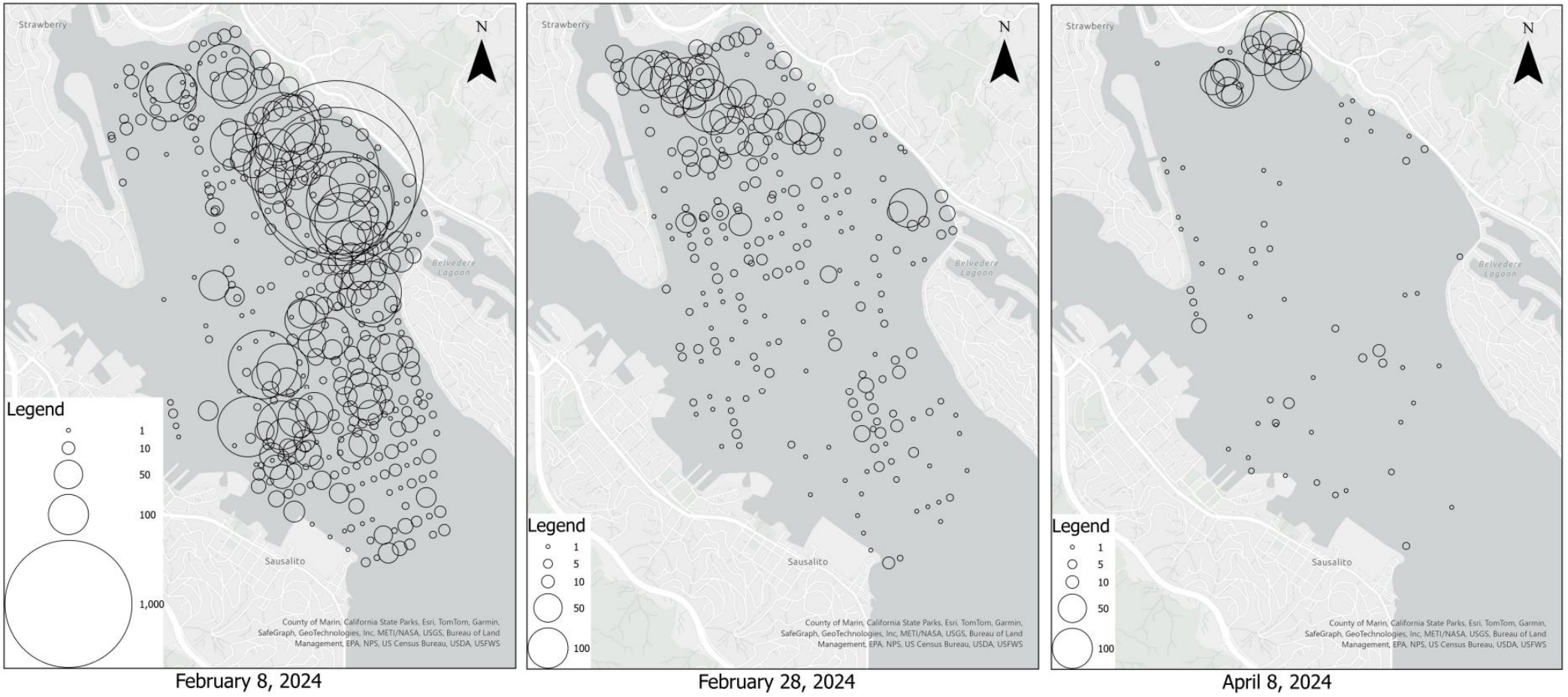


Figure 9b: Rafting waterbirds in Richardson Bay across 2023-2024 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.

