USFWS Johnston Atoll National Wildlife Refuge

Combined Final Report - Crazy Ant Strike Teams XVII & XIX

CAST XVII: 5 December 2018 – 14 June 2019

CAST XIX: 4 December 2019 – 9 June 2020

CAST XVII in the garden from front to back: Eric, Margeaux, Alyssa, Kyra and Pablo

CAST XIX about to depart Johnston from left to right: Trevor, Fletcher, Mason, Rachel and Margeaux

Johnston Atoll NWR Crew Lead/Biotech

Margeaux Wayne

USFWS CAST XVII Volunteers

Eric Baker

Pablo McLoud

Kyra Pruitt

Alyssa Wethington

USFWS CAST XIX Volunteers

Trevor Darling

Rachel Grochowski

Fletcher Moore

Mason Mara-Randazzo

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Yellow Crazy Ant (YCA) Monitoring and Treatment

Yellow Crazy Ant (YCA) 50 m Monitoring Survey

The YCA 50 m Monitoring Survey is a monthly survey which provides for the long-term monitoring of the presence or absence of YCA and other ant species (OAS) within the original YCA infestation area. Stations are positioned at the intersections of a 50 x 50 m grid laid across Johnston Island, with 314 stations total. Depending on the time of year, not all stations are surveyed due to nesting Sooty and Gray-back Terns and Black and Brown Noddies. Each station is baited with a pea-sized dollop of pureed Spam (1 can Spam: 1 cup water) placed on a 4 x 4 inch glazed ceramic tile. The survey begins before sunrise, at first light, and the surveyors return to each station 120 – 140 minutes following the initial baiting to count the number of YCA on each card, as well as the presence or absence of OAS. If a station has more than 40 individual YCA present on the tile, it is marked as ">40".

From November 2011 to January 2016, the YCA 50 m Monitoring Survey was conducted biweekly. However, in February 2016, the frequency of the survey changed to once every four weeks on the basis that the long term data would not be statistically compromised by reducing survey frequency, and other surveys had scheduling priority as the current low density demanded higher resolution surveys than were appropriate in the past.

This section covers the data found on both CAST XVII and CAST XIX. Five YCA 50m Monitoring Surveys were completed on each of these crews (Figure 1). YCA were not detected during any of the surveys conducted by either CAST XVII or CAST XIX. As of the final survey conducted by CAST XIX on 16 April 2021, YCA had not been detected in 43 consecutive 50m Monitoring Surveys. The last YCA detection via this survey was in January 2016.

Over the 50m surveys conducted by CAST XVII, Other Ant Species (OAS) presence ranged between 71.7% - 84.2% of the stations, averaging 76.5%. Additionally, over the 50m surveys conducted by CAST XIX, Other Ant Species (OAS) presence ranged between 88.5% - 91.1% of the stations, averaging 89.7%. While the CAST XIX percentages fall within the typical range found by other CAST crews, the average OAS presence CAST XVII percentages were significantly lower. This notable decline in OAS presence from January to June 2019 may be explained by Hurricane Walaka that affected Johnston Atoll in September 2018. It should also be noted that the immediate effects of Hurricane Walaka were not recorded, with a gap in the 50m Survey data from July 2018 to January 2019.

Additionally, OAS presence has historically shown an inverse relationship to YCA presence. With the decline of YCA presence, the OAS presence has seemingly stabilized between 85-90% other than the dip between January to June 2019. Although the survey is not conducted if it is raining or if there is any standing water on the ground, it should also be noted that the amount of rain in surrounding days or weeks can affect the presence of OAS and YCA as well.

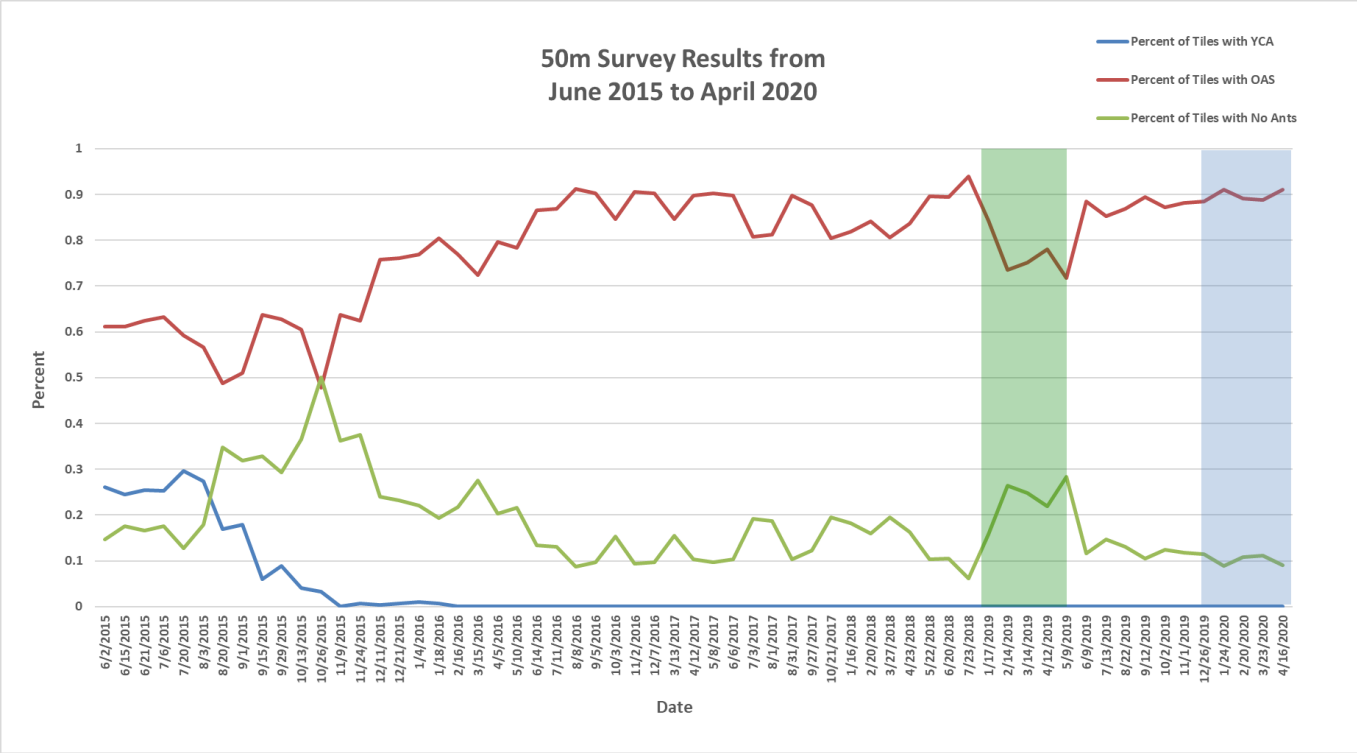


Figure 1: *YCA 50 m Monitoring Survey results from June 2015 – April 2020. The shaded green portion indicates CAST XVIII's tour on Johnston and the shaded blue portion indicates CAST XIX's tour on Johnston*

Yellow Crazy Ant (YCA) Treatment Monitoring Survey

The Treatment Monitoring Survey provides data on the presence or absence of YCA and OAS within the YCA infestation area of Johnston Island. While initially a bi-weekly survey, survey priorities were shifted during CAST X to favor alternative survey techniques and the Treatment Monitoring Survey was conducted once every four weeks. Different from the 50m Monitoring Survey, the Treatment Monitoring stations target areas that are known to have YCA in order to determine more precisely how the YCA population is responding to bait application. During CAST XI the number of monitoring points was nearly doubled to increase the probability of detection.

There are currently 894 stations that are monitored over two consecutive days. Depending on the time of year, not all stations are surveyed due to nesting Sooty and Gray-back Terns and Black and Brown Noddies. Each station is baited with a pea-sized dollop of pureed Spam (1 can Spam: 1 cup water) placed on a 4 x 4 inch glazed ceramic tile. The survey begins before sunrise, at first light, and the surveyors return to each station 90 – 110 minutes following the initial baiting to count the number of YCA on each card, as well as the presence or absence of OAS. If a station has more than 40 individual YCA present on the tile, it is marked as ">40".

CAST XVII Results:

CAST XVII completed Six Treatment Monitoring Surveys. YCA were not detected at any of the stations during any of the surveys (*Figure 2*). OAS presence throughout CAST XVII's tour has ranged from a low of 80.5% to a high of 88.2%. Average OAS presence during CAST XVII was 83.9%, quite a bit lower than the average seen by previous CASTs (typically averaging between 89-94%)

CAST XIX Results:

CAST XIX completed six Treatment Monitoring Surveys. YCA were not detected at any of the stations during any of the surveys *(Figure 2*). OAS presence throughout CAST XIX's tour ranged from a low of 88.4% to a high of 97.7%. Average OAS presence during CAST XVII was 93.5%, quite a bit higher than CAST XVII's average of 83.9%.

CAST XVII and CAST XIX Results:

Similar to the 50m Monitoring Survey, OAS presence typically displays an inverse relationship to YCA presence. OAS presence has varied slightly over the years since YCA numbers declined in 2015. In May 2016, the percent of tiles that detected OAS temporarily declined immediately following the landscape level bait application of the infestation area. Additionally, the OAS presence dipped again temporarily from January to June 2019. As mentioned in the 50m Monitoring Survey results, this can most likely be attributed to the effects of Hurricane Walaka.

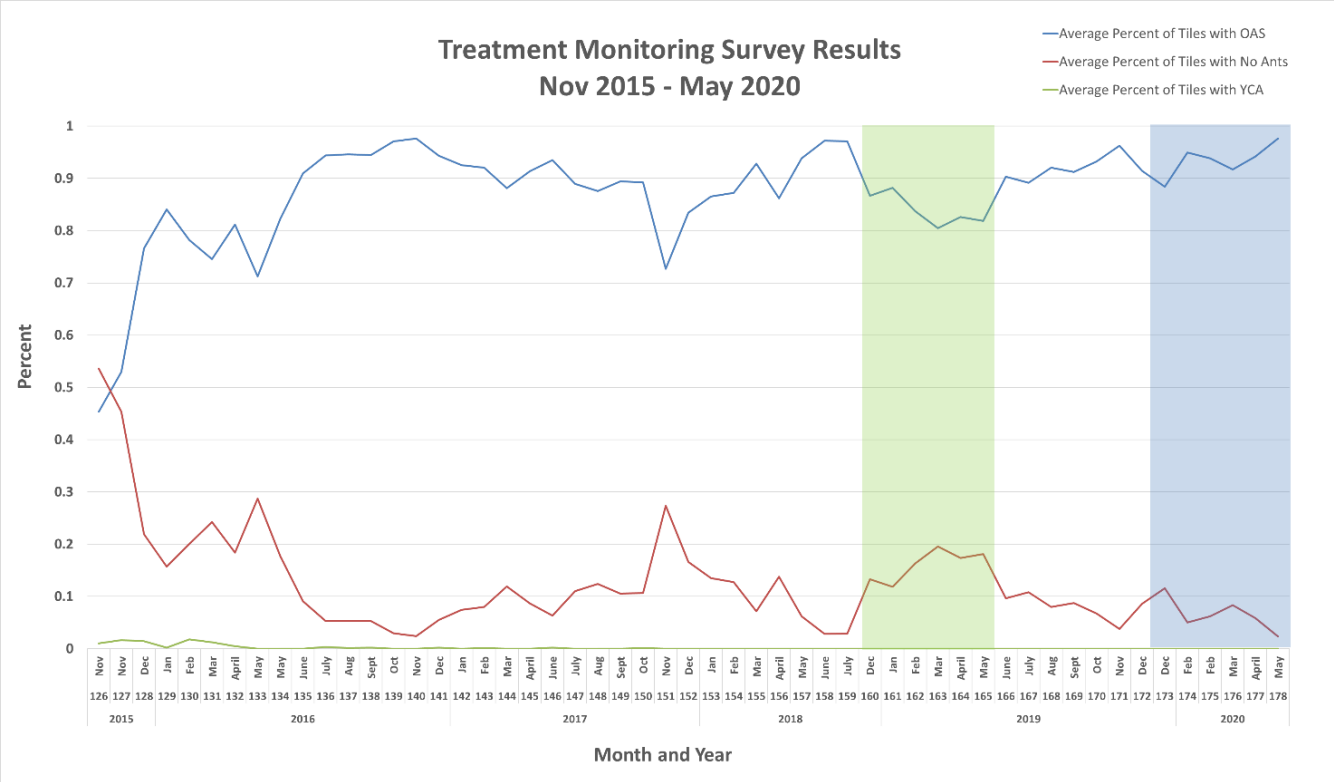


Figure 2. *YCA Treatment Monitoring Survey results from Nov 2015 – May 2020. The shaded green portion indicates CAST XVIII's tour on Johnston and the shaded blue portion indicates CAST XIX's tour on Johnston*

Hand Search Survey (previously Hand Search Tile Survey)

With the recent substantial drop in Yellow Crazy Ant (YCA) population across the island, survey methods such as the YCA 50m Survey and YCA Treatment Monitoring Survey lack the resolution to detect smaller densities of YCA. In order to detect these smaller populations, the Hand Search Survey was implemented during CAST XI's deployment. The purpose of the Hand Search Survey is to detect YCA within the Infestation Zone at as a high a resolution as possible. Each 50m grid square within the Infestation Zone is thoroughly searched by hand, for a minimum of one-person hour or until all possible nesting locations have been examined. Observers line up along the edge of a grid square, space themselves roughly equally across the diameter of the grid square, and advance in a single cardinal direction across the area where YCA were detected. In addition to hand searching, CAST XI originally implemented baited tiles within the squares they were searching. However, the tiles were not found to be effective as the YCA habitat was disturbed by the searching and YCA foraging behavior was altered. Therefore, CAST XI removed the baited tile element from the survey.

Observers thoroughly search the entire monitored area by hand, focusing on ideal YCA habitat such as the bases of trees, concrete edges, and under rocks and other debris. Thorough hand searching techniques include but are not limited to uncovering vegetation stems, raking leaves or other debris, examining limbs and branches, and checking any cracks, cavities, or holes in the ground. Grid squares are searched in the morning hours, beginning shortly after sunrise and ending around 10:30 to avoid the heat of the day, when YCA are less active. If YCA are detected, nests are searched for and when found, flagged. The dominant and surrounding vegetation as well as a description of the nest location was recorded.

In order to declare YCA eradication from Johnston Atoll, it was determined that all 50m grid squares within the infestation zone needed to be hand searched four consecutive times without any YCA detections (via any survey method). In 2019 an Adaptive Hand Searching map with a buffer zone (Figure 3) was developed, as most 50m grid squares had been searched and cleared four times consecutive times, but some 50m grid squares required an additional one to three additional hand searches The primary goal of CAST XX was to search and clear these adaptive hand searching grid squares.

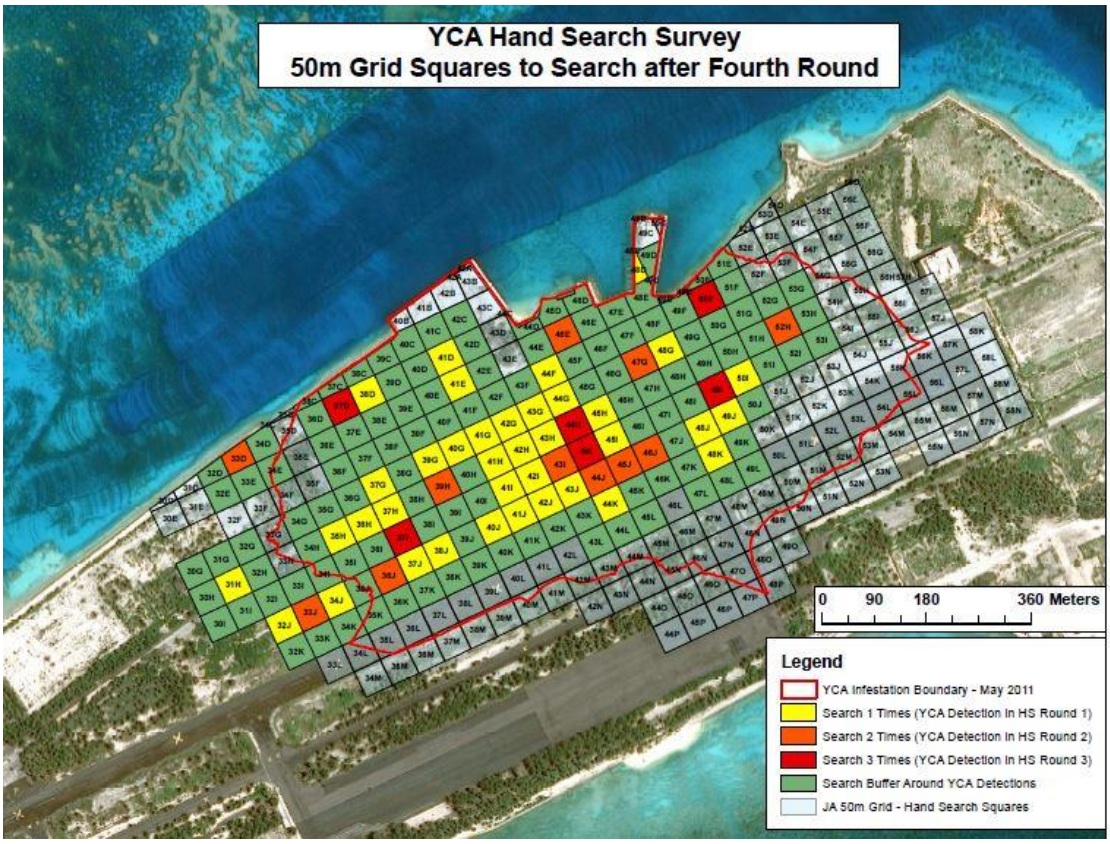


Figure 3. *The adaptive hand searching map, indicating the remaining number of times each 50m grid square still needed to be searched by CAST XIX, including a green buffer around previous detections.*

During the first implementation of the Hand Search Survey, CAST XI detected YCA at 30 of the 367 surveyed grid squares surveyed (8%) through this survey. In the following deployment, CAST XII detected YCA at three of 156 hand searched grid squares (2%), CAST XIII detected YCA in two of the 247 grid squares hand searched (0.8%), and CAST XIV was the last crew to detect YCA via Hand searching, finding YCA at 4 of the 184 grid squares hand searched (2.2%). CAST XV proceeded to conduct Baited Area Monitoring (BAM) on these squares. These results are consistent with the idea that Hand Searching along with Treatment Monitoring is a fine scale method to detect YCA presence, followed by baiting methods to kill of the colony.

CAST XVII Results:

During the CAST XVII deployment, 64 grid squares of the fourth round were hand searched within the Infestation Zone. No YCA were detected via hand searching or any other survey methods within these squares. Some squares were searched over multiple days due to the density of the vegetation. Additionally, six squares were skipped over to be later searched by CAST XVIII, as there were Sooty Terns densely nesting within the squares. The remaining runway square and squares south of the runway were left to be searched by CAST XVIII, prior to completing the adaptive hand searching squared, based on the most recent YCA detections.

