Performance Evaluation of Marine Zoning in the Florida Keys National Marine Sanctuary

Interim Report 1

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INTRODUCTION

This project uses a multi-tiered approach to evaluate Marine Protected Areas (MPAs) in Florida Keys National Marine Sanctuary (FKNMS). Lobsters were re-surveyed after a decade of protection in 13 no-take zones and movement of sonic-tagged lobsters and fish in Western Sambo Ecological Reserve (WSER) and across the offshore reserve boundary were tracked during the summer of 2006. The following comprises the first interim report for all phases of the project for the period June-September 2006.

We sampled spiny lobsters inside 13 marine reserves and their exploited reference areas (Table 1, Figure 1) in the Florida Keys National Marine Sanctuary (FKNMS) during the closed fishing season to determine lobster size, sex, and abundance. Sampling was designed to test the hypothesis that no-take zones would sufficiently protect lobsters so that lobsters in these zones would become larger and more abundant than those in unprotected areas. This year was the 10th year since the network of marine reserves was implemented in July 1997. We also surveyed lobsters in three of the reserves, WSER, Looe Key SPA (LKS), Eastern Sambo Special Use Area/Research Only (ESB), and their reference areas in the fishery during the open fishing season (September).

Sonic tagging field work was originally scheduled to begin in April. However, funding for this project was not received until late May, delaying the hiring of field staff and postponing commencement of field work. In June 2006, however, we were able to deploy 45 sonic receivers in a series of rings around large habitat features such as patch reefs and forereef inside Western Sambo Ecological Reserve (WSER) and a hardbottom offshore bar located south and west of WSER (Figure 2). The goals of this project are to document movement patterns and habitat use of lobster and fish within and around WSER and to evaluate the offshore bar as a potential spawning area for lobster and fish. To this end, we sonic-tagged 30 spiny lobsters and 13 fish within these habitats and tracked their movements from June through September.

METHODS

Lobster Monitoring

Lobsters were surveyed at 13 MPAs and paired reference areas in the fishery during July 2006 (closed fishing season). We stratified sampling within Western Sambo Ecological Reserve (WSER) by habitat type because we expected each habitat to shelter a different size range of spiny lobsters. Strata included forereef, backreef, offshore patch reef (Figure 3). Three replicate surveys were conducted in each stratum. Surveys were conducted in the dominant habitat within the 12 smaller reserves. We completed three replicate surveys on the forereef at Carysfort/South Carysfort Reef SPA (CAR), and one survey in the remaining 11 reserves (Table 2). We

re-surveyed lobsters in WSER, Eastern Sambo Special Use Area/Research Only (ESB), Looe Key SPA (LKS), and their paired reference areas in September 2006 (open fishing season) (Table 2). Sites were divided into four categories for data analysis: 1) WSER/PLS; 2) CAR/PAC; 3) SPAs/References; 4) LKS/MAR.

Divers surveyed spiny lobsters using 60-minute timed-searches. Two teams of divers (consisting of one searcher and one catcher) searched for lobsters for 30 minutes each. Data from the two teams were pooled and considered as one 60-minute survey. Lobsters observed by the catcher but not by the searcher were neither counted nor captured. Time was kept by the searcher using a stopwatch that was turned off while lobsters were being captured.

At the time of capture, each lobster was numbered, and sex and den depth were recorded. All captured lobsters were brought to the boat where size, molt stage, and reproductive status of females (e.g., presence or absence and condition of spermatophores and eggs) were recorded. Lobsters were returned alive to the area of capture. Lobsters that eluded capture were always included in abundance estimates, and, when possible, their sex and estimated-size were recorded.

Lobster abundance was calculated as the total number of lobsters observed in 60 minutes for each site. Abundance of legal-sized lobsters ($\geq$ 76 mm carapace length (CL)) is reported because any increase in lobster size or abundance in reserves would be reflected in the protected portion of the population, i.e., the legal-sized lobsters.

Sonic Tagging

Overview

In June 2006, we deployed 45 sonic receivers in a series of rings around large habitat features such as patch reefs (9.2 km^2), forereef (3.7 km^2) inside Western Sambo Ecological Reserve (WSER) and a hardbottom offshore bar (2.9 km^2) located south and west of WSER (Figure 2). Within these habitats, we tagged 30 spiny lobsters (29 *Panulirus argus* and 1 *P. guttatus*) and 13 fish (10 red grouper, 1 gag grouper, 1 goliath grouper, and 1 black tipped shark) with sonic tags.

On August 27, 2006, we removed 13 shallow water backreef and forereef receivers in preparation for Tropical Storm Ernesto. These receivers were returned to WSER the following week. On September 28-29, 2006, we serviced (cleaned and changed batteries) and downloaded data from all Hawk Channel and backreef receivers. Following a week of bad weather, we serviced and downloaded data from the deep water receivers on Oct 9-11, 2006. We left the receivers in place to monitor a second round of tagging that will serve to study fall movement patterns of lobster and fish.

Lobster Sonic Tagging

We tagged 30 spiny lobsters (29 *P. argus* and 1 *P. guttatus*) with sonic tags (Table 3). Both male and female lobsters were tagged in the patch reef, forereef, and offshore bar zones (Figure 4). More female than male lobsters were tagged on the offshore bar simply because males were rare during the time of tagging.

Data downloaded from the sonic receivers are originally in an ASCII (text) format. These data files contain a log of tag numbers received with date and time. In order to inspect and analyze all the data together, we added the receiver serial number field plus latitude and longitude to each file, then merged all files into a single data set. Movement patterns are assessed by creating location by time matrices for each of the sonic tags. ArcView and Tracking Analyst were used to plot movement patterns. SPSS was used to generate tables of frequencies and major habitat shifts.

Fish Sonic Tagging

Our objectives were to characterize site fidelity and movement of groupers and snappers within and outside WSER. Movements of individual groupers and snappers were tracked using 45 sonic receivers deployed in the WSER (Figure 2).

In June 2006 we tagged 12 groupers (10 red grouper, *Epinephelus morio*, 1 gag grouper, *Mycteroperca microlepis*, and 1 goliath grouper, *Epinephelus itajara*) and one blacktip shark, *Carcharhinus limbatus* in WSER (Figure 5). Fish were tagged with VEMCO sonic tags, either: V16 (16 mm dia.) or V13 (13 mm dia.). Each sonic tag had a unique 4 digit code which was "read" by VEMCO VR2 receivers so each tagged fish was identified by its 4 digit code. Each sonically tagged fish also received an external dart tag displaying the Fish and Wildlife Research Institute (FWRI) phone number.

Fish were captured with hook and line gear, (H & L) and fish traps (Z trap). Nearly equal numbers of tagged fish were captured by each fishing gear, (7 by trap, and 6 by H & L gear). Description of the sampling effort and catch per unit effort, (CPUE), is summarized in Table 5. Fish suitable for tagging were anesthetized with clove oil, respirated with seawater pumped through the mouth, and surgically implanted with the sonic tag. Following tagging, the fish was put in a recovery tank; after the fish recovered from the anesthetic (3-15 minutes) the fish was handed to a diver in the water and the diver swam the fish down toward the bottom for release. Each fish was observed on the bottom for a few minutes, or until the fish swam out of visual range.

Fish positions were recorded by the VEMCO VR2 receivers as described previously in the Lobster Sonic Tagging Section. Because tag frequencies were unique for each individual tagged, the same VR2 receivers were used to record movements of both lobsters and fish. Data were downloaded and analyzed as described in the above section.

RESULTS and DISCUSSION

Lobster Monitoring

We counted a total of 2,423 spiny lobsters using timed surveys --1, 692 during the full census (46 hrs of search time) during the closed fishing season, and 731 in the abbreviated census (22 hrs of search time) during the open fishing season. During the closed season, there were more lobsters in reserves than in references, with the exception being Carysfort SPA (Figure 6). Several Lower Keys site pairs were surveyed during both the closed and open fishing seasons (WSER/PLS, ESB/MSB, LKS/MAR). Considered together, there were nearly the same number of lobsters in the fishery as in reserves during the closed season. Effects of the fishery could be observed in both the reserves and the fishery, by the decrease in the total number of lobsters observed during the open fishing season (Figure 7).

Lobsters in reserves ranged from 20-137mm carapace length (CL) with a mean size of 79.4 mm CL; lobsters in the fishery ranged from 20-148 mm CL with a mean of 77.2 mm CL. Overall, lobsters in reserves were larger than in the fishery, although the largest lobster we encountered (148 mm) found was at Middle Sambo (MSB) in the fishery. It is probable that this lobster "spilled over" from WSER during the closed season.

Legal-sized lobsters were significantly larger in the two large MPAs, WSER and CAR, than in the adjacent fishery sites, PLS and PAC (Figure 8). Legal-sized lobsters in the smaller SPAs were slightly larger than those in the fishery. Surprisingly, legal-sized lobsters at LKS were considerably smaller than those at MAR, even though LKS has been a no-take reserve for more than 25 years. These results suggest that reserve size is an important factor in the efficacy of reserves in protecting motile fishery species such as spiny lobsters.

Abundance (N lobsters per hour) of legal-sized lobsters during the closed fishing season was greatest at WSER and lowest at CAR (Figure 9). Abundance was higher in WES/PLS than in other sites. Legal-lobster abundance was similar in the small SPAs and reference areas. Data comparing long-term trends in lobster abundance at each site will be analyzed and reported in the next interim report.

Sonic Tagging

Overview

Forty-three of the forty-five sonic receivers were found and serviced. Two receivers placed outside the offshore bar in 120 ft of water were not found and are presumed to have been drug from the site by either anchors or trap lines from a commercial fishing boat. These two receivers were 600 meters apart. The subsurface

buoy from another receiver placed approximately 800 meters from the two lost receivers was found within 20 meters of the drop point after an extensive search. Two of the Hawk Channel receivers on the western side of the ring were recovered with flooded battery compartments. These receivers were brought back to the laboratory and were repaired. Both had failed early in the project and therefore contained no data. One additional receiver at the northwest corner of the Hawk Channel ring contained some garbled, unusable data. We suspect that the battery was faulty. We replaced the battery and reinitialized the receiver in September.

Sonic tagging locations were generally out of range of sonic receivers, therefore only movements on the order of a hundred meters or more may be detected. Between June 9th and September 30th, nineteen of the forty-one active receivers recorded 39 separate codes. The receivers detected all of the 29 *P. argus* and 12 of the 13 fish. Three spurious codes probably resulted from the sonic collision of transmissions from two tags, and one code was detected from a nurse shark tagged in the Dry Tortugas by another researcher for an unrelated project.

Lobster Sonic Tagging

All 29 tagged *P. argus* were detected by sonic receivers at least once. More than 75% of the tagged lobsters were detected with 48 hours. The last lobster detection was on September 19th. The sole tagged *P. guttatus* was not detected. All tag detections occurred among the Hawk Channel, forereef, and offshore bar rings of VR2's. Neither the West sentinel nor the East sentinel receivers detected any tags.

Herein, a major habitat shift is defined as a lobster moving from one of the sonic receiver rings (Figure 2) to another ring. Overall, we detected 12 of 29 lobsters (41%) moving between one or more major habitat rings (Table 4). A slightly higher percentage of females (44%) than males (38%) made these large scale movements. These percentages are probably underestimates because some tags went undetected relatively soon after the start of the project. For example nine tags (31%) went undetected after two weeks into the project. Possible fates of these tagged lobsters are; (1) they remained within their ring, (2) they lost their tag due to predation, molting, or the tag fell off, or (3) they emigrated undetected from the region. Another factor that would increase the likelihood of underestimation is that two lost offshore bar receivers were deployed directly south of our tagged forereef lobsters. Some of these forereef lobsters had several periods of more than one week without detections. It is possible these lobsters made trips to the offshore bar, but this is speculation.

An appendix has been attached to this report with individual maps depicting the movement patterns for each lobster we tagged. Each movement map includes the size, sex, and reproductive status (if female) of the tagged lobster, location of tagging, first and last VR2 detecting that lobster, inferred home ranges, and major movements with inferred paths.

Offshore bar tagged lobsters appear to fall into two generalized movement patterns, (1) those that remain on the offshore and (2) those that move to backreef or Hawk Channel late in the summer. We have location information for four of the eight offshore bar tagged lobsters and a diver observation in mid-July for a fifth lobster. Two lobsters stayed on the offshore bar, two traveled to Hawk Channel and one lobster was found on the forereef. We can confirm three lobsters moving into WSER during this study and a fourth probably moved to WSER forereef (inferred by observing the final pattern of VR2 detections but cannot be confirmed).

It is difficult to determine the movements of the eleven forereef sonic tagged lobsters because the rugose topography of the area masks pings. The two lost VR2 on the offshore bar, deployed directly south of the forereef tagging site, also potentially hurt our understanding of lobster movements. Five of the eleven lobsters have been labeled as undetermined because their tags were detected for less than three weeks in the beginning of the study. Three lobsters appear to have remained on the forereef, however, one could possibly be on the offshore bar. Three lobsters moved toward Hawk Channel or backreef by late summer.

Eight lobsters (four male and four female) were tagged in Hawk Channel. The difference between movement patterns of female and male lobsters is striking. All tagged male lobsters stayed within Hawk Channel. All tagged female lobsters traveled to the forereef or offshore bar at least once and returned to Hawk Channel. Three females approached the forereef in an area where offshore bar VR2's were either absent or lost. Therefore it is not possible to determine whether these lobsters stopped at the forereef or continued. One Hawk Channel female did continue to the offshore bar and stayed there for at least one month.

Fish Sonic Tagging

All fish tagged in June 2006 were captured, tagged and released within WSER boundaries and within the Hawk Channel VR2 ring, though some fish were tagged near the southern border of this VR2 ring and were subsequently recorded by some VR2 receivers within the Forereef VR2 ring (Figure 2).

We collected records for a total of 10 red grouper, *Epinephelus morio,* measuring 483 to 635 mm TL (mean = 555.5 mm, SD = 51.68 mm), one gag grouper, *Mycteroperca microlepis*, measuring 640 mm TL, one goliath grouper, *Epinephelus itajara*, measuring 760 mm TL and one blacktip shark, *Carcharhinus limbatus* measuring 1350 mm TL. Figure 5 shows the release location of all tagged fishes. The following section describes each individual fish tagged.

Red grouper (*Epinephelus morio)*:

Tag # 1202: Day tagged: June 14, 2006, Type of tag: V13. Total length (TL): 530 mm. This fish was tagged within a triangle of 5 VR2 receivers (Appendix 2.1), four of which

read the tags code on dates beginning as early as 6/14/06 and as late as 9/15/06. The fish was released outside of the projected 300 meter radius of all of the VR2s but was approximately 0.5 kilometers from two, and approximately 1 kilometer from the two other "reading" VR2 receivers. Interestingly one VR2 (2323) just over 0.5 km. away from the release site did not read the tag, though it was directly in between two other receivers which read the tag. The greatest number of pings detected (342) were read by the western most reading receiver but detection stopped on August 26, while the receivers to the southwest and northwest detected the tag as late as September 15, and Sept. 12, respectively. Although the greatest distance between any of the receivers that read the tag was approximately 1.5 km, the next 3 receivers to the north of the later reading VR2s had malfunctioned, therefore movement to the north within the reserve is one of the possibilities which can't be ruled out. The "home range" area of this fish was 722.6 km^2 and the total number of detections was 744 pings (Table 6).

Tag # 1203: Day tagged: June 14, 2006, Type of tag: V13. Total length (TL): 500 mm. This fish was only detected by VR2 2312 (Appendix 2.2), located approx. 1 km from the release location. Both the release location and the reading VR2 were located within the approximate middle of the Hawk Channel VR2 array; however the receivers to the west and northwest were the three malfunctioning VR2s. This tag was only read from June 16 through July 11 2006. The home range area was 282.7 km^2 and the total # of pings was 46 detected 46, (Table 6).

Tag # 1204: Day tagged: June 9, 2006, Type of tag: V13. Total length (TL): 520 mm. This fish was detected within the expected detection radius of VR2 2328 (Appendix 2.3). It was detected by this VR2 with a maximum of 29 pings on June 10, then an interval with no detection until July 12 at which point it was sporadically detected until August 15. VR2 2319 located 1 km to the ESE of the tag site, along the eastern border of the WSER, detected only 1 ping from this tag on the final detection date of August 15, 2006. The total # of pings detected was 54 (Table 6).

Tag # 1205: Day tagged: June 9, 2006, Type of tag: V13. Total length (TL): 565 mm. This fish was released near two of the malfunctioning VR2s (2322 and 2325), along the western reserve boundary. It was detected by only 1 VR2 (2331) located approximately 1 km to the NNE of the release site (Appendix 2.4). It was detected sporadically from June 18 through September 27, with a maximum number of pings (28) read on August 11, and a total of (119) pings through the entire period. The home range area was 282.7 km^2 (Table 6). Movement to the west would not have been detected because of the malfunctioning VR2s.

Tag # 1209: Day tagged: June 8, 2006, Type of tag: V13. Total length (TL): 597 mm. The fish was released approximately 0.8 km southwest of VR2s 2327 and 2318, and approximately 1 km northeast of VR2 2328 (Appendix 2.5). These 3 VR2s were the only receivers to read tag 1209. VR2s 2327 and 2328 form a nearly linear line with the tagging site in between them in a northeast/southwest direction. VR2 (2328) was the first to read tag 1209 on June 16 with a maximum number of pings (19) on June 21, a

total number of 76 pings and a final ping read September 12. There were large gaps between July 19 to August 25 and August 25 to September 12. These gaps are partially filled in with pings detected by VR2 2327, which first read the tag on June 21 and detected the final recorded ping on September 27. VR2 (2318) located on the eastern boundary of the reserve approximately 0.8 km to the northeast of the tag site only recorded 3 pings on June 21 and 1 ping on July 25. Given the receiver array, the detection pattern suggests against a significant movement to the south. The total # of pings detected was 178 and the home range area was 485.8 km^2 (Table 6).

Tag # 1213: Day tagged: June 9, 2006, Type of tag: V13. Total length (TL): 560 mm. This fish was released in the same location as tag (1205) within the potential detection radii of two malfunctioning VR2s (Appendix 2.6). This tag similarly to tag 1205 was only detected by VR2 (2331), but it was detected far more frequently per day and throughout the entire detection period. It was detected first on June 11 and last on September 27, with a peak day of 117 pings on August 3, and a total number of pings throughout the period of 1,338. The home range area was the same as tag 1205; 282.7 km^2 (Table 6).

Tag # 1278 and Tag # 1274: Day tagged: June 14, 2006, Type of tag: V16. Total length (TL): 635 and 540 mm respectively. Both fishes were released at the same location and time near the center of the Hawk Channel VR2 ring. Both tags were detected by the same five VR2 receivers (Appendix 2.10 & 2.11 and Figure 10). Tags 1278 and 1274 recorded similar total ping detections of 1189 and 1471 respectively, though individual VR2 ping frequencies differed somewhat. Both tags were first recorded on June 15 by the same four receivers but tag 1274 was last detected on August 3, while tag 1278 was recorded until September 22. The home range area was 1954.3 km^2 for both fish (Table 6). The home range shown in Figure 10 for fish 1274 is identical to that of fish 1278.

Tag # 1215: Day tagged: June 8, 2006, Type of tag: V13. Total length (TL): 483 mm. This fish was released just west of tag 1209, (Appendix 2.5). This tag was not detected by any VR2 receiver.

Tag # 1275 (red grouper) and Tag # 1273 (gag grouper, *Mycteroperca microlepis*): Day tagged: June 14, 2006, Type of tag: V16. Total length (TL): 610 and 640 mm respectively. These two groupers were released in the same location at approximately the same time, inside the southwest corner of the Hawk Channel VR2 ring. Both tags were detected by the same six VR2 receivers (Appendix 2.8 & 2.9 and Figure 10). The four VR2 receivers detecting the greatest number of pings were the same for both tags, though the individual VR2 ping frequency percentages differed somewhat. Tag 1275 (*E. morio*) was detected more than twice as many times in total than tag 1273 (*M. microlepis*), (14,095 vs. 5685 pings). Both tags were detected first on June 14, and last on September 22, on VR2 2316, which was nearest to the tag and release location. The home range area was 1080 km^2 for both fish (Table 6). The area shown in Figure

10 for red grouper (tag 1273) is identical to the home range to for gag grouper (tag 1275).

Goliath grouper, *Epinephelus itajara*

Tag # 1218: Day tagged: June 15, 2006, Type of tag: V16. Total length (TL): 760 mm. This fish was released near the center of the Hawk Channel VR2 (Appendix 2.7, Figure 10). The tag was detected by 6 VR2s all to the east and southeast of the release site. VR2 2324 detected only 11 pings and was omitted from the frequency table (Table 6). Of the 23,605 total pings detected, 21,515, (91.1 %) were detected by VR2 2319 and 1,965 pings, (8.3 %) were detected by VR2 2330, both located just outside the eastern reserve boundary. Both VR2s began detection on June 16, and stopped detection on September 28, (VR2 2330), and September 26, (VR2 2319). The goliath grouper appeared to spend the great majority of its 2.5 month tag life more than 1.5 km to the east southeast of the tag and release site. The home range of the goliath grouper was 1706 km^2 (Table 6).

Blacktip shark, *Carcharhinus limbatus*

Tag # 1216: Day tagged: June 15, 2006, Type of tag: V16. Total length (TL): 1,350 mm. This shark was released just west of the eastern reserve boundary within the probable detection range of VR2 2319, (Figure 5). The tag was recorded by VR2 2319 (24 pings), and VR2 2314 (22 pings), only the day of capture, June 15, 2006, indicating a possible exit to the southeast without further detection.

CONCLUSIONS and MANAGEMENT CONSIDERATIONS

Lobster Monitoring

Of the 13 no-take marine reserves we sampled, only the 3000 ha Western Sambo Ecological Reserve is effective in protecting lobsters from harvest. Both size and abundance of legal-sized lobsters in WSER are greater than those in the fishery. Indications of effectiveness were already becoming apparent in WSER the year following closure. However, even after 10 years of harvest prohibition, lobsters are slightly larger but no more abundant in the smaller reserves than in the fishery. In the case of LKS, protection for 25 years has not led to an increase in lobster abundance. If marine reserves are to be effective in protecting spiny lobsters from harvest, they need to be large enough and encompass essential habitats for foraging and spawning in order to decrease the probability of lobsters leaving the protected area during the fishing season.

The appearance of a very large spiny lobster in a fished area (MSB) adjacent to WSER, coupled with the greater abundance of legal-sized lobsters at PLS, the reference area for WES, indicate that lobsters are “spilling over” from WSER into the fishery. This is one of the fishery benefits of marine reserves that may help managers

to garner support from fishers for closing areas to harvest.

Sonic Tagging

Lobster Sonic Tagging

1) The offshore bar area is used as a spawning ground by female lobsters. These spawning lobsters may reside on the offshore bar, forereef, or Hawk Channel. Hawk Channel and offshore bar lobsters have the potential to recruit to the alternate habitat. Reciprocal movements between Hawk Channel and the offshore bar has been demonstrated by females. Thus far, only one male has been shown to move from the offshore bar to Hawk Channel and now after three summer seasons of tagging Hawk Channel males, none have demonstrated movements to either the forereef or offshore bar. (Note: we are continuing this tagging effort and VR2 arrangements into the fall and winter for the first time)

2) The extent to which forereef lobsters use the offshore bar is not known. Circumstantial evidence suggests that some do use the offshore bar. Long gaps of a week or more are present in the transmissions from some forereef lobster tags but if they moved directly south onto the offshore bar, the VR2's placed there to detect that movement were unfortunately lost, probably due to an anchor or trap line dragging them from their position.

3) Toward the end of summer, there appears to be a modest tendency for lobsters on the forereef and offshore bar to move into Hawk Channel and/or the backreef. This finding supports the findings of the marine reserves project where overall, lobster abundance declined on the forereef and increased in Hawk Channel between summer and fall sampling periods.

Fish Sonic Tagging

The data collected indicated that the home range areas for these species vary from as little as 485.8 km^2 to as much as 1954.3 km^2 for groupers detected on 3 or more VR2 receivers (Table 6). All five groupers tagged with the larger more powerful V16 tags had home range estimates from 1080 km^2 to 1954.3 km^2 and were detected by either 5 or 6 receivers. The greatest home range estimated for a V13 tagged grouper, 722.6 km^2, was detected on 4 VR2 receivers. The next greatest home range for a V13 grouper was 485.8 km^2, detected on 3 receivers. The next 5 (V13) tagged groupers were detected on 2 or fewer VR2s, had home range estimates of 282.7 km^2 or less and very low detection frequencies.

Generally the V16 tags were implanted in slightly larger fish than were the V13 tags, but given the data, it is likely that the tag strength was a greater factor than fish size in detection rates and home range estimates. If both groupers and snappers are to be targeted in the next phase of tagging, we recommend that V13 tags be used to

simplify interpretation of habitat usage. Preliminary results suggest that just V16 tags may be appropriate for future tagging efforts of groupers.

As expected, detection frequency increases with the shorter recording “off time” of the tag. This was the case for the goliath grouper (tag # 1218) tagged with a V16 having a very short “off time” (minimum 5 sec. & maximum 30 sec. of no pinging), while the other 4 groupers were tagged with V16 pingers having an “off time” of 40 sec. min. and 114 sec. max. This may account for the goliath groupers detection frequency being 1.7 times that of the next greatest detection frequency (Table 6). The other seven groupers were tagged with a smaller, less powerful V13 tag having an “off time” of 20 sec. min. and 60 sec. max.

The detection frequencies, number of detecting VR2s, and estimated home ranges of any of the tagged fish could have been affected by the three malfunctioning VR2s along the western Hawk Channel VR2 Ring. The V13 tagged grouper would have been the most susceptible due to the coincidental tagging location, (especially tag 1205 and 1213), and due to the V13 tags weaker signal.

Table 1. Lobster Monitoring Sites. Sanctuary Zones (reserves) and their reference areas.

RESERVE	**REFERENCE AREA**
Western Sambo ER (WSER)	Pelican Shoal (PLS)
Carysfort/South Carysfort SPA (CAR)	Pacific Reef (PAC)
Eastern Sambo RO (ESB)	Middle Sambo (MSB)
Grecian Rocks SPA (GDR)	North North Key Largo Dry Rocks (NNDR)
Molasses Reef SPA (MOL)	Pickles Reef (PIC)
Conch Reef RO (CNR)	Little Conch Reef (LCON)
Alligator Reef SPA (ALL)	Alligator Reef West (ALLC)
Tennessee Reef RO (TNR)	Tennessee Reef Light (TNC)
Coffins Patch SPA (COF)	The Donut (COFC)
Sombrero Key SPA (SOM)	Delta Shoal (DEL)
Looe Key SPA (LKS)	Maryland Shoal (MAR)
Looe Key RO (LKR)	Looe Key West Patches (LKRC)
Sand Key SPA (SAN)	Western Dry Rocks (WDR)

Table 2. Lobster Monitoring Site Locations and Sampling Dates.