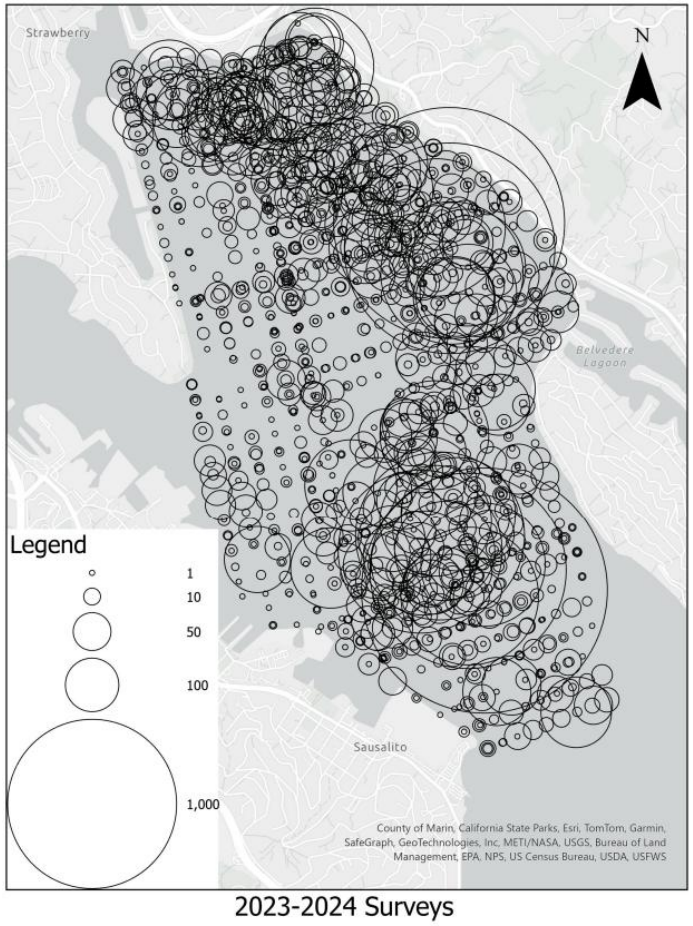


Figure 9c: Rafting waterbirds in Richardson Bay across all 2023-2024 surveys. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each varying legends on each survey. Areas without circles indicate an image where no birds were observed.