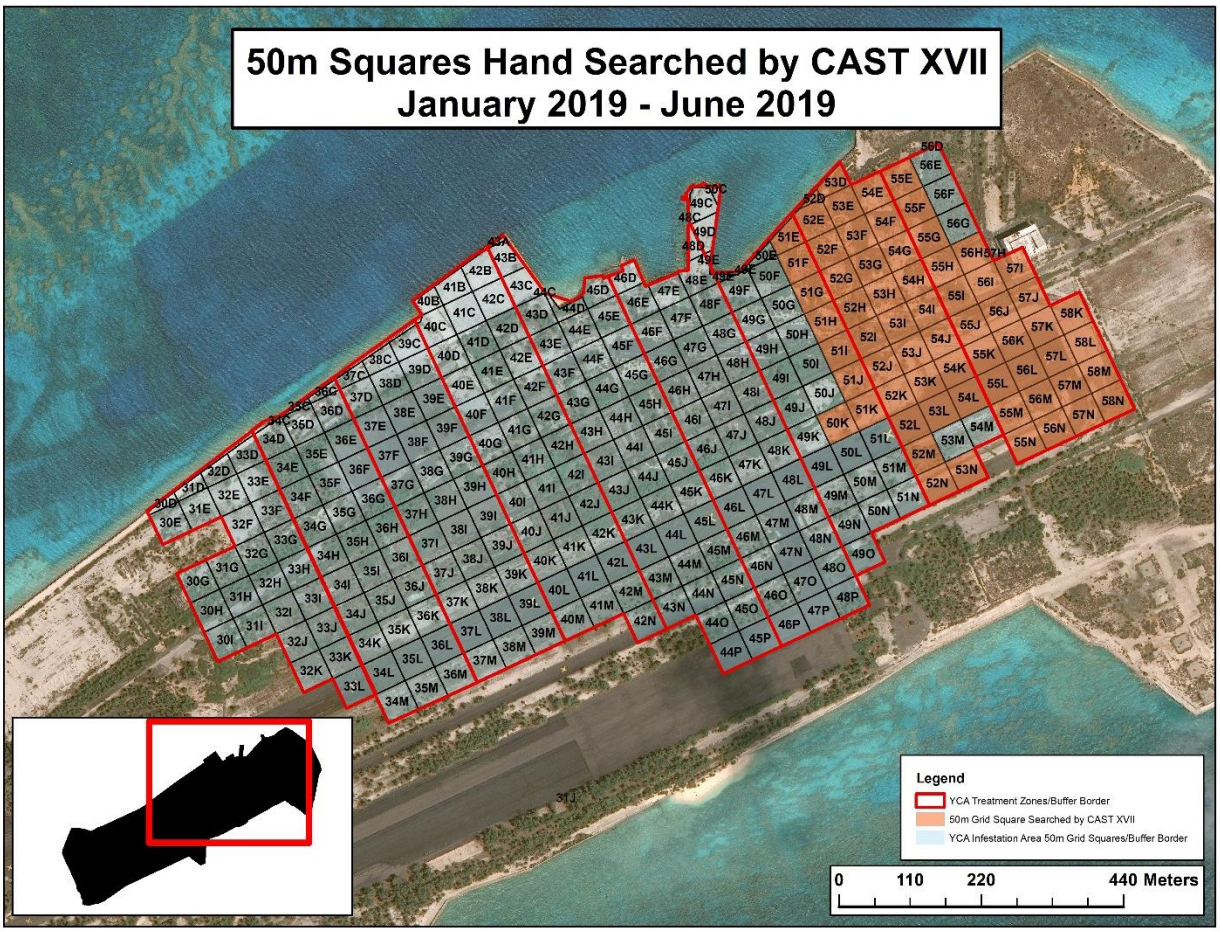


Figure 4. *Orange colored squares represent plots searched by CAST XVII (January – June 2019).*

CAST XIX Results:

During the CAST XIX deployment, 93 of the 194 adaptive grid squares and buffer squares within the Infestation Zone were hand searched (Figure 5). No YCA were detected via hand searching or any other survey methods within these squares. Some squares were searched over multiple days due to the density of the vegetation. CAST XVIII finished the fourth round of hand searching, primarily south of the runway, and CAST XIX was able to start the adaptive round of hand searching in areas still needing to be searched to declare eradication.

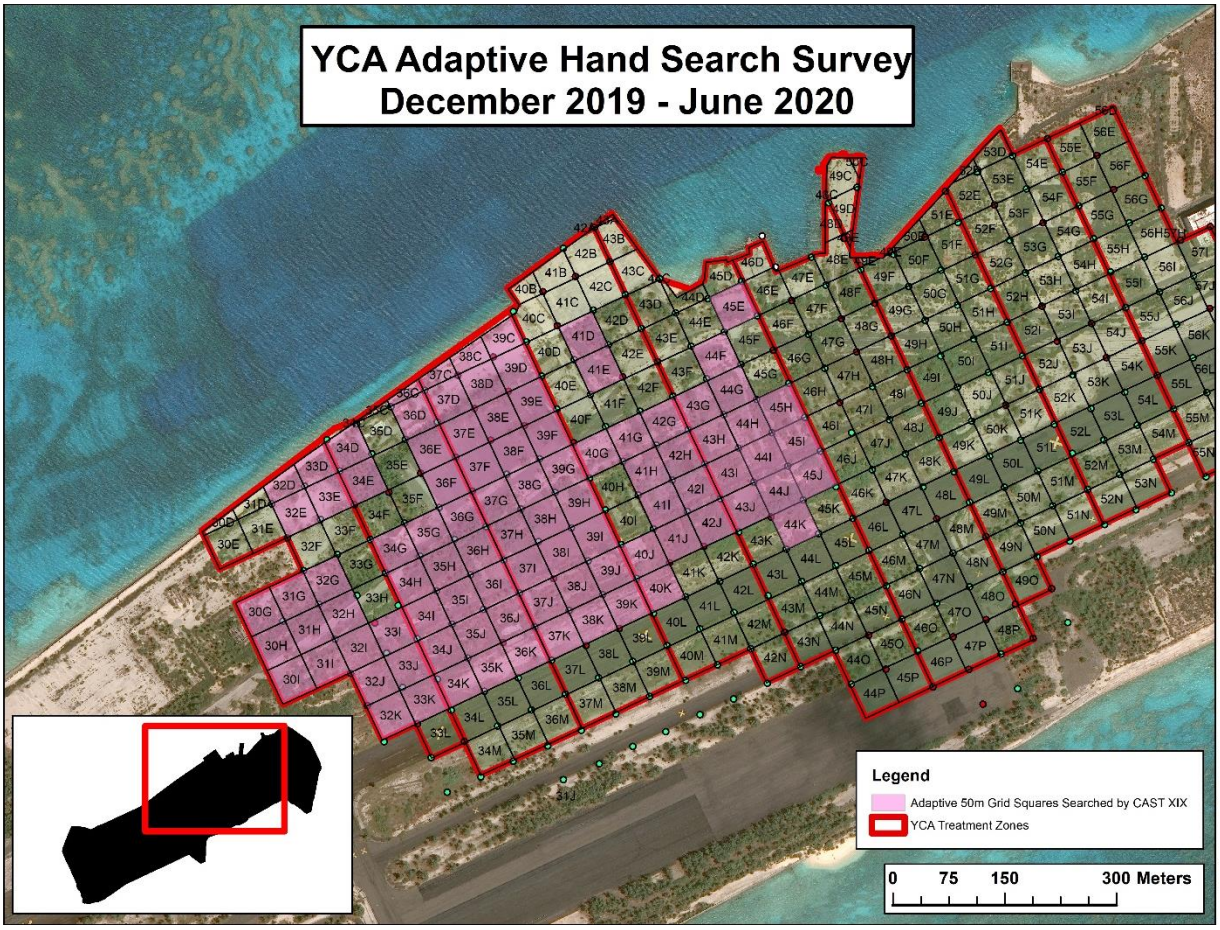


Figure 5. *Pink colored squares represent plots searched by CAST XIX (Dec 2019 – June 2020).*

All-Island Ant Survey

For the All-Island Ant Survey, a plastic 15 mL centrifuge tube is wrapped in aluminum foil in order to provide a dark environment that the ants prefer. The night before the survey the tubes are baited with a small cube of Spam (about 1 cm^3). The survey begins before sunrise, at first light (~0630 HST). The surveyors open the tube and place it at each of the individual stations of the 50 m grid. Surveyors return to each station 120 – 140 minutes after the initial placement to close and collect the tubes. Immediately after the survey, vials were examined for ants and recorded as containing YCA, OAS, or no ants. Vials with no ants were checked by at least two crew members to ensure that no ants were missed. Samples were frozen immediately to euthanize the ants following each day's survey and remained frozen for at least 48 hours before the ants were counted and identified. After the counting and identification, most of the ants were disposed of, keeping only samples for training purposes and for confirmation of rarer species by the entomologists in Honolulu. The resulting data gives a picture of the current ant population on Johnston Island and provides insight into how other ant species are impacted by the presence or absence of the Yellow Crazy Ant, as well as by bait application.

CAST XVII Results:

CAST XVII conducted the 17th All-Island Ant Survey on 4-6 February 2019. This survey provides biannual data on the presence or absence of YCA and other ant species (OAS) over a 50 m grid across Johnston Island. CAST XVII successfully surveyed all 1,048 stations of the 50 m grid.

Out of the 1,048 stations surveyed, no stations contained YCA and 498 stations (47.5%) contained OAS. A grand total of 59,458 ants were identified and counted from the 498 vials containing ants. YCA was last collected during this survey in January 2016. Last year (2018, CAST XV), 805 stations (76.5%) contained OAS and a total of 84,715 ants were identified and counted from the 805 vials containing ants. The dramatic decrease in the number ants collected may be due to Hurricane Walaka, which affected Johnston Atoll in September 2018.

Additionally, one tube was found containing 23 individuals of *Monomorium sechellense,* a species that has never before been observed during this survey. This newly observed species was confirmed by bringing specimen sample back to Honolulu for Mike Richardson, an entomologist in Ecological Services, to identify. All of the other ant species identified during this survey have been reported in previous surveys. Ten different species of ants were identified (Table 1). Two species of ants were observed at 52 of the 498 stations containing OAS and three species of ants were observed at four of the stations.

Table 1: Species collected during the 17th All-Island Ant Survey, 4-6 February 2019. "Unknown" and "Cardiocondyla spp." were specimens that were damaged beyond species recognition.

Species	Number of Stations	Total Number of Ants
Cardiocondyla emryi	1	5
Cardiocondyla spp.	1	1
Monomorium destructor	39	8568
Monomorium floricola	3	481
Monomorium pharaonis	18	610
Monomorium sechellense	1	23
Ochetellus glaber	197	15206
Paratrechina longicornis	75	6797
Solenopsis geminata	107	14082
Tapinoma melanocephalum	48	8209
Tetramorium bicarinatum	30	4844
Tetramorium simillimum	26	628
Unknown	4	3
Stations with no ants collected	555	-
Grand Total		**59,458**

The two most abundant species were *Ochetellus glaber* and *Solenopsis geminata*. In regard to the number of individual ants counted, the most abundant species was *O. glaber* (n= 15,206; 25.6 % of all ants counted). The second most abundant was *S. geminata* (n= 14,082; 23.7%). These two species have been the most abundant and widespread species on Johnston over at least the past seven surveys (i.e., 4 years). It should be noted that the number of stations that *P. longicornis* were observed at more than double over the past year, even with an overall decrease in the number of stations that has OAS present (*Figure 6*).

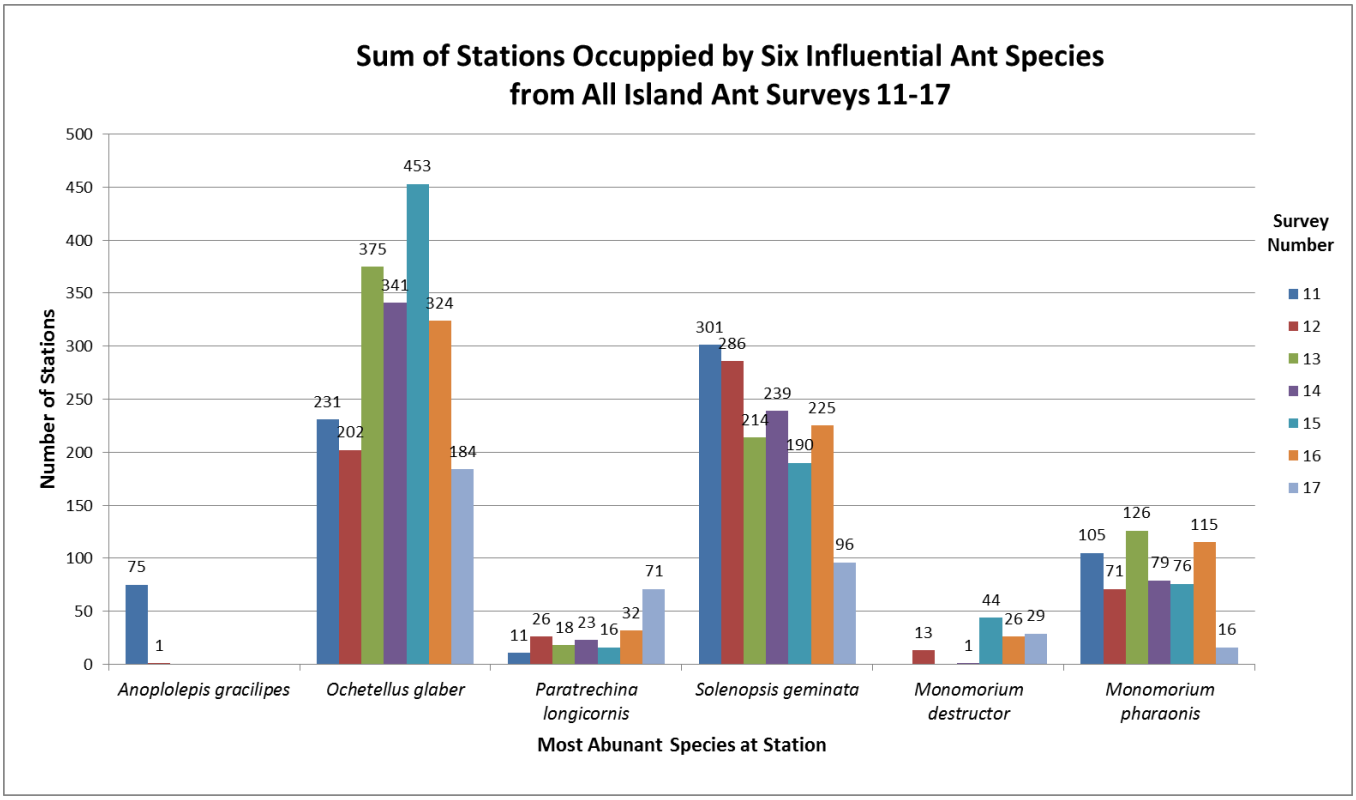


Figure 6. *The count of stations at which six influential ant species were identified over the past seven All-Island Ant Surveys (August 2015-February 2019).*

Of the six influential ant species found on Johnston Island, only *P. longicornis* and *M. destructor* have increased in the number of stations they were detected at since the last All-Island Ant Survey. *M. pharaonis* had an 86% decrease in the number of stations where it was observed to be the most abundant ant species. Of all the species identified, *M. pharaonis* and *M. destructor* were the most difficult to differentiate, especially in tubes containing few specimens. It should also be noted that *P. longicornis* was the most abundant species at 71 stations; more than double the number of stations that it was most abundant during the last All-Island Ant Survey (n=32).

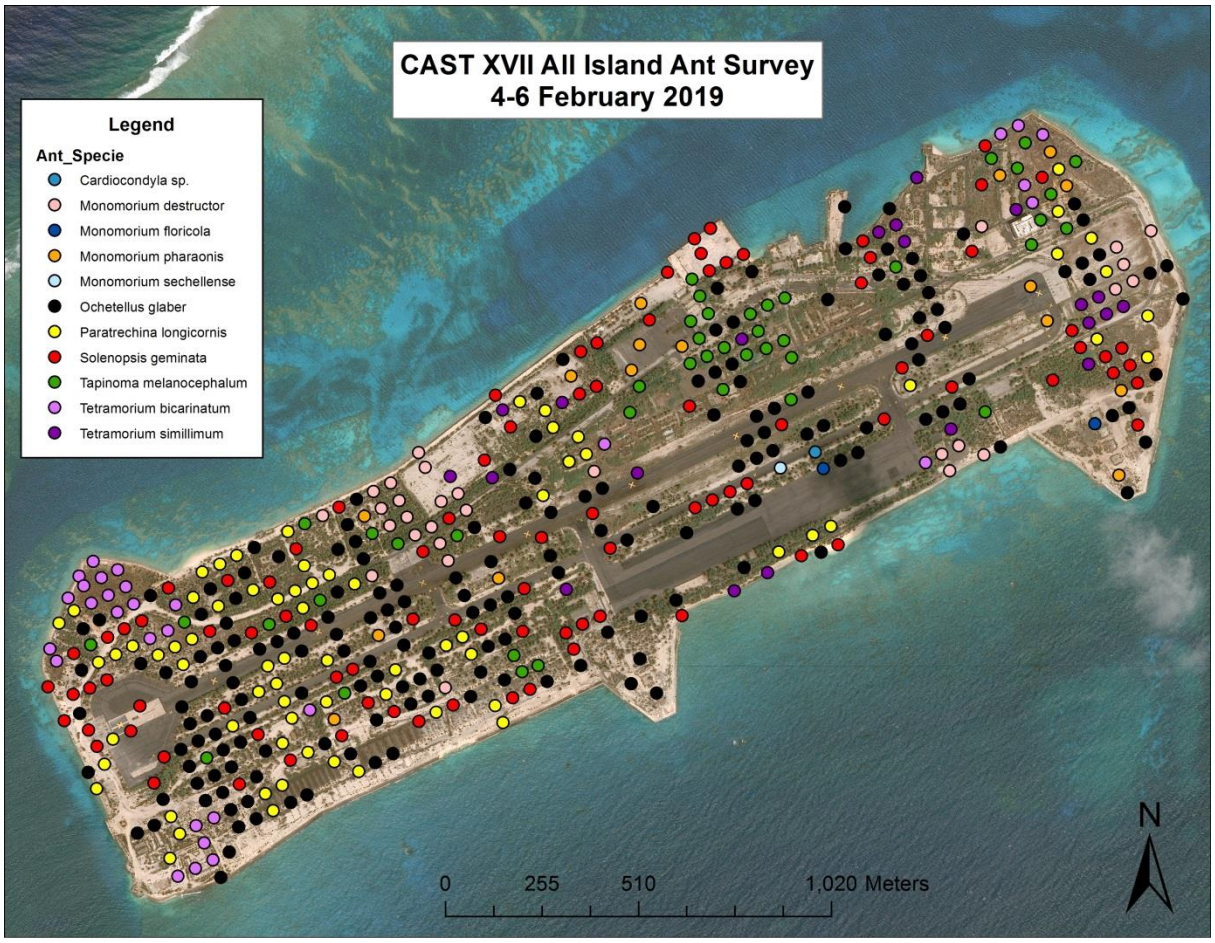


Figure 7. *Distribution of ant species collected on Johnston Island from 4-6 February. When there were two species of ants at the station, only the primary ant species at the stations was included in this figure.*

CAST XIX Results:

CAST XIX conducted the 19th All-Island Ant Survey on 10-12 February 2020. This survey provides biannual data on the presence or absence of YCA and other ant species (OAS) over a 50 m grid across Johnston Island. CAST XIX successfully surveyed 1047 of the 1048 stations of the 50m grid (one station not surveyed due to nesting terns).

Out of the 1,047 stations surveyed, no stations contained YCA (0%), 831 stations (79.4%) contained OAS, and 216 stations (20.6%) did not contain ants. YCA were last collected during this survey in January 2016. Of the 1,048 stations typically sampled, one station was not accessible due to the nesting sooty tern colony.

Table 2. Species collected during the 19th All-Island Ant Survey, 10-12 February 2020. "Unknown" and "Cardiocondyla spp." were specimens that were damaged beyond species recognition.

Species	Number of Stations	Total Number of Ants
Anoplolepis gracilipes (YCA)	0	0
Cardiocondyla minutior	6	36
Cardiocondyla spp.	2	2
Monomorium destructor	41	13781
Monomorium floricola	4	324
Monomorium pharaonis	18	610
Monomorium sechellense	1	3
Monomorium spp.	6	468
Ochetellus glaber	253	17169
Paratrechina longicornis	38	3370
Plagiolepis alluaudi	2	61
Solenopsis geminata	305	45069
Tapinoma melanocephalum	51	6796
Tapinoma spp.	1	1
Tetramorium bicarinatum	48	8365
Tetramorium simillimum	65	1593
Unknown	5	5
Stations with no ants collected	214	-
Grand Total		**100,625**

During the first All-Island Ant Survey collection after Hurricane Walaka (Survey #17), a total of 59,458 ants were identified and counted from the 498 vials containing ants. The number of ants have continued to increase since the hurricane in September 2018, with a total of 70,123 ants identified from the 631 vials containing ants on All-Island Ant Survey 18 and a total of 100,625 ants identified from the 831 vials containing tubes on All-Island Ant Survey 19. The temporary decrease in the number ants collected is most likely explained by the impacts of Hurricane Walaka, as much of the habitat was damaged (i.e. uprooted trees).