PROTECTED ZONES						REFERENCE AREAS					
Date	Site	Habitat	Rep	Latitude (N)	Longitude (W)	Date	Site	Habitat	Rep	Latitude (N)	Longitude (W)
6/23/2006	SOM	Forereef	1	24<22.567	81<06.595	6/23/2006	DEL	Forereef	1	24<37.944	81<05.397
6/26/2006	SAN	Forereef	1	24<27.122	81<52.706	6/26/2006	WDR	Forereef	1	24<26.697	81<55.575
6/30/2006	ESB	Forereef	1	24<49.165	81<66.256	6/30/2006	MSB	Forereef	1	24<48.919	81<67.293
7/3/2006	COF	Patch Reef	1	24<68.538	80<96.362	7/3/2006	COFC	Patch Reef	1	24<69.120	80<94.736
7/5/2006	TNR	Forereef	1	24<76.390	80<75.440	7/5/2006	TNC	Forereef	1	24<74.553	80<78.162
7/20/2006	ALL	Forereef	1	24<50.060	81<62.968	7/20/2006	ALLC	Forereef	1	24<50.306	81<62.196
7/21/2006	CAR	Forereef	1	24<47.911	81<71.687	7/17/2006	PAC	Forereef	1	25<22.204	80<08.354
7/21/2006	CAR	Forereef	2	24<48.214	81<91.746	7/17/2006	PAC	Forereef	2	25<22.385	80<08.428
7/21/2006	CAR	Forereef	3	24<48.092	81<71.928	7/17/2006	PAC	Forereef	3	24<49.606	81<64.931
7/18/2006	MOL	Forereef	1	24<56.454	80<28.449	7/18/2006	PIC	Forereef	1	24<48.341	81<70.782
7/14/2006	CNR	Forereef	1	24<51.374	81<71.429	7/14/2006	LCON	Forereef	1	24<28.924	81<42.234
7/19/2006	GDR	Forereef	1	24<30.035	81<37.712	7/19/2006	NNDR	Forereef	1	25<22.106	80<08.435
7/24/2006	LKR	Patch Reef	1	24<30.522	81<41.635	7/20/2006	LKRC	Patch Reef	1	24<50.235	81<63.264
7/20/2006	LKS	Forereef	1	24<29.002	81<42.213	7/21/2006	MAR	Forereef	1	24<57.000	80<27.257
7/10/2006	WES	Forereef	1	24<50.791	80<37.348	7/10/2006	PLS	Forereef	1	25<00.563	80<22.563
7/10/2006	WES	Forereef	2	24<50.427	80<37.680	7/10/2006	PLS	Forereef	2	24<59.229	80<24.872
7/12/2006	WES	Forereef	3	24<56.307	81<40.113	7/12/2006	PLS	Forereef	3	24<50.228	81<62.801
7/11/2006	WES	Back Reef	1	24<54.617	81<40.361	7/13/2006	PLS	Back Reef	1	25<06.473	80<18.358
7/13/2006	WES	Back Reef	2	25<22.227	80<20.974	7/17/2006	PLS	Back Reef	2	25<08.196	80<17.366
7/17/2006	WES	Back Reef	3	25<22.025	80<21.039	7/18/2006	PLS	Back Reef	3	24<52.198	81<63.237
7/11/2006	WES	Patch Reef	1	25<21.177	80<21.736	7/19/2006	PLS	Patch Reef	1	24<52.424	81<63.261
7/12/2006	WES	Patch Reef	2	24<50.941	81<56.927	7/19/2006	PLS	Patch Reef	2	24<52.527	81<63.027
7/19/2006	WES	Patch Reef	3	24<56.672	81<38.960	7/19/2006	PLS	Patch Reef	3	24<50.478	81<72.038
9/11/2006	ESB	Forereef	1	24<29.503	81<39.766	9/11/2006	MSB	Forereef	1	24<29.298	81<40.533
9/12/2006	LKS	Forereef	1	24<32.753	81<24.325	9/13/2006	MAR	Forereef	1	24<30.668	81<34.228
9/15/2006	WSB	Forereef	1	24<28.752	81<43.031	9/13/2006	PLS	Forereef	1	24<30.011	81<37.781
9/15/2006	WSB	Forereef	2	24<28.818	81<42.784	9/14/2006	PLS	Forereef	2	24<30.011	81<37.229
9/18/2006	WSB	Forereef	3	24<28.924	81<42.307	9/14/2006	PLS	Forereef	3	24<30.288	81<37.103
9/19/2006	WSB	Back Reef	1	24<28.942	81<42.787	9/13/2006	PLS	Back Reef	1	24<30.086	81<37.964
9/19/2006	WSB	Back Reef	2	24<28.929	81<42.974	9/20/2006	PLS	Back Reef	2	24<30.165	81<37.779
9/20/2006	WSB	Back Reef	3	24<28.981	81<42.318	9/20/2006	PLS	Back Reef	3	24<30.247	81<37.370
9/21/2006	WSB	Patch Reef	1	24<30.338	81<42.333	9/22/2006	PLS	Patch Reef	1	24<31.325	81<39.422
9/21/2006	WSB	Patch Reef	2	24<29.711	81<42.482	9/22/2006	PLS	Patch Reef	2	24<31.608	81<39.107
9/25/2006	WSB	Patch Reef	3	24<30.658	81<42.051	9/25/2006	PLS	Patch Reef	3	24<31.378	81<39.953

Table 3. Status, size, and detection history of lobsters fitted with sonic tags.

Tag	Sex	Cl mm	RS[1]	Date tagged	First detection	Last detection	Count of detections[2]
Lobsters tagged on the offshore bar							
885	Female	74	NOF	6/09/06	6/14/06	9/10/06	534
893	Female	85	NBF	6/09/06	8/20/06	8/25/06	453
894	Male	86		6/09/06	6/10/06	8/20/06	2061
896	Female	73	NOE	6/09/06	6/10/06	6/20/06	117
897	Female	76	NOE	6/09/06	6/10/06	6/25/06	148
899	Female	81	NOE	6/09/06	6/09/06	7/20/06	694
906	Male	75		6/09/06	6/09/06	8/26/06	1071
938	Female	75	NOF	6/09/06	6/11/06	8/08/06	1951
Lobsters tagged on the forereef							
886	Male	96		6/08/06	6/10/06	6/17/06	16
887	Female	90	NOE	6/08/06	6/10/06	6/29/06	118
892	Female	89	RNF	6/08/06	6/10/06	8/08/06	21
898	Male	88		6/08/06	6/10/06	6/20/06	15
900	Female	79	NOE	6/08/06	6/09/06	7/30/06	321
917	Male	104		6/08/06	9/10/06	9/10/06	1
918	Female	74	NOE	6/08/06	6/10/06	7/25/06	90
923	Male	99		6/08/06	6/09/06	9/19/06	282
926	Male	113		6/08/06	6/16/06	6/16/06	2
929	Female	66	NOE	6/08/06	6/08/06	6/28/06	188
930	Female	84	ROF	6/08/06	6/14/06	8/04/06	341
934	Male	85		6/08/06	6/10/06	8/17/06	128
Lobsters tagged on patch reefs							
888	Female	71	ROE	6/09/06	6/11/06	6/25/06	234
889	Male	92		6/14/06	6/14/06	7/26/06	66
890	Female	71	NOE	6/09/06	6/15/06	7/26/06	195
891	Male	83		6/08/06	6/16/06	8/16/06	102
895	Male	108		6/14/06	6/14/06	8/25/06	453
901	Female	75	RNE	6/09/06	6/10/06	8/28/06	406
902	Male	112		6/09/06	6/16/06	9/15/06	2019
908	Male	91		6/14/06	6/15/06	6/15/06	16
912	Female	87	ROE	6/09/06	6/10/06	7/26/06[3]	8720

[1]Reproductive status (RS) of female lobsters; three letter indicate condition of ovaries (R= ripe, N=not ripe), eggs (O=orange, B=brown, N=no eggs), and spermatophore (F=fresh, E=eroded, N= none) in that order

[2]All detected lobsters were *Panulirus argus*. One *Panulirus guttatus* was tagged on the forereef with a smaller less powerful tag and was never detected.

[3]This lobster clearly molted or somehow lost it's tag on 7/26/06; however, we continued to detect this tag until 8/19/06.

Table 4. Overall movement patterns of sonic tagged lobsters with the initial June (early summer) habitat and late summer habitat provided the lobster was tracked for two months. Habitat codes are OB = offshore bar; FR = forereef; BR = backreef; HC = Hawk Channel[1]

Code	Sex	CL mm	Summer Early Hab	Summer Late Hab	Notes
885	F	74	OB	OB?	Appears to have stayed on OB; shift toward FR perhaps on 9/10
893	F	85	OB	OB	Appears to have stayed on OB
894	M	86	OB	?	Unknown, last records on OB
896	F	73	OB	?	Unknown
897	F	76	OB	FR	Appears to move toward FR; found by divers on FR 7/10
899	F	81	OB	?	Unknown, last records on OB
906	M	75	OB	HC	Moved to FR then HC on 8/19
938	F	75	OB	HC	Moved to HC on 8/03 - 8/07
886	M	96	FR	?	Unknown
887	F	90	FR	?	Unknown, headed toward HC on 6/29
892	F	89	FR	FR	Appears to stay on FR, long gaps in detections
898	M	88	FR	?	Unknown
900	F	79	FR	FR?	Moves toward HC on 6/29 but ends back on FR
917	M	104	FR	HC	Never detected until one ping in HC on 9/10
918	F	74	FR	FR/OB	Last records on a remote VR2 between FR and OB
923	M	99	FR	BR	Move to BR and HC 7/17, then BR by 8/21
926	M	113	FR	?	Only two FR detections on 6/16
929	F	66	FR	?	Still on FR on 6/28
930	F	84	FR	BR	Excursion to HC 6/17, then FR, moves to BR 7/14
888	F	71	HC	HC?	Made spawning run to FR with eggs, returns 6/25
889	M	92	HC	HC?	Stays in HC, perhaps molted in late July
890	F	71	HC	HC?	Spawning run to FR 6/23; returns 6/30; second trip 7/09, returns 7/12 maybe molts 7/26
891	M	83	HC	HC	Stays in HC, some wide moves however
895	M	108	HC	HC	Brief one night contact with BR receiver then back to HC
901	F	79	HC	OB/FR	Heads for FR 6/11, back to HC on 7/03, travels east to west on OB and FR until we lose the signal on 8/28
902	M	112	HC	HC	Stays in HC
908	M	91	HC	?	Detected by a eastern WSER boundary receiver on 6/16, one day after tagging, presumably a spillover lobster.
912	F	87	HC	?	Disappears two days after tagging (presumably to spawn), returns to HC by 6/27, in HC until 7/22, travels to FR by 7/23, presumably molts on 7/29

because tag stops moving

[1]Movement maps of each lobster are in Appendix 1

Table 5 Acoustic tagging effort in June, 2006 in Western Sambo Ecological Reserve (WSER).

Date	Method	Location	Effort (hrs)	Catch (# fish)	CPUE (fish hr^{-1})	Species
06/08/06	Hook/Line	Patch reef	2.42	1	0.41	*E. morio*
06/08/06	Trap	Patch reef	4.40	1	0.23	*E. morio*
06/09/06	Hook/Line	Patch reef	1.92	1	0.52	*E. morio*
06/09/06	Trap	Patch reef	4.00	2	0.50	*E. morio*
06/14/06	Hook/Line	Patch reef	1.75	1	0.57	*M. microlepis*
			1.75	2	1.14	*E. morio*
06/14/06	Trap	Patch reef	3.05	3	0.98	*E. morio*
06/15/06	Hook/Line	Patch reef	1.92	1	0.52	*C. limbatus*
06/15/06	Trap	Patch reef	3.15	1	0.32	*E. itajara*

Table 6. Estimated area of home range by minimum convex polygon (MCP) method, number of receivers signaled and frequency of detections for individual groupers tagged June – September, 2006 in Western Sambo Ecological Reserve (WSER).

Species	ID	TL (mm)	Transmitter	Area (km^2)	Receivers signaled	Detection frequency
E. itajara	1218	760	V16	1706.0	6	23605
M. microlepsis	1273	640	V16	1080.0	6	5645
E. morio	1202	530	V13	722.6	4	744
E. morio	1209	597	V13	485.8	3	178
E. morio	1204	520	V13		2	54
E. morio	1213	560	V13	282.7+	1	1338
E. morio	1205	565	V13	282.7+	1	119
E. morio	1275	610	V16	1080.0	6	14095
E. morio	1274	540	V16	1954.3	5	1471
E. morio	1278	635	V16	1954.3	5	1189
E. morio	1203	500	V13	282.7+	1	46

+ estimated from range of single VR2 receiver

Figure 1. Lobster Monitoring Sites in Florida Keys National Marine Sanctuary

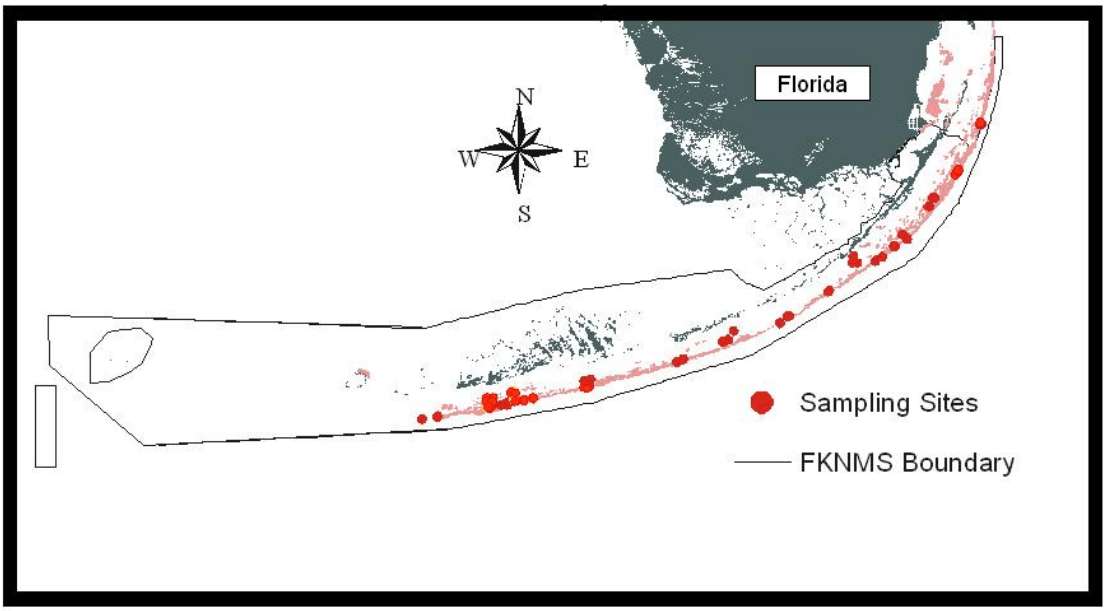


Figure 2. Sonic receiver deployment sites within and around Western Sambo Ecological Reserve. The circles around the deployment site indicate the approximate range of detection (~300 m) of VR2 receivers with V16 sonic tags. The sonic receivers were arranged into three interlocking rings or zones.

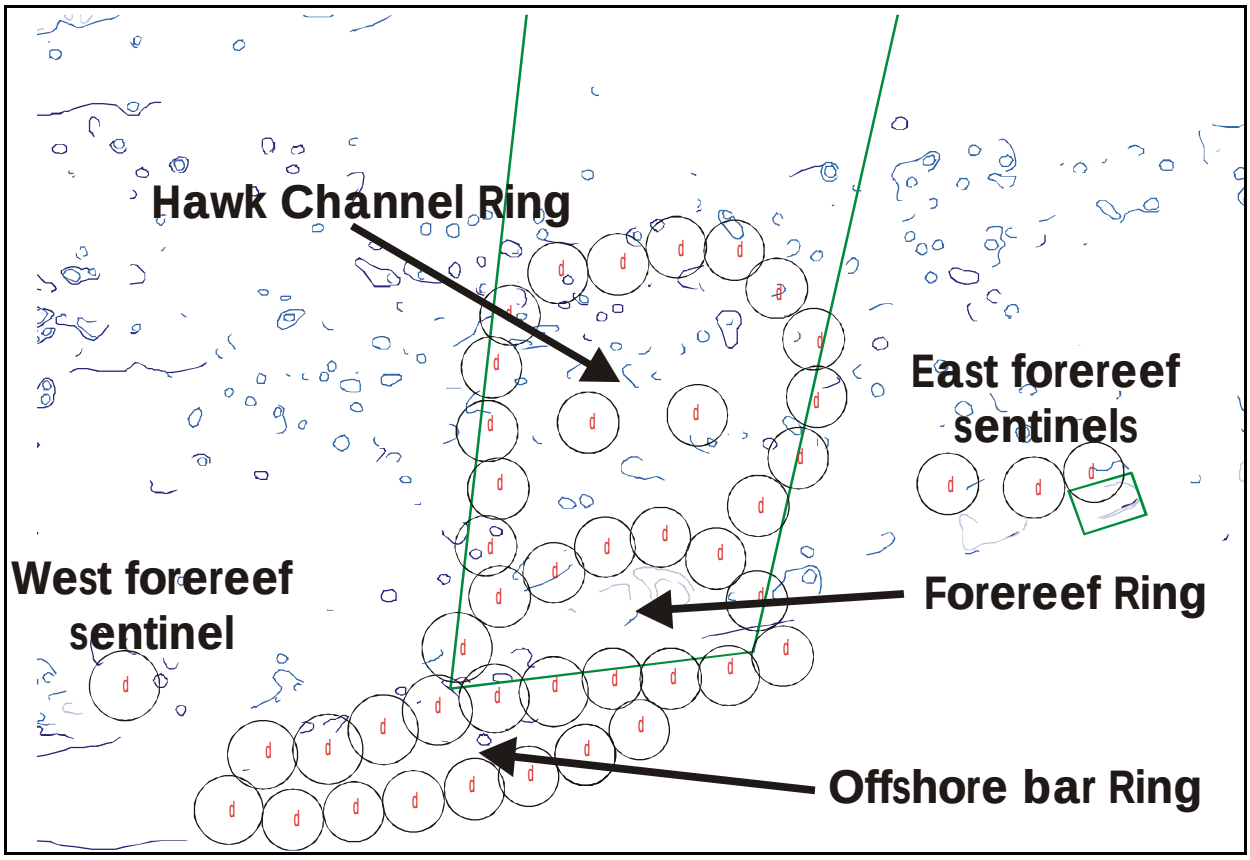


Figure 3. Study sites in Western Sambo Ecological Reserve (WSER) and Pelican Shoal (PLS). Habitat strata included forereef, backreef, and offshore patch reefs.

.

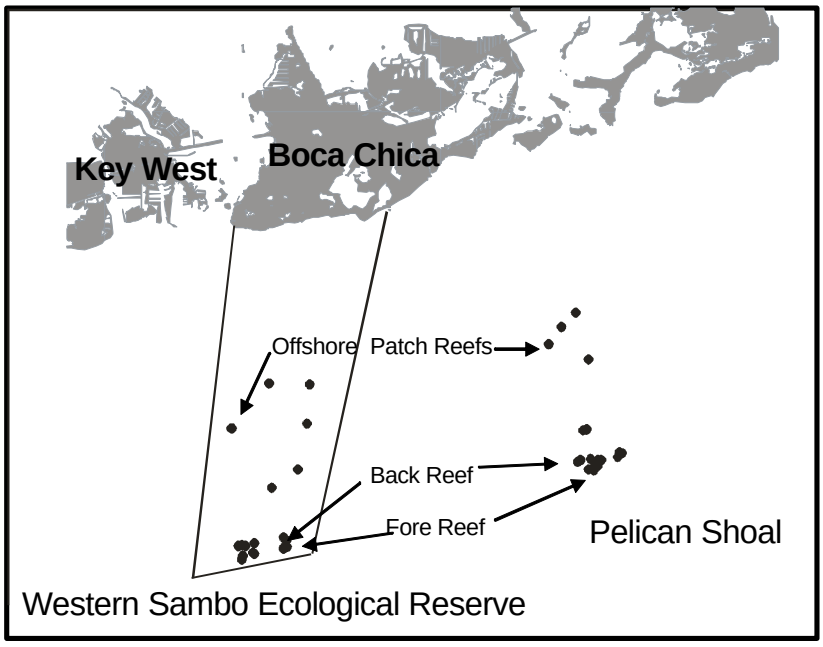


Figure 4. Location, count and sex of sonic tagged lobsters.

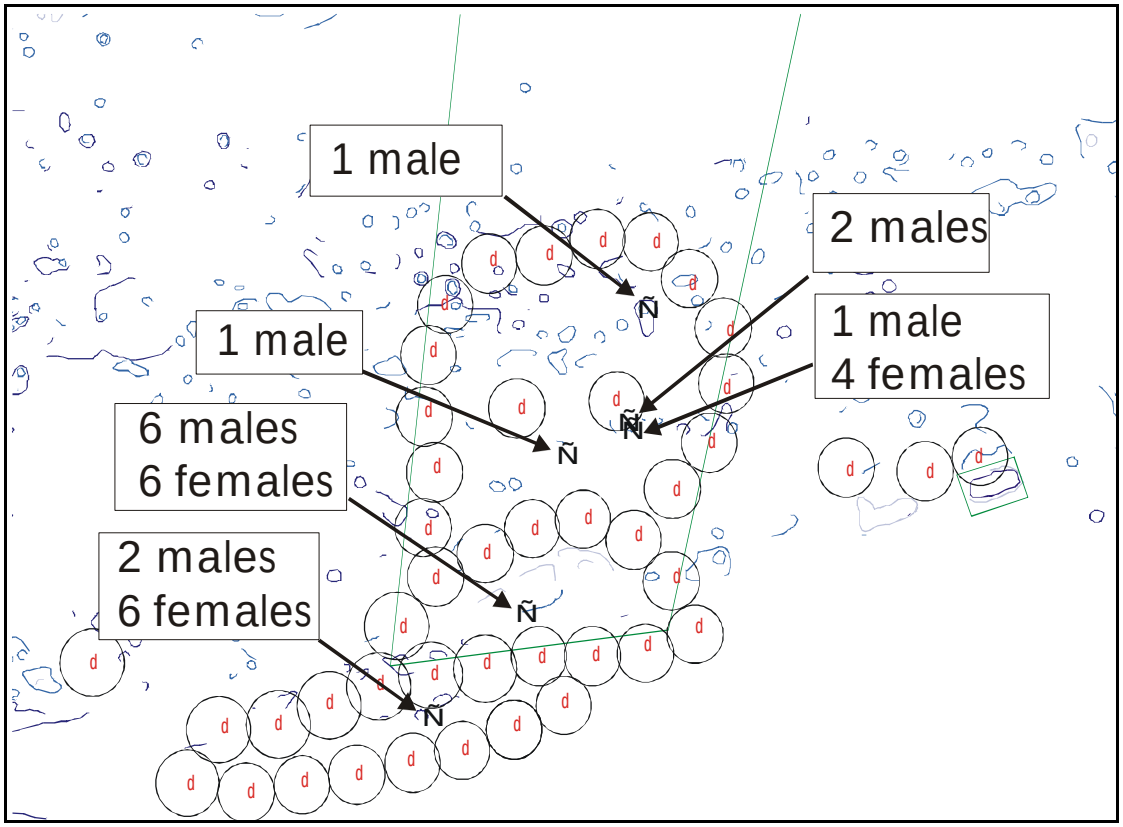


Figure 5. Location of release (+), count and species of tagged fishes in June 2006 in Western Sambo Ecological Reserve (WSER).

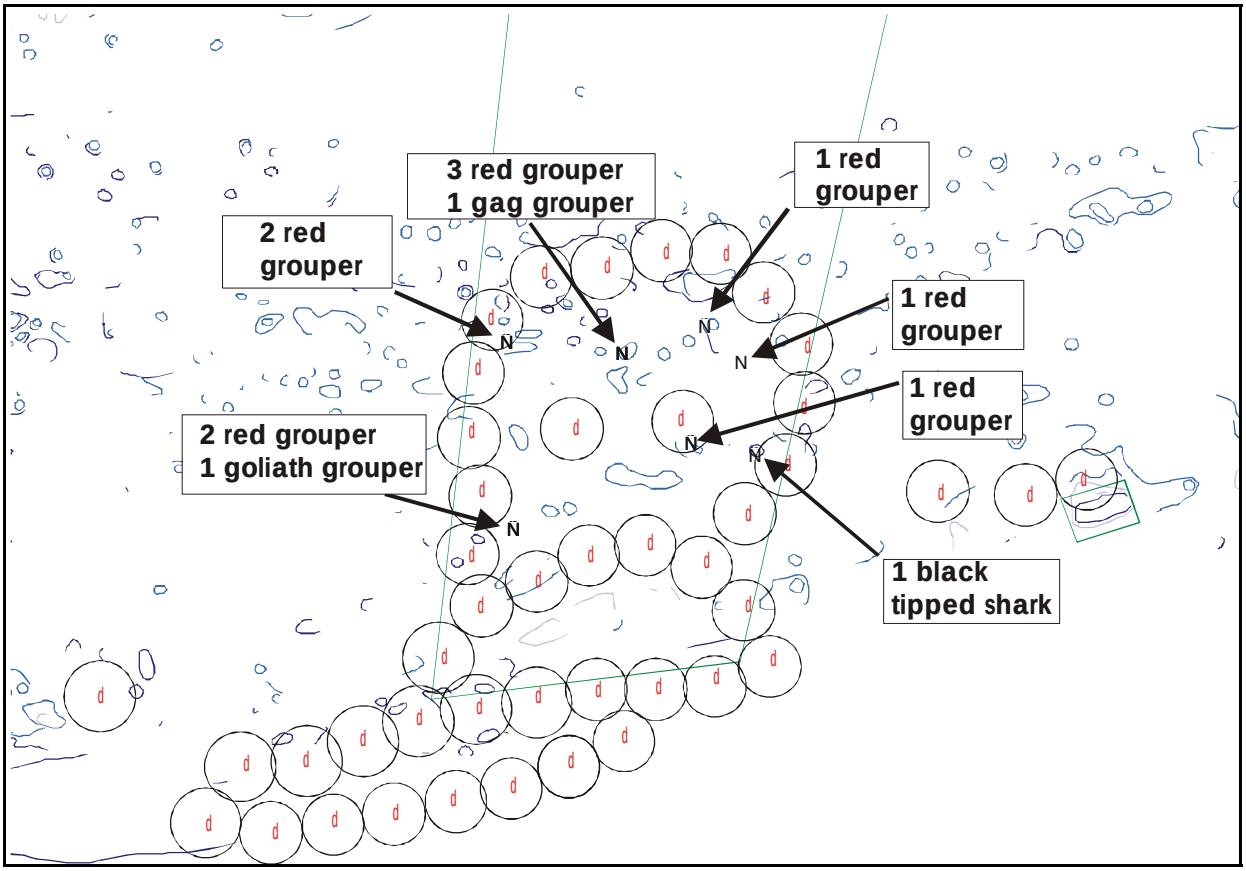


Figure 6. Total number of spiny lobsters observed in 13 reserve/reference pairs in Florida Keys National Marine Sanctuary during the 2006 closed fishing season.