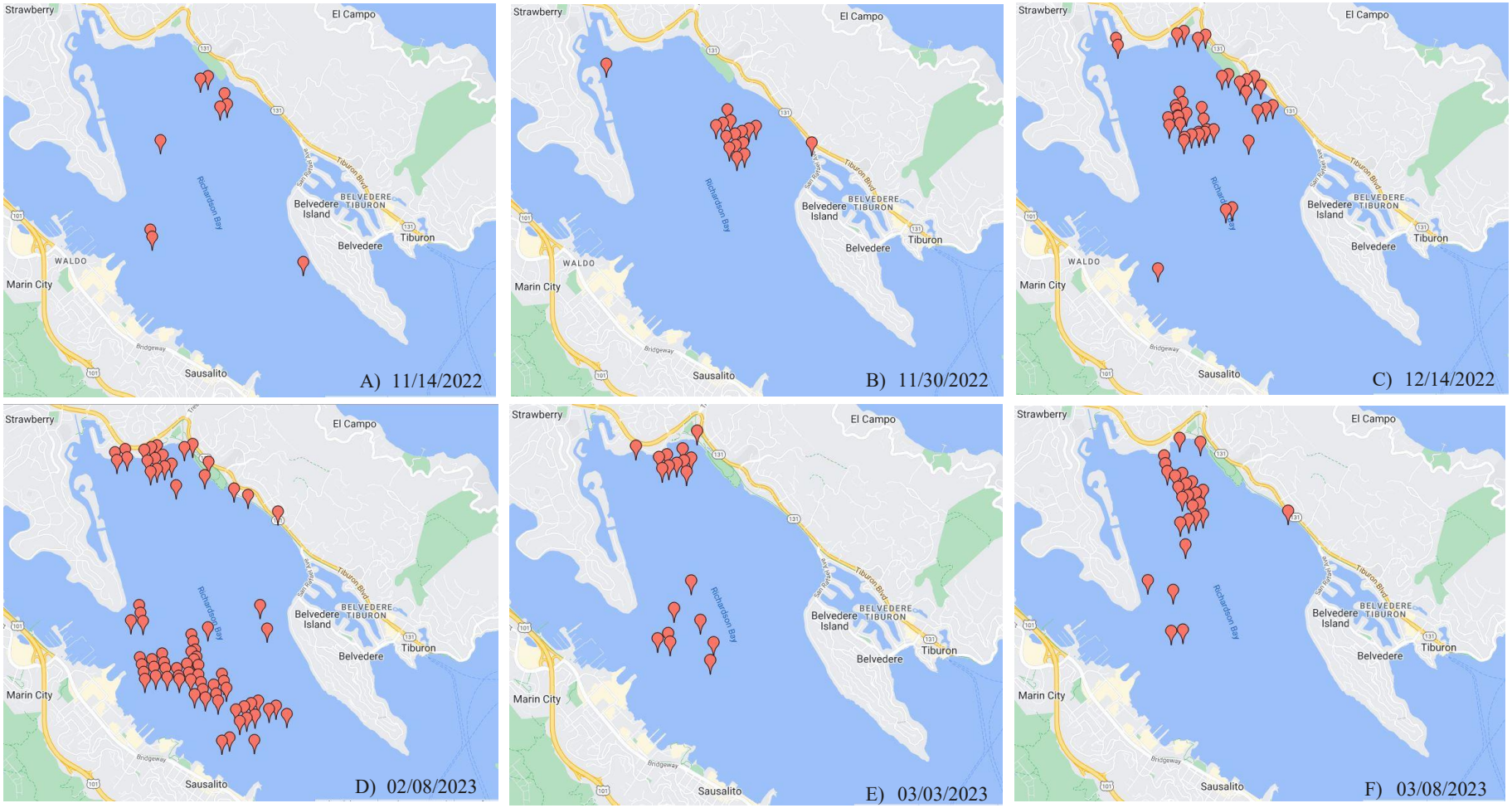


Figure 10. Locations of rafting waterbirds in Richardson Bay from November 2022 to March 2023. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.)