The two most abundant species were *Solenopsis geminata* and *Ochetellus glaber.* In regard to the number of individual ants counted, the most abundant species was *S. geminata* (ants= 45,069; 44.8% of all ants counted / vials=305; 29.1% of all sampled vials). The second most abundant was *O. glaber* (ants= 17,169; 17.1% / vials=253; 24.2% of all sampled vials). These two

species have been the most abundant and widespread species on Johnston over at least the past nine surveys (5 years).

Additionally, one tube was found containing 3 individuals of *Monomorium sechellense* was collected, a species that had never before been observed before All-Island Ant Survey 17. All of the other ant species identified during this survey have been reported in previous surveys. Twelve different species of ants were identified (Table 1). Two different species of ants were observed at 76 of the 831 stations containing OAS and three different species of ants were observed at five of the stations.

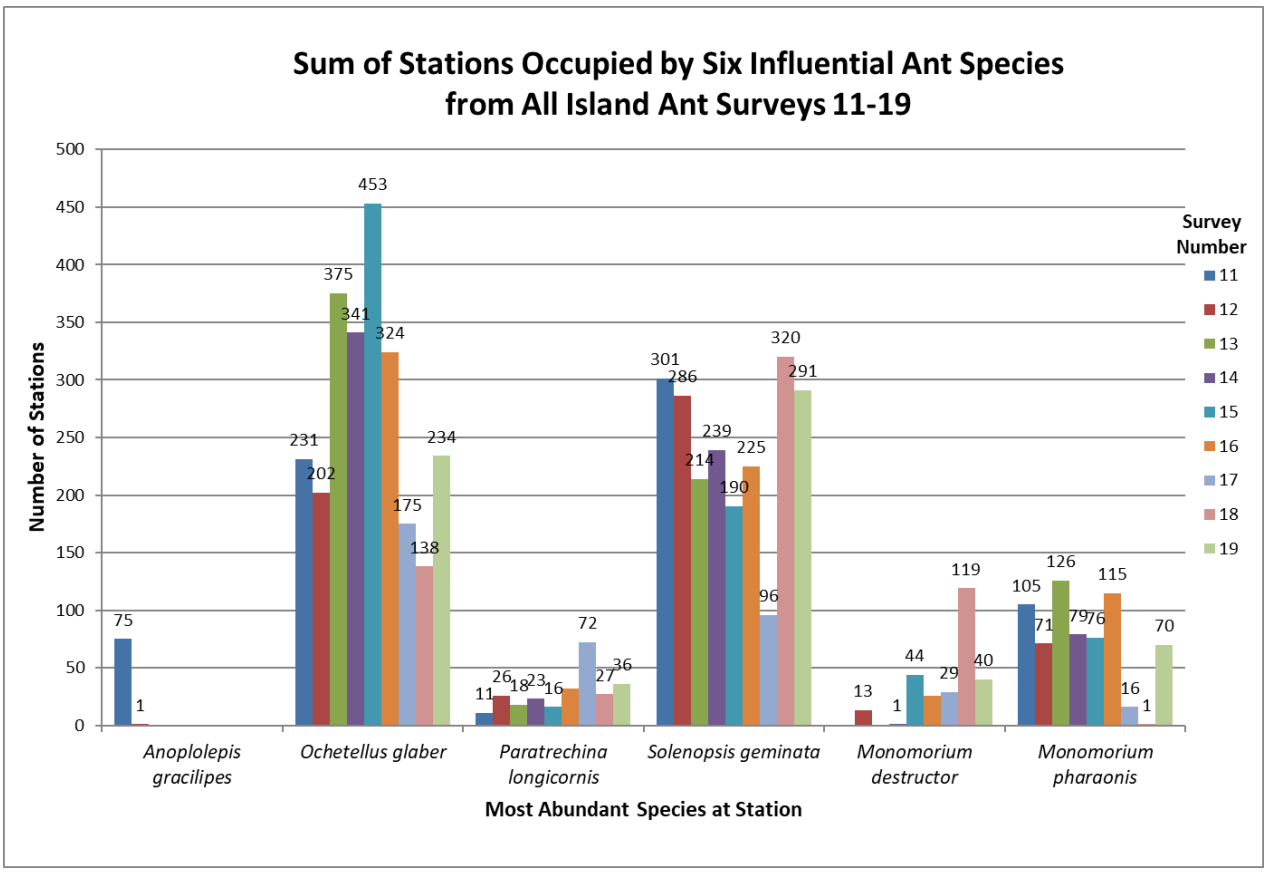


Figure 8. *The count of stations at which six influential ant species were identified over the past nine All-Island Ant Surveys (August 2015-February 2020).*

Of the six influential ant species found on Johnston Island, *O. glaber*, *P. longicornis* and *M. pharaonis* have increased in the number of stations they were detected at since the last All-Island Ant Survey. The number of *M. destructor* decreases significantly since the last All-Island Ant Survey, while *M. pharaonis* increased significantly. Of all the species identified, *M. pharaonis* and *M. destructor* were the most difficult to differentiate, especially in tubes containing few specimens. These samples were sent back to Honolulu for further identification.

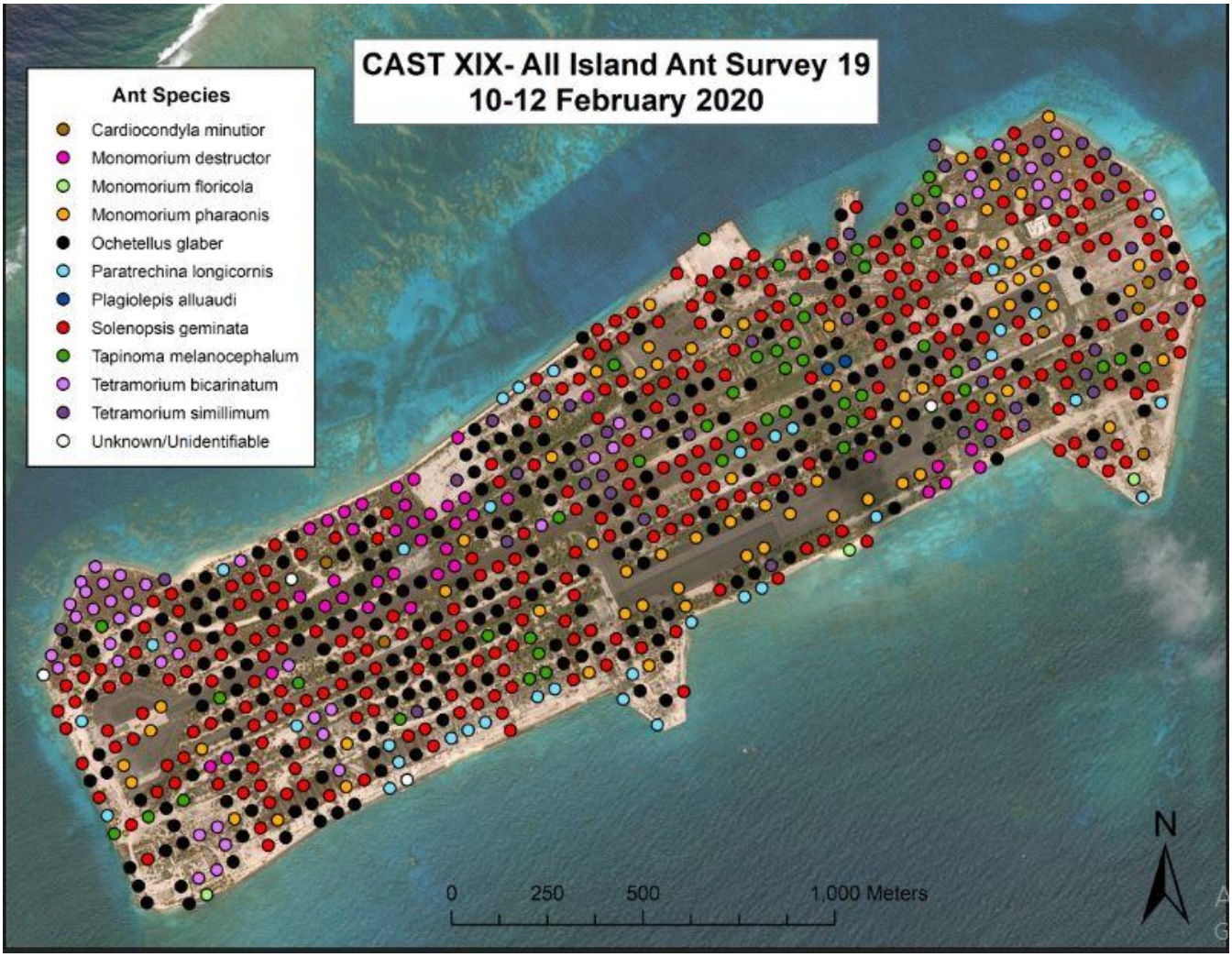


Figure 9. *Distribution of ant species collected on Johnston Island from 10-12 February 2020. When there were two species of ants at the station, only the primary ant species at the stations was included in this figure.*

OAS Comeback Survey

The OAS Comeback Survey, which started in January 2012, is typically conducted every two months with the purpose to monitor changes in the OAS composition within the YCA Infestation Area of Johnston Island. Small (1 cm^3) pieces of SPAM are put into 15 mL centrifuge tubes early in the morning, prior to the survey. Surveys begin at first light (~0630 HST) when vials are opened and placed at 81 flagged stations scattered throughout the infestation area. Team members return to each station 60-80 minutes later to close and collect the SPAM-baited tubes. Tubes with ants present are frozen for minimally 48hrs to later be counted and identified to the species level.

CAST XVII Results:

CAST XVII completed the OAS Comeback Survey on two occasions (March 2019 & May 2019). During each survey, 81 stations were successfully monitored. No YCA were collected at any of the sites during any of the surveys. On 19 March 2019 (Survey #40), OAS were detected at 32 stations (39.5%), a total of 728 ants were identified, and two stations contained two species. On 21 May 2019 (Survey #41), OAS were detected at 23 stations (28.4%), a total of 1,096 ants were identified, and no stations contained two or more species.

CAST XIX Results:

The OAS Comeback Survey was completed by CAST XIX on two occasions (January 2020 & April 2020). During each survey, 81 stations were successfully monitored. No YCA were collected at any of the sites during any of the surveys. On 13 January 2020 (Survey #45), OAS were detected at 37 stations (45.7%), a total of 1,186 ants were identified, and one station contained two species. On 8 April 2020 (Survey #46), OAS were detected at 44 stations (54.3%), a total of 3,139 ants were identified, and one station contained two species.

CAST XVII and CAST XIX Results:

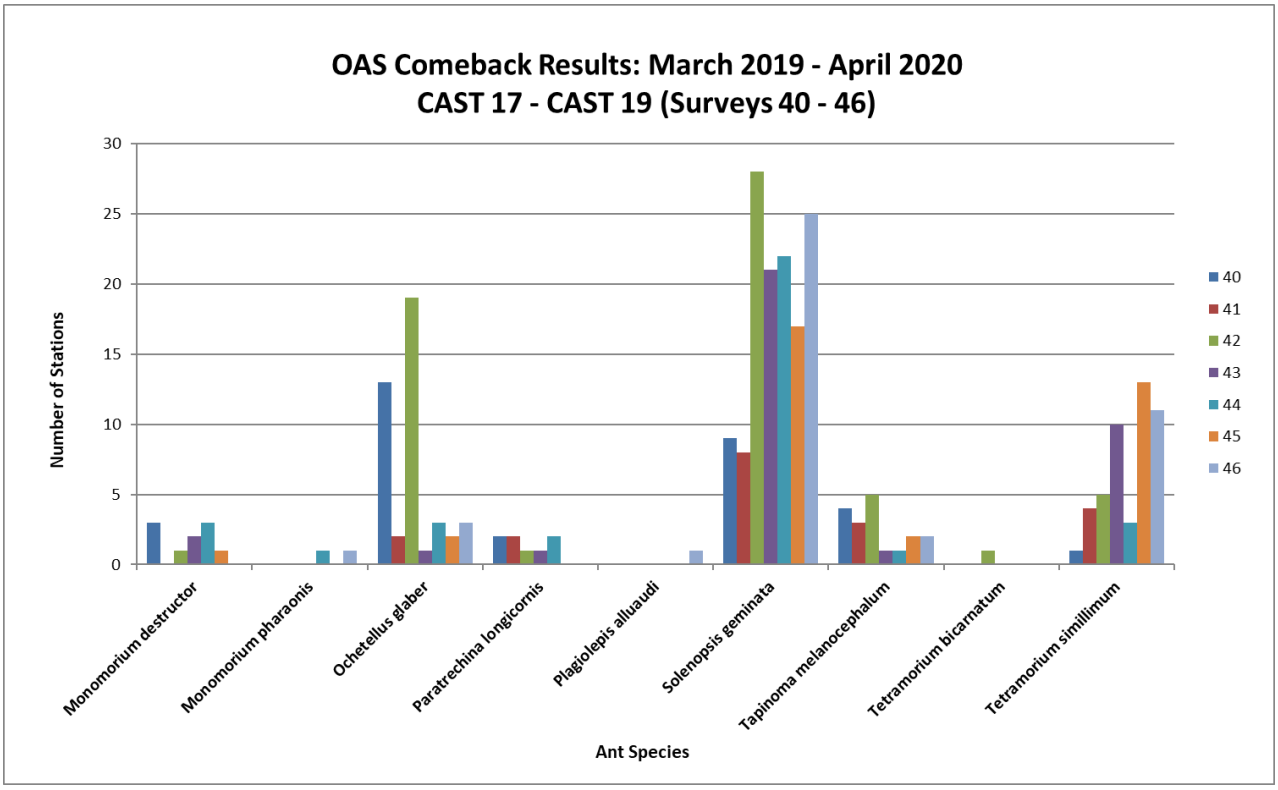


Figure 10. *Compares the number of stations of each identified OAS species from March 2019 – April 2020.*

The OAS presence number of stations found on previous surveys conducted since January 2012 averages at 38.1% of stations having collected ants. The second CAST XVII survey was well below this average (28.4%) and the two CAST XIX surveys were well above this average (45.7% and 54.3%). The collection results may be highly variable as the centrifuge tubes only have one entrance. Additionally, the two most collected ant species on CAST XVII were S. *geminata* and *O.glaber*, while the two most collected ant species on CAST XIX were *S. geminata* and *T. simillimum* (*Figure 10*). The last survey conducted by CAST XIX collected *P.alluaudi* and *M. pharaonis*, which are not detected as frequently in OAS Comeback Survey.

Non-Infestation Survey

Several YCA monitoring routes were set up at frequently used areas around the island following the detection of YCA in the camp area in April 2013. These routes include the Camp area (n = 92), around the Trash Bunker (n = 23), North Perimeter Road, and near the Gravel Land Farms between the Camp entrance and the beginning of the YCA infestation area (n = 65). Ceramic tiles and 7 x 11 cm plastic cards are baited with pureed Spam (1 can spam: 1 cup water) beginning at first light before sunrise (approximately 0610-0710 HST, depending on time of year). Observers return 60 minutes later to record the number of YCA on each baited tile or card as well as the presence or absence of other ant species (OAS). The frequency of the survey has varied, but overall became less frequent as only one YCA detection was found using this method in April 2013, after a YCA presence was already known to be established at camp. However, this was successful method to ensure that YCA were not being brought to frequented areas from the infestation zone by the crew.

CAST XVII Results:
Due to survey prioritization on CAST XVII, the Non-Infestation Survey was not conducted. This was primarily decided because CAST XVII had to reestablish the camp and all survey routes after Hurricane Walaka. The Treatment Monitoring Survey, 50m Monitoring Survey, All-Island Ant Survey and OAS Comeback Survey routes took precedence over the Non-Infestation Survey routes.

CAST XIX Results:
CAST XIX completed the Non-Infestation Survey on two occasions (February 2020 & April 2020). During each survey, 180 YCA monitoring stations at the Camp (92 stations), North Perimeter Road (65 stations), and Trash Bunker (23 stations) were successfully monitored. YCA were not detected at any of the sites during any of the surveys. On 18 February 2020, OAS were detected at 167 stations (92.7%). On 13 April, OAS were detected at 166 stations (92.2%). The last YCA detection during these surveys was on the Camp route on 13 August 2013.

Bait Application

No bait application occurred on CAST XVII or CAST XIX in response to YCA detections, as YCA were not detected via any of the surveying methods – Treatment Monitoring Survey, 50m Survey, the Hand Search Survey, or the OAS Comeback Survey.

Historically, CAST crews used bait containing the insecticide Safari (dinotefuran) delivered in water absorbing polyacrylamide ("hydrogel") crystals matrix to treat YCA. This was found to be the most effective form of bait application, followed by a cat food matrix.

All recipes using the insecticide Safari were mixed to have a final active ingredient concentration of 0.05%. The active ingredient concentration in the cat food recipe is based upon the final mass of bait. The concentration in the hydrogel recipe is based upon the volume of water used. The current recipes, per kilogram of bait mixed, are as follows:

Hydrogel: *780mL H20, 195g sucrose, 7.6g Large crystal hydrogel, 7.6g Small crystal hydrogel, 2.0g Safari*

Cat food: *250g Friskies cat food, 250 mL Karo corn syrup, 500mL water, 2.5g Safari, xanthan gum*

Seabird and Shorebird Monitoring

Mean Incubation Counts (MIC)

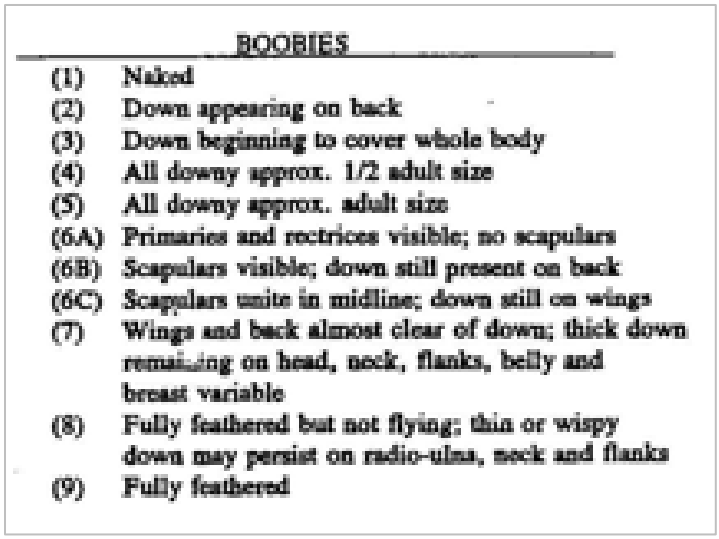
On Johnston Island there are three groups of seabirds monitored by CAST crews. These groups, the Tropicbirds (*Phaethon*), the Boobies (*Sula*), and the Frigatebirds (*Fregata*), are monitored using routine nest counts. The timing of each of these mean incubation counts (MIC) is based on the mean incubation period of each species as described in *The Birds of North America* (Schreiber et al., 1996, Schreiber et al., 2009, Gauger et al., 2002). Tropicbirds are monitored every 43 days, boobies are monitored every 46 days and frigatebirds are monitored every 55 days. Additionally, Johnston Island is divided into 22 seabird sectors (Figure 11) to standardize survey areas and break the surveys into manageable regions.

CAST XVII and CAST XIX surveyed seabird sectors using the following method; crew members dispersed at equidistant lengths in parallel to each other at one of the boundaries of a sector, then, maintaining the same pace, they each walk a straight line transect to the opposite end of the sector. The distance between crew members is determined by the density of vegetation of the transect. Each crewmember is responsible for counting the active nests directly in the transect they walk in order to avoid double counts of birds. The crew repeats this method going from one boundary of the sector to the opposite boundary until the entire area has been covered. From such surveys, crews can determine how many birds are actively reproducing on the island and which months have the highest levels of reproduction.