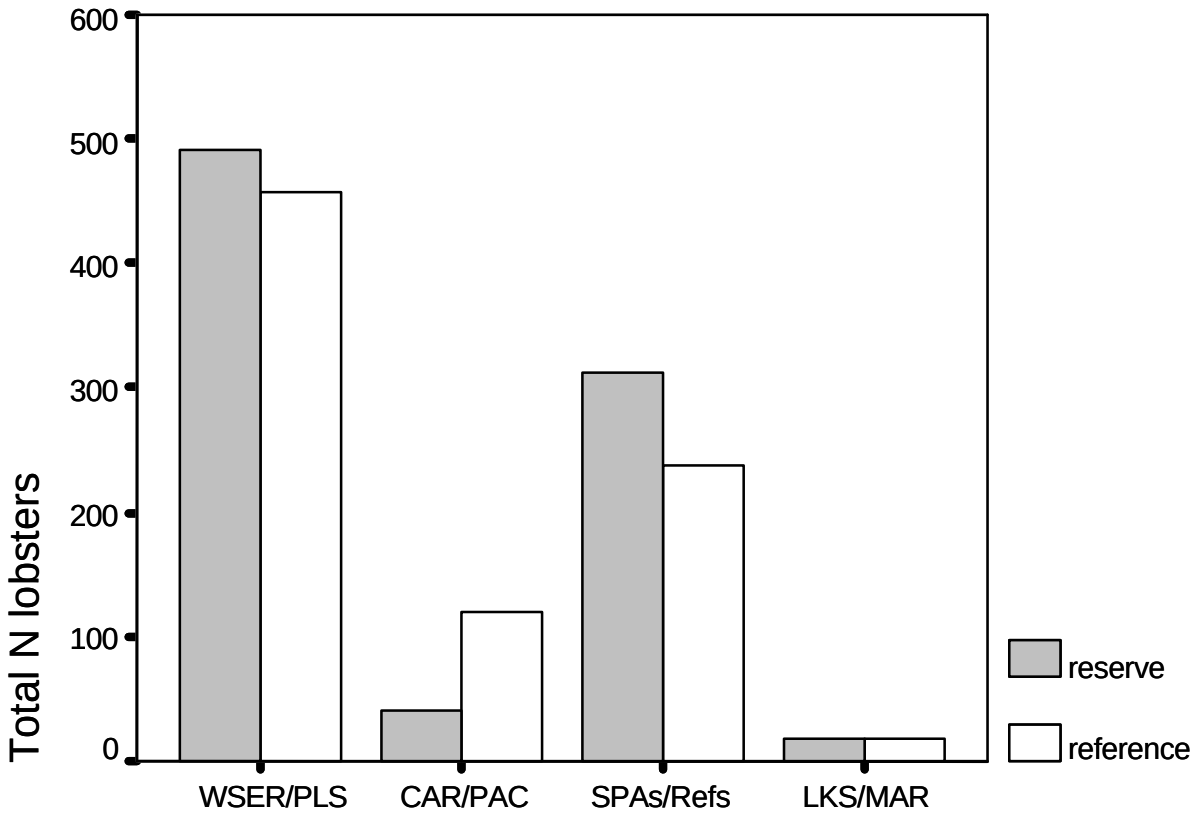


Figure 7. Total number of spiny lobsters observed in selected Lower Keys reserves during the open (July) and closed (September) fishing seasons of 2006.

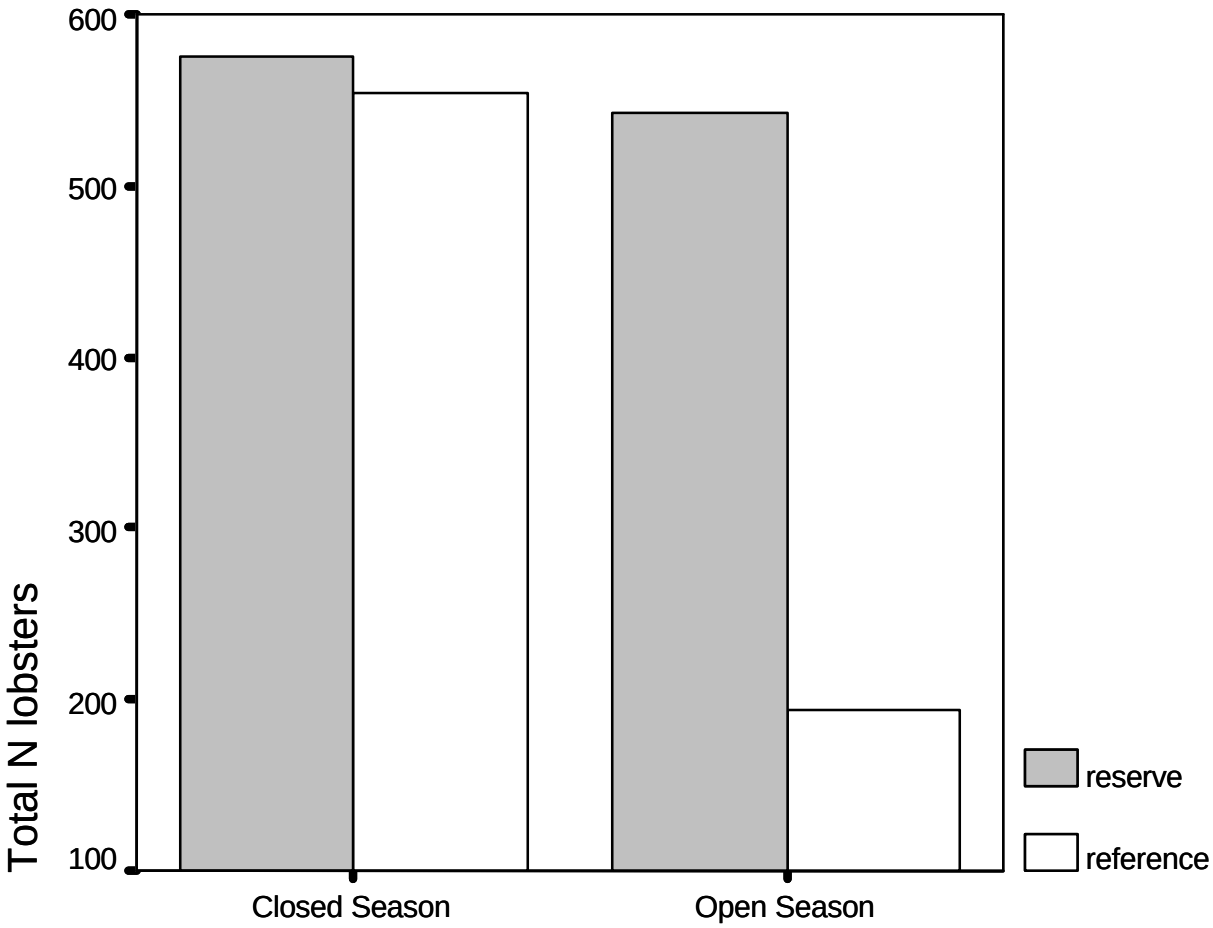


Figure 8. Size of Legal-Sized Spiny Lobsters in Florida Keys National Marine Sanctuary during the closed fishing season, July 2006.

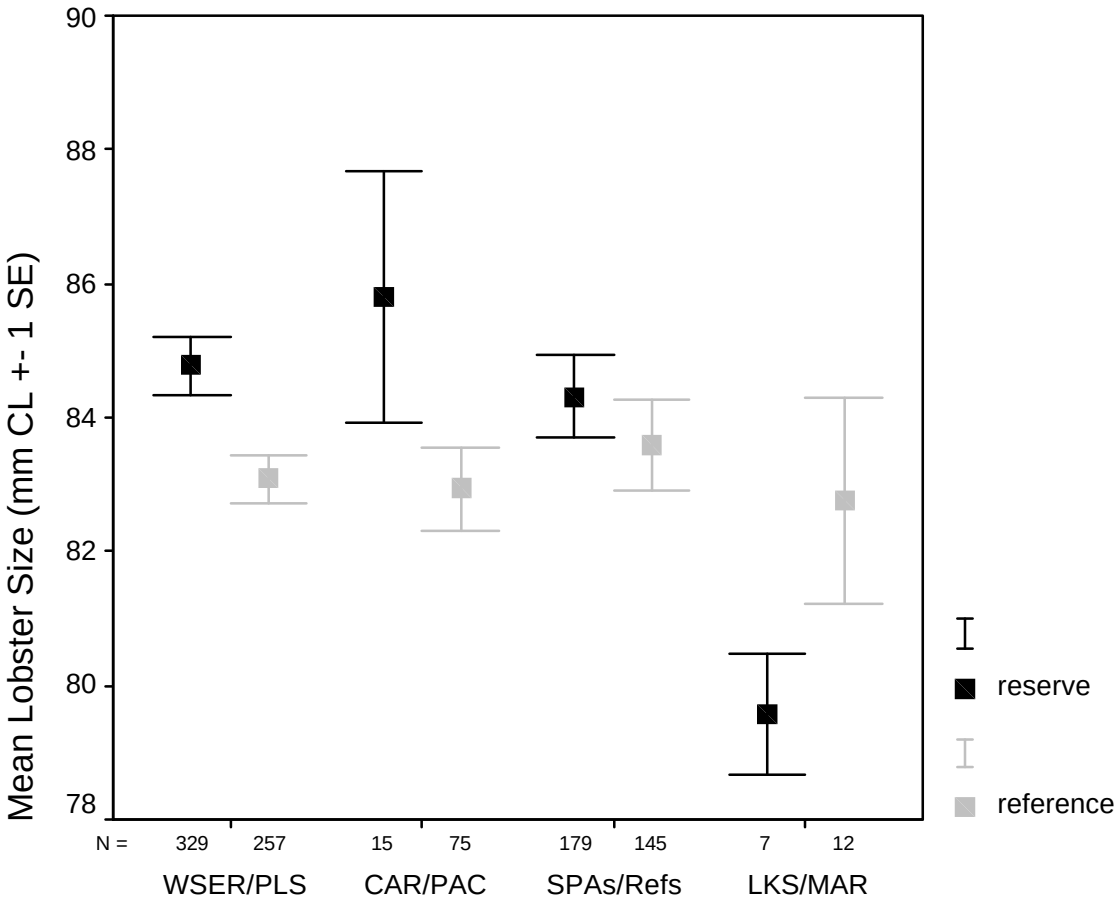


Figure 9. Abundance of Legal-Sized Lobsters in FKNMS reserves and reference areas during the closed fishing season, July 2006.

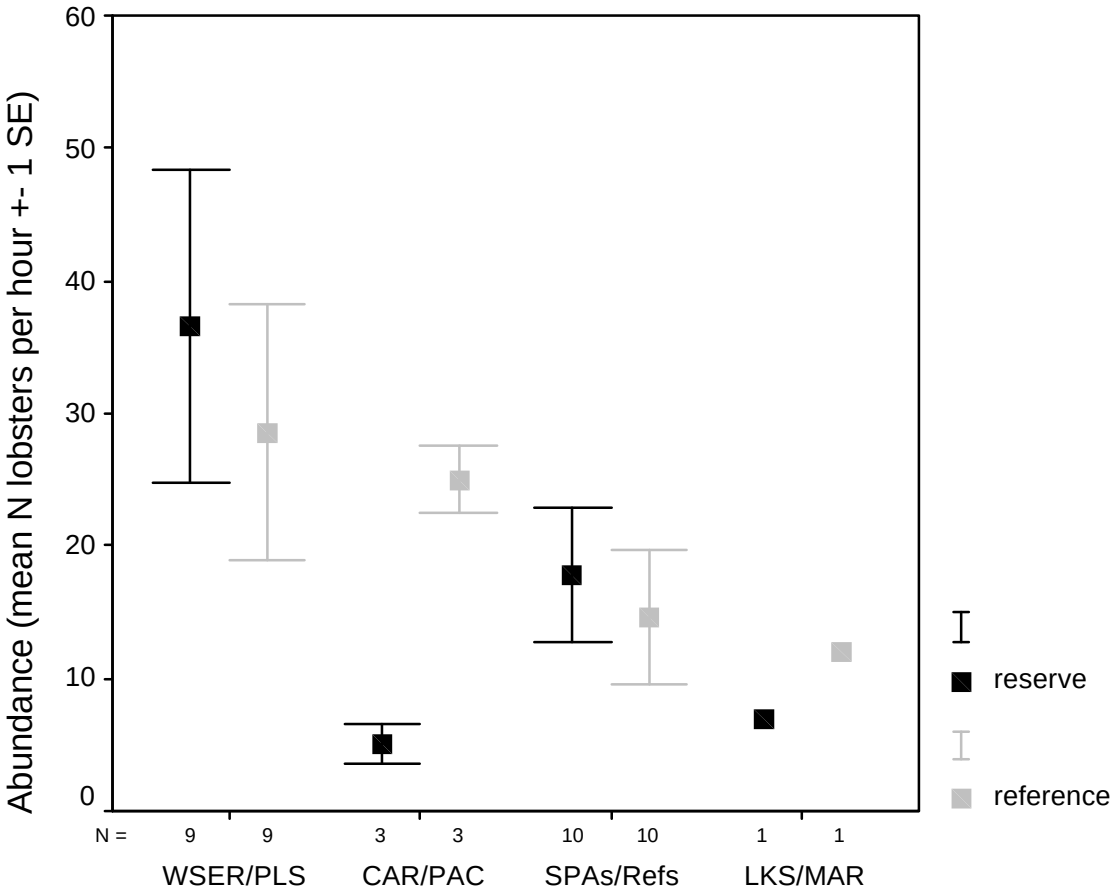
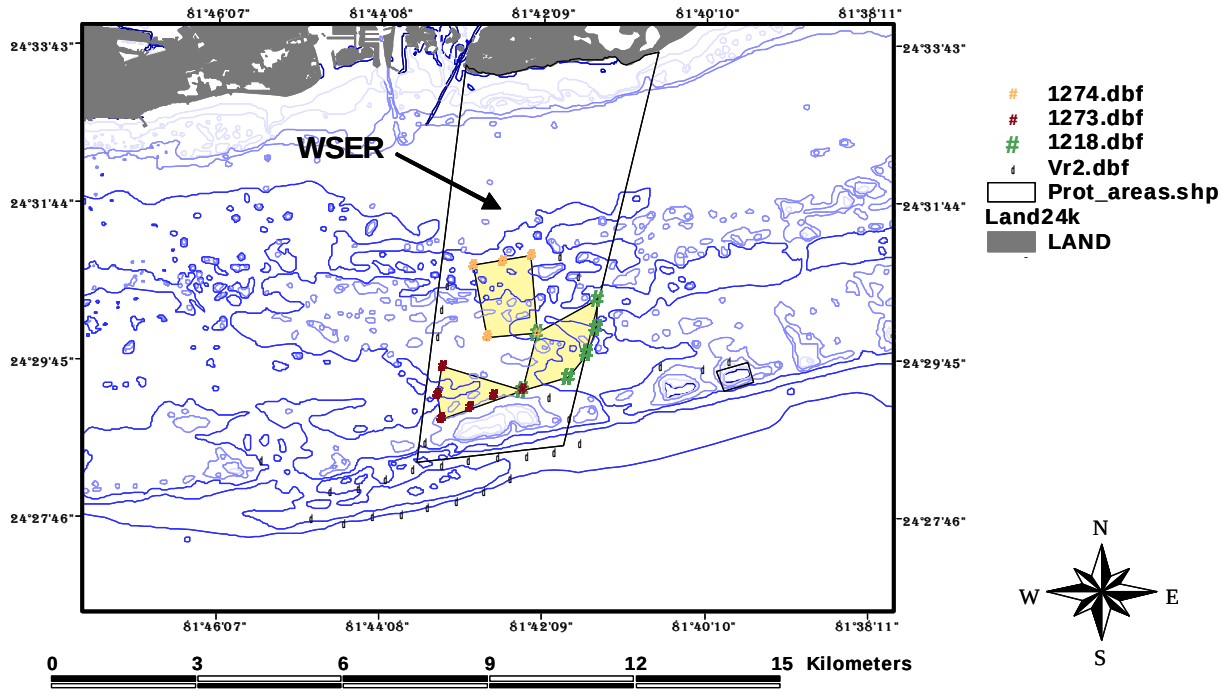
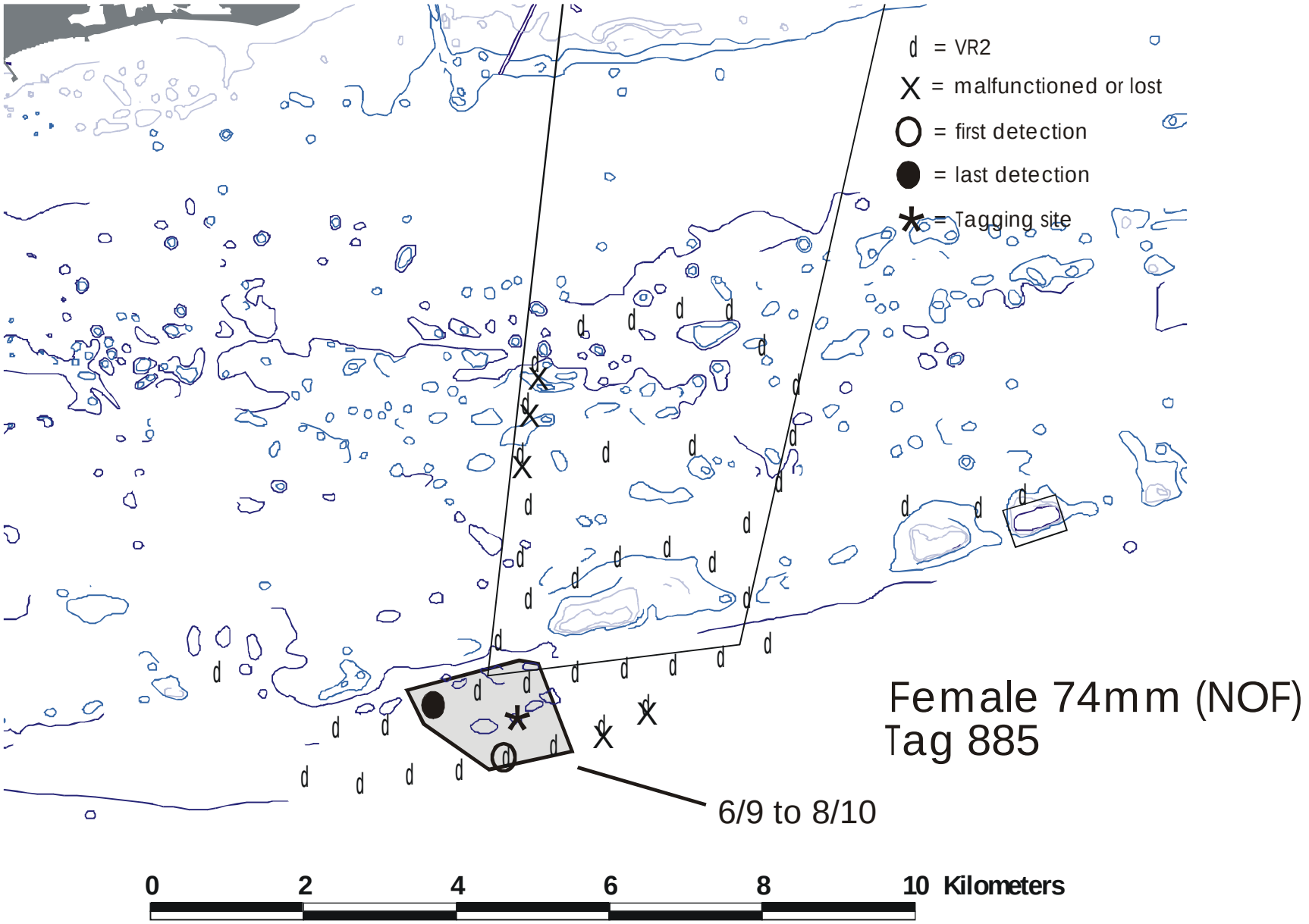


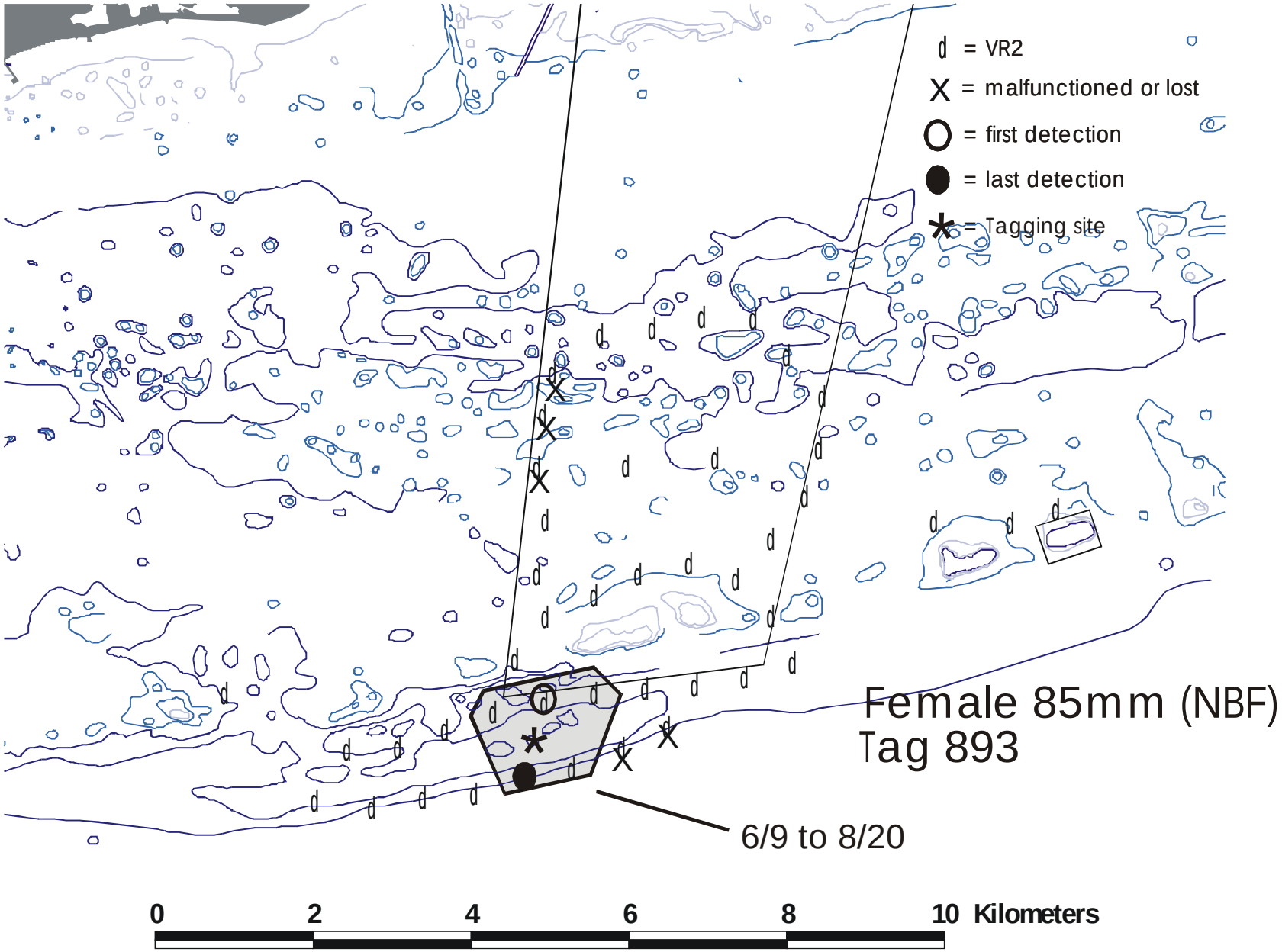
Figure 10. Apparent home range (shaded area) estimated by minimum convex polygon (MCP) method for goliath grouper (1218), gag grouper (1273) and red grouper (1274) during June – September, 2006 in Western Sambo Ecological Reserve (WSER).

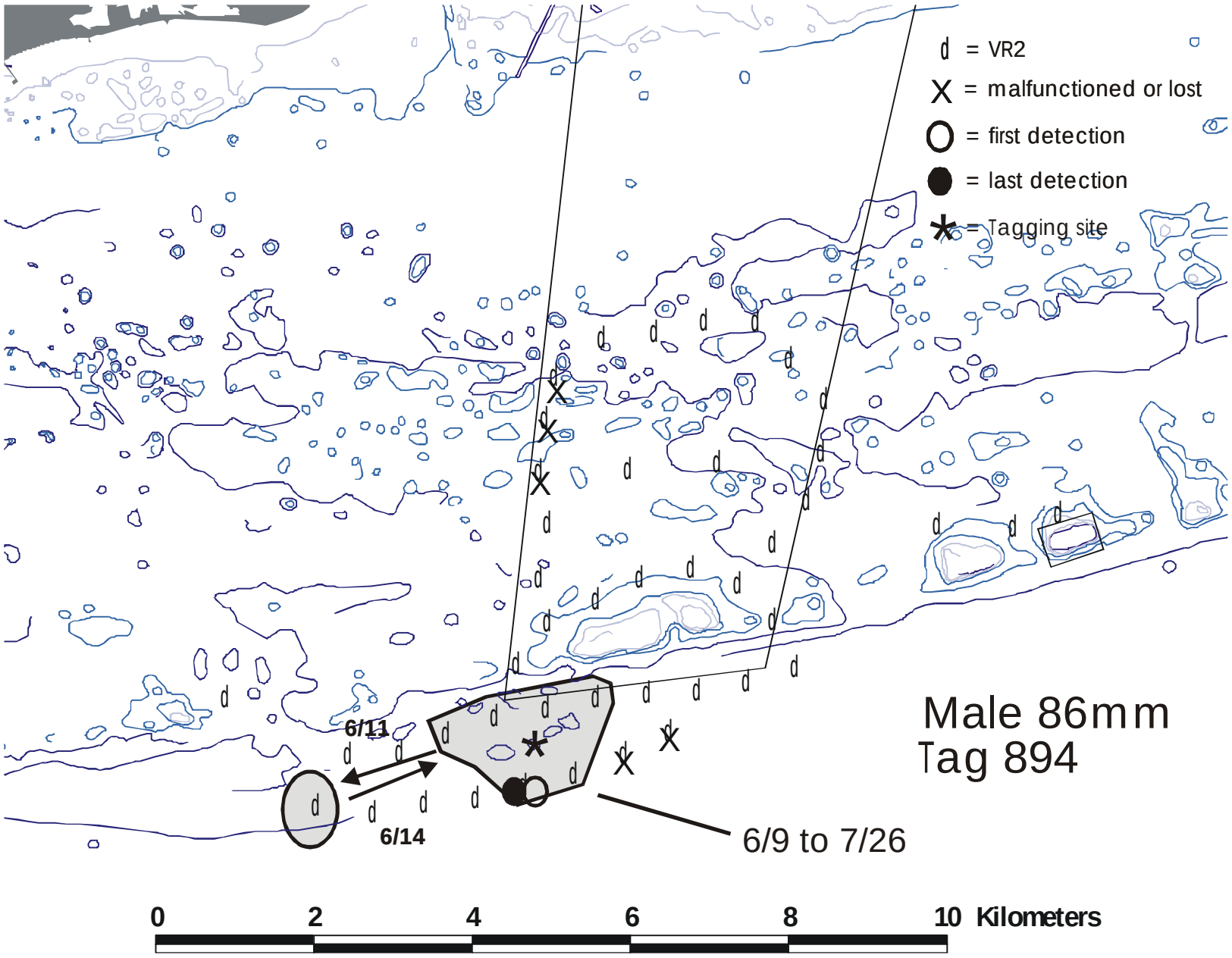


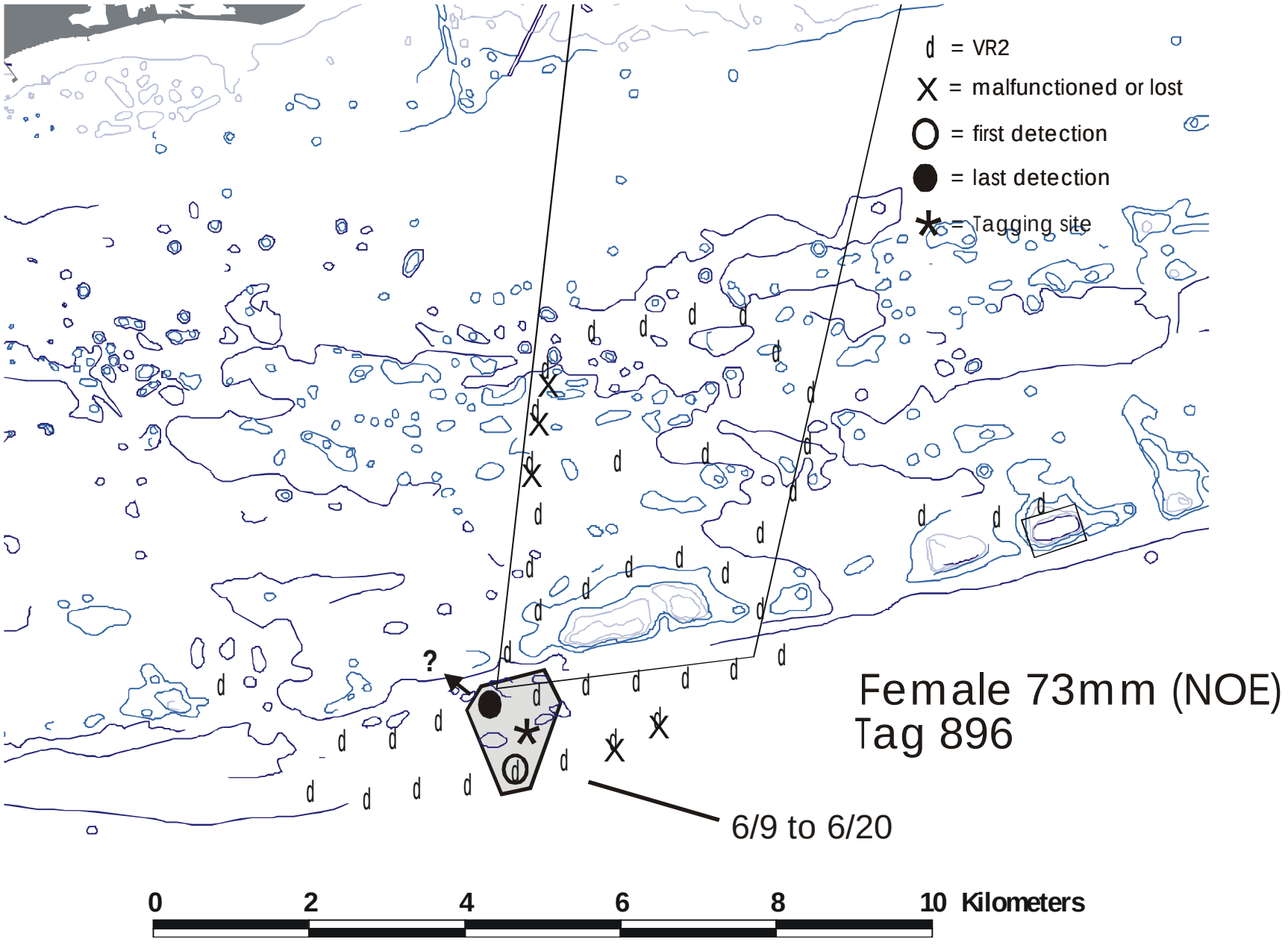
Appendix 1. Movement and inferred home range maps for individual lobsters tagged in June 2006. Shown are initial tagging sites, first and last VR2 detections, approximate migration routes and home ranges. The sex, size, and reproductive status (females only) are given. The reproductive status code consists of three letters, the first being ovary status (N = not ripe, R = ripe), second is color of eggs (N = none, O = orange, B = brown), and third is spermatophore status (N = none, F = fresh, E = eroded).