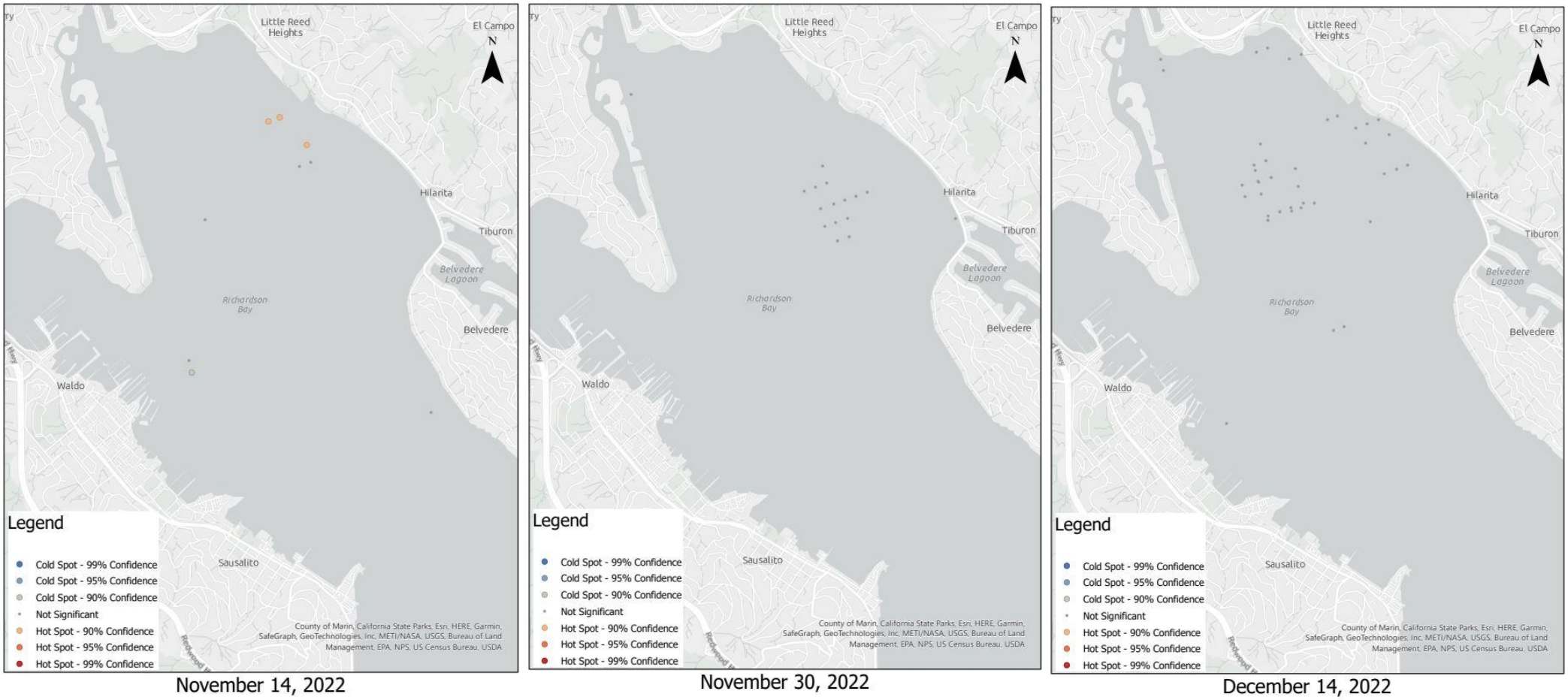


Figure 11a: Rafting waterbird heat maps of Richardson Bay across 2022-2023 survey period. Dots indicate the locations of rafting birds. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.



Figure 11b: Rafting waterbird heat maps of Richardson Bay across 2022-2023 survey period. Dots indicate the locations of rafting birds. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.



Figure 12a: Rafting waterbirds in Richardson Bay across 2022-2023 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each survey has unique upper and lower bounds.