Figure 11. *The 22 seabird survey sectors on Johnston Island.*

Brown Booby, Red-footed Booby, and Masked Booby Mean Incubation Counts

Brown Boobies (Sula leucogaster, BRBO), Red-footed Boobies (Sula sula, RFBO), and Masked Boobies (Sula dactylatra, MABO) exhibit asynchronous and non-seasonal breeding behavior on Johnston Atoll. Active booby nests are counted once every mean incubation period (46 days for Red-footed Boobies and 43 for Brown Boobies and Masked Boobies) in an attempt to monitor the total breeding population on the island. Due to the historically low numbers of Brown Boobies and Masked Boobies that nest on Johnston, all three Booby species are surveyed within the same mean incubation period as the Red-footed Boobies: 46 days. All 22 seabird sectors were surveyed for nests via wide, straight-line transects and recorded as having an egg or a chick. In all surveyed sectors, chicks were classified along a growth-stage spectrum with stage 1 being a small, completely naked chick and stage 9 being a fully feathered, nearly fledged chick (*Figure 12). Nests were determined as unconfirmed when observers could see nesting material and a brooding adult, but the presence of an egg or chick could not be verified. Most of the unconfirmed nests were too high off the ground to see inside the nest or to tip the adult. Some unconfirmed nests were inaccessible due to the nesting Sooty Tern colony, typically located in the northeast corner of Johnston Island.*



BOOBIES

(1) Naked
(2) Down appearing on back
(3) Down beginning to cover whole body
(4) All downy approx. 1/2 adult size
(5) All downy approx. adult size
(6A) Primaries and rectrices visible; no scapulars
(6B) Scapulars visible; down still present on back
(6C) Scapulars unite in midline; down still on wings
(7) Wings and back almost clear of down; thick down remaining on head, neck, flanks, belly and breast variable
(8) Fully feathered but not flying; thin or wispy down may persist on radio-ulna, neck and flanks
(9) Fully feathered

Figure 12. *Staging guide to all of the booby species during each MIC since 2011*

CAST XVII:

CAST XVII conducted four Mean Incubation Counts of the booby populations on Johnston Island in January 2019, February 2019, April 2019, and May 2019. The survey usually took three to four days to complete. Additionally, CAST XVII recorded active Brown Booby nests, finding between 5-13 nests with the peak occurring during the April MIC.

CAST XIX Results:

CAST XIX conducted three Mean Incubation Counts of the booby populations on Johnston Island in January 2020, March 2020, and April 2020. The survey usually took three to four days to complete. Additionally, CAST XIX recorded active Brown Booby nests, recording between 9-12 nests with the peak also occurring during the April MIC.

CAST XVII and CAST XIX Results:

As in all past years of CAST surveys, the Red-footed Booby was the most common nesting species on Johnston Island. CAST XVII observed a record high of 4,394 active RFBO nests in February 2019, followed by dip in the peak nesting observed by CAST XIX (Figure 13). CAST XIX observed 3,587 active RFBO nests during the peak 2020 nesting season.

The seasonal fluctuations in the number of active RFBO nests during CAST XVII's tour were consistent with historical data from previous CASTs and there were no unexpected peaks or troughs. There was a 15.2% increase in the maximum number of active RFBO nests between Spring 2018 and Spring 2019. Followed by an 18.4% decrease in the peak number of active RFBO nests between Spring 2019 and Spring 2020, not following previous trends. This was the most significant decline in the peak nesting trend of RFBOs since the beginning of the CAST project. This may be attributed to the variation in number of unknown booby nests recorded by

the crews when the birds nest too high to confirm. This uncharacteristic dip may also be due to the El Nino Southern Oscillation (ENSO) cycle or food availability, which is often associated with the skipping of a breeding season in Boobies and other long-lived birds (Nelson 1969, Erikstad et al. 1998, Cubaynes et al. 2010).

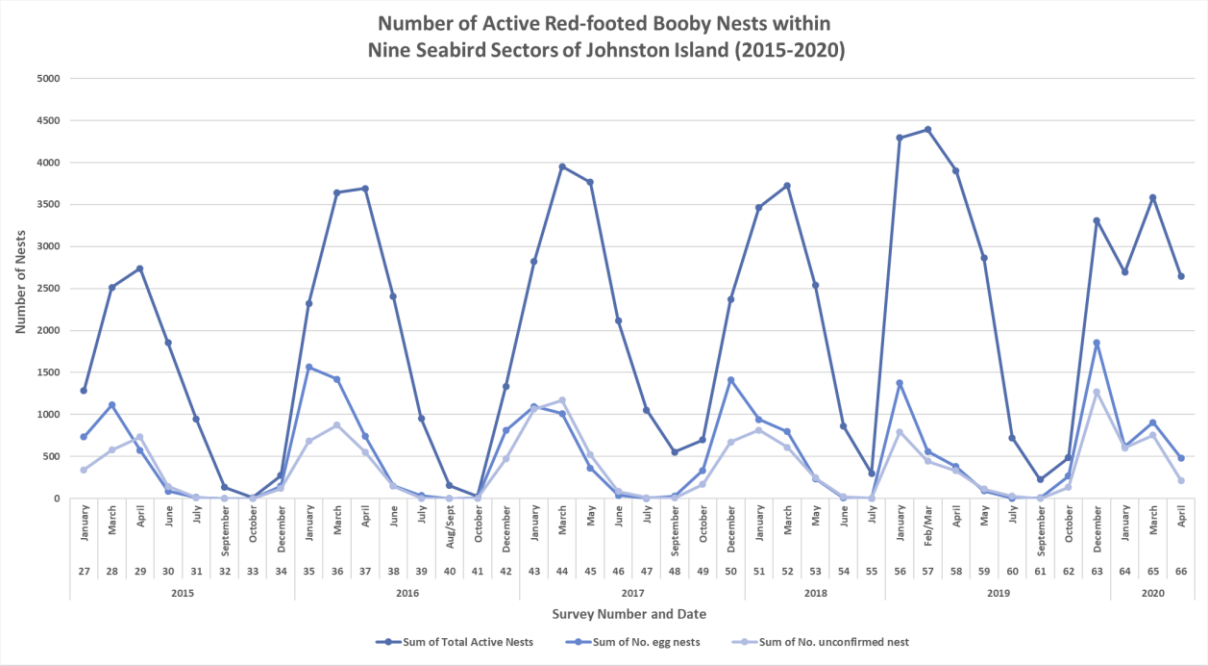


Figure 13: *Total number of active Red-footed Booby nests on Johnston Island, 2015-2020. Note the gap in data collected from July 2018 to January 2019 due to the Hurricane Walaka evacuation, and the gap from April 2020 to January 2021 due to Covid-19.*

Both CAST XVII and CAST XIX did not observe any active Masked Booby nests on Johnston Island during their deployments, although on select occasions MABO were observed flying over the eastern side of the island or perched along the seawall. Juvenile MABOs were also observed flying around the northern and eastern shores of the Johnston Island, indicating that breeding activities are taking place on the outer islands of Johnston Atoll.

Red-tailed and White-tailed Tropicbird Mean Incubation Count

Red-tailed Tropicbirds (Phaethon rubricauda, RTTR) and White-tailed Tropicbirds (Phaethon lepturus, WTTR) are surveyed for breeding activity on Johnston Atoll in nine sectors (2, 3, 4, 5, 9, 13, 16, 17, and 20) every 43 days (Figure 14) to coincide with the mean incubation period for Tropicbirds. The three outer island sectors are not surveyed. Sectors are surveyed for nests via loose, straight-line transects and recorded as having an egg or chick. Chicks are classified along a ten-category growth stage spectrum with 1 as a small chick completely covered in down and 10 being a fully feathered, nearly fledged chick.

Figure 14. *Johnston Island RTTR MIC regularly surveyed seabird sectors*

CAST XVII Results:

On four occasions, CAST XIX surveyed the nine Seabird Sectors for active RTTR and WTTR nests (January 2019, February 2019, April 2019 and May 2019). This survey was completed in approximately 4-5 workdays. The total number of active nests increased by 515 (17.0%) nests from the previous peak-season MIC conducted by CAST XVII (from 3,033 active RTTR nests in in March 2018 to 3,548 nests in April 2019) (Figure 15).

CAST XIX Results:

On four occasions, CAST XIX surveyed the nine Seabird Sectors for active RTTR and WTTR nests (December 2019, January 2020, March 2020, and April 2020). This survey was completed in approximately 4-5 workdays. The total number of active nests increased by 411 (11.6%) nests from the previous peak-season MIC conducted by CAST XVII (from 3,548 active RTTR nests in in April 2019 to 3,959 nests in March 2020) (Figure 15).

CAST XVII and CAST XIX Results:

Within the 22 seabird sectors across Johnston Island, the nine sectors routinely surveyed each mean incubation period were observed. CAST XIX documented, a record high of 3,959 active Red-tailed Tropicbird (RTTR) nests within the nine sectors. This number follows the trend of

previous years, in which the total number of active nests has exceeded the number of nests recorded in the past year's MIC (Figure 15).

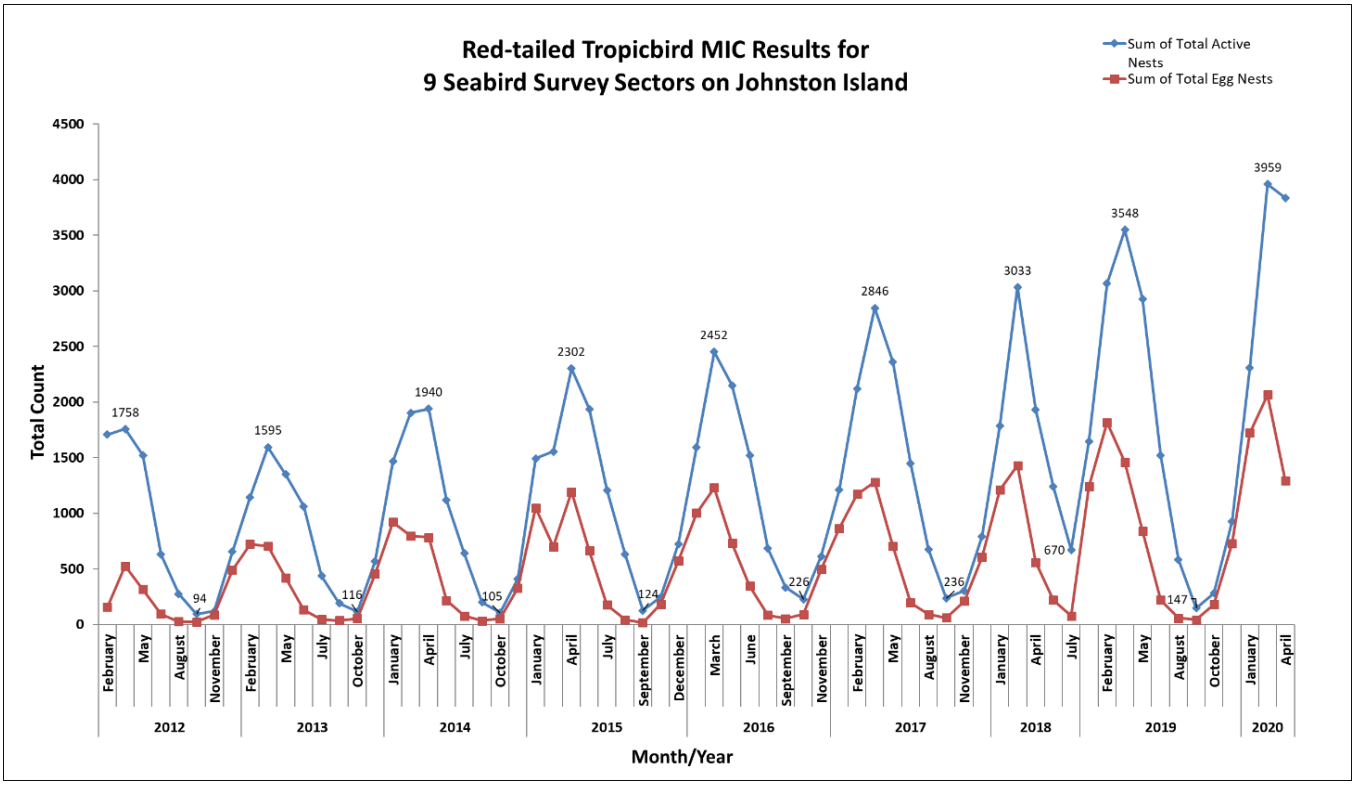


Figure 15. *Red-tailed Tropicbird nesting totals across nine seabird sectors (2, 3, 4, 5, 9, 13, 16, 17, & 20) since February 2012. Note the gap in data collected from July 2018 to Jan 2019 due to the Hurricane Walaka evacuation, and the gap from April 2020 to January 2021 due to Covid-19.*

All-Island Red-tailed and White-tailed Tropicbird Survey

Once a year, since February 2012, CAST crews have completed an All-Island Red-tailed and White-tailed Tropicbird Survey including all 22 of the seabird sectors on Johnston Island (Figure 16). This survey is conducted as close to the annual peak in nest activity as possible so a minimum population size on Johnston Island can be extrapolated. Based on the peak breeding season from previous years, as well as monitoring both the routine Tropicbird MIC data and activity at the Reproductive Plots, it was determined that this MIC would fall as close to peak nest activity as possible. Other than the additional Seabird Sectors monitored, the survey protocols and staging of chicks is the same as the regularly conducted Tropicbird MIC.

CAST XVII Results:

In all of the 22 sectors of Johnston Island **a total of 9,599 active RTTR nests** were counted (Figure 16). Of the total active nests, 5,545 contained chicks in various stages of development, and 4,052 nests contained eggs. Only two nests were recorded as unconfirmed as observers were unable to reach the nest with a tipping stick to confirm chick or egg presence. Both unconfirmed nests were due to their location at the perimeter of the Sooty Tern colony. Additionally, any tropicbird nests within the Sooty Tern colony in sectors 1, 14, and 15 were not counted as to not disturb the colony or accidentally step on any eggs. The number of unconfirmed nests since last year (2017, CAST XV) has decreased drastically (from 422 to 2).

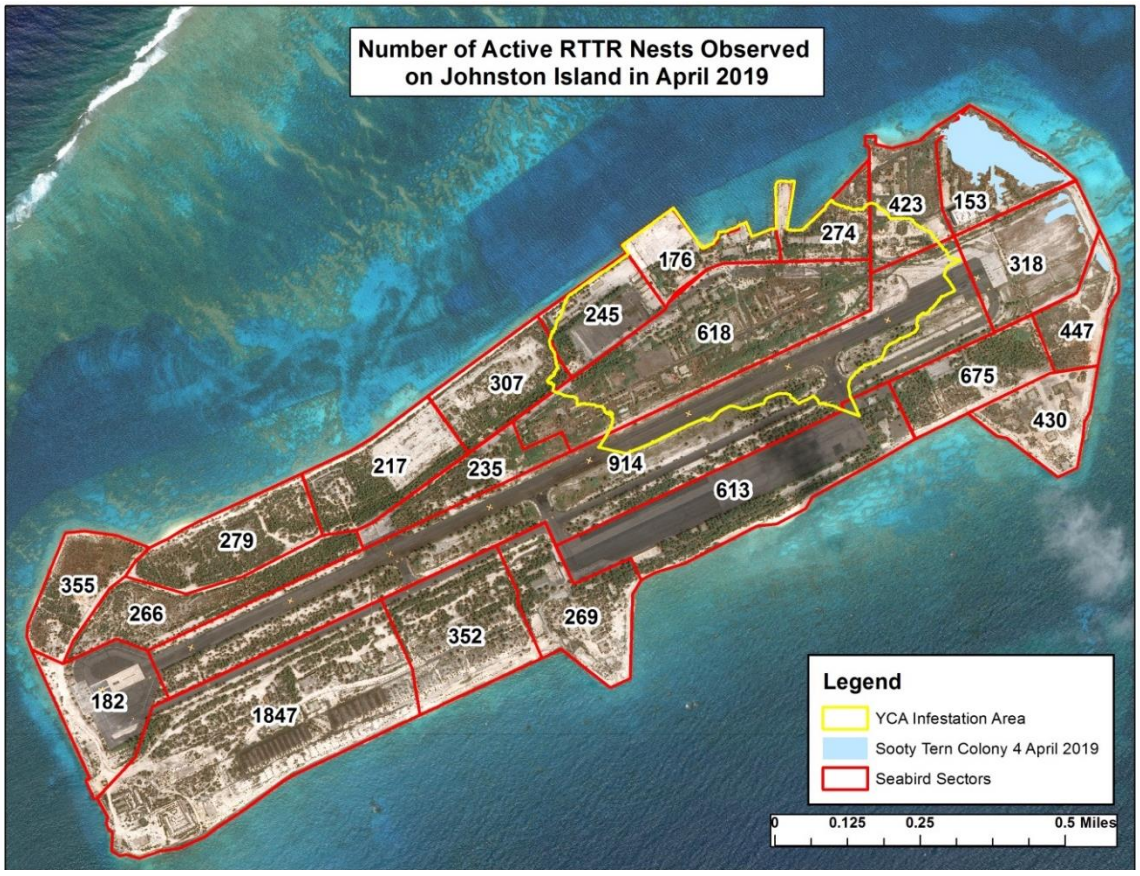


Figure 16. *Active Red-tailed Tropicbird nests counted in each seabird sector from 1-6 & 8 April 2019. Across all sectors a total of 9,599 active nests were recorded. The area in blue indicates the extent of the incipient Sooty Tern colony that was not surveyed in order to avoid stepping on eggs.*

CAST XIX Results:

In all of the 22 sectors of Johnston Island **a total of 10,884 active RTTR nests** were counted (Figure 17). Of the total active nests, 5,048 (46.4%) contained chicks in various stages of development, and 5,811 (53.4%) nests contained eggs. Twenty-five (25) nests were recorded as unconfirmed as observers were unable to reach the nest with a tipping stick to confirm chick or

egg presence. The unconfirmed nests were due to their location at the perimeter of the Sooty Tern colony. Additionally, any tropicbird nests within the Sooty Tern colony in sectors 1, 2, and 15 were not counted as to not disturb the colony or accidentally step on any eggs. The number of unconfirmed nests since last year has increased slightly (from 2 to 25) from the 2019 all-island survey (65).

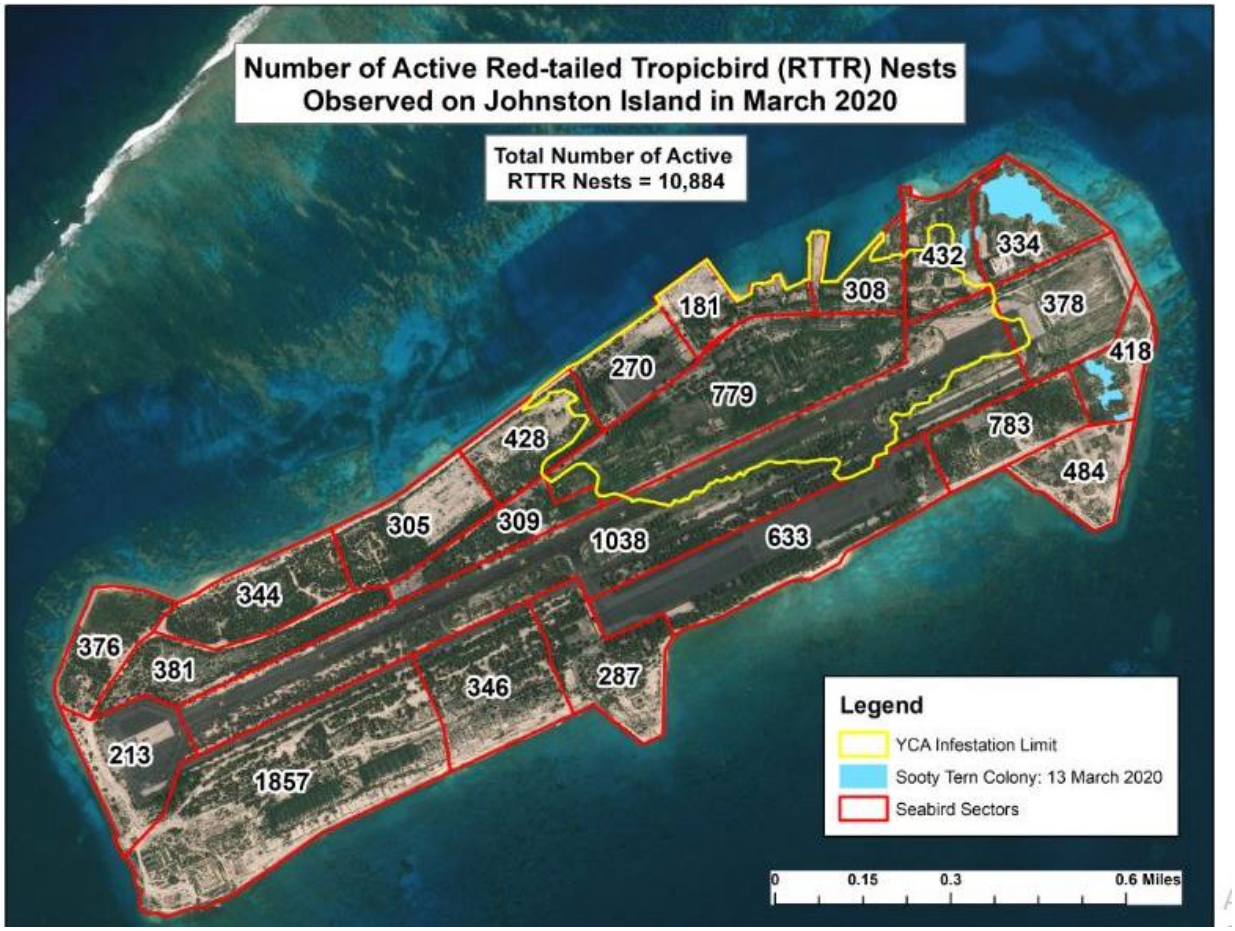


Figure 17. *Active Red-tailed Tropicbird nests counted in each seabird sector from 9-14 & 16-19 March. Across all sectors a total of 10,884 active nests were recorded. The area in blue indicates the extent of the incipient Sooty Tern colony that was not surveyed in order to avoid stepping on eggs.*

In addition to the Red-tailed Tropicbirds, 13 White-tailed Tropicbird active nests were counted. Eight nests (six egg and two chick nests) were identified in the nine regularly surveyed MIC sectors. Five other nests with eggs were recorded in the remaining sectors (one nest in each of sectors 7, 8, 11, 21, 22).