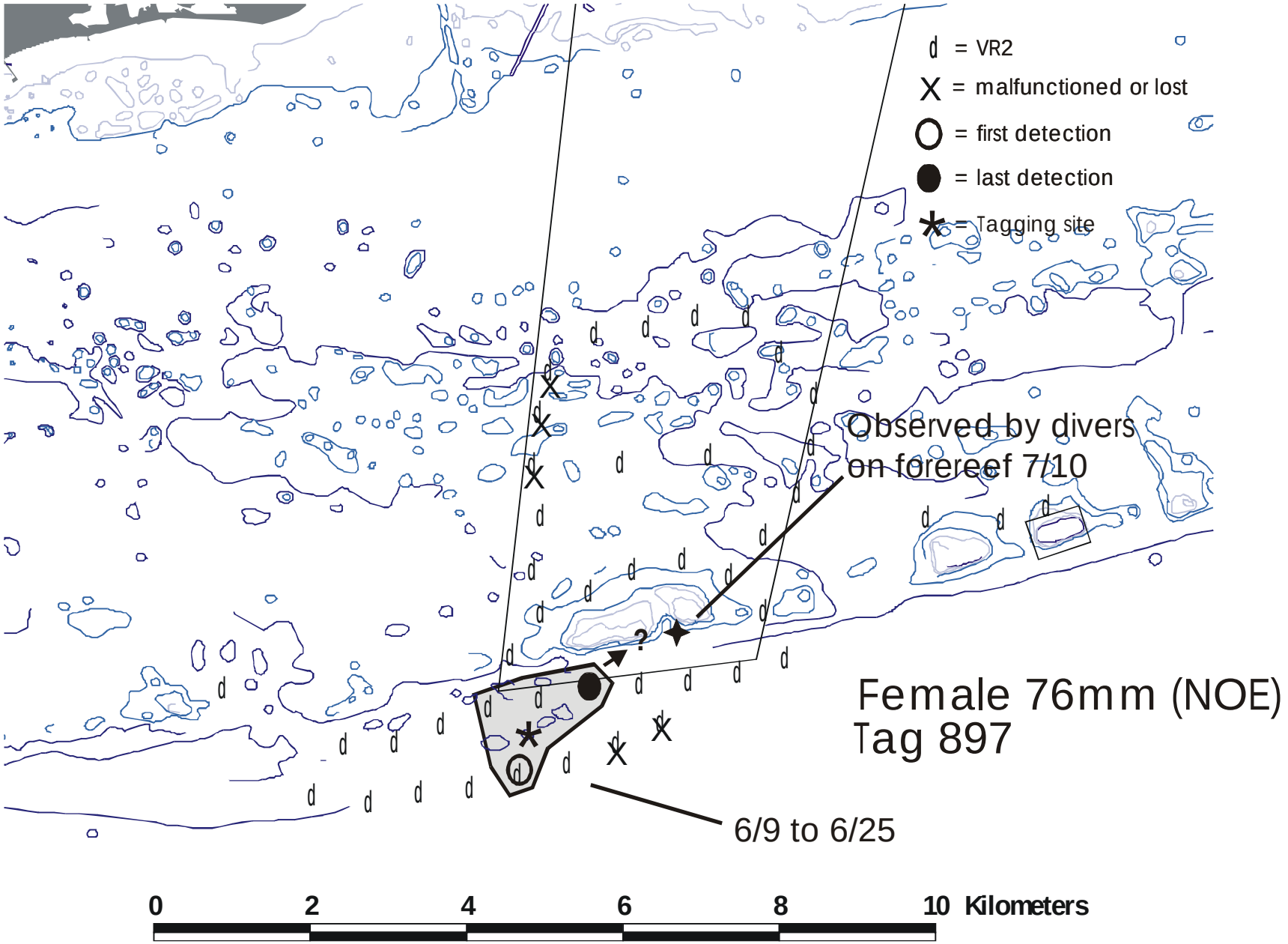
Offshore bar lobsters

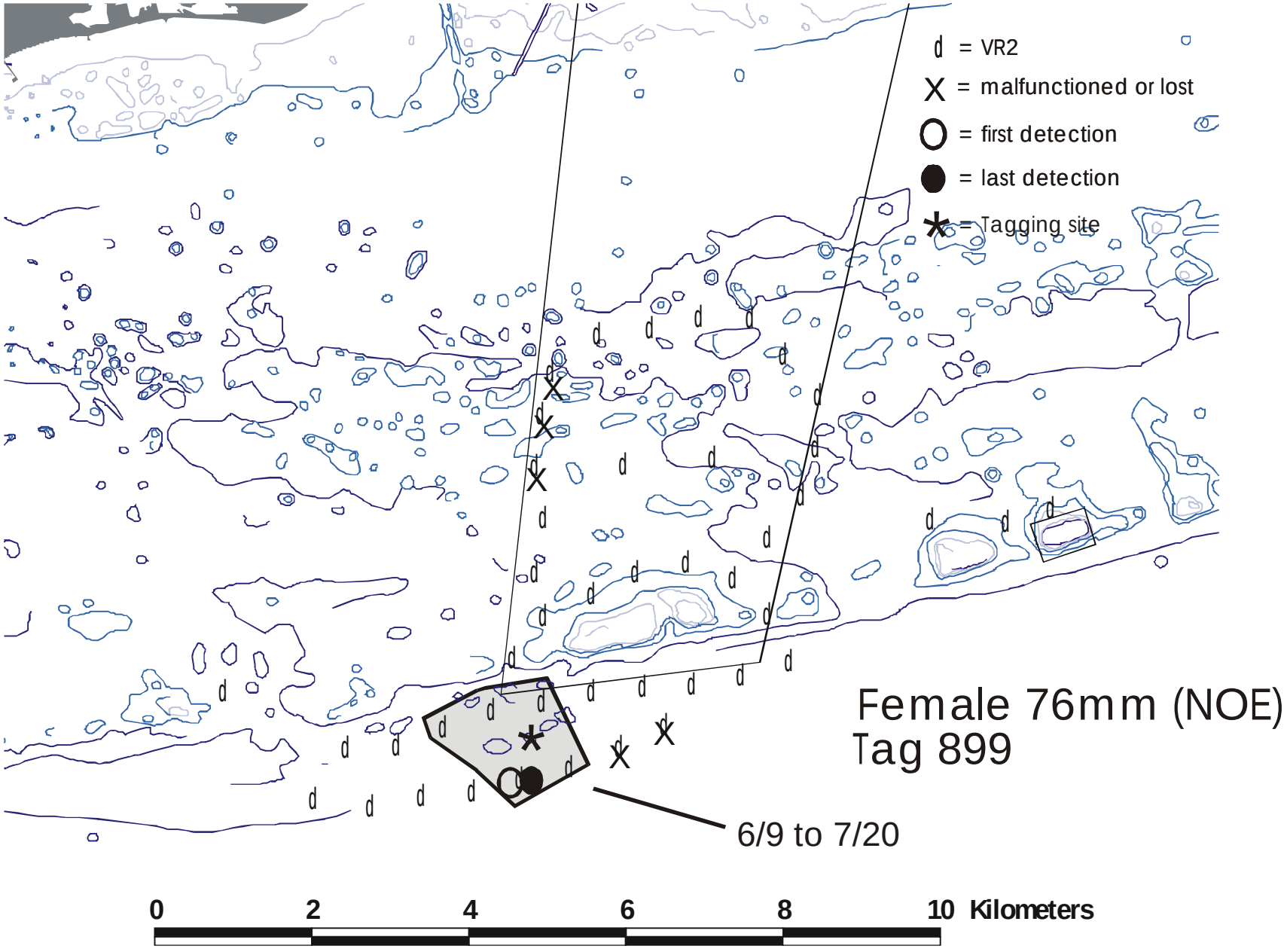

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
✱ = Tagging site
Female 74mm (NOF)
Tag 885
6/9 to 8/10
0
2
4
6
8
10 Kilometers

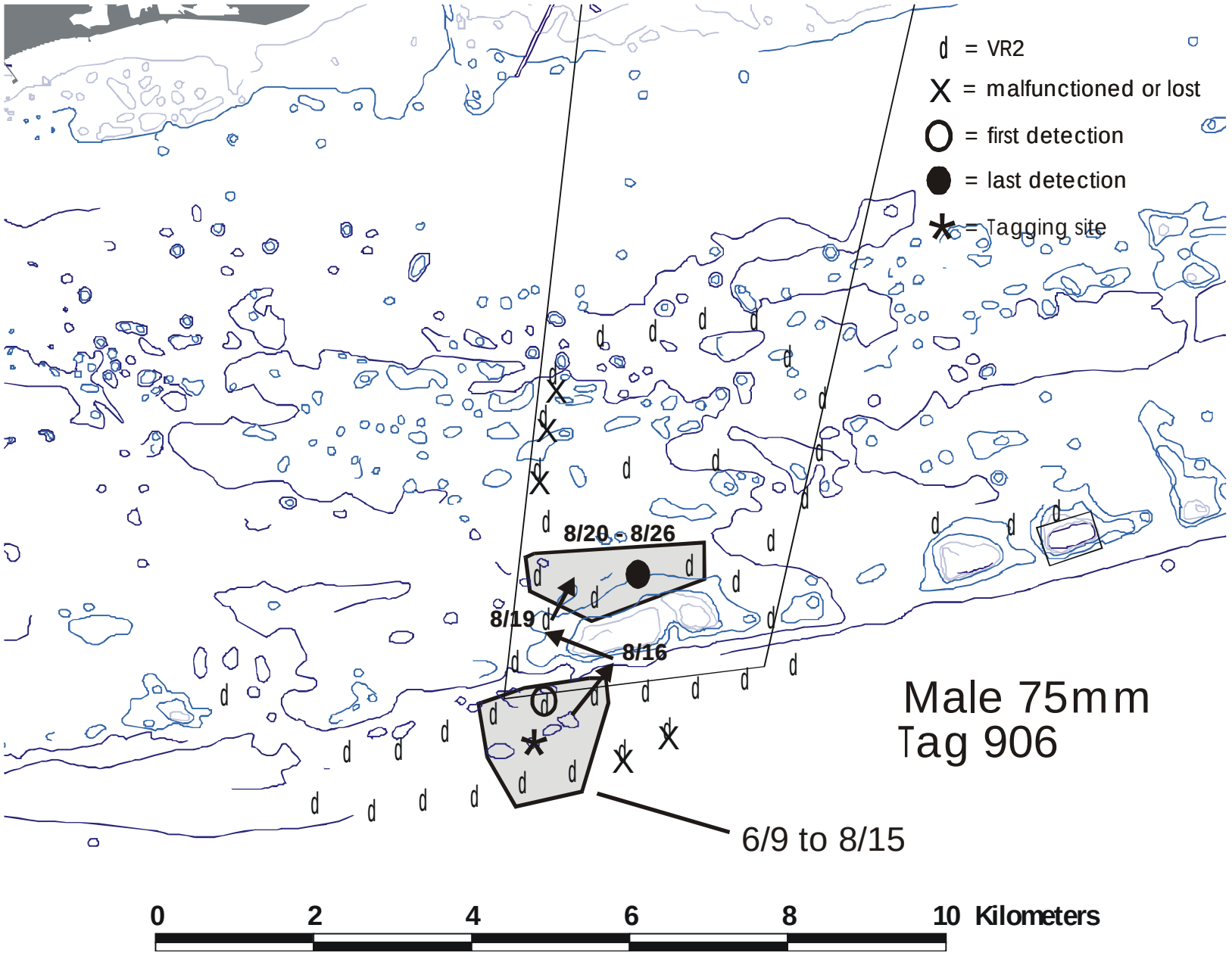

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
* = Tagging site
Female 85mm (NBF)
Tag 893
6/9 to 8/20
0
2
4
6
8
10 Kilometers

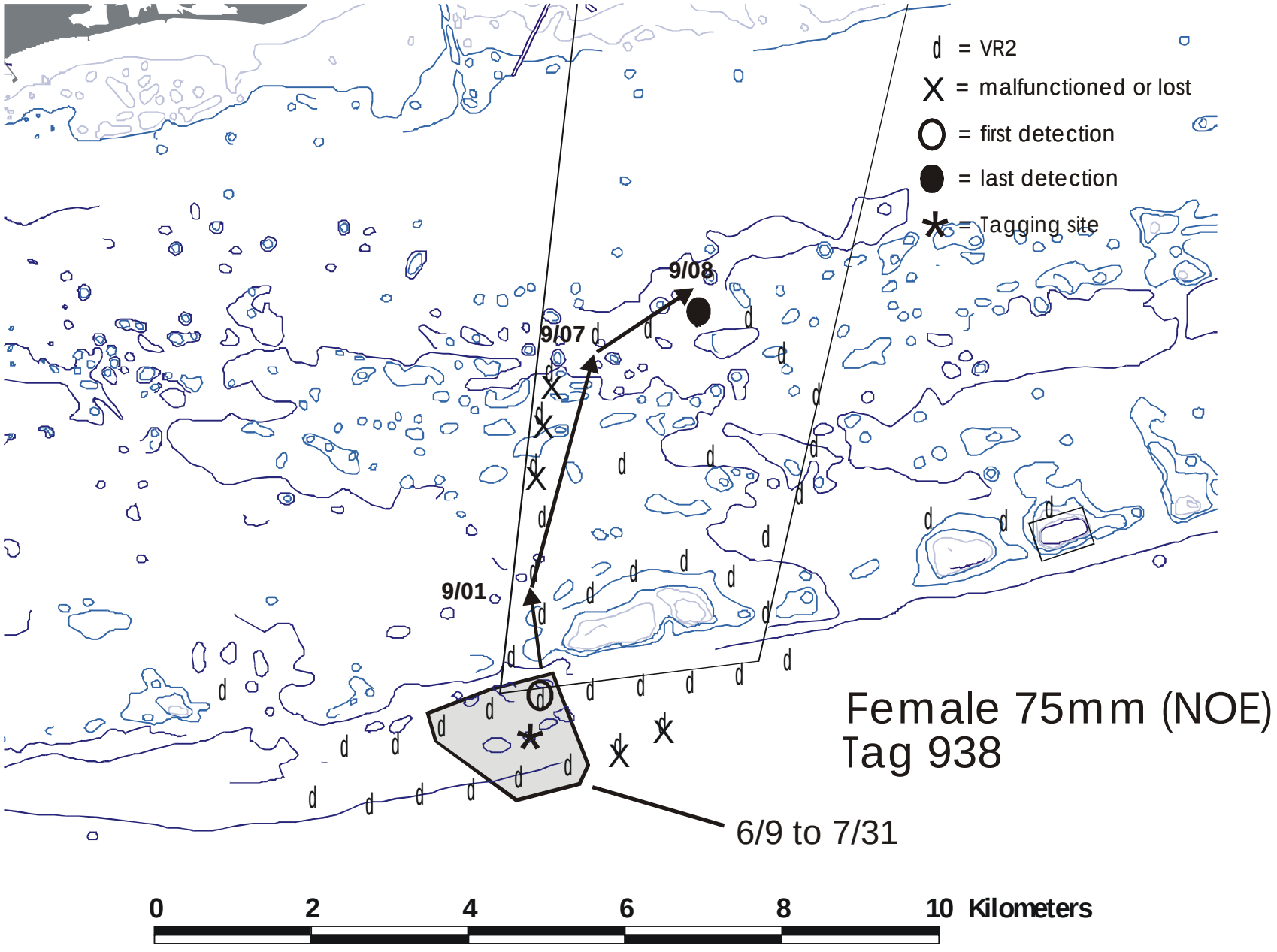

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Male 86mm
Tag 894
6/11
6/14
6/9 to 7/26
0
2
4
6
8
10 Kilometers


= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
?
Female 73mm (NOE)
Tag 896
6/9 to 6/20
0
2
4
6
8
10 Kilometers

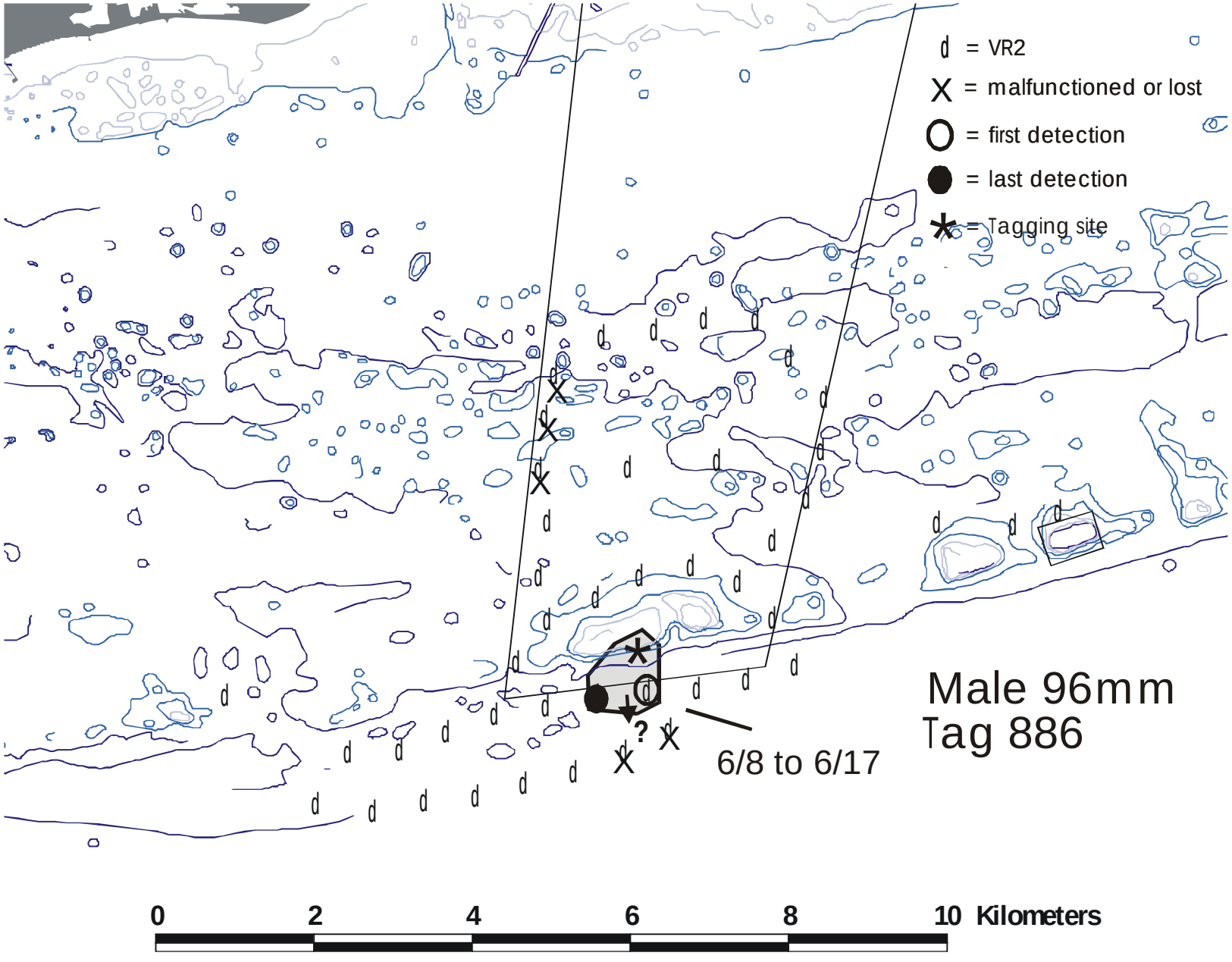

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Observed by divers
on forereef 7/10
Female 76mm (NOE)
Tag 897
6/9 to 6/25
0
2
4
6
8
10 Kilometers

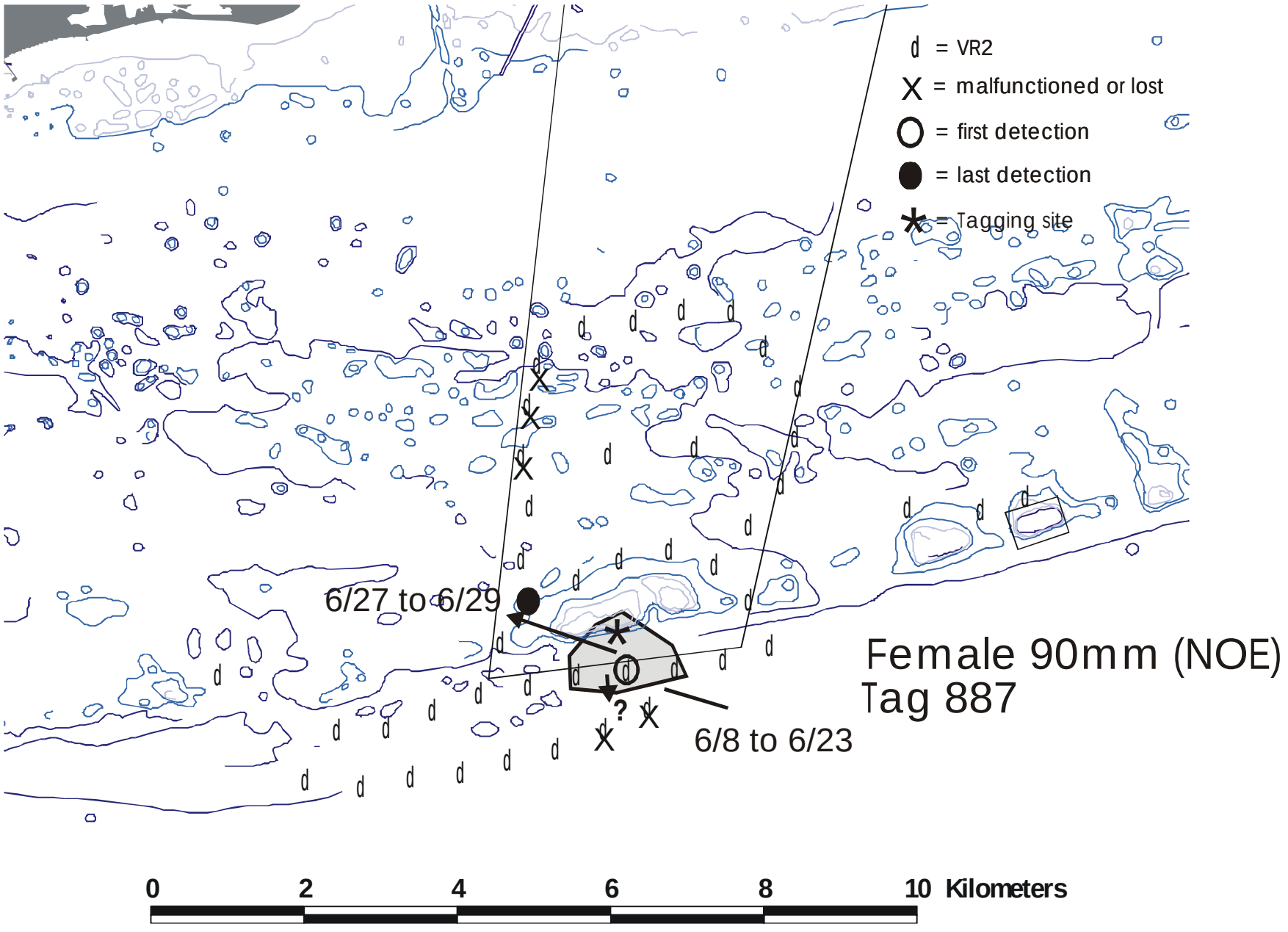

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
* = Tagging site
Female 76mm (NOE)
Tag 899
6/9 to 7/20
0
2
4
6
8
10 Kilometers