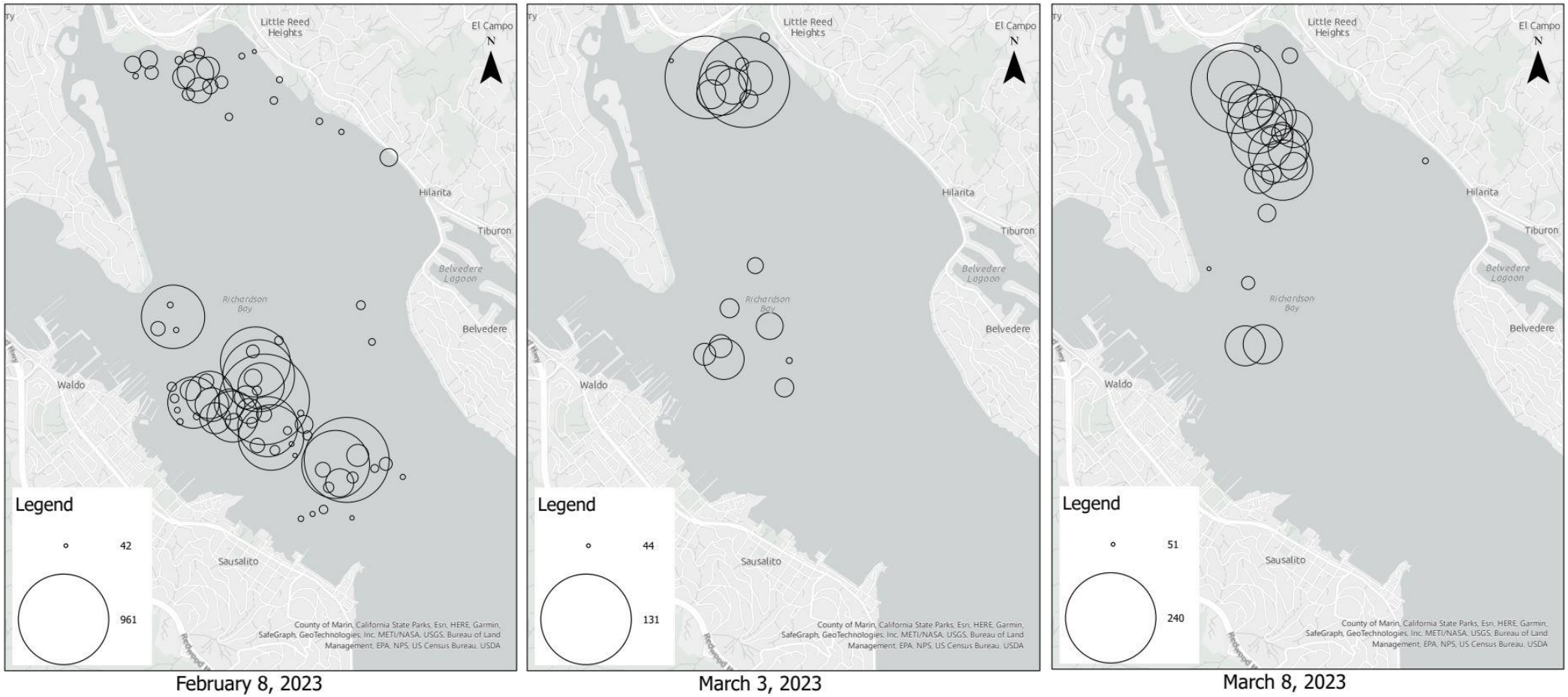


Figure 12b: Rafting waterbirds in Richardson Bay across 2022-2023 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each survey has unique upper and lower bounds.



Figure 13. Locations of rafting waterbirds in Richardson Bay from November 2021 to March 2022. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.)

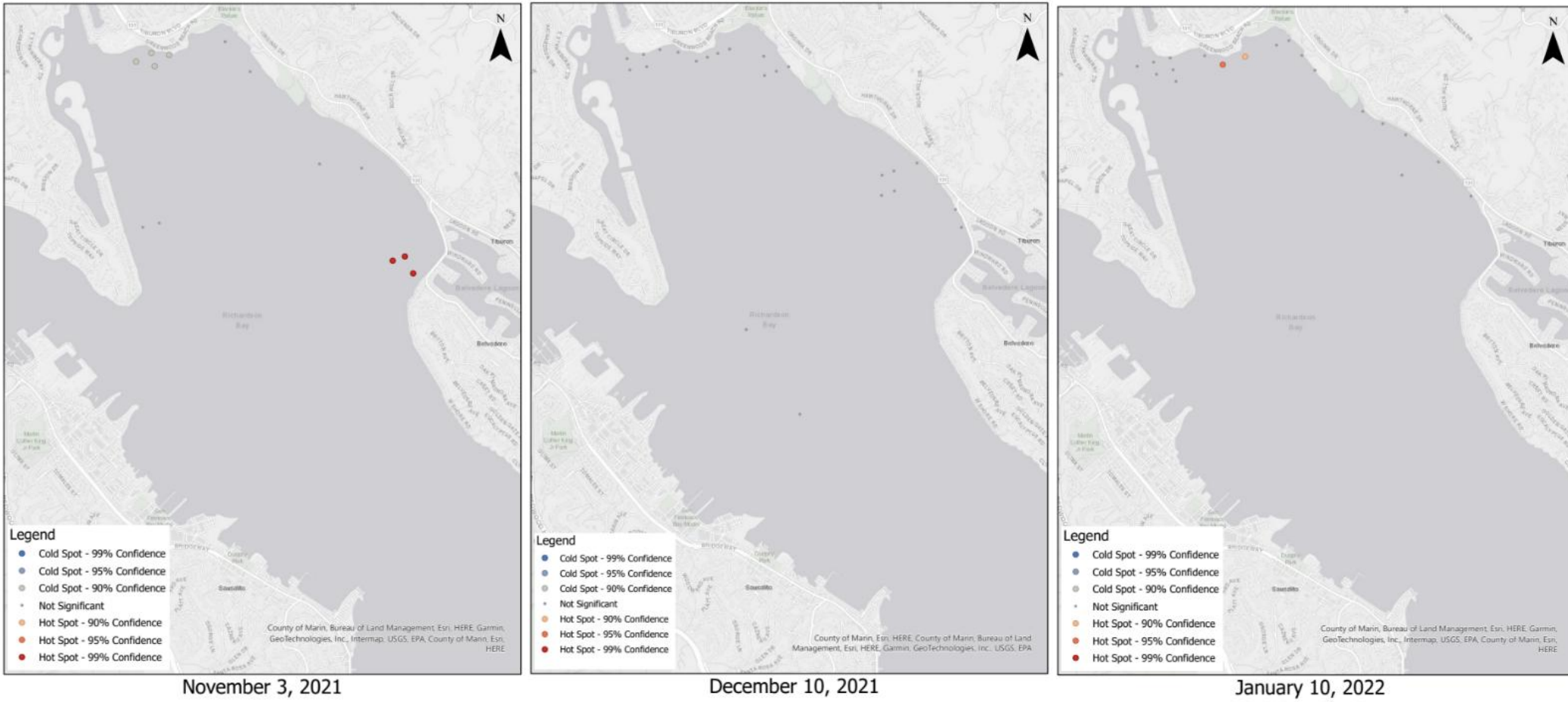


Figure 14a: Rafting waterbird heat maps of Richardson Bay across 2021-2022 survey period. Dots indicate the locations of rafting birds. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.