CAST XVII and CAST XIX Results:

It should also be noted that many nests were surrounded by extremely dense vegetation and an overwhelming presence of wasp nests. The density of vegetation on Johnston Island (primarily thickets of *Leucaena leucocephala* and *Pluchea indica*) is notably increasing each

year, making parts of the island nearly impenetrable for surveying. Because of the vegetation growth and increasing number of wasp nests, the margin of error has almost certainly increased as well.

Additionally, the original All-Island Tropicbird Survey conducted in February 2012 recorded 5,212 active nests, marking Johnston Island as the largest known RTTR breeding colony in the world. Every year since has witnessed an increasing number of active nests. From the 2018 to 2019 All-Island MIC, the number of active RTTR nests increased by 12.0% (1,032 more active nests). From the 2019 to 2020 All-Island MIC, the number of active RTTR nests increased by 13.4% (1,285 more active nests), demonstrating that Johnston Island remains a crucial breeding site for Red-tailed Tropicbirds.

Great Frigatebird Mean Incubation Count (MIC)

As Great Frigatebirds (Fregata minor) exhibit asynchronous and aseasonal breeding behavior on Johnston Atoll, the number of active Great Frigatebirds nests are counted and staged once every mean incubation period (55 days), with the goal of monitoring the total breeding population on the island.

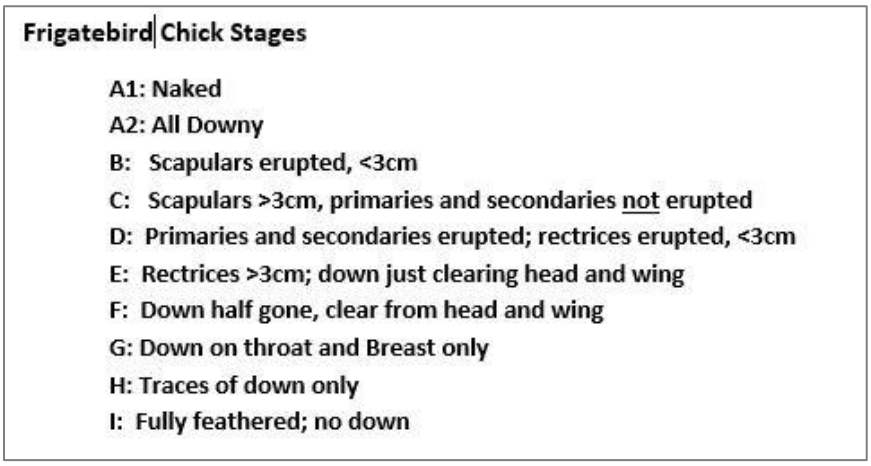


***Figure 18**. Staging guide to the Great Frigatebird nests surveyed during each MIC since 2011.*

CAST XVII Results:

On three occasions, CAST XIX surveyed all 22 Seabird Sectors for active Great Frigatebird nests (January 2019, March 2019, and May 2019). This survey was always completed in less than one work day. CAST XVII recorded the most active Great Frigatebird nests (n=27) since May 2012 (n=52), showing the beginning of the upward trend of frigatebird nesting on Johnston Island (*Figure 19*).

CAST XIX Results:

On four occasions, CAST XIX surveyed all 22 Seabird Sectors for active Great Frigatebird nests (December 2019, February 2020, March 2020, and May 2020). This survey was always completed in less than one workday. Notably, a significant increase and record high number of active nests (n=74) was documented in February 2020 (*Figure 19*).

CAST XVII and CAST XIX Results:

Following previous nesting behavior, all of the Great Frigatebirds nests observed by CAST XVII and CAST XIX on Johnston Island were located on the eastern section of the island - primarily in Seabird Sectors 14 and 15, with the occasional nest in Seabird Sectors 1 and 16. It should also be noted that between August 2013 and March 2016, no active Great Frigatebird nesting was observed on Johnston Island (*Figure 19*). However, during this period, Johnston Island typically had large numbers of adult and juvenile frigatebirds present, as breeding took place on the outer islands.

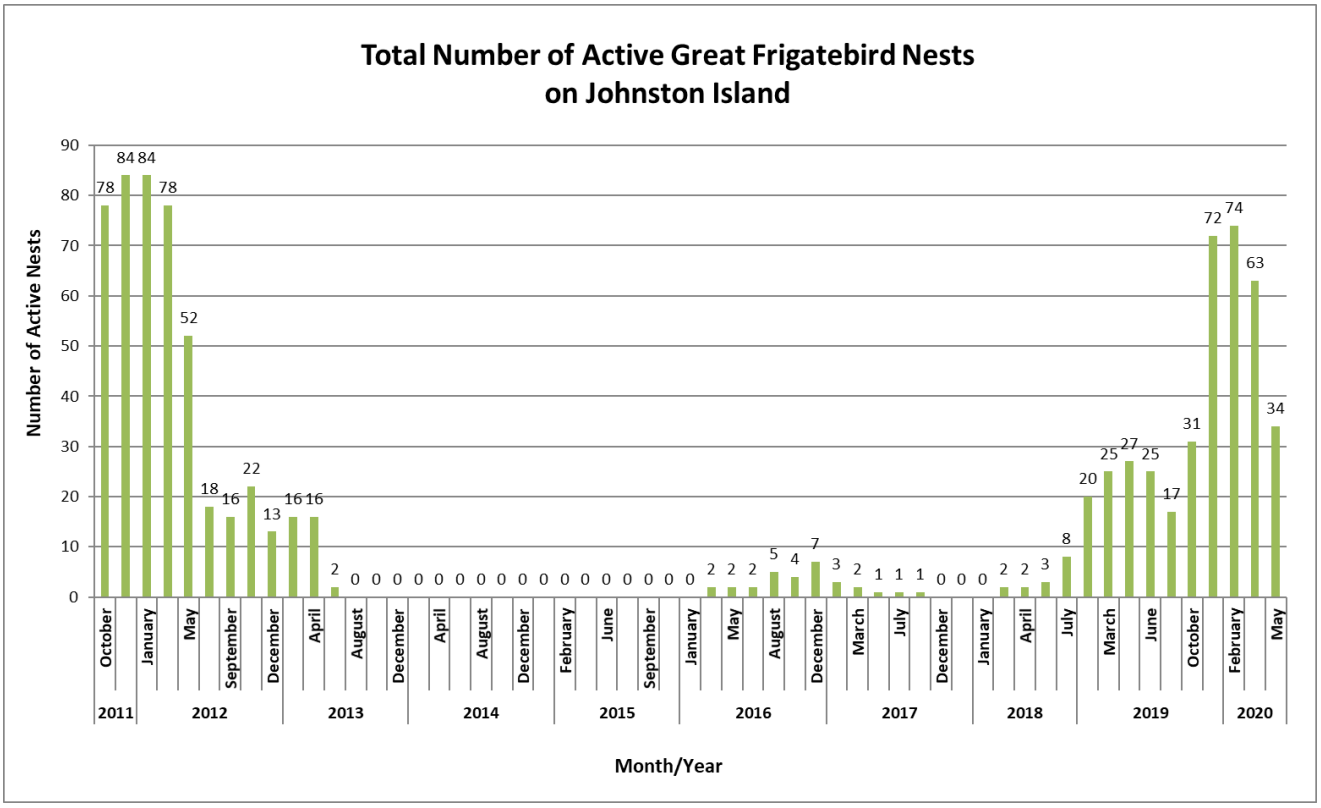


Figure 19*: This graph shows all active Great Frigatebird nests surveyed during each MIC from 2011-2020. Note: There is a six-month gap in observation between May 2020 and December 2020, and a five-month gap in observations between July 2019 and January 2020.*

Tropicbird Reproductive Plots

During their deployment, the members of CAST conducted weekly Tropicbird Reproductive Plot Surveys to monitor nesting success of the island's Red-tailed Tropicbird and White-tailed Tropicbird. These surveys were conducted both inside and outside of the YCA infestation area in an attempt to observe the effect of YCA presence on nesting success of Red-tailed and White-tailed Tropicbirds on the island. The Reproductive Plot Surveys began in April 2014.

Reproductive Plot Surveys are conducted in ten 2,500 m^2 plots around the island. Nine of these plots are inside existing 50m grid squares and the tenth is made up of sections of four 50m grid quadrants (Figure 20). Each week CAST members visited their assigned plots and catalogued nest locations and the presence of an egg or a chick. Similar to the Tropicbird MIC surveys, Reproductive Plot Surveys record the developmental stage of chicks, but also monitor overall nest success by taking into account chick mortality and fledgling success for each nest.

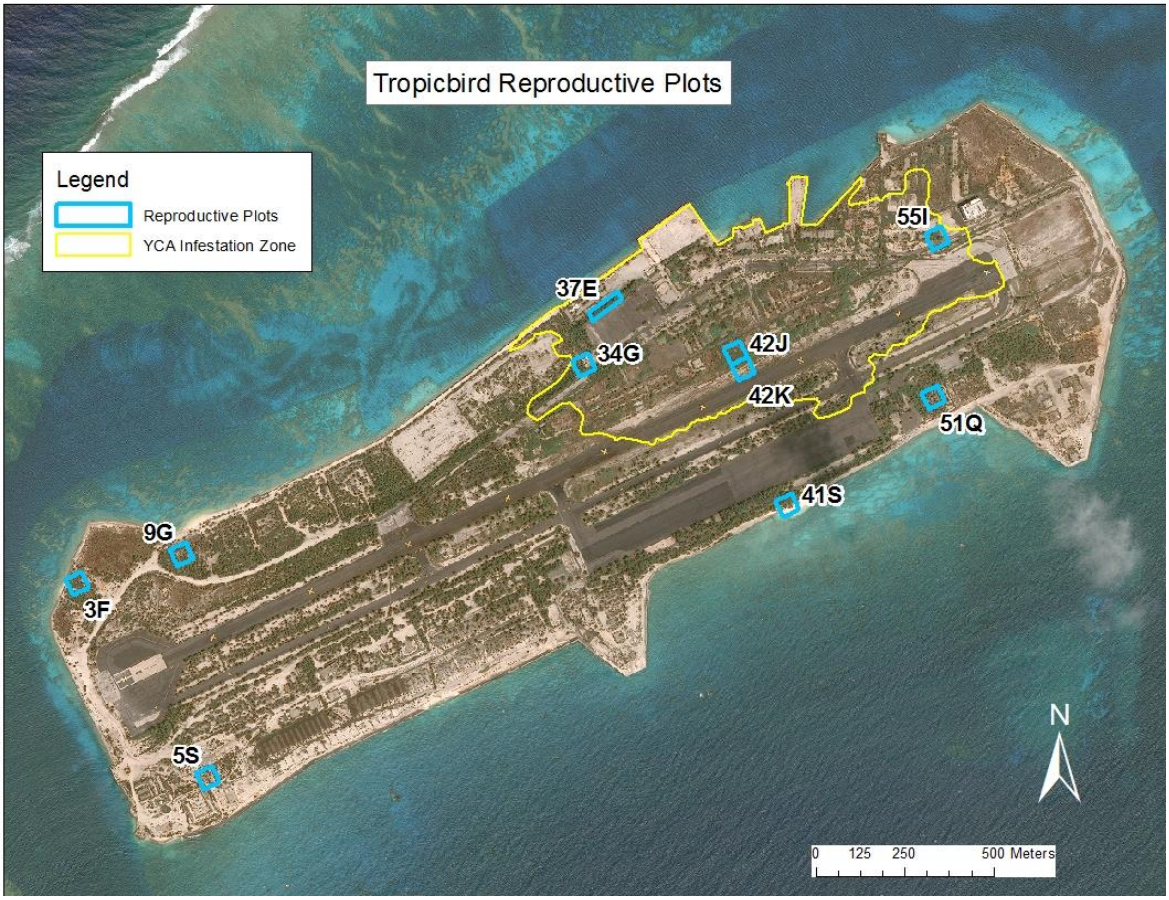


Figure 20. *Location of the Tropicbird Reproductive Plots on Johnston Island*

CAST XVII and CAST XIX Notes:

Due to malfunctions with the Microsoft Access databases, the RTTR Reproductive Plots could not be analyzed for each crew. Initial notes have been temporarily made until the database issues can be resolved with the assistance of a database manager.

CAST XVII Results:

From summarized notes of each week's observations on CAST XVII a total of 580 nests were laid during the CAST XVII portion of the 2019 hatch year (i.e., 19 November 2018 to 17 May 2019). Two hundred nineteen (282) of these nests reached a terminus (fledging or failure); 56.3% (n=159) of nests have successfully fledged, while 43.6% (n=123) of nests have failed. This data will be further analyzed once the issues with Access are resolved.

CAST XIX Results:

From summarized notes of each week's observations on CAST XIX, a total of 633 eggs were laid in the 2020 hatch year (i.e., 19 November 2019 to 5 June 2020). As a crew was not deployed on Johnston from June – November 2020, the 2020 hatch year observations were not completed and 371 nests were left still active. The number of fledged and successful nests was not able to be calculated using the database. This data will be further analyzed once the issues with Access are resolved.

Shorebird/Non-Pelagic Bird Survey

An all-island Shorebird and Non-Pelagic Bird Survey is conducted biweekly. Four transects (Figure 21) are walked east-to-west by four people in unison, and in radio contact to avoid missing or double-counting birds. All shorebirds and non-pelagic birds are recorded for each transect. This survey takes approximately 90 minutes to complete the ~2-mile-long routes. Surveys began between 7:00 and 8:00 HST.

Non-pelagic birds are defined as birds that do not depend on marine resources for survival. Surveys were performed during the USFWS's tenure on the active US Air Force Johnston Atoll installation from 1991 to 2001. They ceased upon base closure and resumed in 2010 with the establishment of the CAST program. Due to growth of forests on the island following abandonment, survey routes were changed in 2011 to improve visibility for counts (Figure 21). Regular radio checks are necessary to maintain pacing of surveyors and avoid re-counting of birds. Survey transects are approximately 2 miles (3.1 km) long, typically taking 75 minutes to complete. Seven common species are normally recorded: Bristle-thighed Curlew (Numenius tahitiensis), Pacific Golden Plover (Pluvialis fulva), Wandering Tattler (Heteroscelus incanus), Sanderling (Calidris alba), Ruddy Turnstone (Arenaria interpres), Cattle Egret (Bubulcus ibis), and Hawaiian Short-eared Owl (Asio flammeus sandwichensis). Other species of interest are recorded if observed.

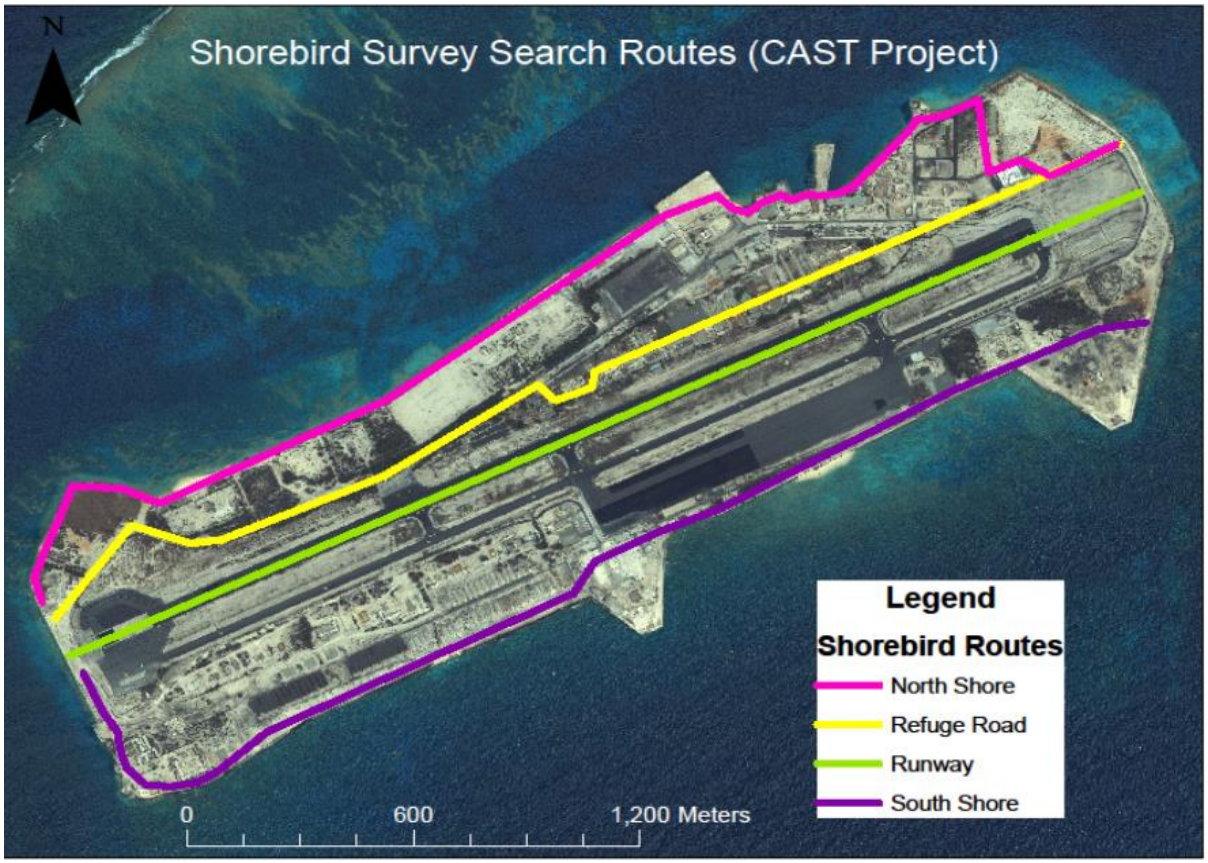


Figure 21. *Shorebird/Non-Pelagic Bird Survey transects on Johnston Island as surveyed since 2011.*

CAST XVII Results:

CAST XVII performed 12 surveys from 4 January 2019 to 6 June 2019. For 6 out of 12 surveys, Bristle-thighed Curlews were the most common shorebird. Typically, the Pacific Golden Plover is the most common shorebird observed in the majority of the surveys. However, as expected, the Pacific Golden Plover, Ruddy Turnstone, and Bristle-thighed Curlew remained the three most common shorebirds. Additionally, there was a spike of these species in April 2019, which is not consistent with the seasonal observations made by previous CAST crews. Typically, there is an increase in these three species over the winter and a decline in April/May. The Hawaiian Short-eared Owl, Wandering Tattler and Sanderling were least common species observed, with maximum sightings of seven, eleven and nine birds, respectively.