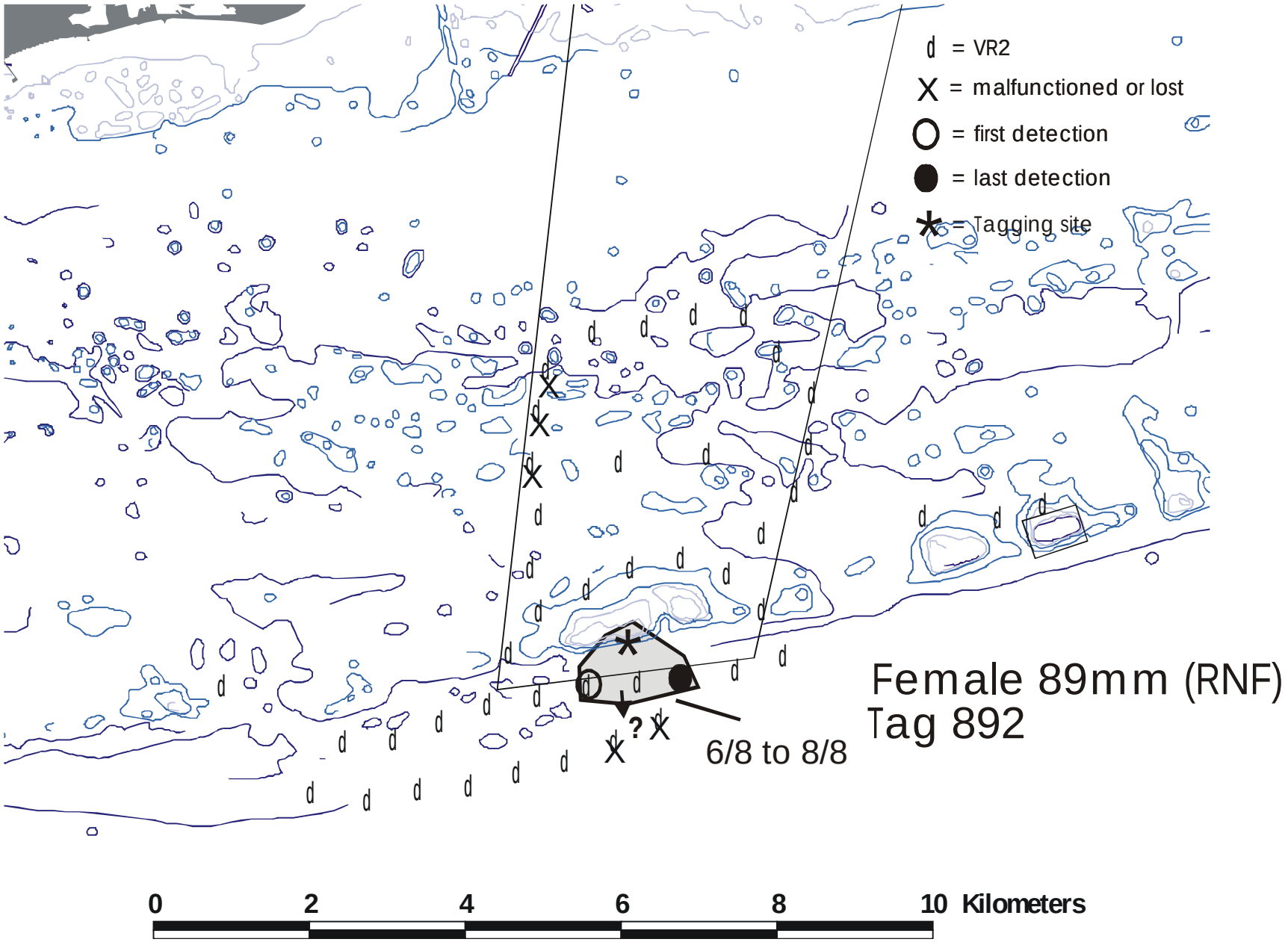

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
8/20 - 8/26
8/19
8/16
Male 75mm
Tag 906
6/9 to 8/15
0
2
4
6
8
10 Kilometers

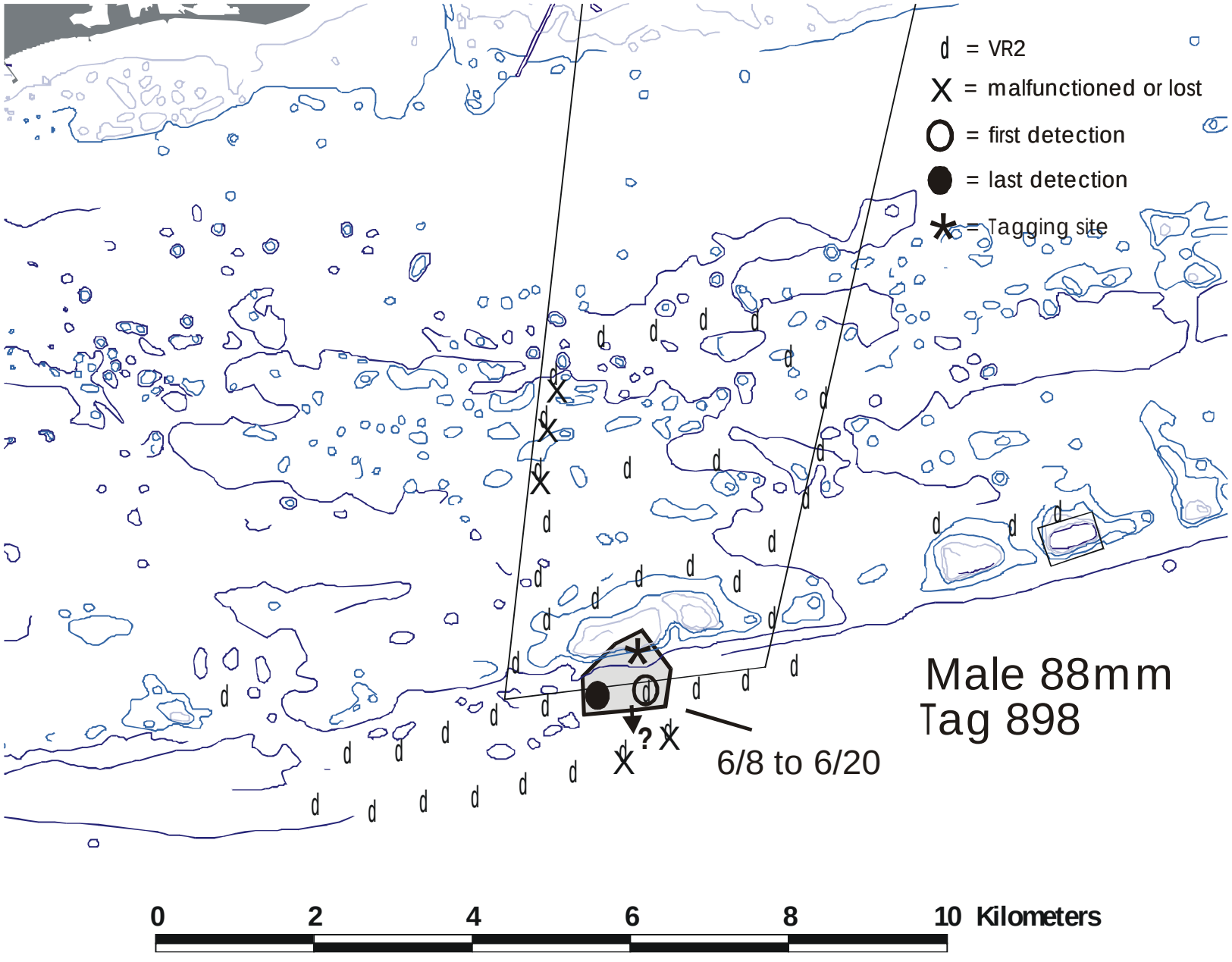

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
9/08
9/07
9/01
Female 75mm (NOE)
Tag 938
6/9 to 7/31
0
2
4
6
8
10 Kilometers

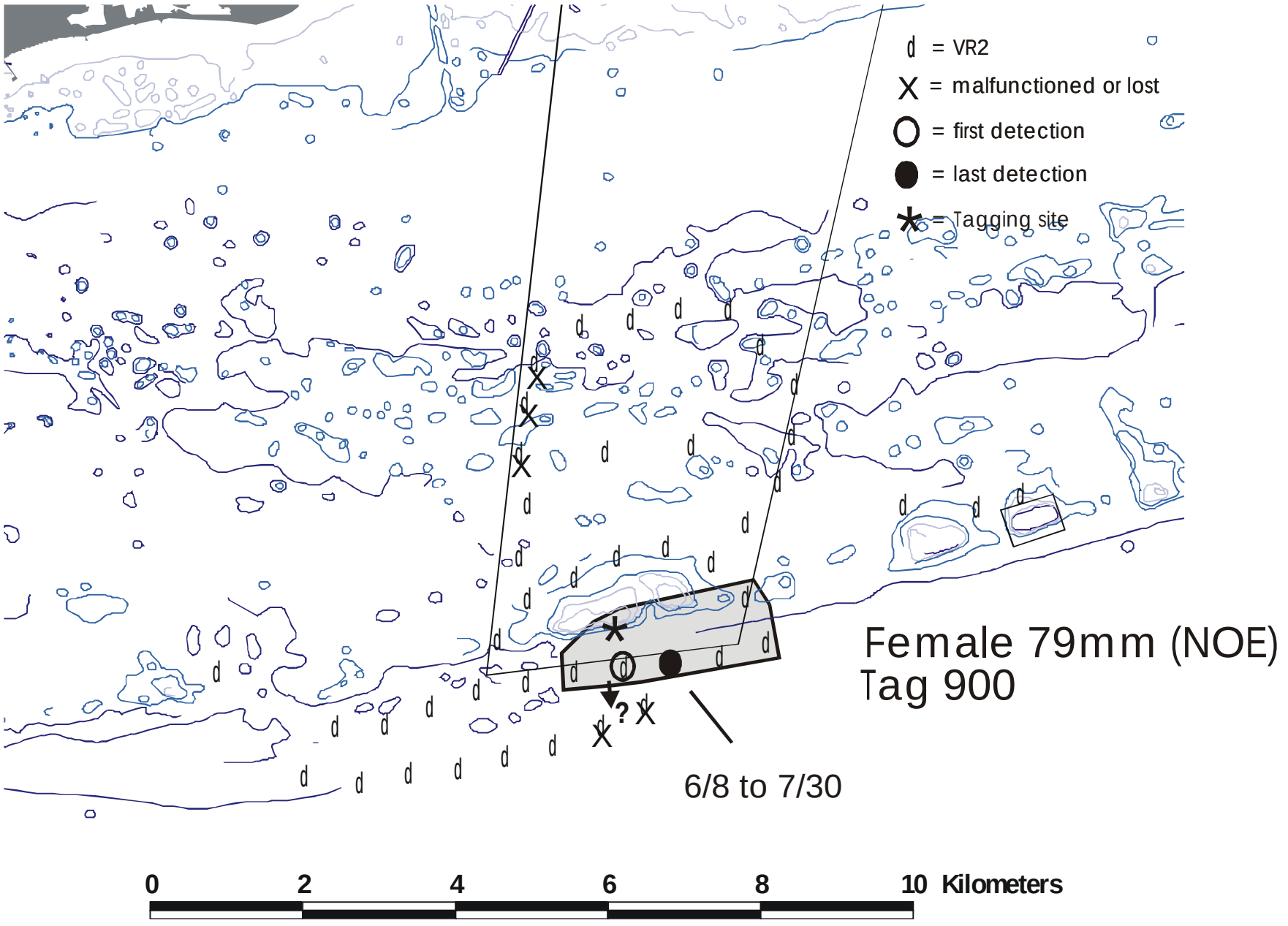
Forereef lobsters

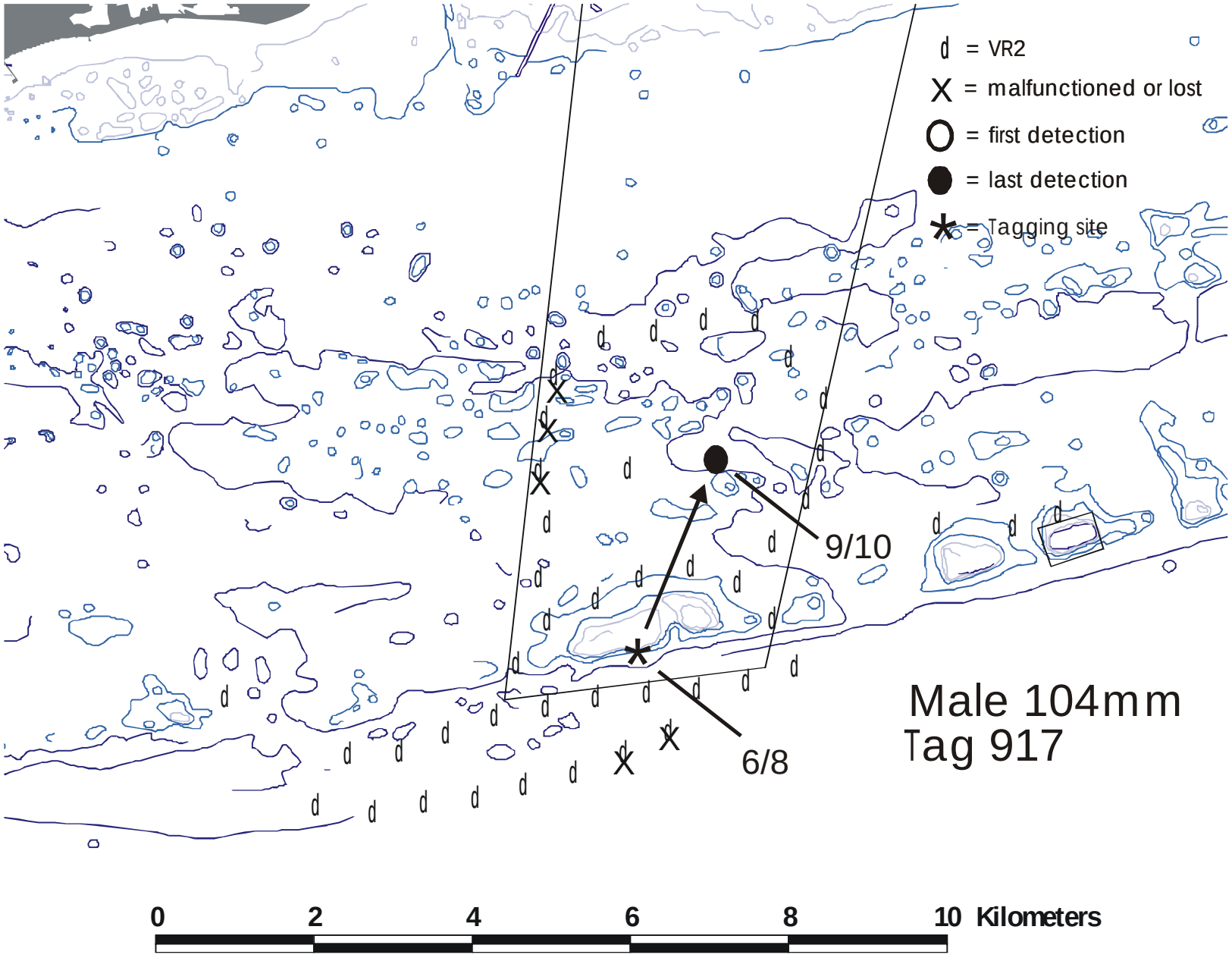

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Male 96mm
Tag 886
6/8 to 6/17
0
2
4
6
8
10 Kilometers

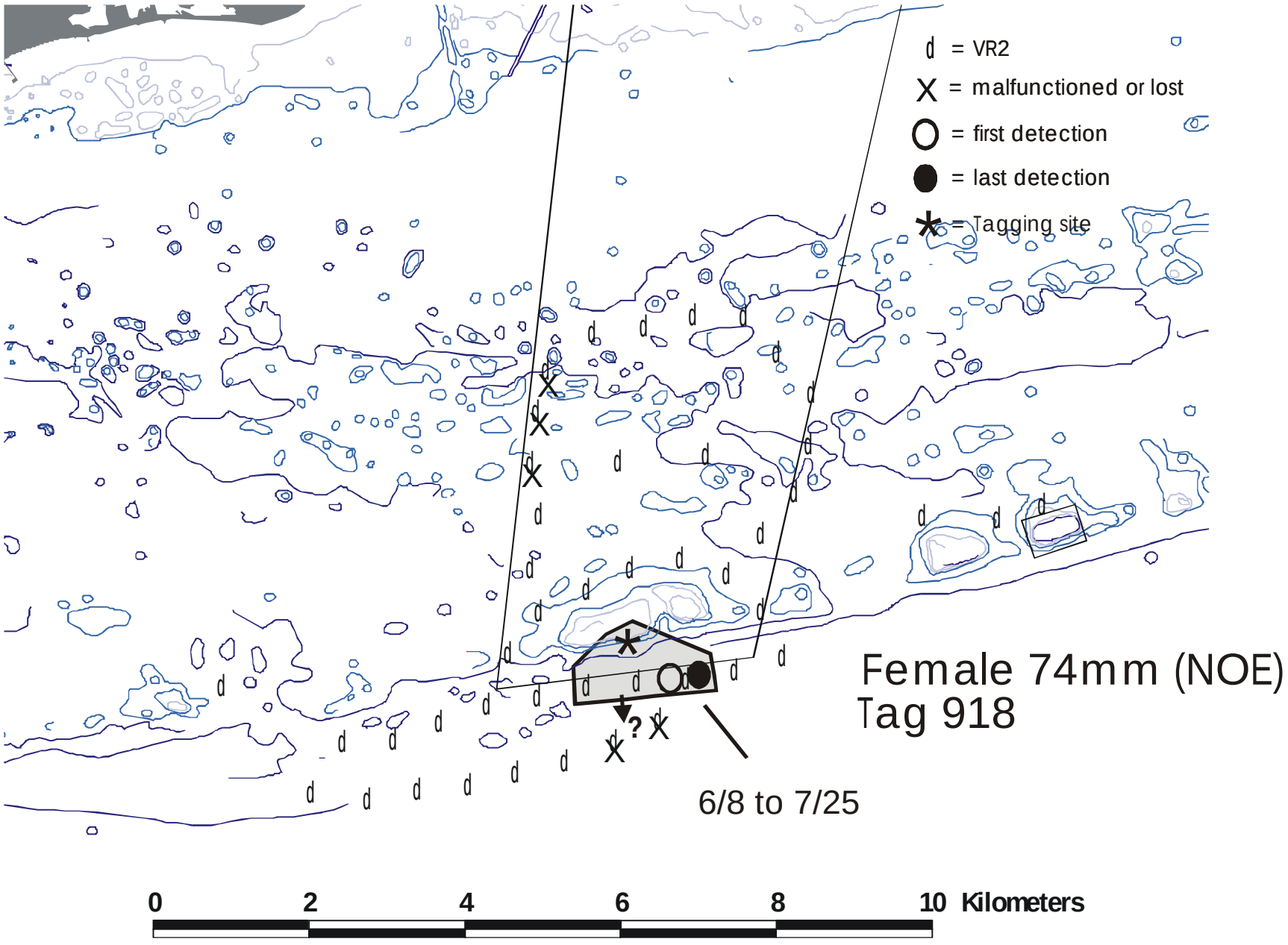

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
✱ = Tagging site
6/27 to 6/29
6/8 to 6/23
Female 90mm (NOE)
Tag 887
0
2
4
6
8
10 Kilometers

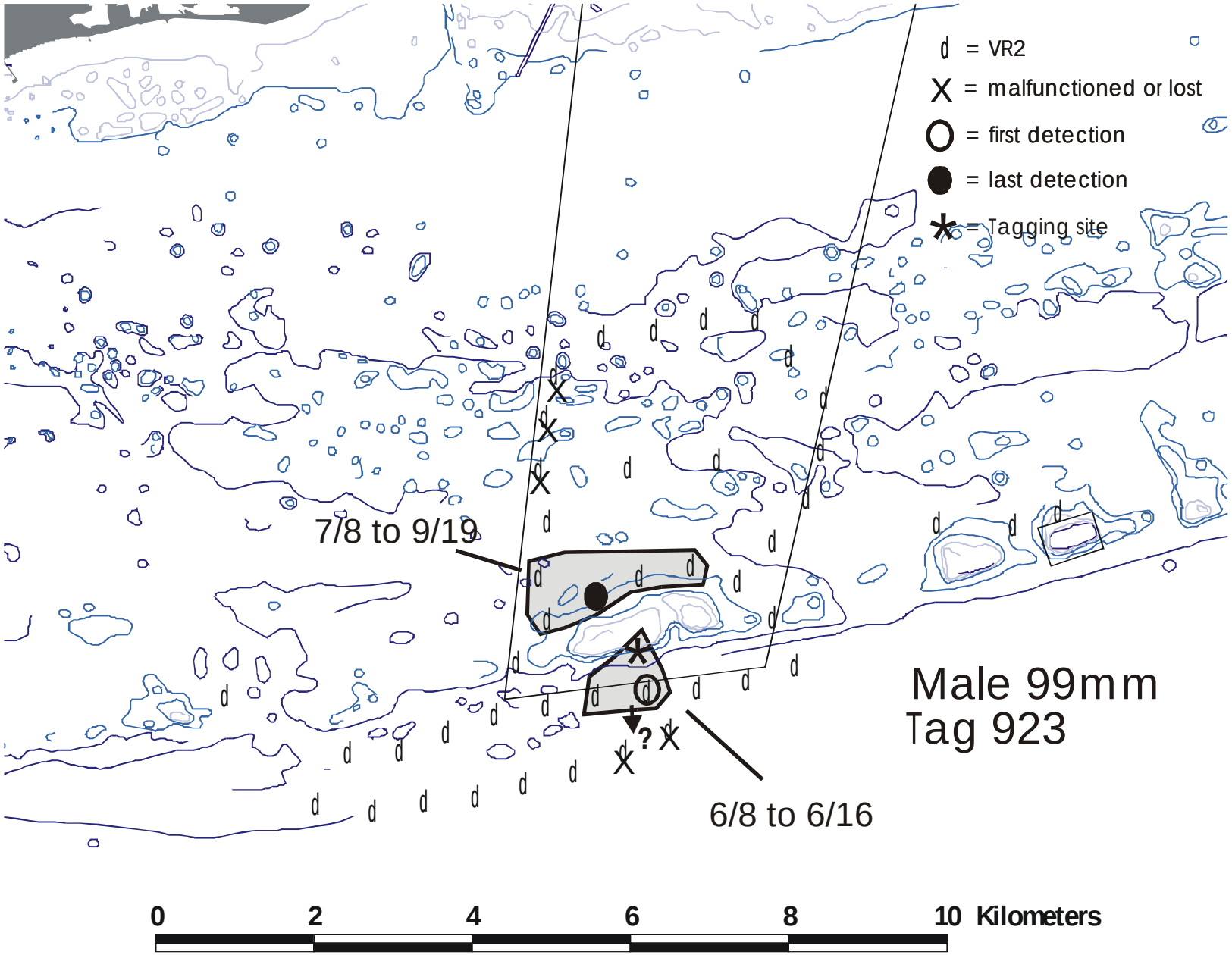

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Female 89mm (RNF)
Tag 892
6/8 to 8/8
0
2
4
6
8
10 Kilometers

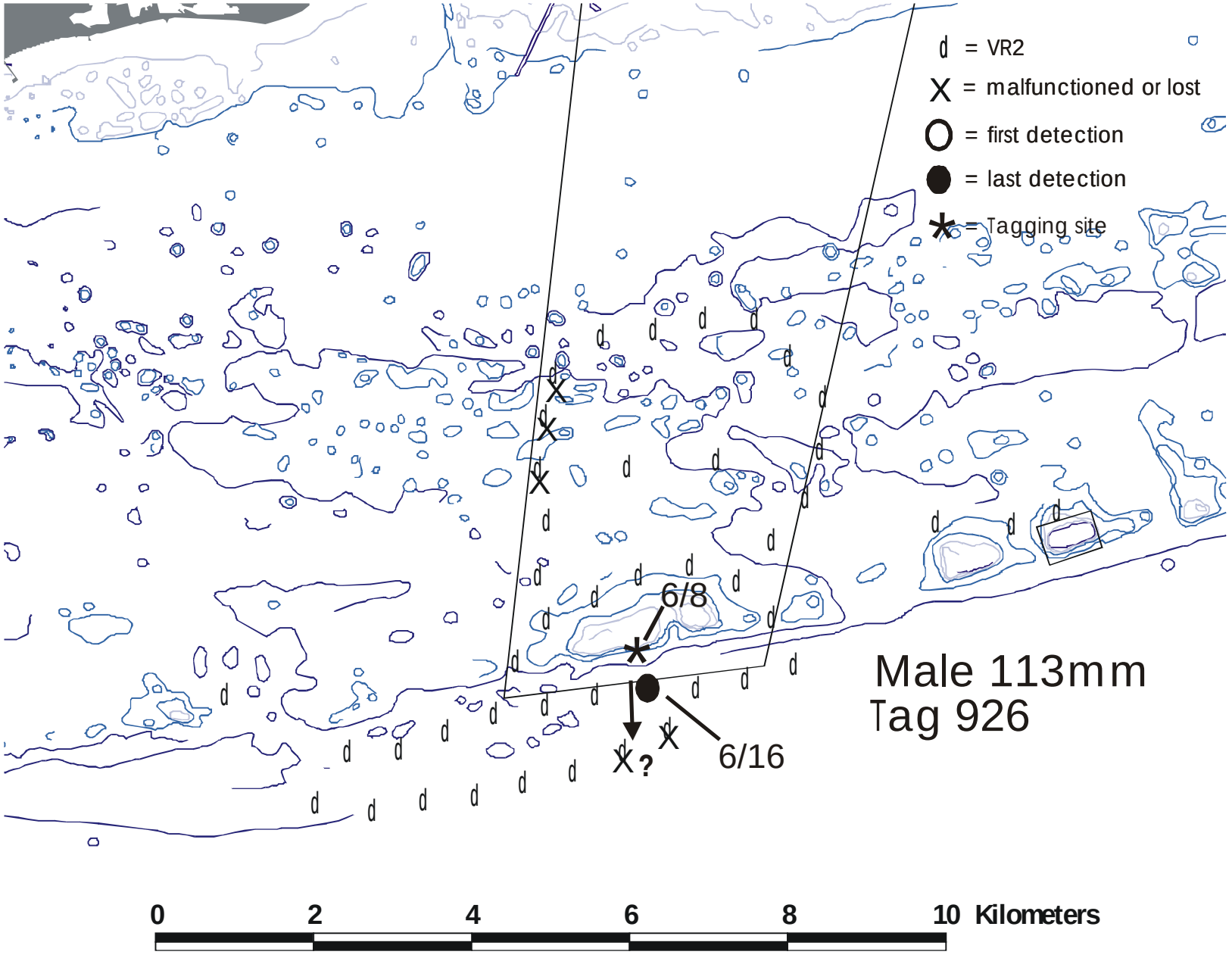

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Male 88mm
Tag 898
6/8 to 6/20
0
2
4
6
8
10 Kilometers