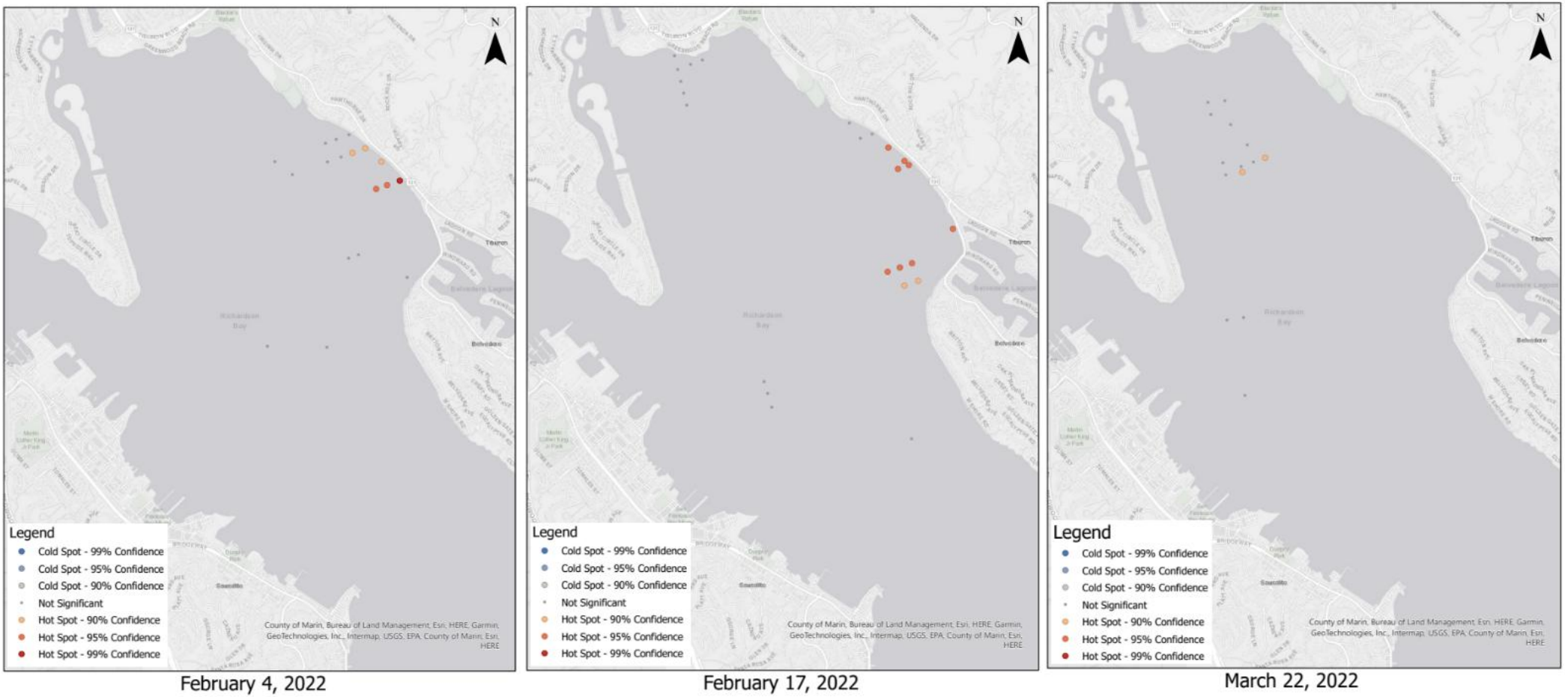


Figure 14b: Rafting waterbird heat maps of Richardson Bay across 2021-2022 survey period. Dots indicate the locations of rafting birds. Warmer colors indicate statistical hotspots with the largest number of birds. Cooler colors indicate statistical cool spots with the lowest number of birds.