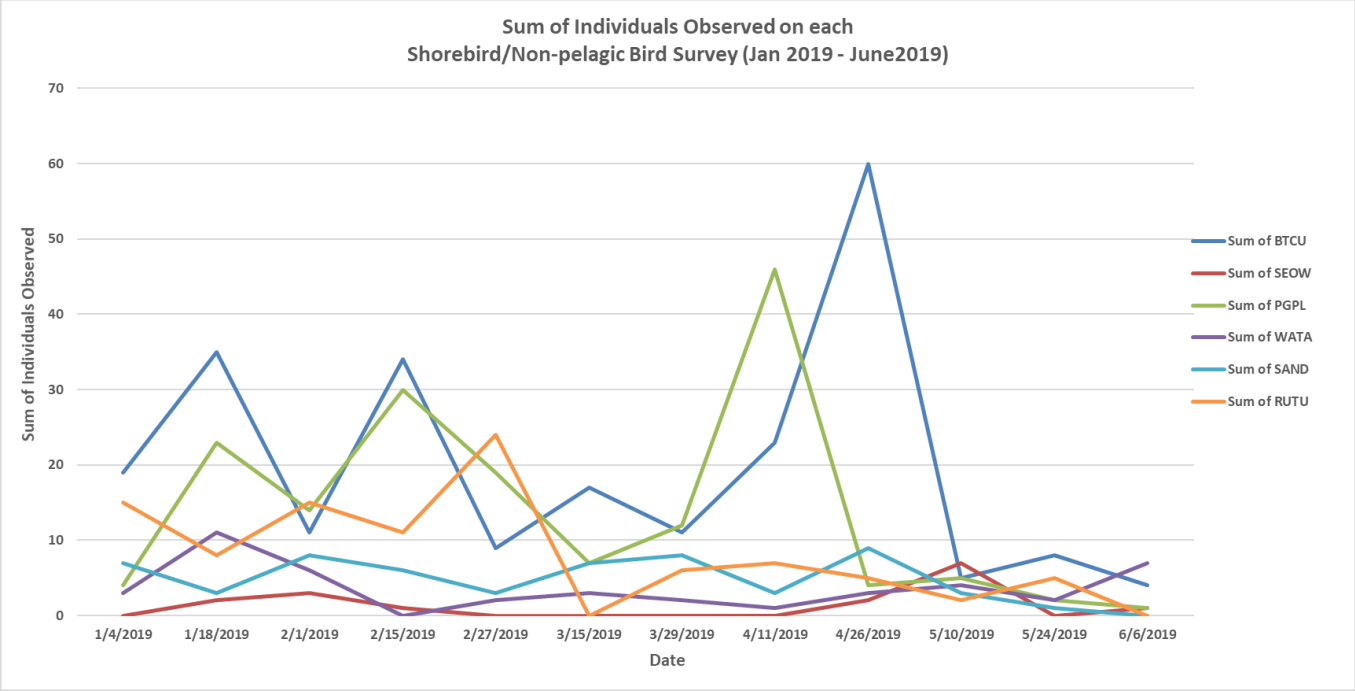


Figure 22. *Total number counted per survey of each common shorebird/non-pelagic species during CAST XVII on Johnston Island. Abbreviations: Bristle-thighed Curlew (BTCU), Pacific Golden Plover (PGPL), Ruddy Turnstone (RUTU), Wandering Tattler (WATA), Sanderling (SAND) Hawaiian Short-eared Owl (SEOW)*

CAST XIX Results:

CAST XIX performed 13 surveys from 20 December 2019 to 6 June 2020. For 10 out of 13 surveys, Pacific Golden Plovers were the most common shorebird. Numbers of the three most common shorebirds, the Ruddy Turnstone, Pacific Golden Plover and Bristle-thighed Curlew, increased over the winter season (*Figure 23*). A decline in these species was observed in late April and May. This is also consistent with the seasonal observations by previous CAST crews. The Hawaiian Short-eared Owl, Wandering Tattler and Sanderling were least common species observed, with maximum sightings of two, five and thirteen birds, respectively.

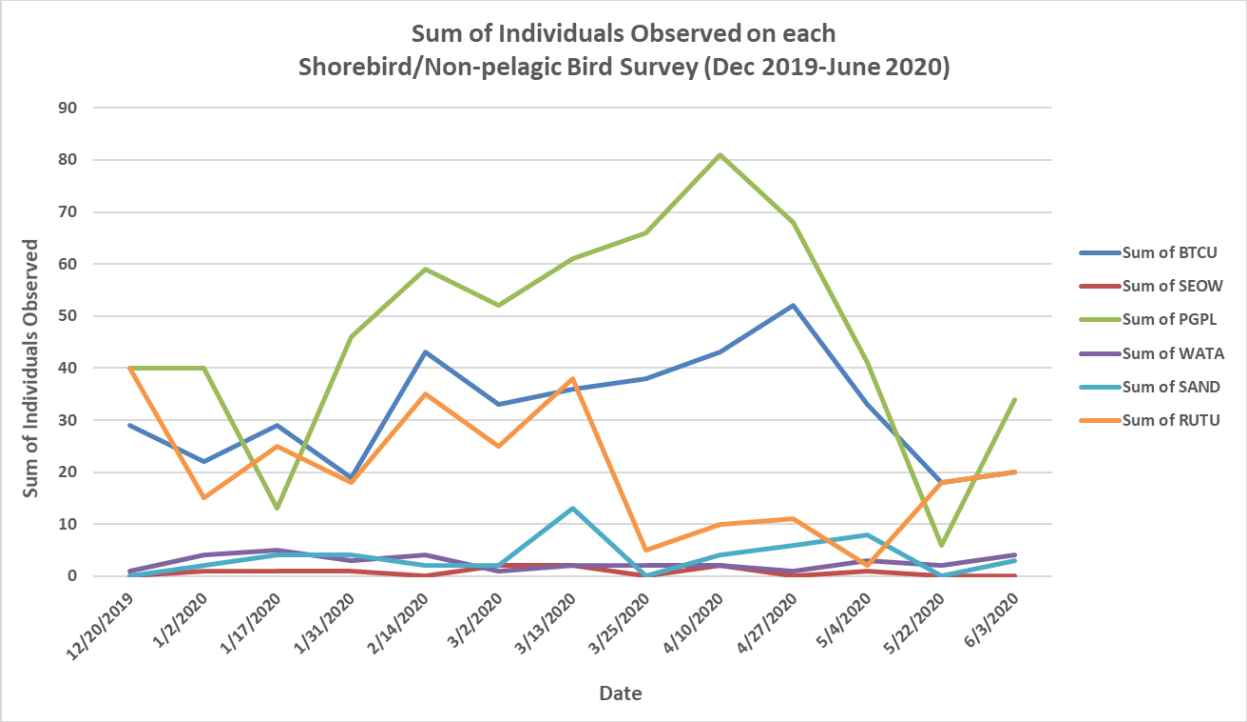


Figure 23. *Total number counted per survey of each common shorebird/non-pelagic species during CAST XIX on Johnston Island. Abbreviations: Bristle-thighed Curlew (BTCU), Pacific Golden Plover (PGPL), Ruddy Turnstone (RUTU), Wandering Tattler (WATA), Sanderling (SAND), Hawaiian Short-eared Owl (SEOW).*

Results from CAST XVII and CAST XIX:

Cattle Egrets are not native to Johnston Atoll but are established and breed on Johnston Island. The average number of Cattle Egrets sighted during each Shorebird and Non-Pelagic Bird Survey has been generally increasing throughout the CAST project (*Figure 24*). A slight decrease in the average was observed in 2018, but has risen since. CAST XIX observed the highest average to date, averaging more than nine Cattle Egrets observed during each survey. Additionally, both the CAST XVII and CAST XIX crews noted several Cattle Egret eggs and chicks on Johnston Island. Adults were also seen predating upon tern and tropicbird eggs.

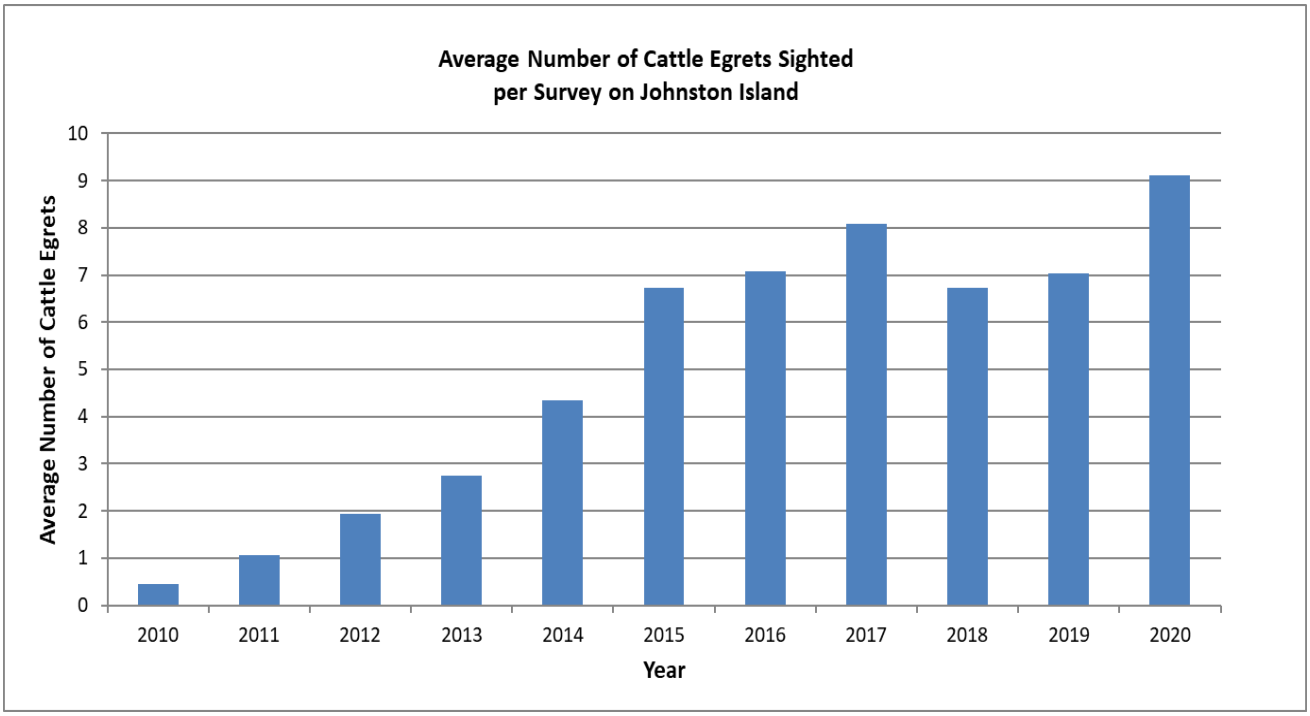


Figure 24. *Average number of Cattle Egrets counted during each Shorebird/Non-Pelagic Bird Survey, 2010-2020. Includes summarized data from both CAST XVII and CAST XIX.*

Birding Highlights and Anecdotal Observations

Other Seabird and Regularly Observed Non-Pelagic Species

In addition to the seabirds regularly monitored through mean incubation counts (tropicbirds, boobies, and frigatebirds), there are several other seabird species that nest on Johnston Island. Other seabird species of note include Sooty Terns, Gray-backed Terns, White Terns, Black Noddies, Brown Noddies, and Wedge-tailed Shearwaters. Additionally, the Hawaiian Short-eared Owl and Cattle Egret, both monitored in the Shorebird/Non-pelagic Bird Survey, have been observed nesting on Johnston Island.

Sooty Terns *(Sterna fuscata oahuensis)*

CAST XVII Notes:

The Sooty Terns were hand-mapped on CAST XVII almost every week. However, as the GIS software was not functional for the majority of the CAST XVII crew, only one official map was made to show the extent of the Sooty Tern Colony. On 28 March 2019, the Sooty Tern colony was observed at its largest extent of season on the northeast end of Johnston Island (*Figure 25*). At this point the colony just north of the runway had approximately 10% of birds on eggs and approximately 30 chicks observed (stages 2-3). Some dead chicks were also observed on Refuge Road. Throughout April and May, most of the chicks hatched and fledged from Johnston Island. There were still fledglings present, although the colony had dramatically reduced in size, at the end of the CAST XVII.

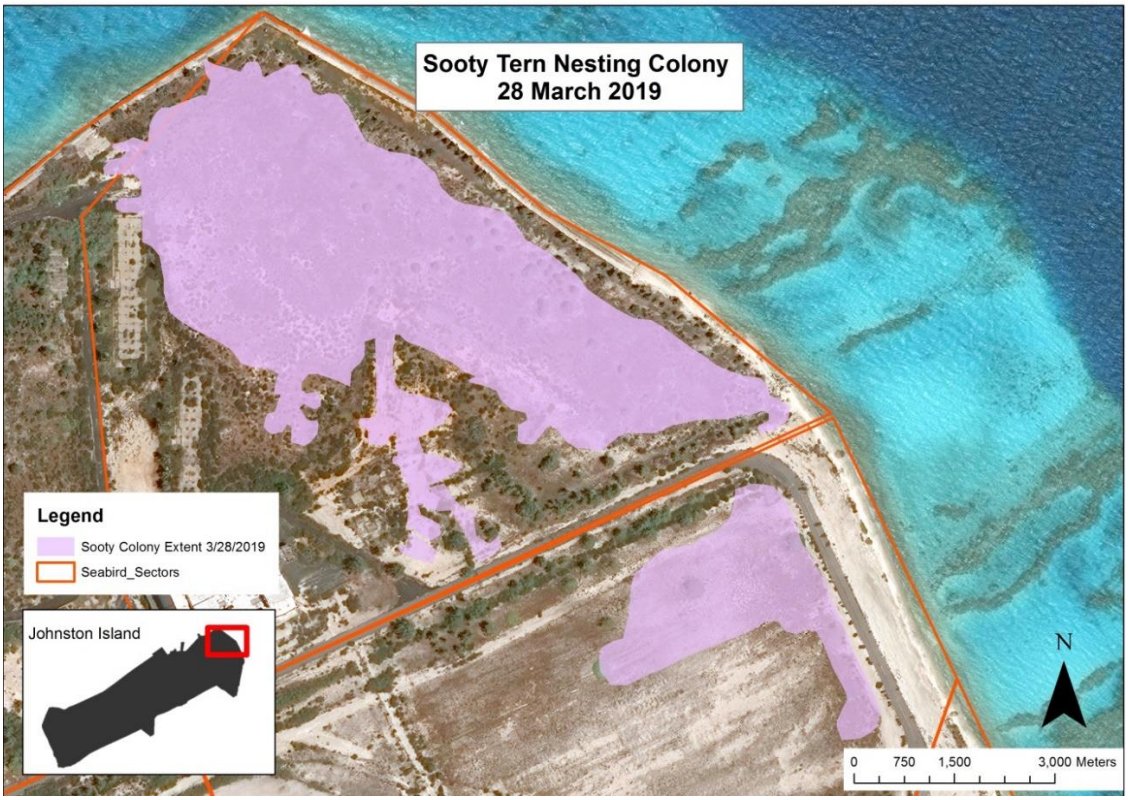


***Figure 25**. Extent of Sooty Tern colony as of 28 March 2019.*

CAST XIX Notes:

The timing of the breeding Sooty Tern colony on Johnston Island varies significantly from year to year. CAST XIX mapped the colony on a weekly basis using Trimbles and GIS software.

On 19 December 2019, CAST XIX made their first observation of the colony and found it to have increased slightly from the previous mapping completed by CAST XVIII on 6 December 2019. From 6 December to 19 December, the colony increased from 21,026 square meters to 22,853 square meters. Loafing and mating behavior was still being observed, with a large portion of the birds incubating eggs (*Figure 26*).

The Sooty Tern colony was then mapped on 31 January 2020 and found to be at its maximum size during the CAST XIX season, occupying 43,533 square meters. The colony was mapped on 6 & 13 February 2020, and found to have decreased slightly during each recording, with an occupancy of 38,294 square meters on 13 February 2020. At this time, the terns in the northeast colony had mostly chicks and the remaining nests had eggs. Additionally, the dark purple portion of the colony in Seabird Sector 14 contained hundreds of cracked eggs from an unknown cause, without any chicks or adults present (*Figure 27*).

By 2 April 2020, the colony decreased significantly in size to only 2,042 square meters. Finally, as of 9 April 2020, there were approximately 200-300 nesting terns remaining in the colony. Most of those remaining nesting terns had late-staged chicks and fledglings (*Figure 28*).

***Figure 26**. Extent of Sooty Tern colony as of 19 December 2019.*

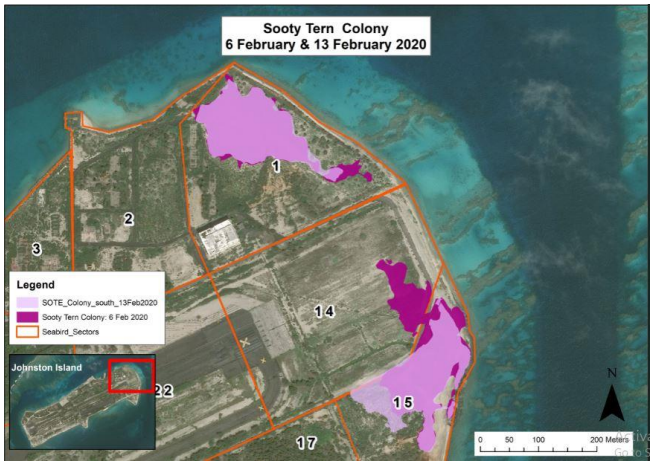


***Figure 27.** Extent of Sooty Tern colony as of 6 & 13 February 2020.*

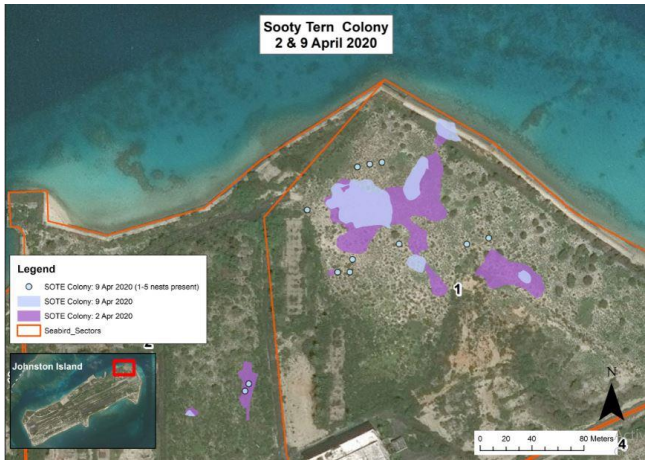


***Figure 28.** Extent of Sooty Tern colony as of 2 and 9 April 2020.*

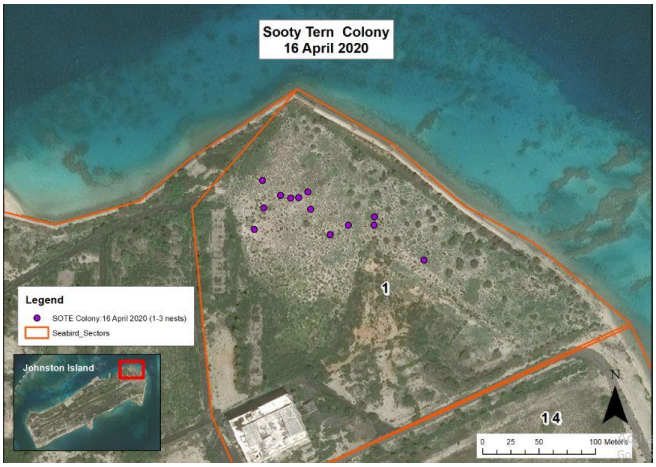


***Figure 29.** Extent of Sooty Tern colony as of 16 April 2020.*

Gray-backed Terns *(Sterna lunata)*

CAST XVII Notes:

In early February 2019, Gray-backed Terns were first seen flying around the eastern end of Johnston Island. In March, they were regularly observed flying around the Tide Station Peninsula and the eastern end of Johnston Island, with two Gray-backed Tern nests recorded on the east end. Through April and May the colony continued to be seen nesting around the tide station peninsula and the eastern end of Johnston Island. In early June, new Gray-backed Tern nests were observed in Seabird Sector 14 (around 61L & 62L) and an additional dozen nests were recorded on the east end (around 61K & 62K). No Gray-backed chicks were observed during CAST XVII.