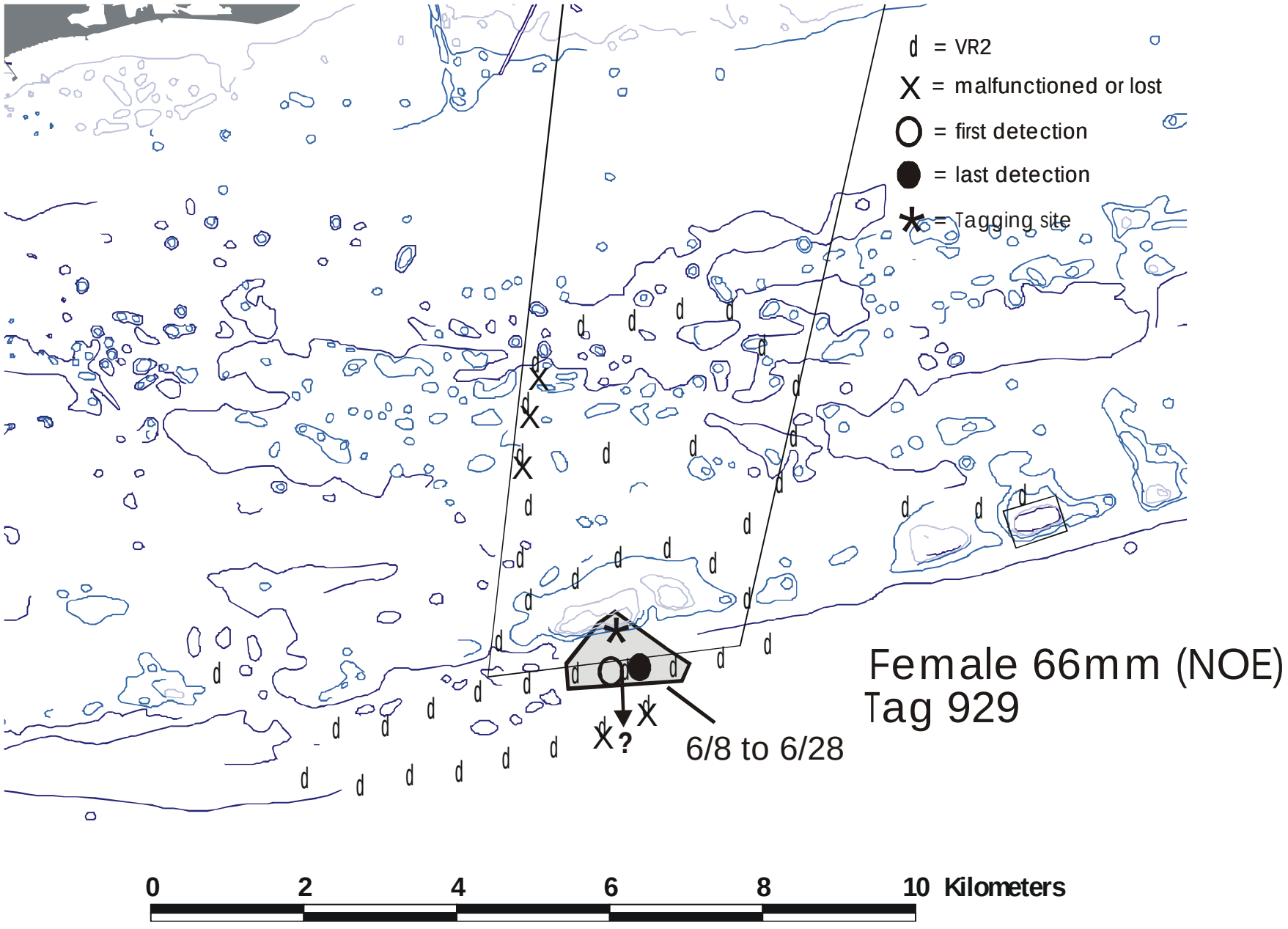

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
✱ = Tagging site
Female 79mm (NOE)
Tag 900
6/8 to 7/30
0
2
4
6
8
10 Kilometers

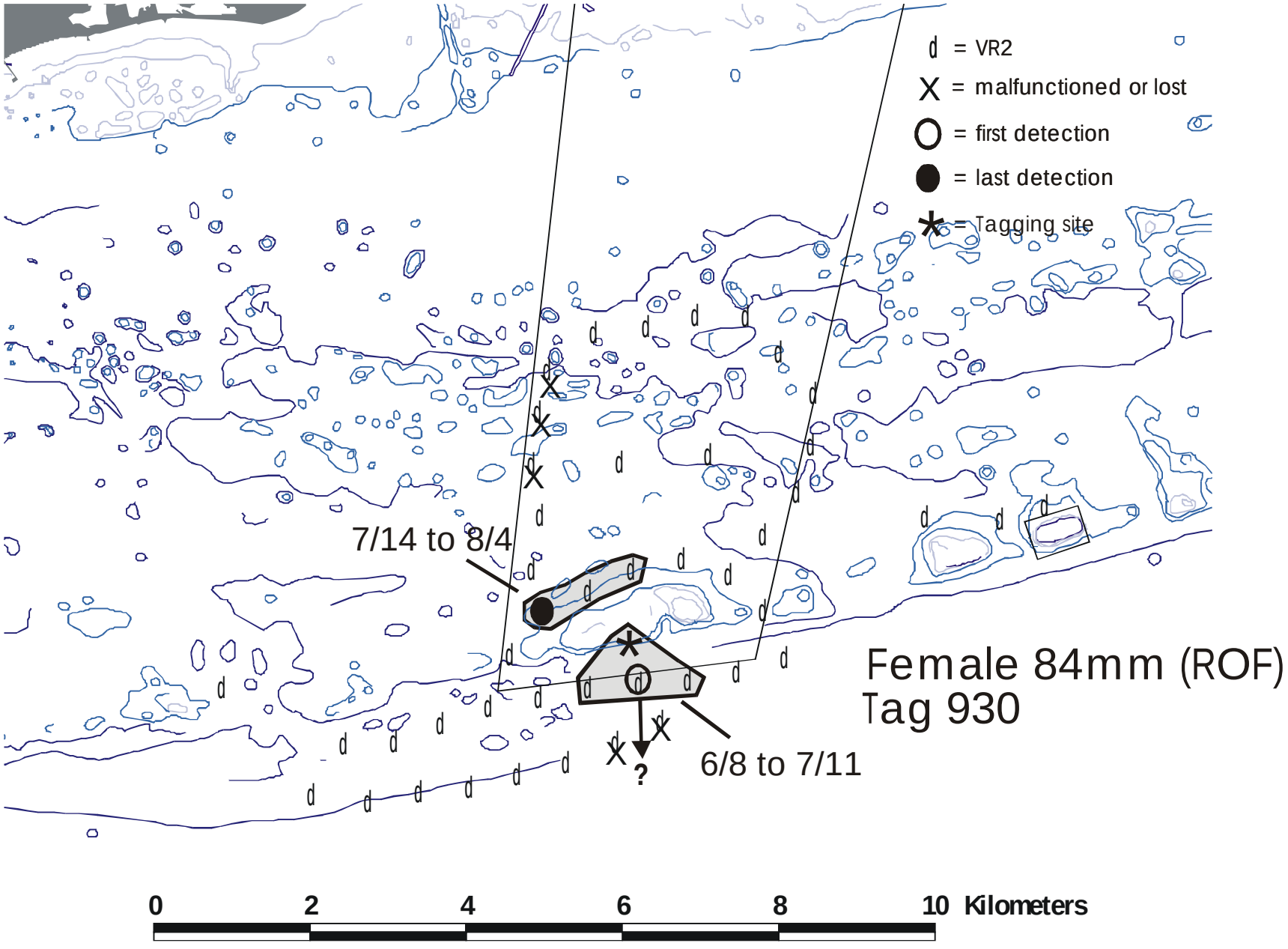

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
9/10
6/8
Male 104mm
Tag 917
0
2
4
6
8
10 Kilometers

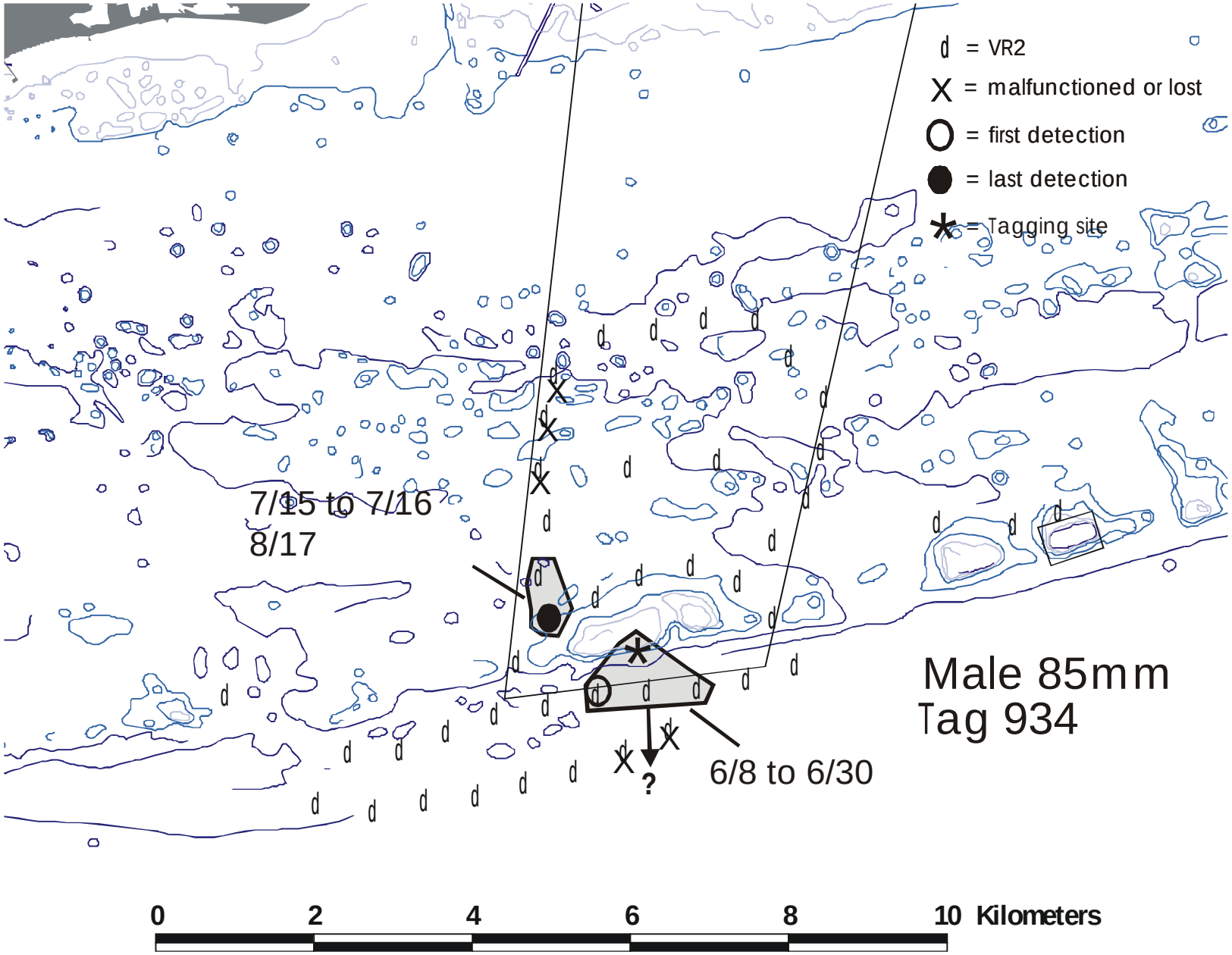

d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
✱ = Tagging site
Female 74mm (NOE)
Tag 918
6/8 to 7/25
0
2
4
6
8
10 Kilometers


d = VR2
X = malfunctioned or lost
O = first detection
= last detection
= Tagging site
7/8 to 9/19
Male 99mm
Tag 923
6/8 to 6/16
0
2
4
6
8
10 Kilometers

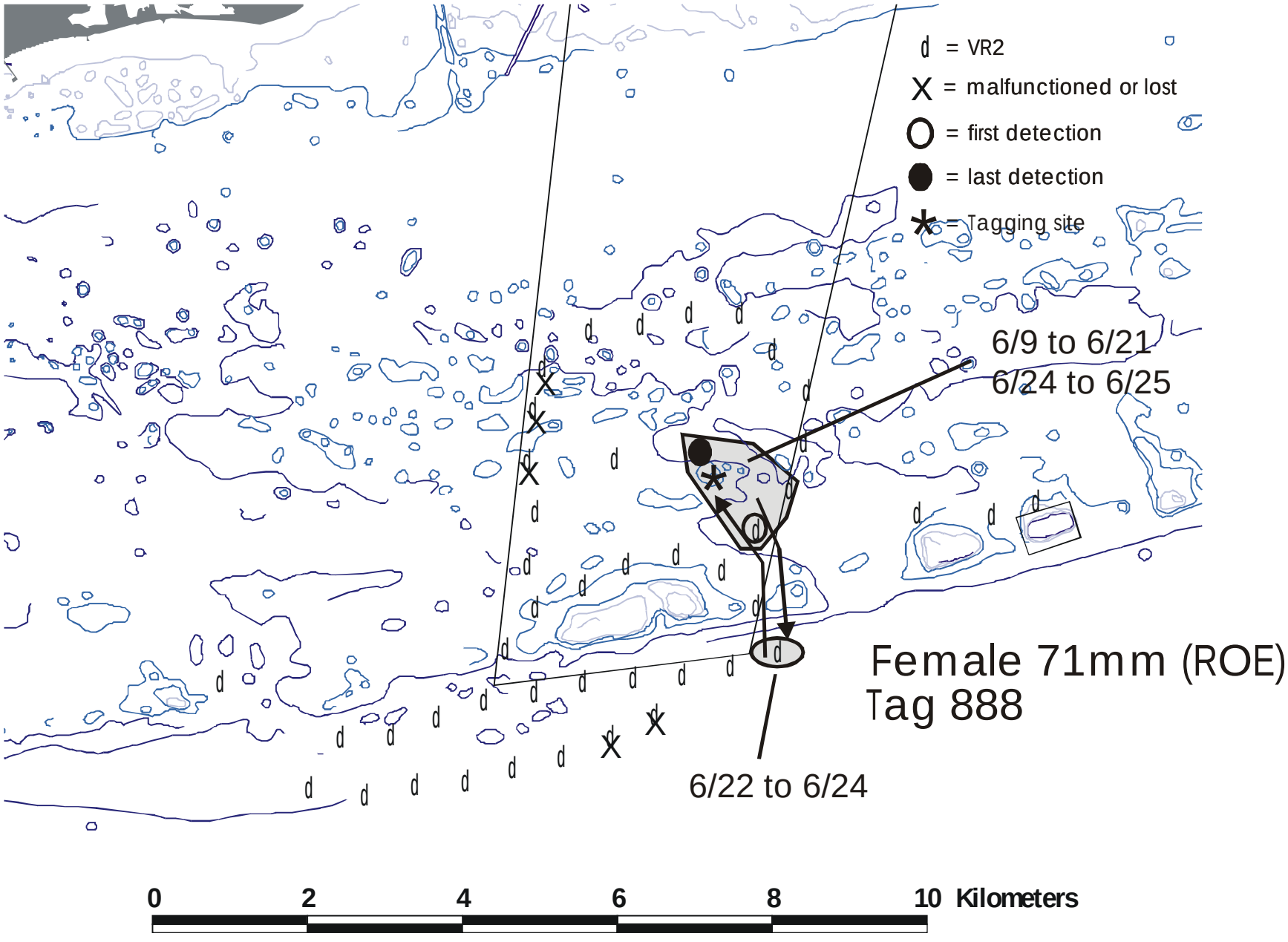

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
6/8
6/16
Male 113mm
Tag 926
0
2
4
6
8
10 Kilometers

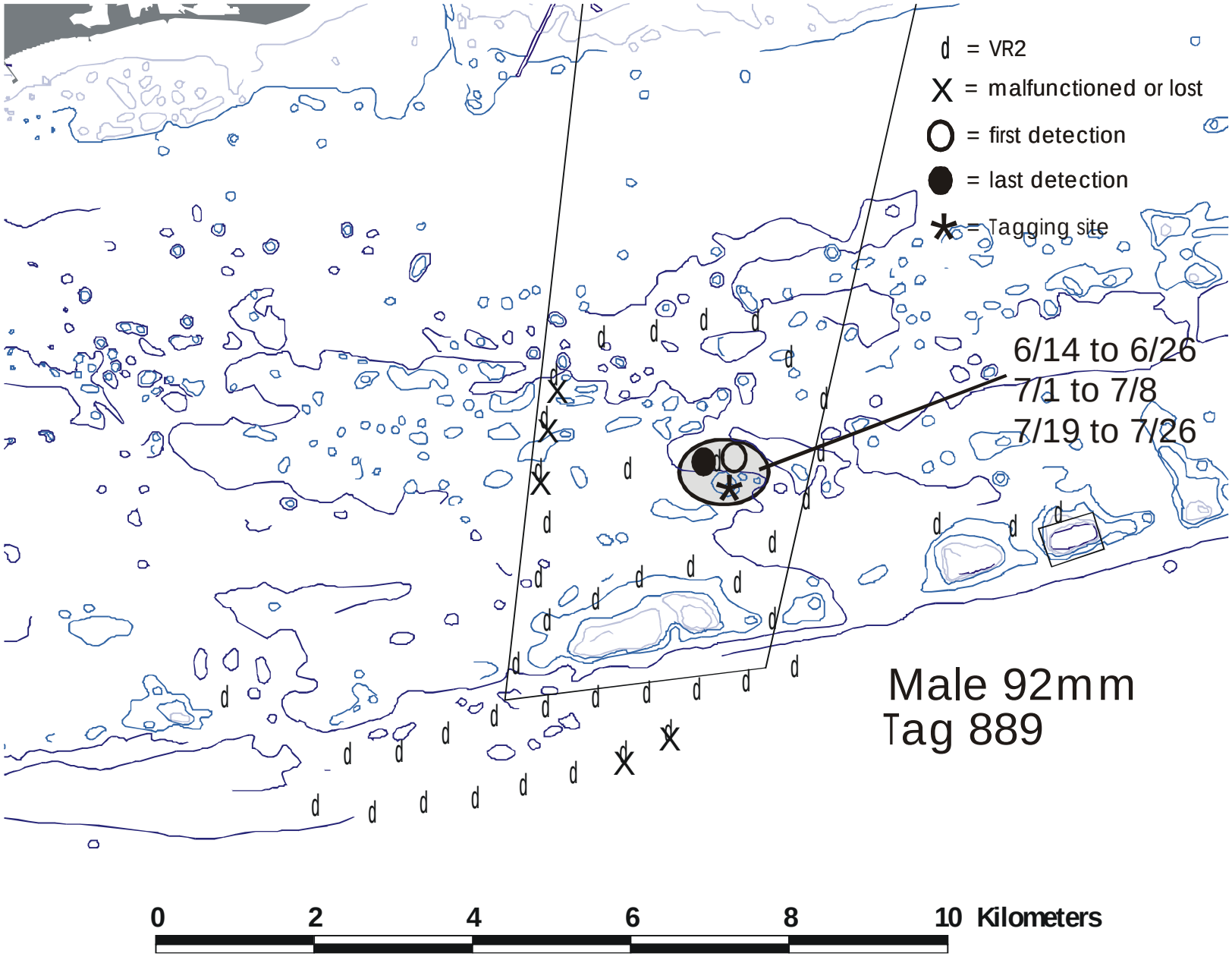

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
Female 66mm (NOE)
Tag 929
6/8 to 6/28
0
2
4
6
8
10 Kilometers

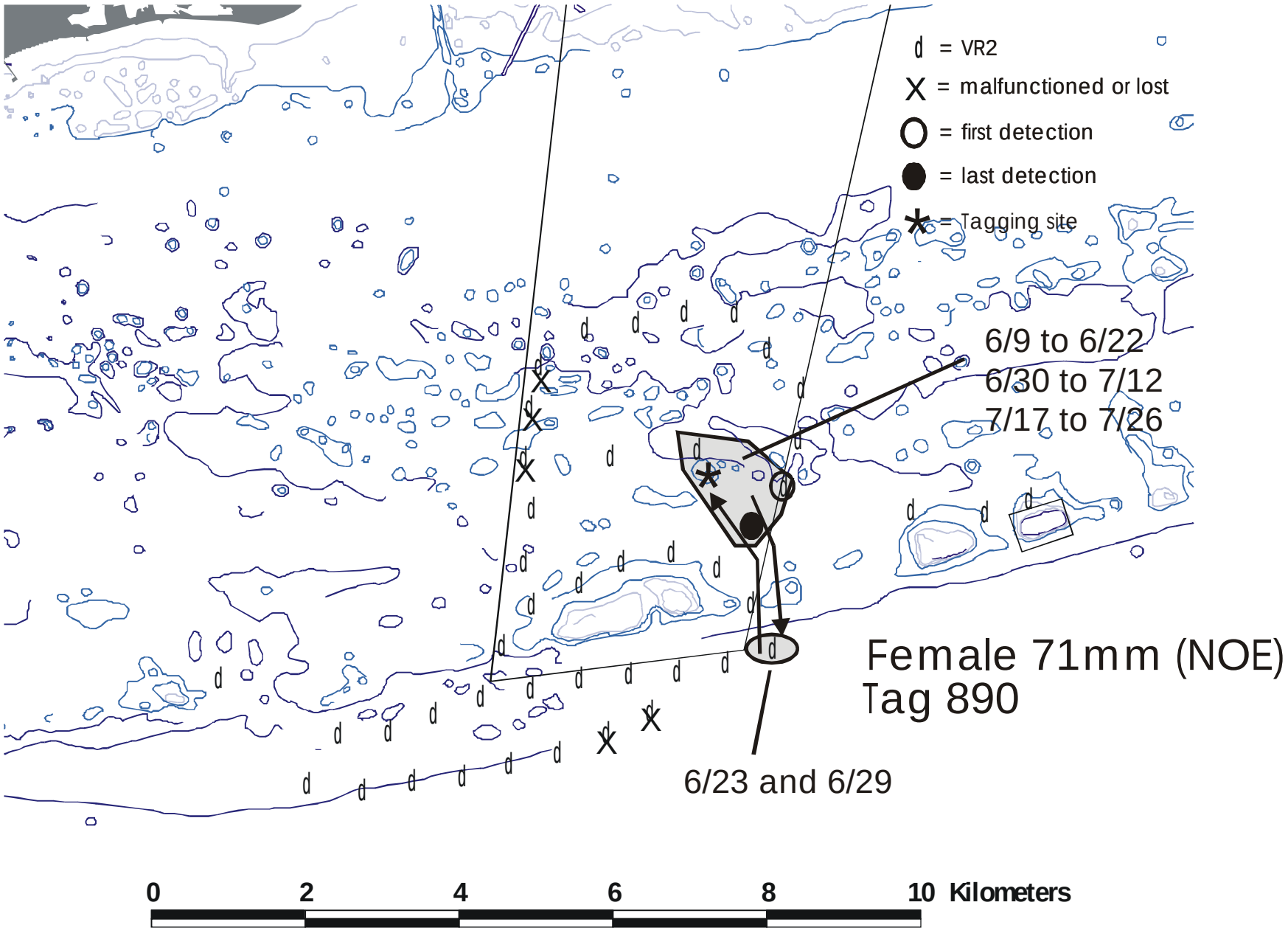

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
7/14 to 8/4
6/8 to 7/11
?
Female 84mm (ROF)
Tag 930
0
2
4
6
8
10 Kilometers

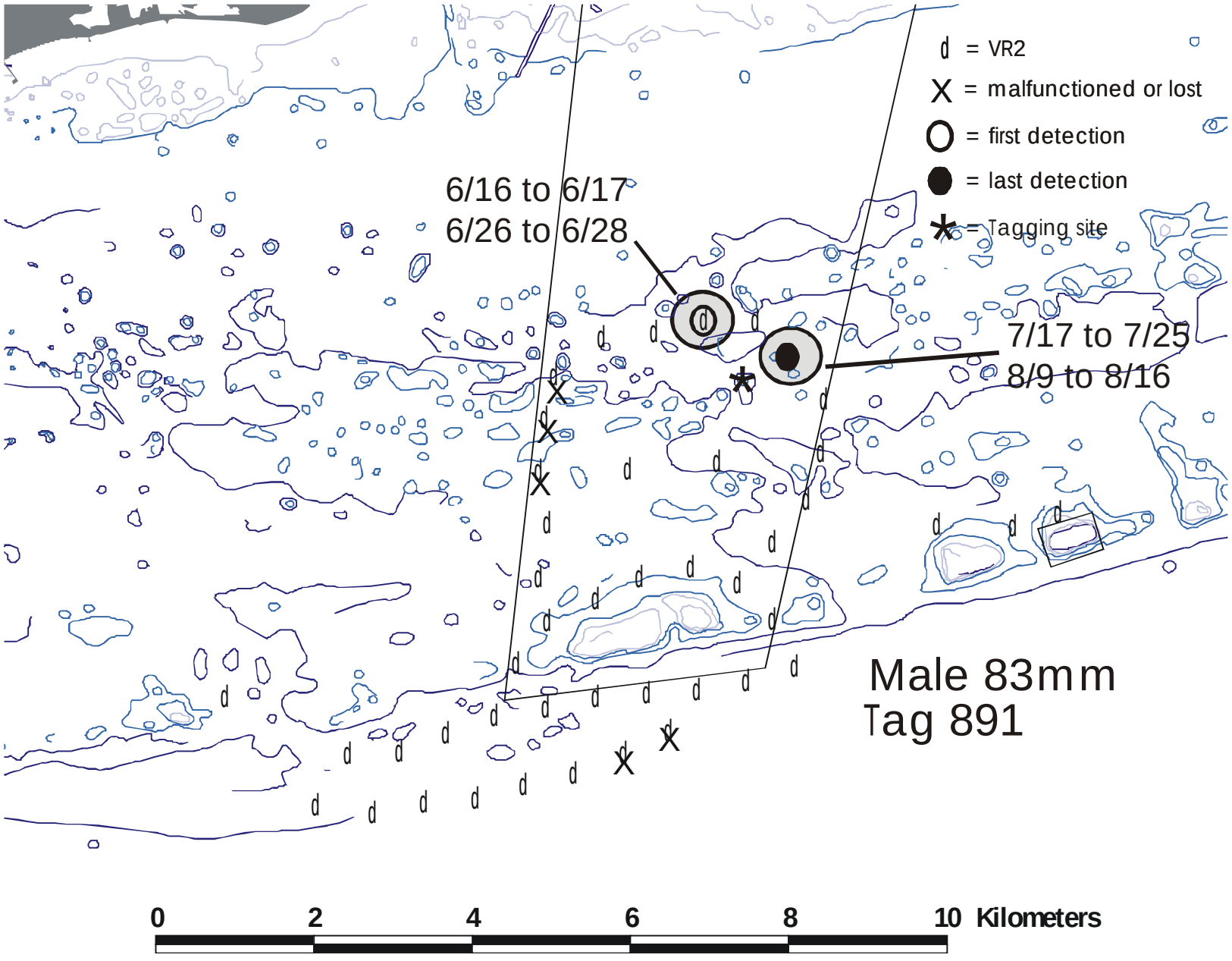

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
7/15 to 7/16
8/17
Male 85mm
Tag 934
6/8 to 6/30
?
0
2
4
6
8
10 Kilometers