Figure 15a: Rafting waterbirds in Richardson Bay across 2021-2022 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each survey has unique upper and lower bounds.

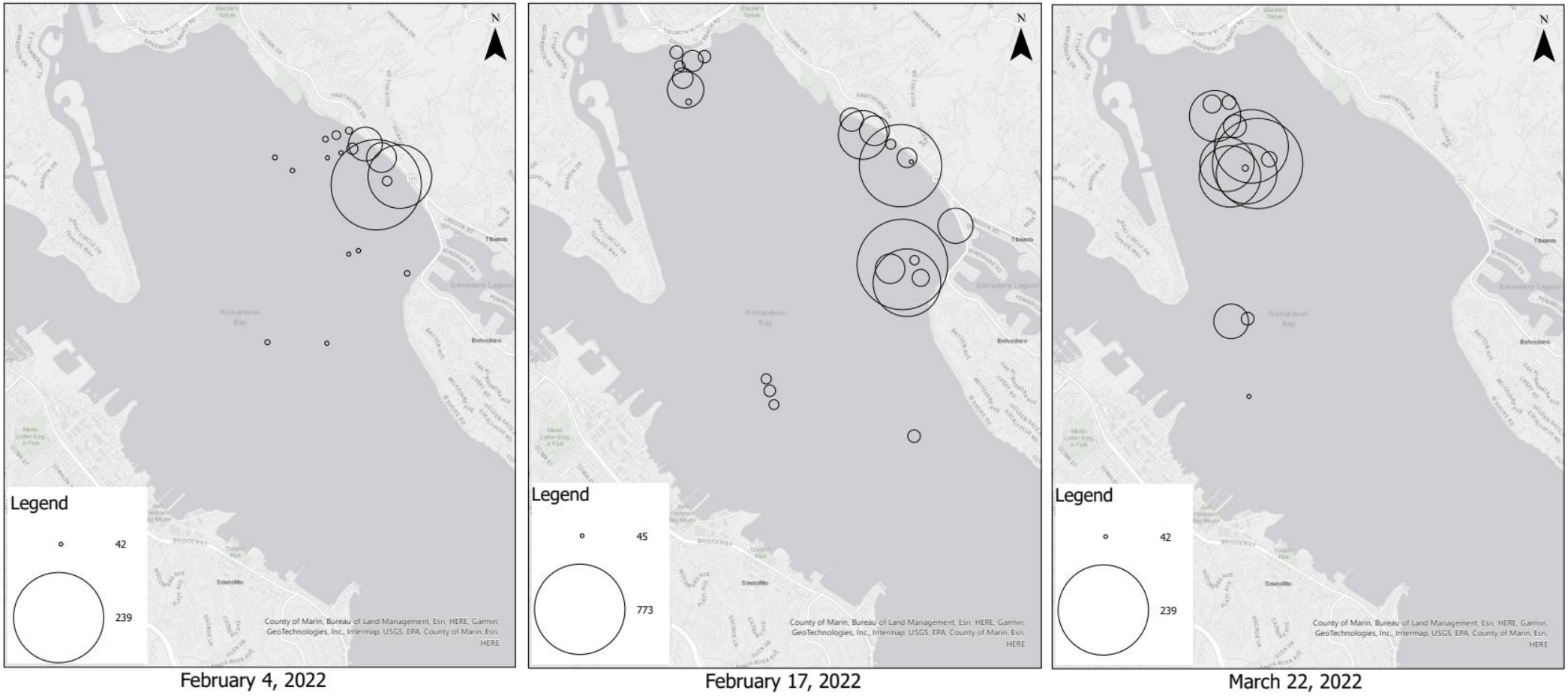


Figure 15b: Rafting waterbirds in Richardson Bay across 2021-2022 survey period. Concentric circle sizes correspond to number of waterbirds counted within each whole or partial raft. Please note, each survey has unique upper and lower bounds.