CAST XIX Notes:

In early February 2020, Gray-backed Terns were first observed flying over the eastern end of Johnston Island. By mid-April, a few Gray-backed Terns were seen nesting in the vegetation on the Tide Station Peninsula, at the end of the runway, and the northern edge of Seabird Sectors 2 and 3. They also continued to be seen flying around the eastern shore of Johnston Island. In May, the colonies become more established and eggs were observed. In early June, CAST XIX made their last observation and the Gray-backed Tern colony was still continuing to grow on the east end of the island, with many chicks seen off the southeast end of the runway. Additionally, chicks were observed in the colonies on the Tide Station Peninsula and at and the northern edge of Seabird Sectors 2 and 3.

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White Terns *(Gygis alba)*

CAST XVII and CAST XIX Notes:

From anecdotal observations over CAST XVII and CAST XIX, it seems as though the number of White Terns on Johnston Island has decreased over the CAST project. This is most likely due to predation, as the adult carcasses are frequently found with typical signs of Hawaiian Short-eared Owl predation. There were fewer than five nests observed on each crew and both crews observed at least one of the chicks predated upon.

Figure 30*. White Tern chick on CAST XIX (photo credit: Fletcher Moore)*

Black Noddies *(Anous minutus melanogenys)*

CAST XVII Notes:

In mid-January 2019, Black Noddies were first observed flying around the eastern end of Johnston Island. In March, the Black Noddy population were seen roosting and nesting in the trees around Corner Beach (on the north shore, just east of the Wharf). Approximately 30 nests were observed around Corner Beach. Additionally, the 50m plot, 51Q, had Black

Noddies roosting in trees. During the last observation by CAST XVII in early June, the Corner Beach population expanded to 50+ nests and birds were still seen at 50m plot, 51Q. No chicks were recorded.

CAST XIX Notes:
In early February 2020, Black Noddies were first observed flying around the eastern portion of Seabird Sector 13 and around the internet, but had not begun nest building. In mid-April, they were regularly observed flying around the internet gathering nesting material and displaying courtship behaviors, with one chick observed at the internet. At this time, the eastern portion of Seabird Sector 13 also had fewer adults with many empty nests. During the last observation by CAST XIX in early June, the Black Noddies were still regularly observed flying around the internet with a few more chicks in the nests. Additionally, the eastern portion of Seabird Sector 13 had approximately 30 nests, but many nests remained empty.

Brown Noddies *(Anous stolidus pileatus*)

CAST XVII Notes:
In mid-January 2019, Brown Noddies were first observed flying around the eastern end of Johnston Island. By March, the colony on east of the runway and on the Tide Station Peninsula were established and continued to grow, while displaying courtship and loafing behaviors. In April, they were nesting around the Tide Station and in areas with little vegetation in Seabird Sector 3, and were on eggs near plots 59J and 61I. During the last observation by CAST XVII, the Tide Station and Seabird Sector 3 colonies slightly expanded and had individuals incubating eggs. Additionally, two newly hatched chicks were observed in Seabird Sector 3.

CAST XIX Notes:
In mid-April 2020, Brown Noddies were first observed in small numbers on the Tide Station Peninsula and flying around eastern sectors of the Johnston Island. By early June, the Brown Noddies were still in small numbers on Johnston Island on the Tide Station Peninsula and flying around eastern sectors of the island, but had not nested.

Wedge-tailed Shearwaters *(Puffinus pacificus)*

CAST XVII and XIX Notes:
On both CAST crews, the Wedge-tailed Shearwaters first arrived in early April. They were originally identified at night by their distinct wailing call. In the subsequent days and weeks, they were seen more frequently displaying courtship behavior. The first freshly dug burrows were also seen during this time. The shearwaters primarily have burrows around the Ant Lab in Seabird Sector 13, in the southeastern section of Seabird Sector 13, and in Seabird Sector 17. However, more burrows were noticed in Seabird Sector 16 during both of these CAST

crews. Some shearwaters may have been incubating eggs by the time of the CAST XVII and CAST XIX crew departures, but no chicks were yet observed in June 2020/June 2021.

Hawaiian Short-eared Owls "Pueo" *(Asio flammeus sandwichensis)*

CAST XVII Notes:
One Pueo nest was observed during the CAST XVII All-Island Tropicbird MIC. No follow-up on nest success was conducted. Additionally, seven adults were seen at one time during the Shorebird and Non-Pelagic Bird Survey.

CAST XIX Notes:
Four Pueo nests were observed during CAST XIX. Nests were all detected on the ground in shallow nest bowls within pluchea shrubs. Detections usually occurred during tropicbird MICs or when adults were seen flushing from a location.

Nest 1:

- On 6 March 2020, discovered with 1 hatched chick and 3 eggs. One adult flushed from the nest
- On 10 March 2020, nest contained 3 hatched chicks and 1 egg. No adults were present and 3 dead downy Red-tailed Tropicbird chicks and one dead Sooty Tern were present
- On 22 March 2020, no chicks were present in the nest. Approximately 3-4m from the nest, one chick was seen in another pluchea bush with a dead tropicbird chick. Both adults were flying overhead.

Nest 2:

- Discovered in March 2020 with 3 eggs
- Revisited a few days later and had 4 eggs
- Later visited and the nest was determined to be abandoned with all eggs still present

Nest 3:

- Discovered in March 2020 with 3 chicks and 1 egg, with an additional egg a few feet outside of the nest bowl
- Upon returning to the nest within the month, the chicks had left the nest, the egg in the nest appeared to have hatched and the egg outside of the nest bowl was still in the same location

Nest 4:

- On 19 March 2020, the nest was discovered with 5 eggs (one potentially cracked). No adults were seen at the nest.
- The nest was visited in the following days with no change
- The nest was eventually determined to have failed

CAST XVII and CAST XIX Notes:

As this species is quite elusive, they are not frequently observed during the Shorebird and Non-Pelagic Bird Survey. The exact number of individuals is difficult to estimate, but most likely at least 15 and up to 40 individuals. The Pueo were also observed predating on many of the seabird species on Johnston Island. Both CAST XVII and CAST XIX observed instances where they were flushed while feeding and found many carcasses where the cause of death was characteristic of the way the Pueo feed (the spine and head ripped from the body). It appeared their prey primarily consisted of young Red-tailed Tropicbird chicks, Sooty Terns, Gray-backed Terns and White Terns.

Observed Vagrants

This section lists accounts of species that are not regularly seen on Johnston Atoll.

CAST XVII Notes:
One unknown species of gull was observed by two crew members during CAST XVII. No pictures were captured and no further identification was able to be made.

CAST XIX Notes:
One Laughing Gull (*Leacophaeus atricilla)* was observed during the CAST XVIII / CAST XIX changeover in December 2019. Members from both CAST crews as well as some individuals on the changeover observed it. The gull was thought to be in after first-year plumage.

Marine Monitoring

Sea Turtle Survey

The objective of the Sea Turtle survey is to monitor the status of Green Sea Turtles and to detect any major changes in their presence over time. Each survey was performed for one hour, every other week and required simultaneous observations by surveyors atop the east and west sides of Johnston Island's JACADS peninsula. Each observer counted the number of turtles from their respective sides of the peninsula being mindful not to count the same individual twice.

CAST XVII Results:
Ten Sea Turtle Surveys were conducted during CAST XVII's deployment with a mean of 5.30±3.16 SD turtles observed per survey, compared to a mean of 10.53±4.93SD turtles observed per survey since January 2012 (n = 173). CAST XVII averaged 3.40 turtles observed did east side of the JACADS peninsula, compared to an average of 1.90 turtles observed on the west side of the peninsula.

CAST XIX Results:
Eleven Sea Turtle Surveys were conducted during CAST XIX's deployment with a mean of 5.18±1.54 SD turtles observed per survey, compared to a mean of 10.56±5.31SD turtles observed per survey since January 2012 (n = 197). CAST XIX averaged 3.00 turtles observed did east side of the JACADS peninsula, compared to an average of 2.18 turtles observed on the west side of the peninsula.

CAST XVII and CAST XIX Results:
From January 2012 to May 2020, observers have seen a mean of 3.41 turtles on the west side and 7.10 turtles on the east side. The cause of the discrepancy between turtle sightings from the west side and east side of the peninsula is unknown. CAST XVII and CAST XIX also saw more turtles in late spring compared to the winter and early spring. There are no other obvious trends in overall sea turtle presence around Johnston Island. Surveys were conducted on a fairly even mix of sunny and cloudy days with varying wind speeds and tidal conditions. These conditions did not appear to have any major effect on turtle sightings.

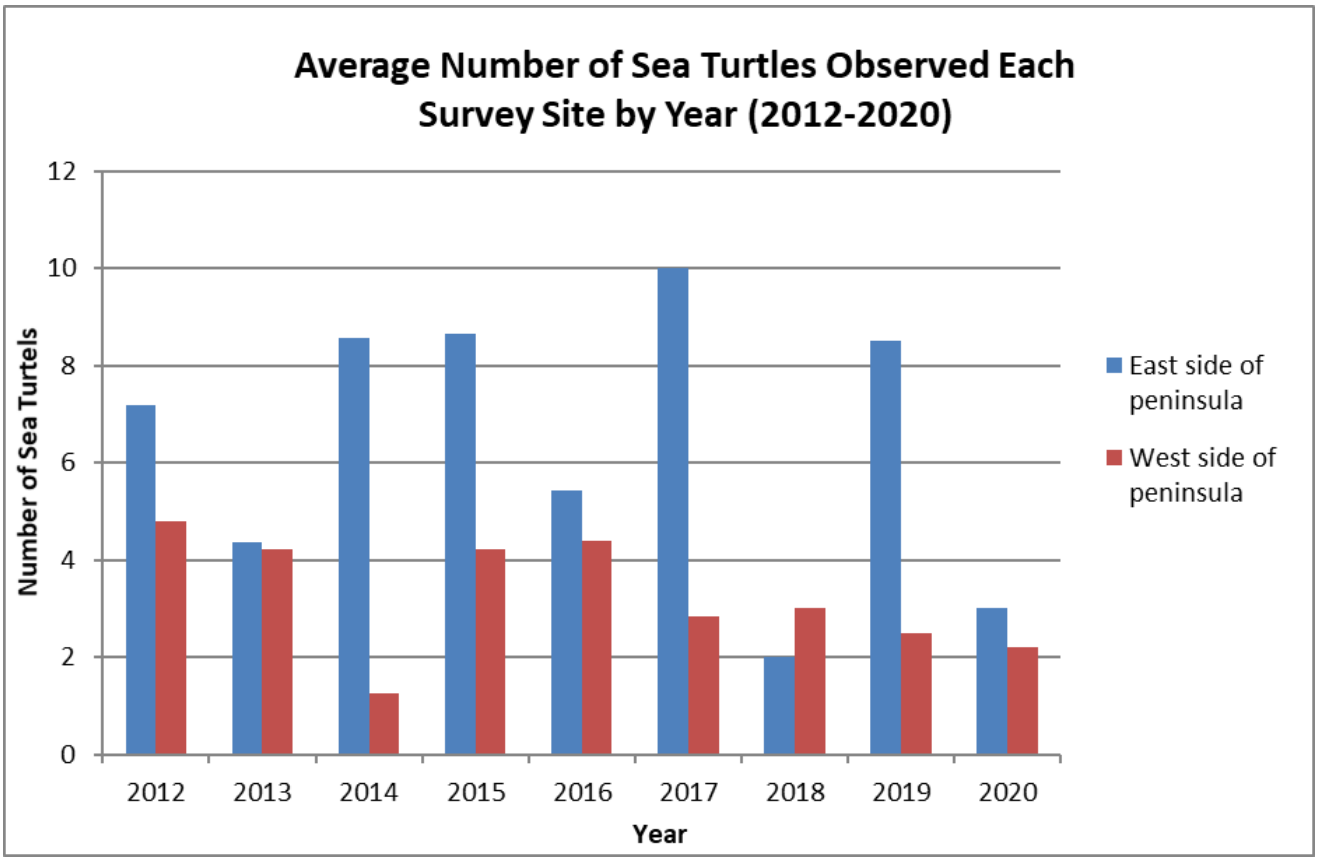


Figure 31. *Green Sea Turtles observed from the JACADS Peninsula on Johnston Island from January 2012 to May 2021. Note: there is a gap in the data from Sept-Dec 2018 due to the Hurricane Walaka Evacuation.*

NOAA Marine Debris Shoreline Survey

Marine debris has become one of the most widespread pollution problems in the world's oceans and waterways today. The NOAA Marine Debris Program (MDP) serves as a centralized marine debris resource within NOAA, coordinating and supporting activities within NOAA and with other federal agencies.

Standing-stock studies provide information on the amount and types of debris on the shoreline. Debris within discrete transects at the shoreline site is tallied during standing stock surveys. This is a quick assessment of the total load of debris and is used to determine the density (# of items per unit area) of debris present. Debris density reflects the long-term balance between debris inputs and removal and is important to understanding the overall impact of debris. Prior to deployment, NOAA trains outgoing CASTs for the monitoring of marine debris on Johnston Island. Because of the possible contaminants found on Johnston Island and the limited sandy shoreline, USFWS opted for a Standing-Stock Study to be conducted once a month on the South beach of Johnston Island. This data is reported to NOAA to be accumulated in their long-standing database.

Twenty transect lines were established every 5 meters along the length of South Beach (south of 50m grid squares 41S and 42S). These run from the vegetation line to the water and remained marked and constant throughout CAST XVII's deployment, although transect lengths are subject to variation with beach movement. CAST XVIII slightly adjusted the 20 transects on the beach, shifting the transects about one meter over. CAST XIX used the same transects as CAST XVIII. Prior to each survey, transects are selected using the random number table in Appendix C of the NOAA Marine Debris Shoreline Survey Field Guide (Opfer & Lippiatt, 2012). Due to differences in tides and shoreline shifting, GPS points are recorded for the endpoints of the four randomly selected transects to track beach movement. Every manmade material item in each randomly selected 5m-wide transect that is at least 2.5cm in diameter (roughly the size of a bottle cap) is recorded and categorized. The total number of marine debris items recorded by CAST XVII and CAST XIX are shown in Table 3 and Table 4, respectively.

CAST XVII Results:

Table 3. Marine debris recorded by material class during six surveys on the South Beach of Johnston Island in 2019

	Plastic	Metal	Glass	Rubber	Lumber	Fabric	Total
January (early)	42	3	16	2	0	0	63
January (late)	33	0	14	5	0	3	55
February	51	1	19	0	3	1	75
March	14	0	5	0	0	0	19
April	11	0	9	3	0	2	24
May	39	2	13	2	0	2	58
Total	190	6	76	12	3	7	294

The most prevalent debris category was “Plastic”, with an average of 32 items found per transect per survey. This is nearly 2.5 times greater than the second most prevalent category, “Glass,” with an average number of 13 items recorded per transect per survey. Hard plastic fragments and bottle caps were the most frequently observed items. Most transects also had uncounted debris present behind the vegetation line from occasional large storm surges, and large debris such as several pieces of treated lumber (2-5m in length).

CAST XIX Results:

Table 4. Marine debris recorded by material class during five surveys on the South Beach of Johnston Island in 2020.

	Plastic	Metal	Glass	Rubber	Lumber	Fabric	Total
January	113	4	27	3	2	0	149
February	61	8	10	4	3	4	90
March	47	3	20	4	4	0	78
April	69	3	15	3	2	1	94
May	60	6	13	3	4	9	95
Total	350	24	81	17	15	15	506

The total amount of debris observed by CAST XIX was considerably greater in the five surveys conducted (n=506) compared to the six conducted by CAST XVII (n=294). Again, “Plastic” was the most prevalent debris category with an average of 70 items found per transect per survey. This was over 4 times greater than the second most prevalent category, “Glass,” with an average number of 16 items recorded per transect per survey. Like CAST XVII, hard plastic fragments and bottle caps were the most frequently observed items. Uncounted debris present behind the vegetation line from occasional large storm surges was still present.

Marine Survey

The objective of the Marine Survey on Johnston Atoll is to establish and maintain a relative index of fish species and numbers on the reef habitats surrounding Johnston Atoll. Two transects are currently monitored: East Camp and West Camp. The East and West Camp transects, running perpendicular to the north shore, are both swum during one survey. These transects have been monitored since 2012. The South Shore Transect, which was monitored from February 2014 to August 2016, runs parallel to shore for approximately 300 meters. The Camp transects are surveyed every week, unless conditions do not allow for the survey to be conducted or ant or bird surveys take precedence. On both transects, individual fish within one meter of the transect line are counted and identified to species.

The habitat of Camp Reef is characterized by coral outcroppings and ridges separated by sandy-bottomed canyons. As with most shallow locales around Johnston, the dominant coral species is Acropora cytherea, and other corals such as Montipora spp. and Pocillopora spp. are common. This location is one of the more sheltered areas around the island with respect to wave action and circulation. Both transects begin in the coral rubble near the seawall and extend north over the reef for their duration, however, the East transect hugs the eastern reef edge, where the reef opens into a little basin that sits between the main Camp Reef and a smaller patch reef still farther to the east. Sandy bottoms make up a greater portion of the West transect.

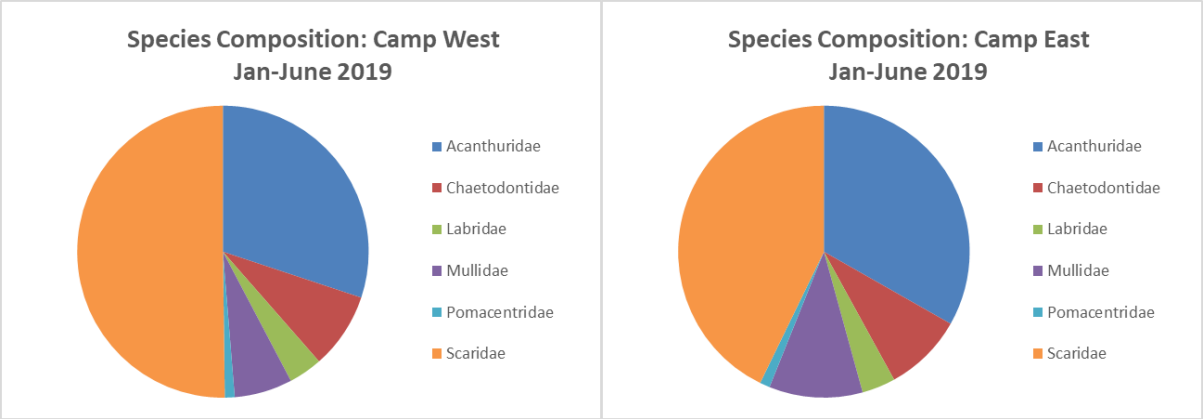
CAST XVII Results:

During CAST XVII, 22 marine surveys were conducted at both Camp Reef locations. A total of 25,565 individuals were counted across 21 families and 69 distinct species. The two Camp Reef transects are comparable in both abundance and diversity (Table 5).

Table 5: Summary of total sums and average fish counts observed during Marine Surveys during CAST XVII's tour on Johnston Island.

Transect	Total Count	Average Individuals	Species Observed	Families observed
West	12204	555	56	17
East	13361	607	66	19
Camp Reef			69	21

Like previous CAST crews, the population composition is similar across both transects and differences in species composition are minimal (*Figures 32 & 33*). The most common species belong to the Parrotfish, Goatfish, Butterflyfish, Wrasse and Surgeonfish families on both transects (refer to Appendix A for scientific names and common names).