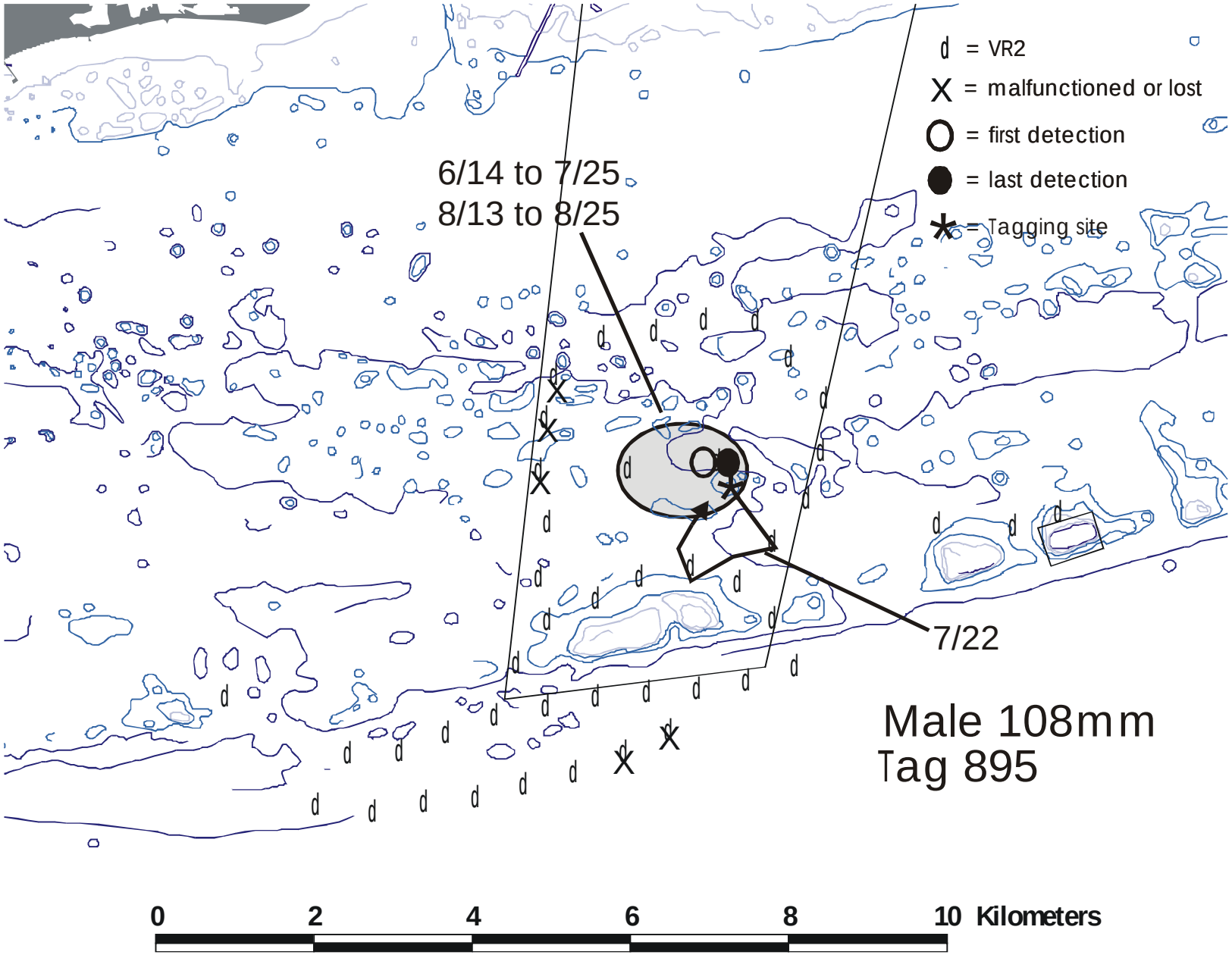
Hawk Channel Lobsters

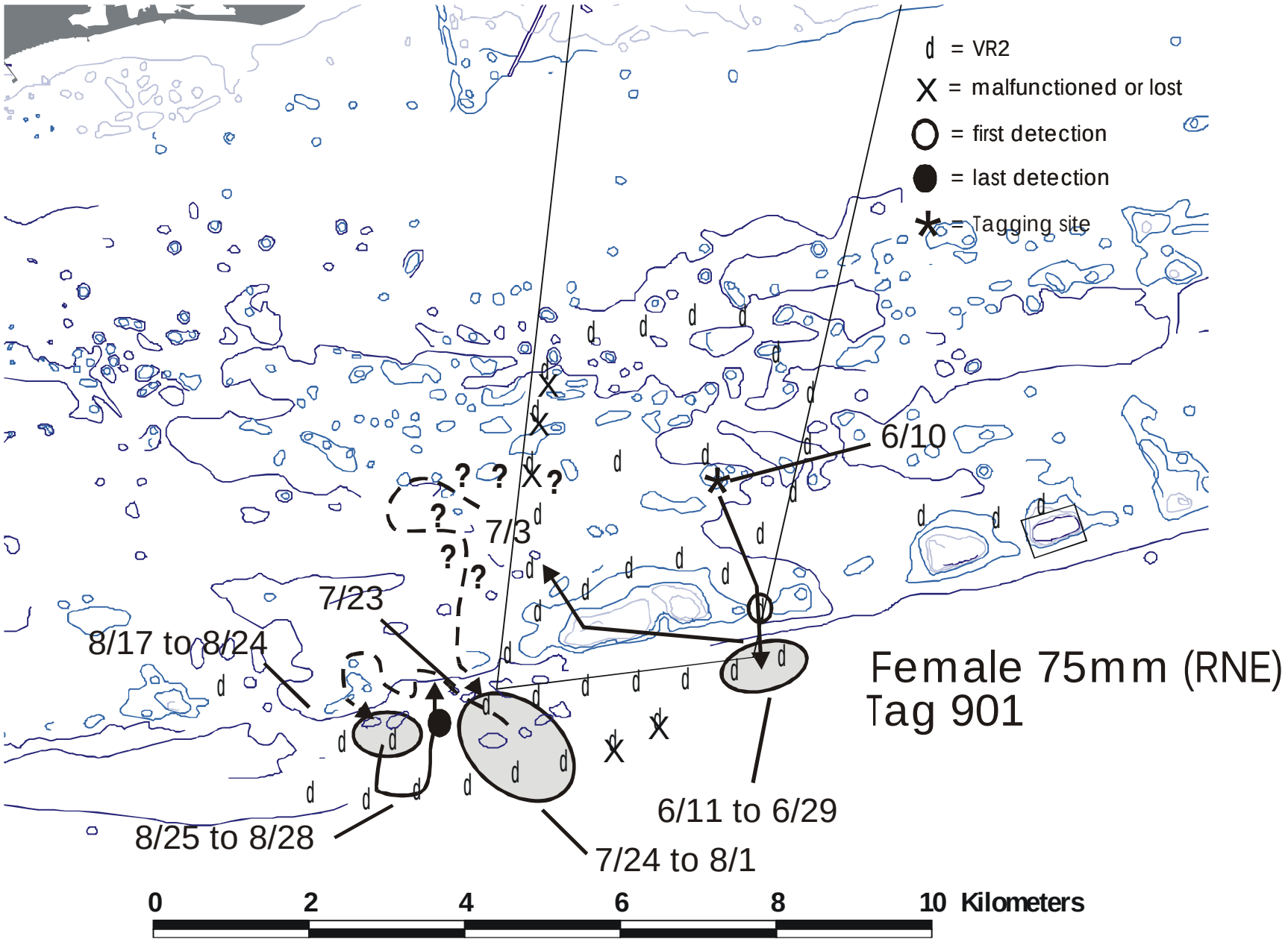

d = VR2
X = malfunctioned or lost
O = first detection
= last detection
= Tagging site
6/9 to 6/21
6/24 to 6/25
Female 71mm (ROE)
Tag 888
6/22 to 6/24
0
2
4
6
8
10 Kilometers

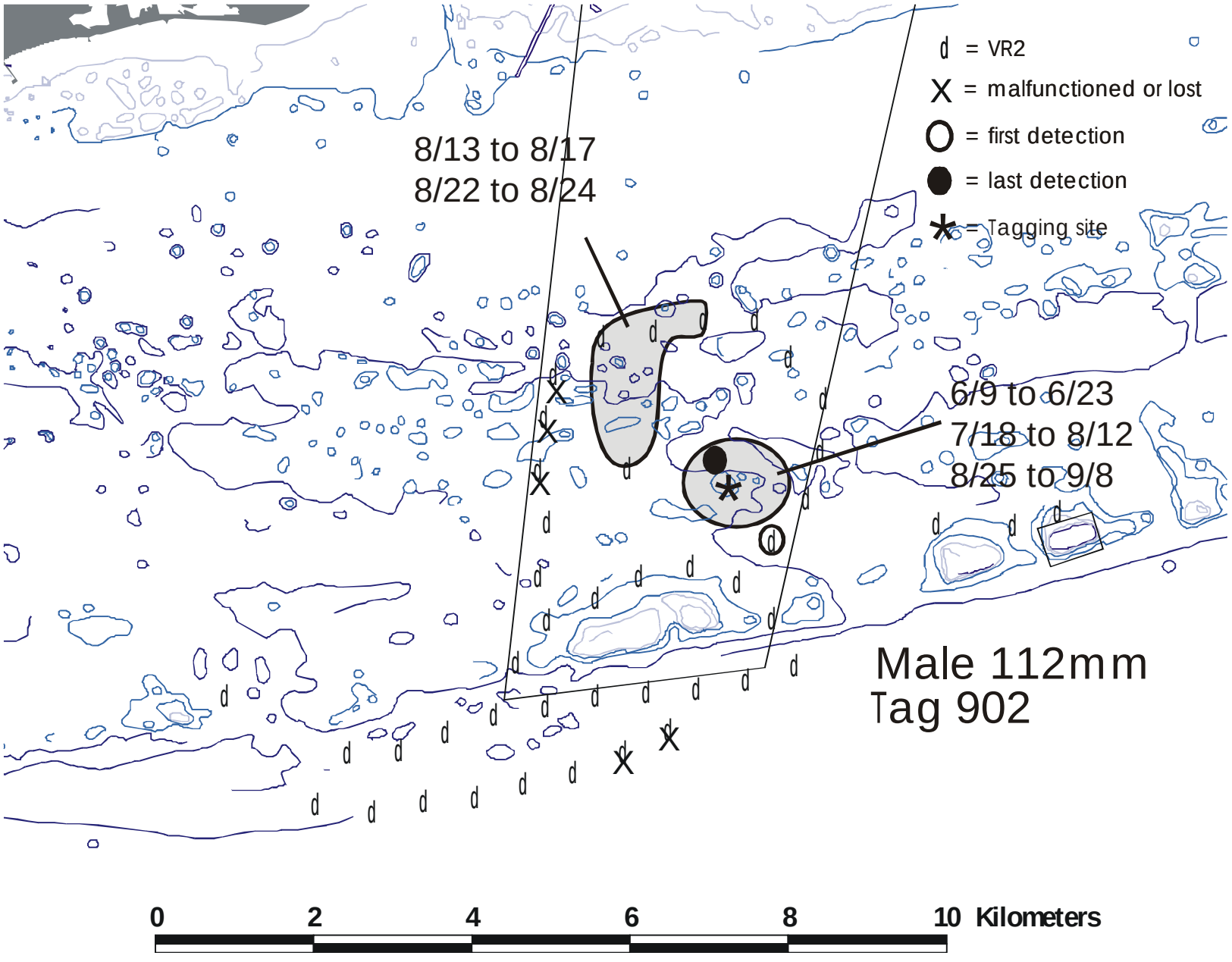

d = VR2
X = malfunctioned or lost
O = first detection
= last detection
= Tagging site
6/14 to 6/26
7/1 to 7/8
7/19 to 7/26
Male 92mm
Tag 889
0
2
4
6
8
10 Kilometers

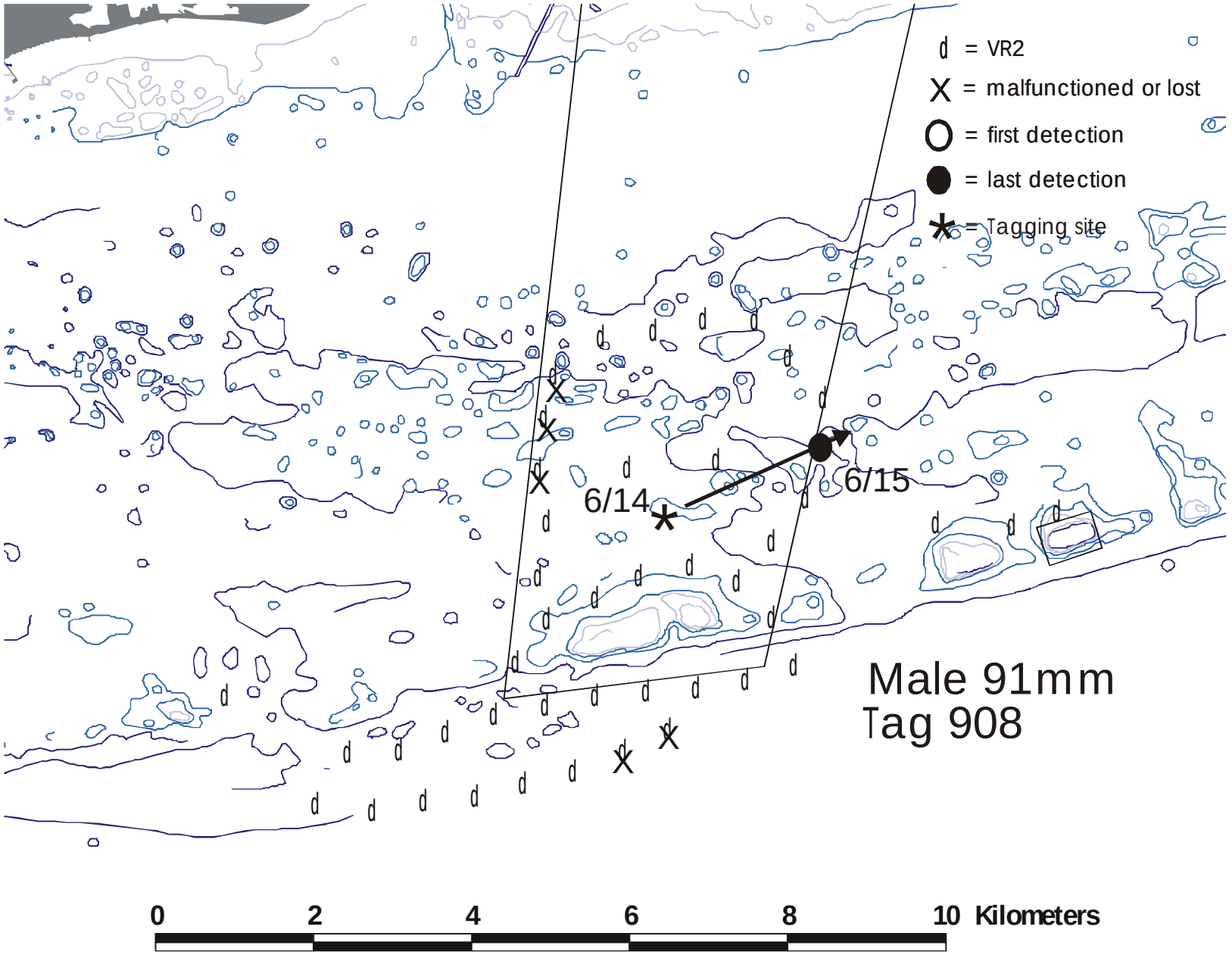

d = VR2
X = malfunctioned or lost
O = first detection
= last detection
= Tagging site
6/9 to 6/22
6/30 to 7/12
7/17 to 7/26
Female 71mm (NOE)
Tag 890
6/23 and 6/29
0
2
4
6
8
10 Kilometers

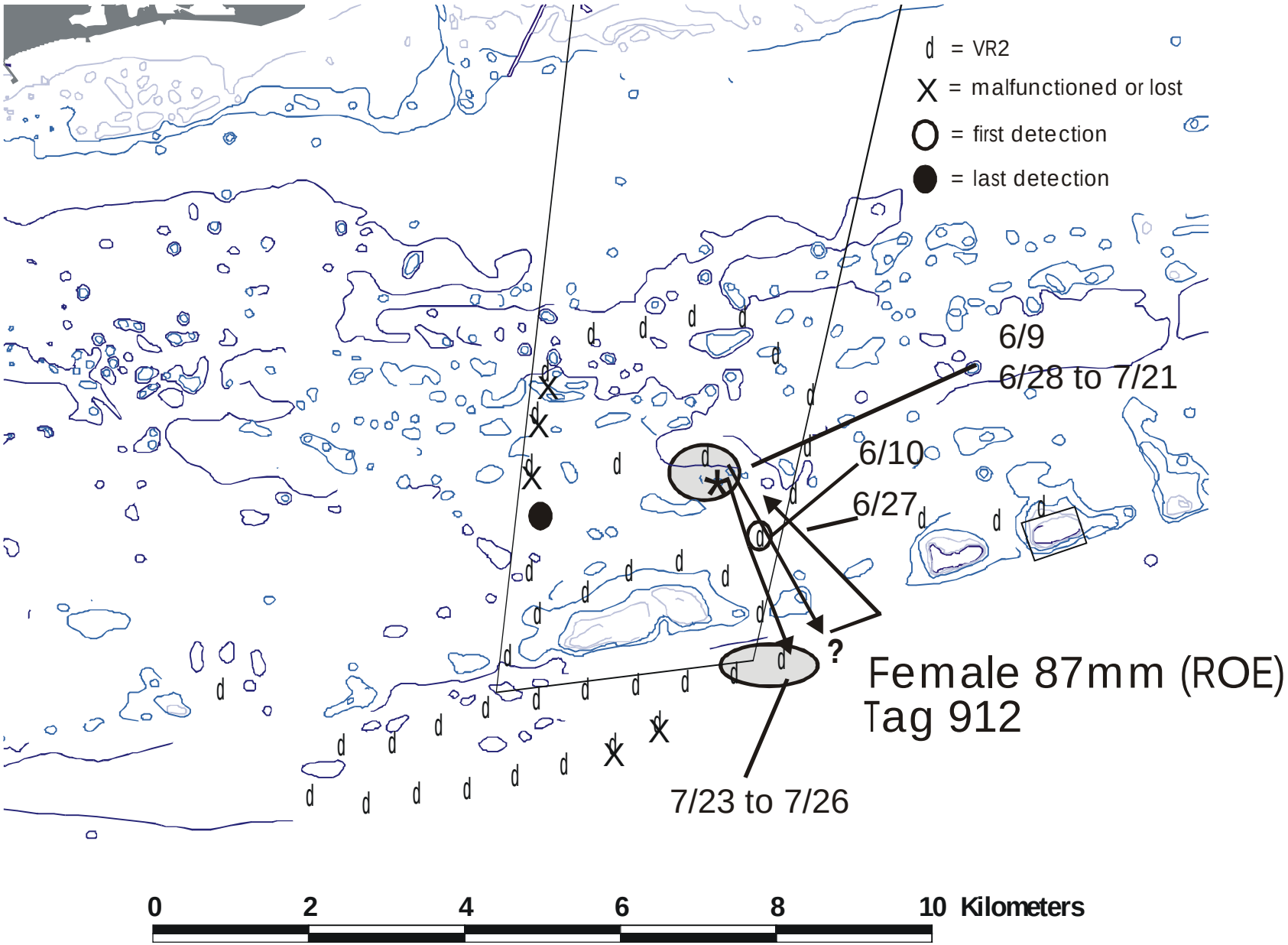

d = VR2
X = malfunctioned or lost
O = first detection
= last detection
* = Tagging site
6/16 to 6/17
6/26 to 6/28
7/17 to 7/25
8/9 to 8/16
Male 83mm
Tag 891
0
2
4
6
8
10 Kilometers


= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
6/14 to 7/25
8/13 to 8/25
7/22
Male 108mm
Tag 895
0
2
4
6
8
10 Kilometers

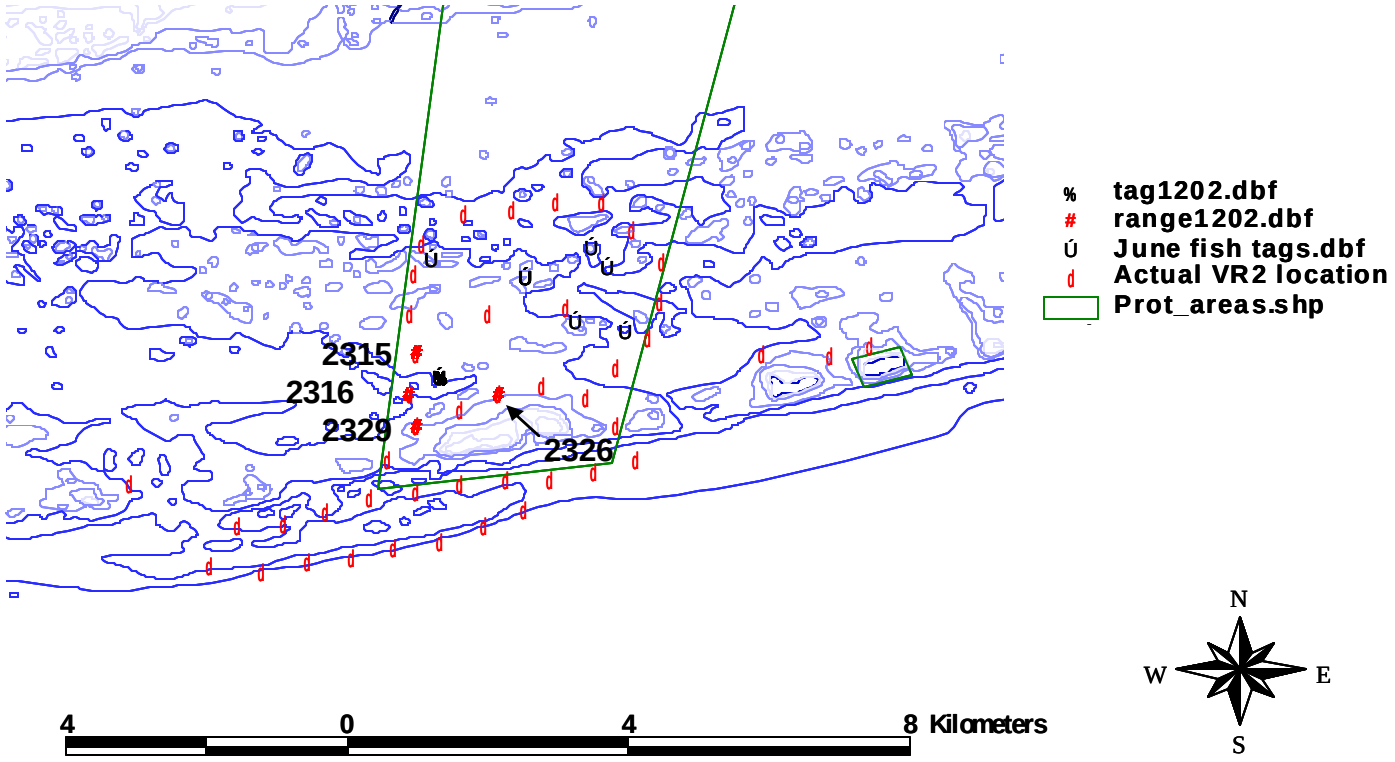

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
6/10
7/3
7/23
8/17 to 8/24
8/25 to 8/28
7/24 to 8/1
6/11 to 6/29
Female 75mm (RNE)
Tag 901
0
2
4
6
8
10 Kilometers


= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
8/13 to 8/17
8/22 to 8/24
6/9 to 6/23
7/18 to 8/12
8/25 to 9/8
Male 112mm
Tag 902
0
2
4
6
8
10 Kilometers

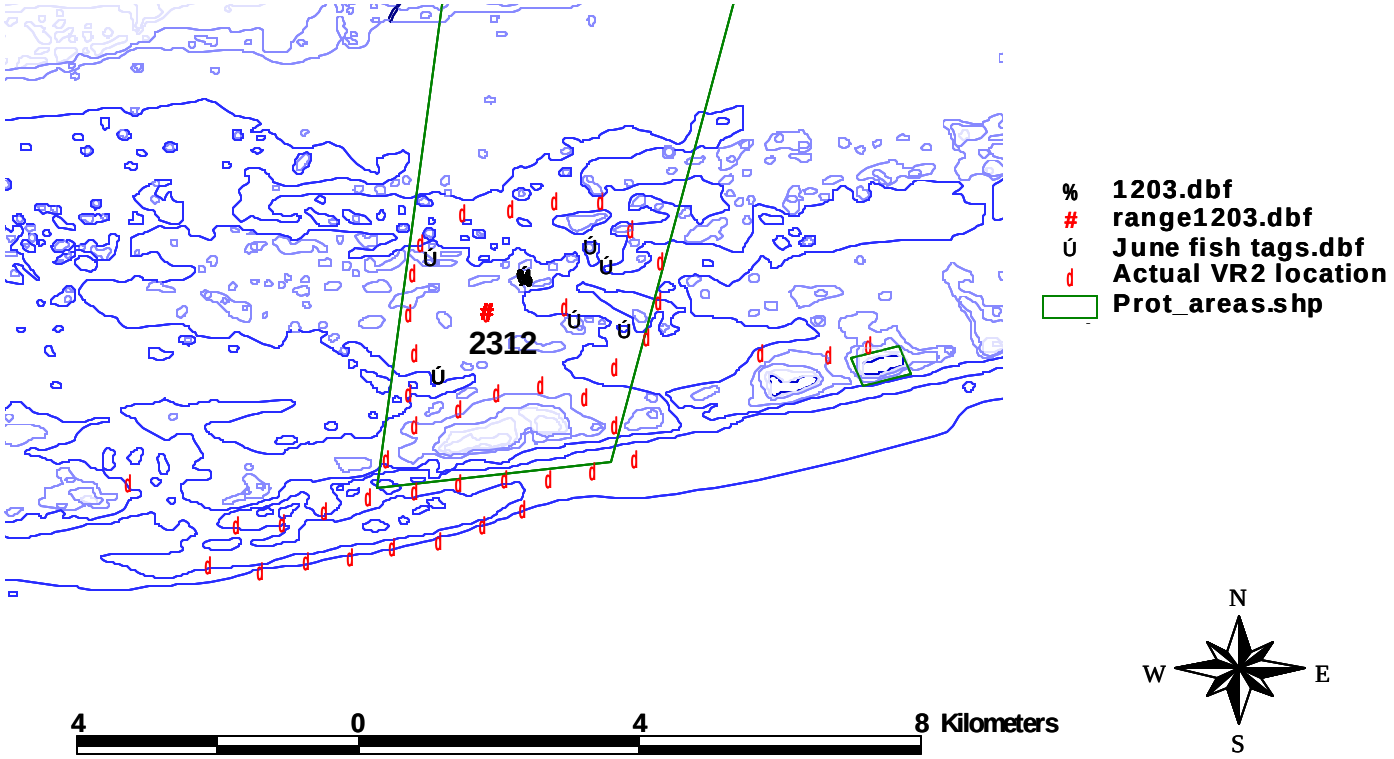

= VR2
= malfunctioned or lost
= first detection
= last detection
= Tagging site
6/14
6/15
Male 91mm
Tag 908
0
2
4
6
8
10 Kilometers


d = VR2
X = malfunctioned or lost
O = first detection
● = last detection
6/9
6/28 to 7/21
6/10
6/27
?
Female 87mm (ROE)
Tag 912
7/23 to 7/26
0
2
4
6
8
10 Kilometers