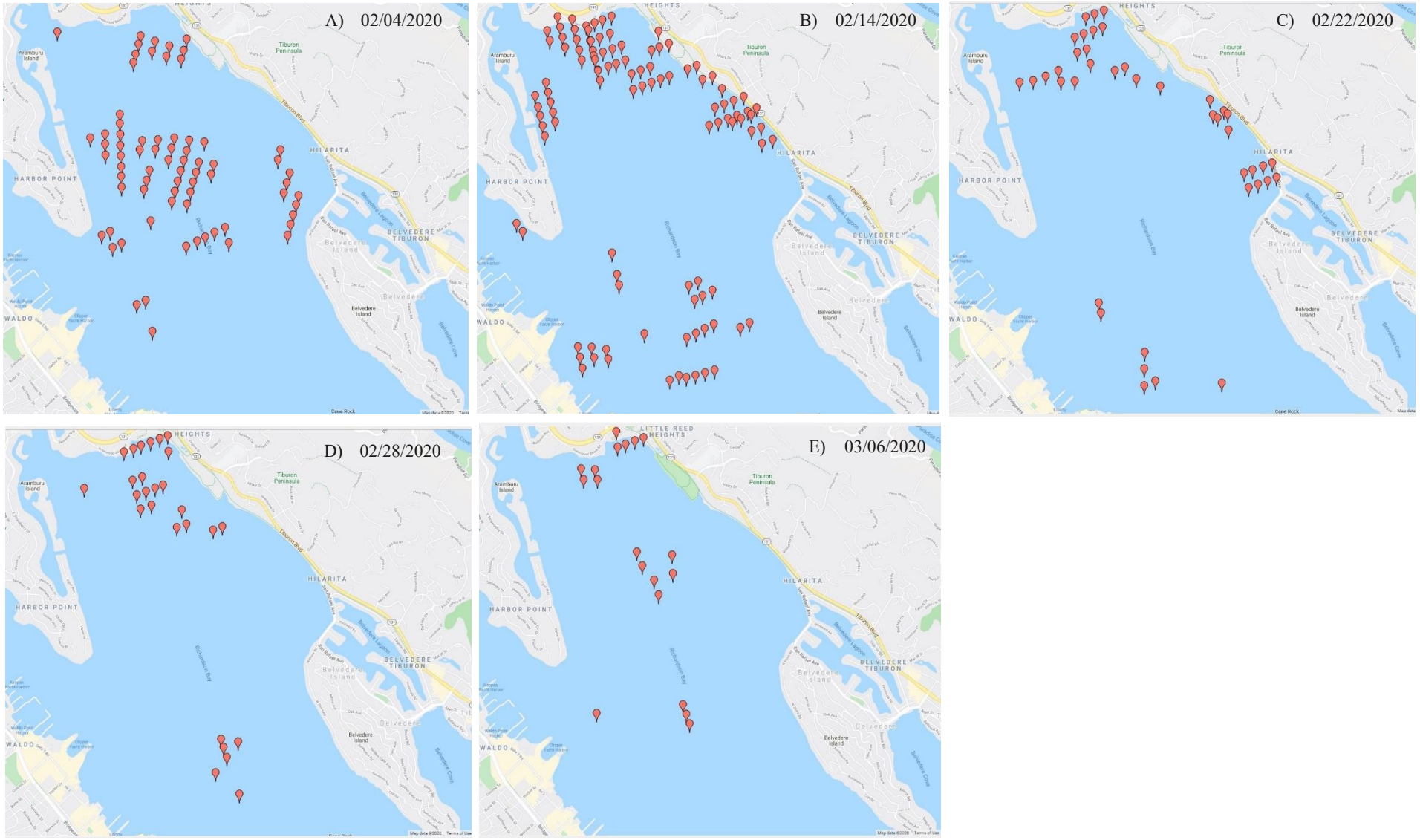


Figure 16: Locations of rafting waterbirds in Richardson Bay from February 2020 to March 2020. Red pins represent partial or whole rafts. (A raft of birds is 40 individuals or more.)



Figure 17: Rafting waterbird heat maps of Richardson Bay across 2020 study period. Dots indicate the locations of rafting waterbirds. Warmer colors indicate rafts with the largest number of birds where cooler colors indicate rafts with the lowest number of birds for that survey date.