***Figures 32 & 33**: Relative composition of the six primary fish families on each transect from January to June 2019. All other families comprise of less than 3% of species observations.*

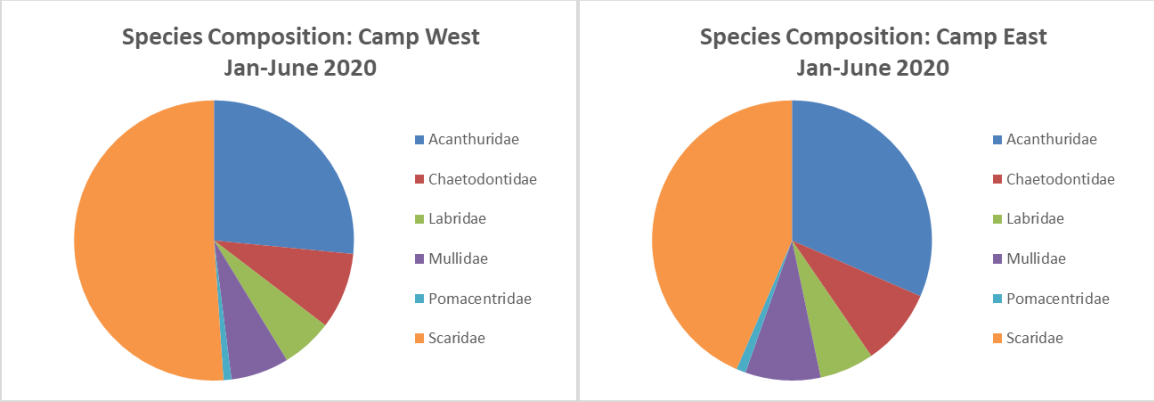
CAST XIX Results:

During CAST XIX, 21 marine surveys were conducted at both Camp Reef locations. A total of 13,212 individuals were counted across 23 families and 66 distinct species. The two Camp Reef transects are comparable in both abundance and diversity (Table 6).

Table 6: Summary of total sums and average fish counts observed during Marine Surveys during CAST XIX's tour on Johnston Island.

Transect	Total Count	Average Individuals	Species Observed	Families observed
West	5858	279	55	19
East	7354	350	60	21
Camp Reef			66	23

Like CAST XVII and previous CAST crews, the population composition is similar across both transects and differences in species composition are minimal (*Figures 34 & 35*). The most common species belong to the Parrotfish, Goatfish, Butterflyfish, Wrasse and Surgeonfish families on both transects (refer to Appendix A for scientific names and common names).



Figures 34 & 35*: Relative composition of the six primary fish families on each transect from January to June 2020. All other families comprise of less than 3% of species observations.*

Vegetation Management

Klu

Klu (*Acacia farnesiana*) is a thorny invasive weed that fails to provide suitable nesting habitat for seabirds. CASTs XVII and XIX continued Klu monitoring and management in the five sites regularly searched by previous CASTs: south of the Internet Café, north of the Tennis Courts, the far Western Shore, the large Gravel Pile on the southern edge of Seabird Sector 17, and Corner Beach in Sector 4 (*Figure 36*). Sites were visited once a month, spending a minimum of one person-hour in each location searching for plants and seedlings.

CAST XVII and CAST XIX both conducted six surveys with 30 person-hours spent searching for Klu on each crew. Klu was not detected on either CAST crew at any of the sites. The last Klu detection was by CAST XVI on the Southeast boundary of the internet stand on 25 July 2018 during the RTTR MIC. The one Klu plant was approximately 4 feet tall. Even if years go between detections, the Klu seedbank still exists on Johnston Island and therefore, it is necessary for the crews to keep searching the five sites.

Figure 36. *Five locations surveyed for the removal of Klu by CAST XVII and CAST XIX. Klu was not detected at any of the sites.*

Garlon Application

*In 2017, a permit was acquired for herbicide application in order to clear any vegetation that reached nuisance levels on Johnston Atoll. In several locations across Johnston Island, especially the designated landing area surrounding the runway, common Ironwood (*Casuarina equisetifolia*), Indian Fleabane (*Pluchea indica*), Kou (*Cordia subcordata*), Sea Grape (*Coccoloba uvifera*) and Haole Koa (*Leucaena leucocephala*) have reached nuisance levels. During the CAST XII- CAST XIII changeover, CAST XIV – CAST XVI changeover and CAST XVI redeployment, a team of sawyers and swampers felled many ironwoods from both sides of the runway. CAST XIII, CAST XIV, and CAST XV had also cleared problematic vegetation. CAST crews continued the initiative by cutting and treating all main branches with Garlon 4-Ultra (*triclopyr*), while adhering to all guidelines posted in the Garlon Application SOP. In addition to the runway, CAST crews treat woody vegetation threatening the structural integrity of camp bunkers and the vegetation surrounding the "Internet Café" area. On Johnston, the survey routes—which are not treated with Garlon—are managed per survey on a continual basis, as to not impact the integrity of data collected. These include the multiple ant survey routes that are impacted by the ever-growing flora of the island. This process of trail cutting is crucial to the completion of these surveys in a timely and effective manner.*

The Garlon 4 Ultra was mixed to the manufacturer's recommended ratio: 1 part Garlon 4 Ultra concentrate to four parts MSO (activator/oil). From which, CAST XIII derived the following recipe:

1 Liter herbicide = 200 mL Garlon 4 Ultra, 800 mL MSO, and 1 – 2 mL of dye

CAST XVII Results:

Due to survey prioritization and having to reestablish the camp after Hurricane Walaka, CAST XVII contributed many person-hours to vegetation management, but did not apply Garlon. Any debris from Hurricane Walaka was cleared from the runway area and some additional vegetation was cleared (detailed in the Trail Maintenance sections below).

CAST XIX Results:

On 2, 6 & 8 April 2020, CAST XIX cleared the sides of the runway of invasive vegetation and applied Garlon 4 Ultra to prevent regrowth. CAST XIX treated a total of 9.16 acres (3.66 hectares) using a total of 8000mL of Garlon mixture, containing 1600mL of Garlon and 6400mL of activator. Per the manufacturer's label, there is 6045mL/L of active ingredient. Total active ingredient applied on those dates mentioned equaled 4826mL at a rate of 526.86 mL per acre.

Table 7. Total acreage and Garlon active ingredient applied during CAST XIX

Total Acre (ac)	Rate per Acre (L/acre)	Total Herbicide (mL)	Active Ingredient (mL/L)	mL Active Applied	mL Active Ingredient /Acre
9.16 ac	0.87 L/ac	8000mL	6045mL/L	4826mL	526.86mL/ac

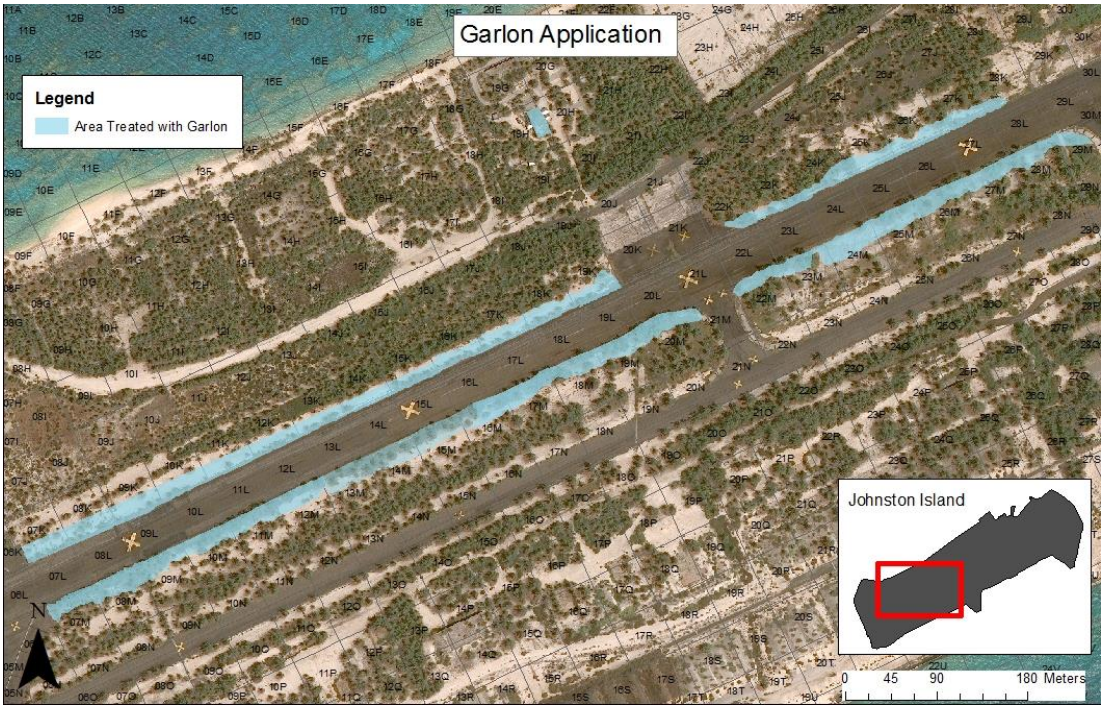


Figure 37: *Garlon 4 Ultra application along the runway*

Trail Maintenance

CAST XVII Notes:

Clearing of vegetation along the YCA 50m Monitoring Survey, YCA Treatment Monitoring Survey and All-Island Ant Survey routes was a priority upon CAST XVII's arrival to Johnston. The routes had not been maintained due to the Hurricane Walaka evacuation of CAST XVI. It took weeks to clear the downed vegetation and reflag the survey routes. After re-establishing these routes trail maintenance was conducted as needed, mostly after rainy periods and in preparation for CAST XVIII.

In addition to the survey routes, CAST XVII had to clear the roads of vegetation along with the changeover crew (December 2019) in order to access the camp and navigate around the island. CAST XVII continued to clear the roads on island and maintained the runway.

CAST XIX Notes:

CAST XIX inherited well-maintained survey routes from CAST XVIII and continued to clear vegetation along these routes as needed, mostly after rainy periods and during the first few weeks of the deployment. CAST XIX continued to clear the roads on island and maintained the runway (detailed in the Garlon Application section above).

Other Work

Tide Station Maintenance

The University of Hawaii monitors a tide station on Johnston Island to study sea level changes because of climate change. This research is conducted in the same manner in over 80 other places around the world to provide data from a wide range of oceanic locations. The instruments and monitoring equipment, including two underwater tidal switches and a solar panel that powers a transmitter, are cleaned regularly to ensure proper data collection.

CAST XVII Notes:

During the CAST XVII deployment, the crew cleaned the tide station and solar panel on a monthly basis. The equipment functioned normally throughout CAST XVII and did not require further maintenance.

CAST XIX Notes:

In the first few months of the CAST XIX deployment, the tide station stopped transmitting data. Many hours were spent troubleshooting with Jason Klem, a University of Hawaii Tide Station Monitor, who is responsible for the equipment. Analysis programs were downloaded and used to test for the malfunction. As there was not a software issue, it was determined that a piece of transmitting equipment had malfunctioned. This will require replacement of the equipment and maintenance by UH Tide Station personnel. The CAST crew continued to clean the tide station equipment and solar panel on a monthly basis to maintain the functioning equipment.

Weather

A number of basic weather conditions are measured and monitored regularly on Johnston Island. A rain gauge is located on the east side of camp and checked each morning, and a Kestrel unit mounted on a tripod near the runway collects temperature and wind data every hour on the hour.

CAST XVII Results:
Throughout CAST XVII, the crew experienced fairly typical conditions for Johnston Atoll. The data for fully observed months is included below, as observations began at the very end of December 2018 and ended at the beginning of June 2019. The total rainfall for CAST XVII's tour, from January through May 2019, was 2.59 inches – less than the typical average rainfall for winter season crews.

The average wind speeds from CAST XVII are consistent with historical data. Generally, the trade winds originate from the ENE at Johnston, which was also observed on CAST XVII. The wind speed remained relatively normal and stable over the CAST XVII season (Table 8).

Table 8. Summary of collected weather data for Johnston Atoll, from January to May 2019, from the Kestrel model 4500 Weather and Environmental Meter and the rain gauge.

Month	Avg. Temp (°F)	High Temp (°F)	Low Temp (°F)	Avg. Wind Speed (m/s)	Rain (mm)
January	78.8	85.2	71.2	4.90	6.15
February	76.5	83.9	65.5	4.52	16.00
March	77.3	84.2	69.5	5.36	5.75
April	79.0	86.9	71.2	5.28	15.99
May	80.3	88.6	69.4	4.055	21.81
Total					**65.70mm**

CAST XIX Results:

Throughout CAST XIX, the crew experienced fairly typical conditions for Johnston Atoll other than the amount of rainfall. Observations began 14 December 2019 and went through May 2020. The total rainfall for CAST XIX's tour was 482.85mm (18.90 inches), with 253.50mm (9.98 inches) in the first two weeks of the crew.

Like CAST XVII, the average wind speeds from CAST XIX are consistent with historical data. The trade winds still typically originated from the ENE at Johnston. The wind speed remained relatively normal and stable over the CAST XIX season, with a slight dip in April (Table 9).

Table 9. Summary of collected weather data for Johnston Atoll, from 14 December to 23 May 2019, from the Kestrel model 4500 Weather and Environmental Meter and the rain gauge.

Month	Avg. Temp (°F)	High Temp (°F)	Low Temp (°F)	Avg. Wind Speed (m/s)	Rain (mm)
December					253.50
January	79.6	87.3	70.7	4.23	31.35
February	78.1	85.3	70.2	5.14	49.50
March	77.9	86.4	68.4	4.61	112.50
April	79.3	87.8	68.9	3.60	14.50
May	80.5	87.8	71.6	4.05	21.50
Total					**482.85mm**

CAST XVII Summary

Upon initial arrival, CAST XVII took over an abandoned field camp due to the Hurricane Walaka evacuation of CAST XVI. The crew had to reestablish many of the survey routes and setup the camp from a completely packed away state. After a slower start than normal, CAST XVII still had a successful field season and was able to complete all of the scheduled surveys. Most notably, YCA were not detected using any of the established survey method. Additionally, a record number breeding red-tailed tropicbirds (active nests = 9,599) and red-footed boobies (active nests = 4,394) during this season. The most great frigatebird nests were also recorded since May 2012, with 27 active nests. CAST XVII wrapped up their season and assisted in the training and establishments of CAST XVIII before heading back to Honolulu.

CAST XIX Summary

CAST XIX was deployed in December 2019, inheriting a well maintained survey routes and camp from CAST XVIII. Again, no yellow crazy ants were observed via any of the surveys throughout this season. The nesting red-tailed tropicbirds were observed at another record high of 10,884 active nests and the great frigatebirds also continued to increase, with 74 active nests. However, the number of red-footed boobies decreased slightly, with 3,587 active nests observed. Due to the Covid-19 pandemic, a crew did not replace this crew. CAST XIX packed up the camp and were picked up via a plane in June 2020.

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Appendix A

Marine Species Database:

Family	Genus	Species	Common Name
Chaetodontidae	*Chaetodon*	*auriga*	Threadfin Butterflyfish
Chaetodontidae	*Chaetodontidae*	*trifascialis*	Chevron Butterflyfish
Chaetodontidae	*Chaetodon*	*citrinellus*	Speckled Butterflyfish
Chaetodontidae	*Chaetodon*	*lunulatus*	Oval Butterflyfish
Chaetodontidae	*Chaetodon*	*ornatissimus*	Ornate Butterflyfish
Chaetodontidae	*Chaetodon*	*ephippium*	Saddleback Butterflyfish
Chaetodontidae	*Chaetodon*	*quadrimaculatus*	Fourspot Butterflyfish
Chaetodontidae	*Chaetodon*	*multicinctus*	Multiband Butterflyfish
Chaetodontidae	*Forcipiger*	*flavissimus*	Common Longnose Butterflyfish
Chaetodontidae	*Chaetodon*	*unimaculatus*	Keyhole/Teardrop Butterflyfish
Scaridae	*Chlorurus*	*spilurus*	Bullethead Parrotfish
Scaridae	*Scarus*	*psittacus*	Palenose Parrotfish
Scaridae	*Scarus*	*rubroviolaceus*	Ember Parrotfish
Scaridae	*Scarus*	*dubius*	Regal Parrotfish
Scaridae	*Chlorurus*	*perspicillatus*	Spectacled Parrotfish
Scaridae	*Calotomus*	*carolinus*	Stareye Parrotfish
Acanthuridae	*Acanthurus*	*nigroris*	Blueline Surgeonfish
Acanthuridae	*Acanthurus*	*triostegus*	Convict Tang
Acanthuridae	*Acanthurus*	*achilles*	Achilles Tang
Acanthuridae	*Acanthurus*	*olivaceus*	Orangeband Surgeonfish
Acanthuridae	*Acanthurus*	*blochii*	Ringtail Surgeonfish
Acanthuridae	*Naso*	*lituratus*	Orangespine Unicornfish
Acanthuridae	*Naso*	*unicornis*	Bluespine Unicornfish
Acanthuridae	*Ctenochaetus*	*strigosus*	Goldring Surgeonfish
Acanthuridae	*Zebrasoma*	*flavescens*	Yellow Tang
Acanthuridae	*Zebrasoma*	*veliferum*	Sailfin Tang
Mullidae	*Mulloidichthys*	*flavolineatus*	Square-spot Goatfish
Mullidae	*Mulloidichthys*	*vanicolensis*	Yellowfin Goatfish
Mullidae	*Parupeneus*	*cyclostomus*	Blue Goatfish
Mullidae	*Parupeneus*	*multifasciatus*	Manybar Goatfish
Mullidae	*Parupeneus*	*insularis*	Island Goatfish
Mullidae	*Parupeneus*	*pleurostigma*	Sidespot Goatfish
Labridae	*Thalassoma*	*duperrey*	Saddle Wrasse
Labridae	*Thalassoma*	*quinquevittatum*	Five-stripe Wrasse
Labridae	*Thalassoma*	*lutescens*	Sunset Wrasse
Labridae	*Thalassoma*	*trilobatum*	Christmas Wrasse
Labridae	*Epibulus*	*insidiator*	Slingjaw Wrasse

Labridae	*Oxycheilinus*	*unifasciatus*	Ringtail Wrasse
Labridae	*Stethojulis*	*balteata*	Belted Wrasse
Labridae	*Gomphosus*	*varius*	Bird Wrasse
Labridae	*Coris*	*gaimard*	Yellowtail Coris
Labridae	*Thalassoma*	*purpureum*	Surge Wrasse
Labridae	*Thalassoma*	*ballieui*	Old Woman Wrasse
Pomacentridae	*Abudefduf*	*sordidus*	Blackspot Sergeant Major
Pomacentridae	*Dascyllus*	*albisella*	Domino Damselfish
Pomacentridae	*Plectroglyphidodon*	*johnstonianus*	Blue-eye Damselfish
Balistidae	*Rhinecanthus*	*aculeatus*	Lagoon Triggerfish
Balistidae	*Melichthys*	*niger*	Black Triggerfish
Balistidae	*Melichthys*	*vidua*	Pinktail Triggerfish
Kyphosidae	*Kyphosus*	*sandwicensis*	Gray Chub
Kyphosidae	*Kyphosus*	*vaigiensis*	Brassy Chub
Tetraodontidae	*Arothron*	*meleagris*	Spotted Puffer
Tetraodontidae	*Canthigaster*	*jactator*	White Spotted Toby
Ostraciidae	*Ostracion*	*meleagris*	Spotted Boxfish
Ostraciidae	*Ostracion*	*whitleyi*	Whitley's Boxfish
Zanclidae	*Zanclus*	*cornutus*	Moorish Idol
Carangidae	*Caranx*	*melampygus*	Bluefin Trevally
Carangidae	*Scomberoides*	*lysan*	Leatherback
Carangidae	*Caranx*	*sexfasciatus*	Big-Eyed Jack
Carangidae	*Carangoides*	*orthogrammus*	Yellow-Spotted Jack
Lutjanidae	*Aphareus*	*furca*	Forktail Snapper
Carcharhinidae	*Carcharhinus*	*amblyrhyynchos*	Grey Reef Shark
Fistulariidae	*Fistularia*	*commersonii*	Cornetfish
Monacanthidae	*Cantherhines*	*dumerilii*	Barred Filefish
Synodontidae	*Synodus*	*variegatus*	Reef Lizardfish
Holocentridae	*Sargocentron*	*spiniferum*	Saber/Longjaw Squirrelfish
Aulostomidae	*Aulostomus*	*chinensis*	Trumpetfish
Kuhlidae	*Kuhlia*	*sandvicensis*	Hawaiian Flagtail
Sphyraenidae	*Sphyraena*	*Barracuda*	Great Barracuda