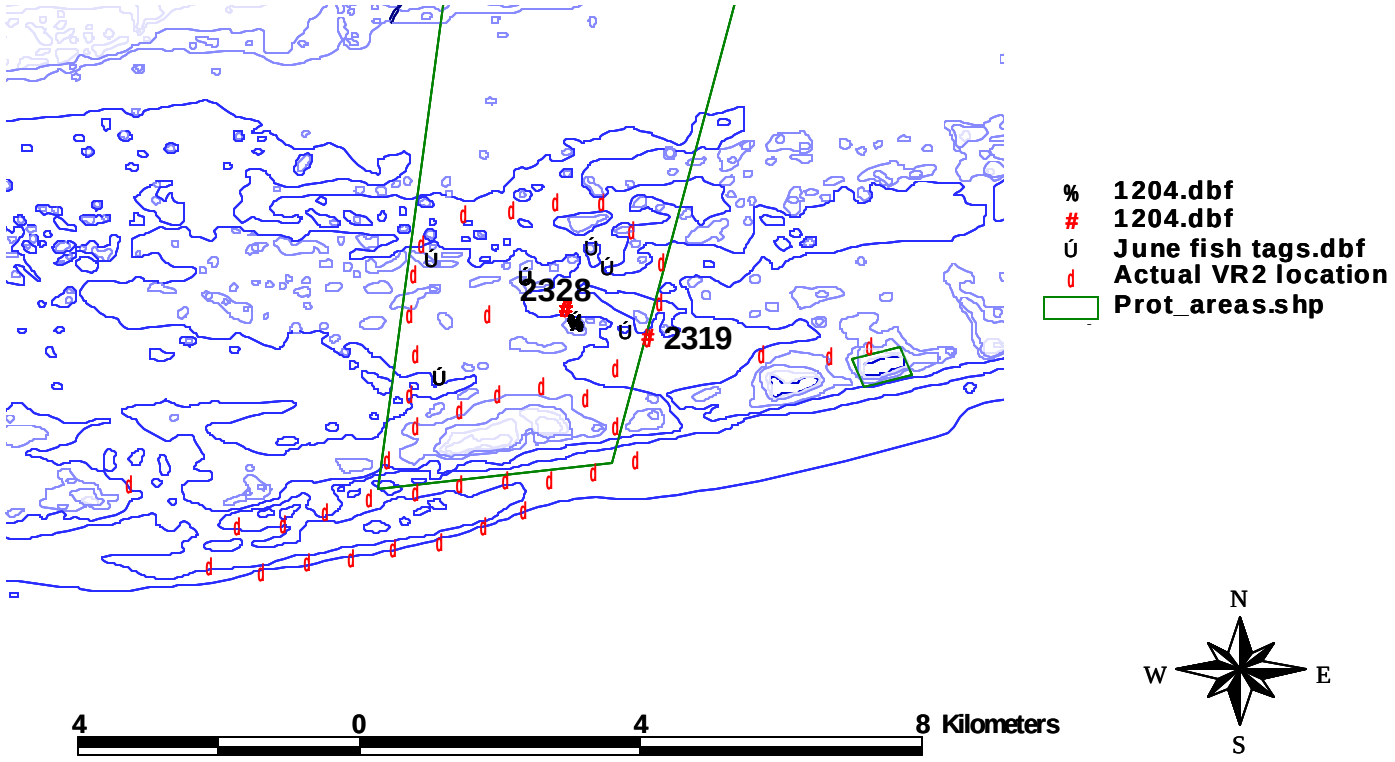
Appendix 2.1. Acoustically tagged fish release sites, VR2 locations and range of receivers signaled by individual fish within the Western Sambo Ecological Reserve (WSER) protected area. *E. morio* – Tag # 1202



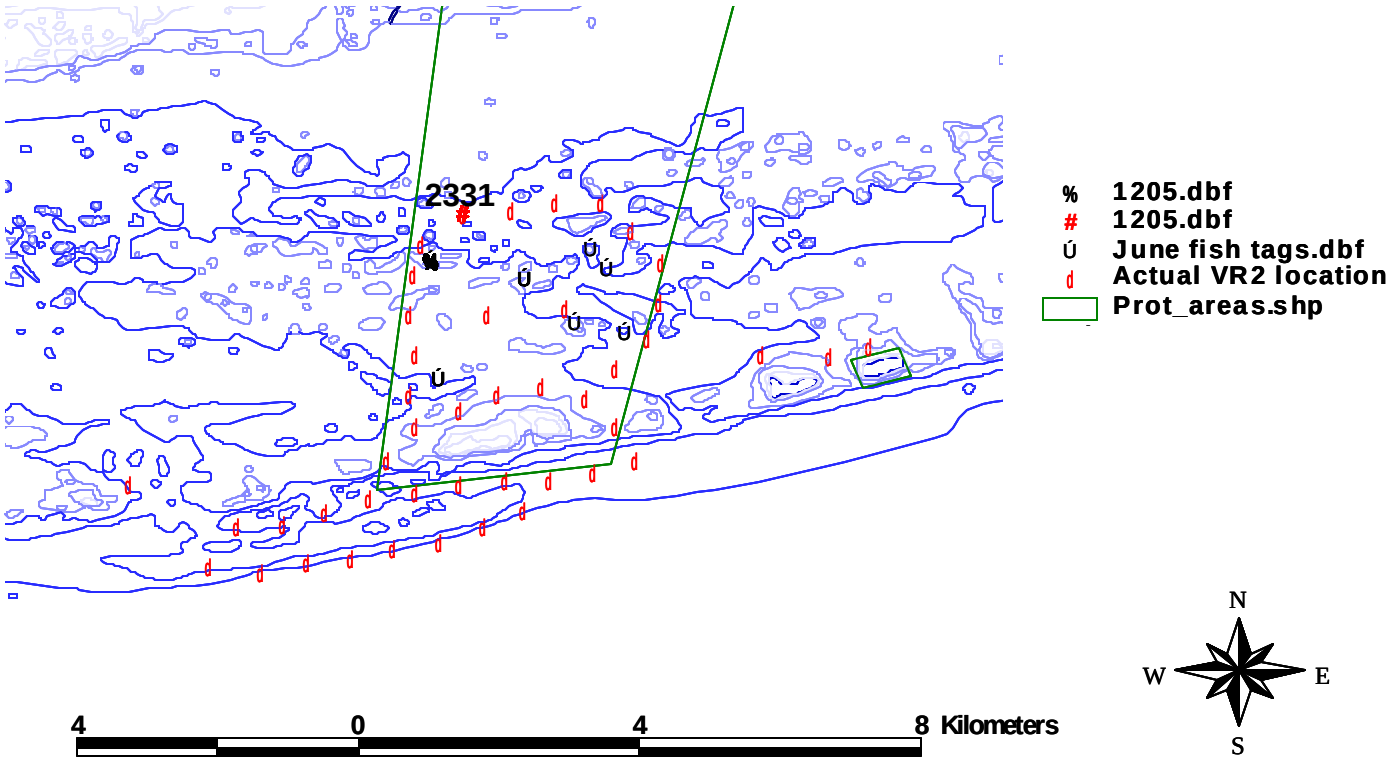
Appendix 2.2. *E. morio* – Tag # 1203



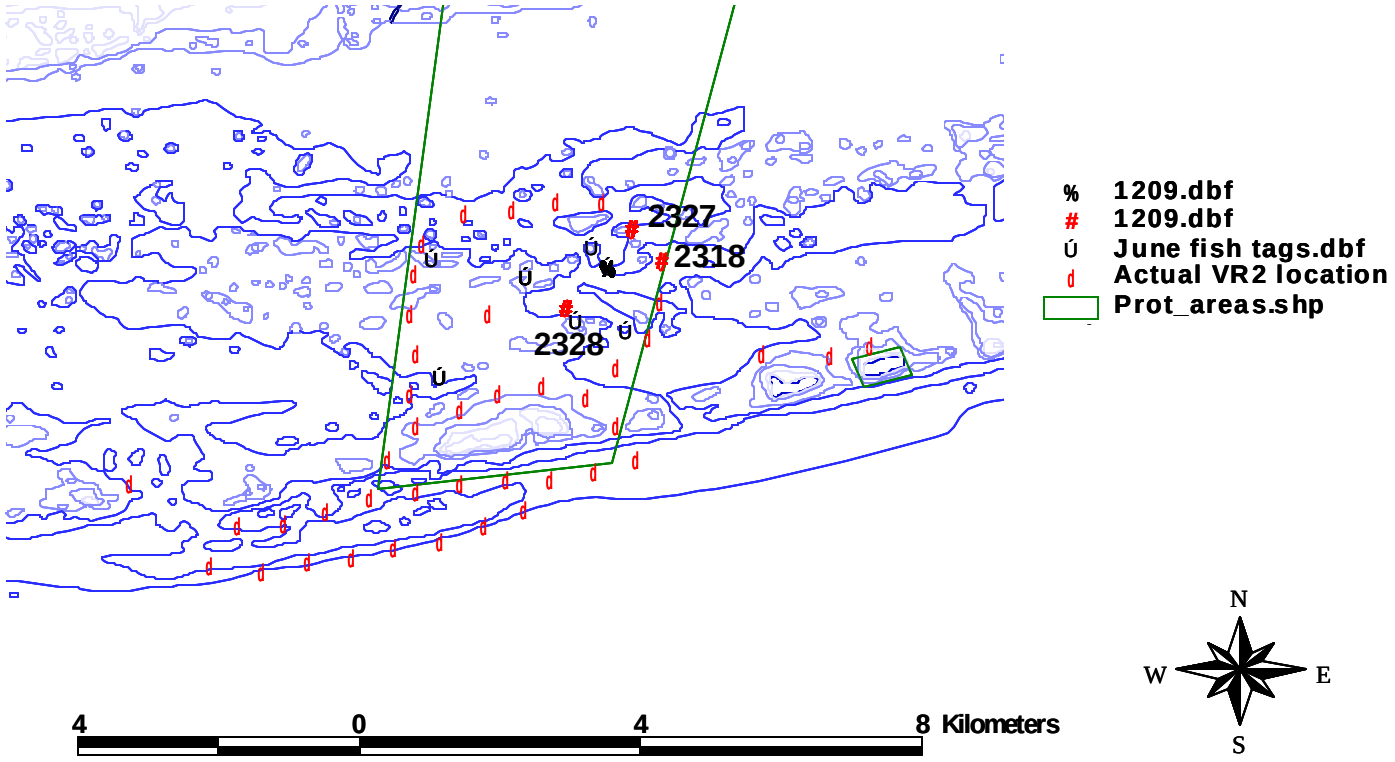
Appendix 2.3. *E. morio* – Tag # 1204



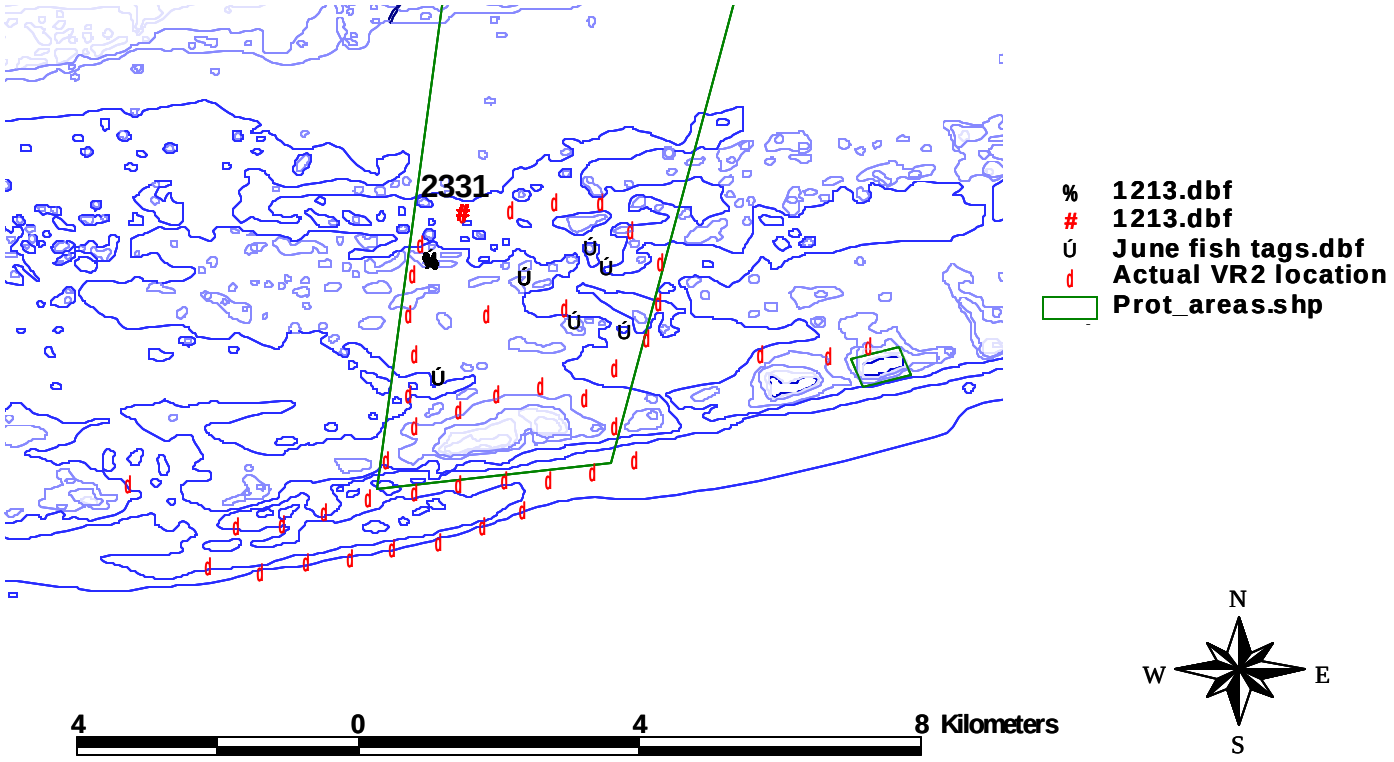
Appendix 2.4. *E. morio* – Tag # 1205



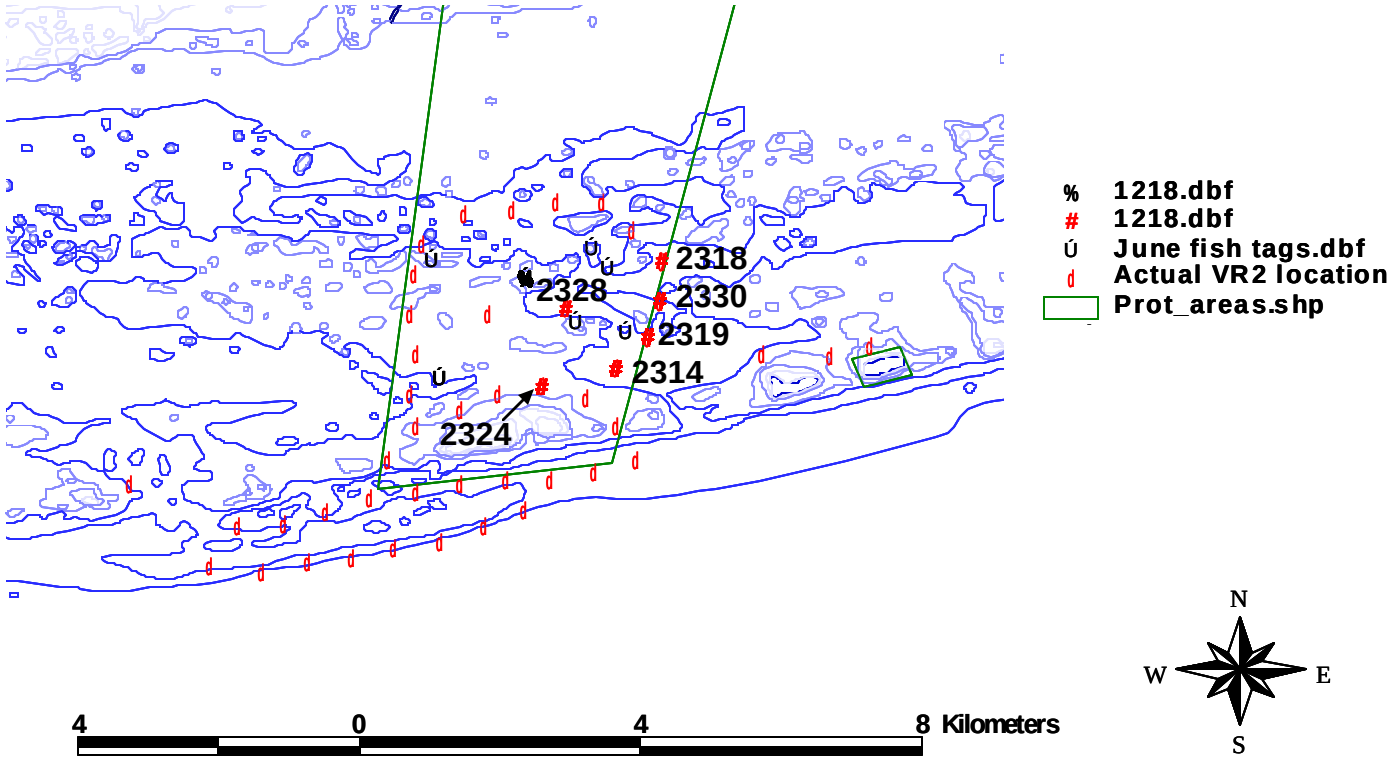
Appendix 2.5. *E. morio* – Tag # 1209



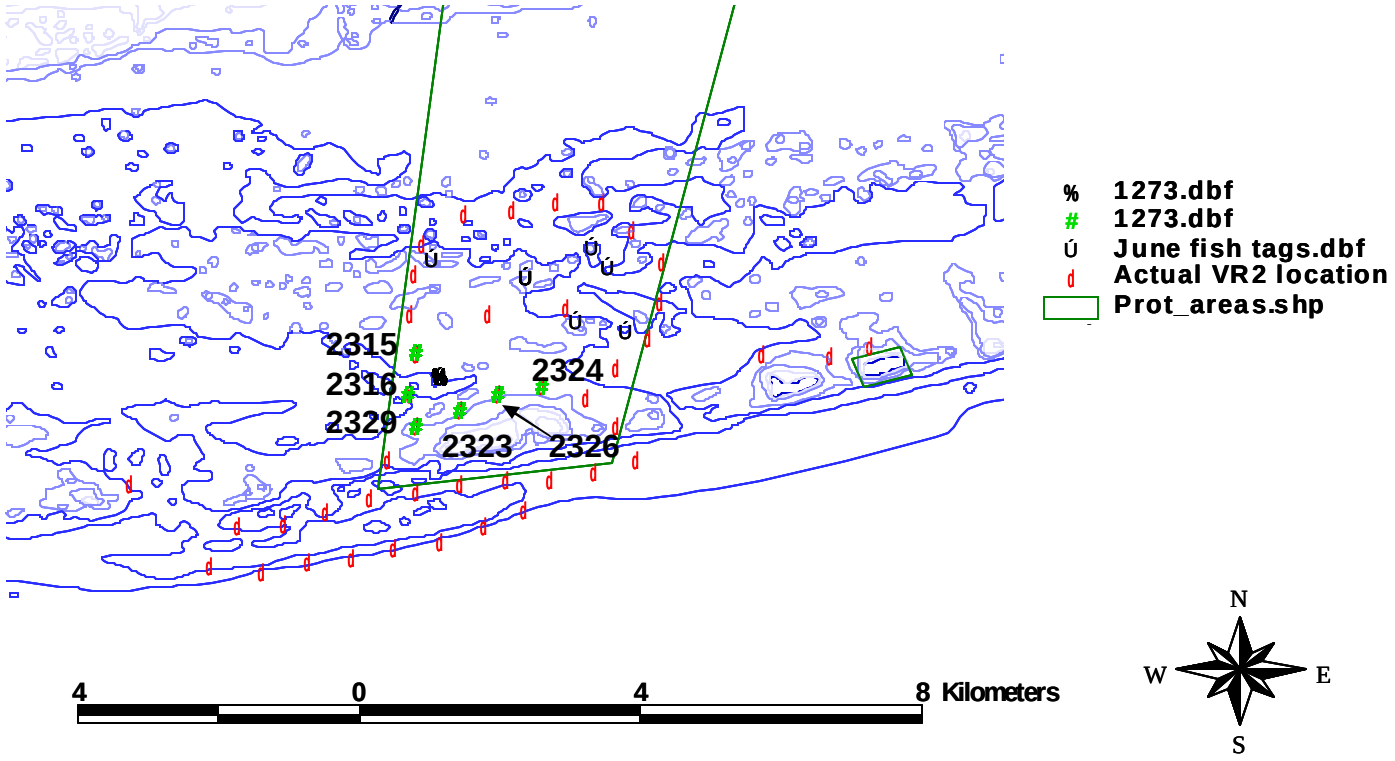
Appendix 2.6. *E. morio* – Tag # 1213



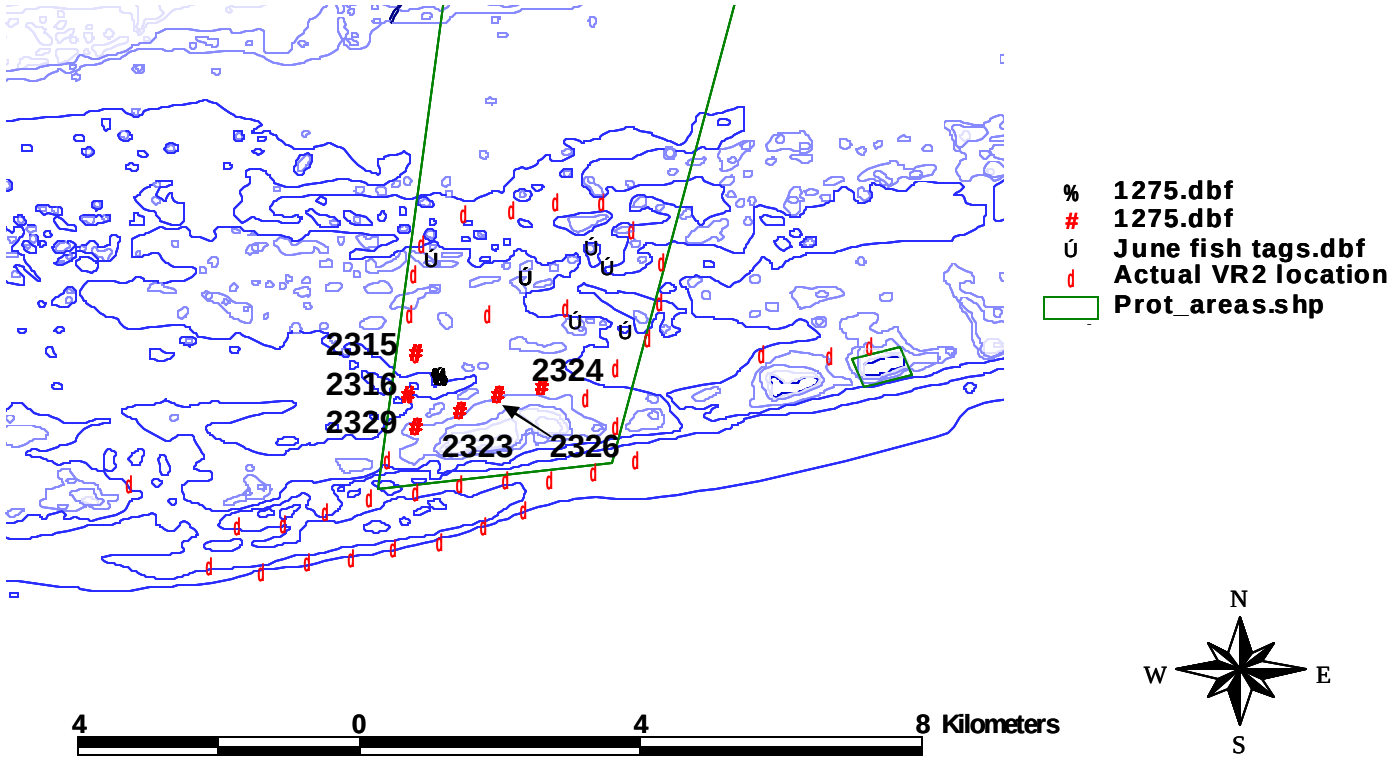
Appendix 2.7. *E. itajara* – Tag # 1218



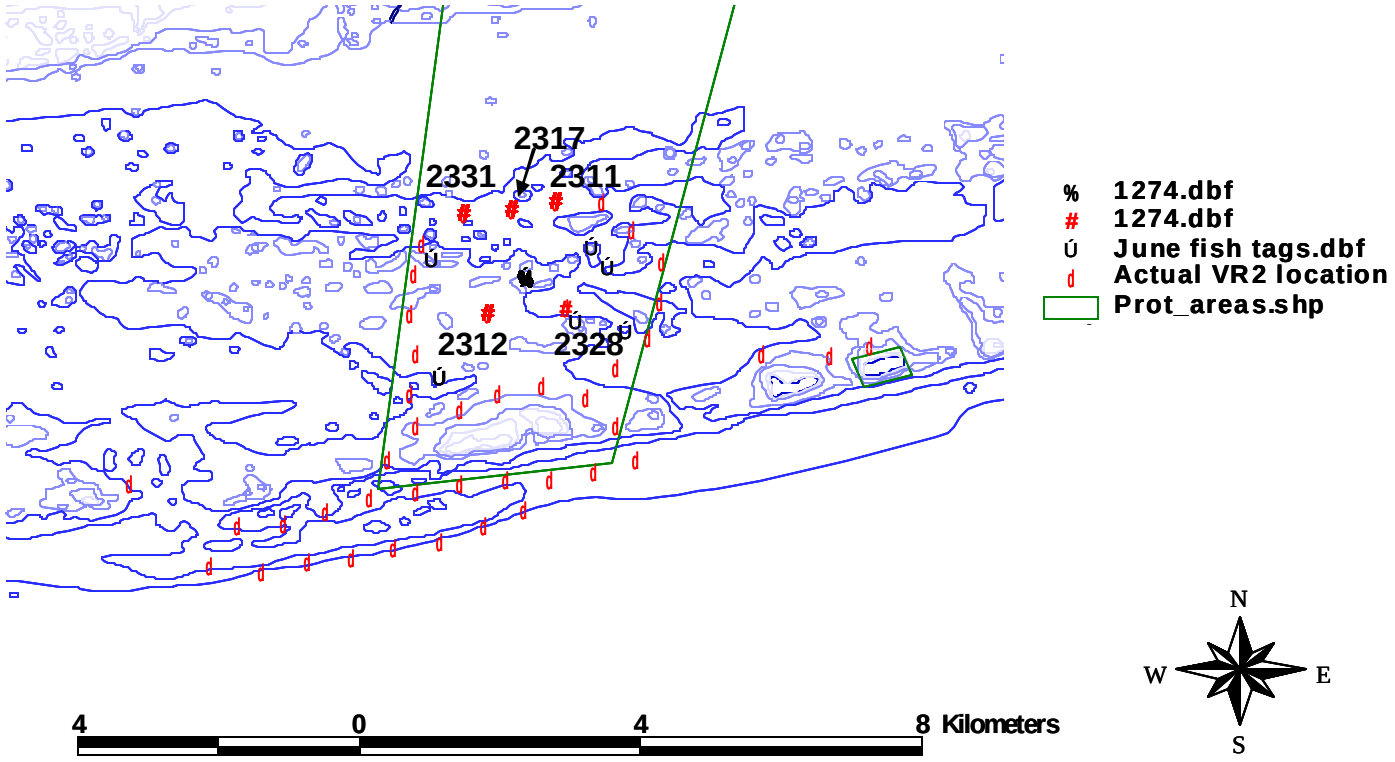
Appendix 2.8. *M. microlepsis* – Tag # 1273



Appendix 2.9. *E. morio* – Tag # 1275



Appendix 2.10. *E. morio* – Tag # 1274



Appendix 2.11. *E. morio* – Tag # 1278