Basic summmary and preliminary results for the FastGPS Tag accuracy analysis

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FastGPS Analysis - Field Tests

Methods:
- I downloaded all data from the data portal on 19 March 2020 after performing location processing.
- For each PTT ID, I opened the FastGPS files and corrected the Time records by subtracting the Time Offset (after confirming with Matt that this was correct). I also subtracted 4hrs, so times were reported as local times to directly compare with our focal follow data
- I manually went through all FastGPS records and compared them to our focal follow data records. Any tag times that were within 2 minutes of a focal follow observation of the tagged individual that included a distance and bearing estimate were identified as a 'snap' (*i.e.,* a matched record) for further analyses. We identified 56 snaps (179062 = 16 snaps, 179063 = 23 snaps, 179064 = 17 snaps)
- Five of the snaps did not have latitude/longitude data available from the FastGPS records. This left 54 snaps for analysis (179062 = 13 snaps, 179063 = 21 snaps, 179064 = 20 snaps)
- I created a spreadsheet that contained all snaps records from the FastGPS files downloaded from the portal along with the focal follow data recorded from the field.
- Within this spreadsheet I added columns to identify corresponding location data from the boat's GPS. Given we had set our GPS to record every fro seconds, I had to find the time from the GPS that was closest to the time recorded for our follow observation, and record that corresponding time, latitude, and longitude. All track times were within 5 seconds of the follow observation time.
- All location data were projected to NAD 83 UTM 17N in R, so that measurements of distance could be made in km/m.
- The *true* dolphin locations were estimated using the destpoint function from the geosphere package in R. I used the location obtained from the boat's GPS from the time that was closest to the reported focal follow observation time, along with our estimates of the distance and bearing of the dolphin from the boats location. Note: 5 distances were estimated from a range finder, 49 were estimated by eye. Bearing estimates were made from a hand held compass.
- Distances between the estimated *true* dolphin locations and the locations reported by the FastGPS tags were calculated using the pointDistance function from the raster package in R.

Updated May 6, 2019:
- Edmund Bryant recently updated the location processing system, LocSolve, used to derive the locations from Fastloc records and re-ran the tag data to compare with the older version's output. Below you will find the results from both location processing runs (old and new LocSolve). With the new processing, all records had residuals less than 35 and 29 records used 5 or more satellites to acquire locations. This resulted in 29 'good' quality locations using the new LocSolve, versus 15 from the older LocSolve version.

Table 1. Summary statistics of distances estimated between the dolphin's *true* location and the tag's esimated location for all FastGPS snaps, as well as those deemed to be 'good' quality. Good quality snaps are considered to be those that were acquired using at least 5 satellites and that had residuals less than 35

Data	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
All - Old LocSolve	54	269.914	49.178	564.152	2.10394	2926.52
All - New LocSolve	54	49.880	30.774	60.723	0.47081	264.83
Good - Old LocSolve	15	70.701	38.659	84.724	2.10394	273.14
Good - New LocSolve	29	44.272	24.628	62.912	0.96406	264.83

Table 2. Summary statistics for good quality FastGPS location data by PTT ID

LocSolve	PTT	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
Old	179062	4	89.003	32.347	123.149	18.18050	273.14
New	179062	5	70.630	26.871	109.060	6.90712	264.83
Old	179063	2	61.718	61.718	70.553	11.82915	111.61
New	179063	8	37.227	26.134	37.320	4.06090	118.24
Old	179064	9	64.563	38.659	77.603	2.10394	253.56
New	179064	16	39.558	23.062	57.312	0.96406	238.46

Tables 1 and 2 demonstrate that the new LocSolve processing system appeared to improve the accuracy of the FastGPS locations in reference to the dolphins true locations.

The difference in the times reported by the FastGPS tag and those used from our focal follow observations and boat tracks to estimate dolphin locations affected the estimated distances between the dolphin and tag locations (Figure 1).

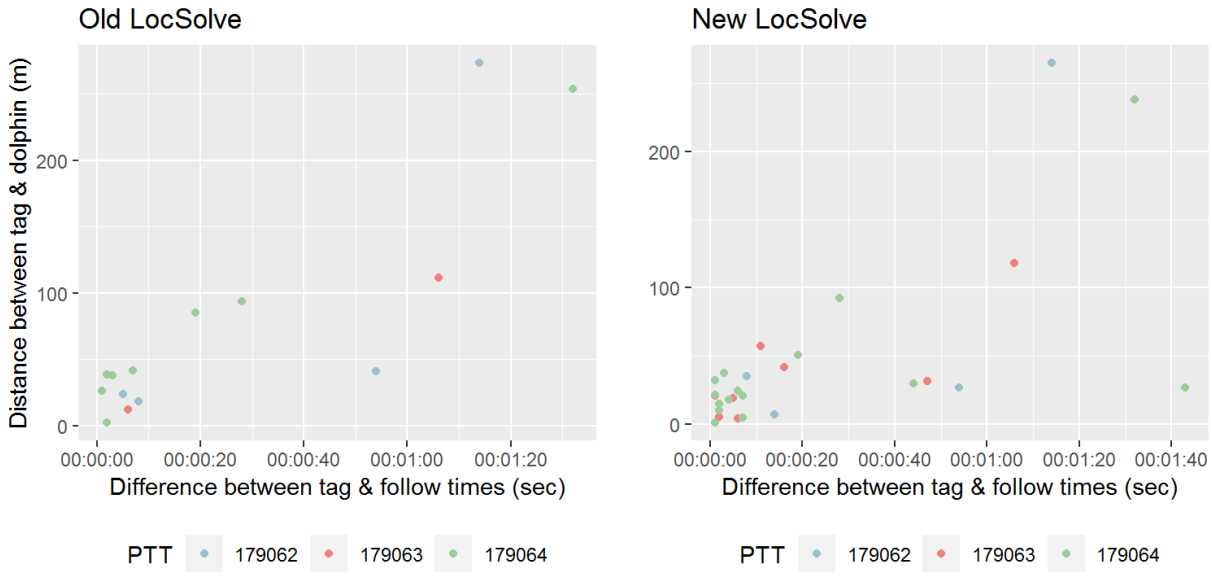

Figure 1. The relationship between the lag in time between the data transmitted by the tag (old and new LocSolve location processing) and that recorded during our focal follow observations to the distances estimated between the tag and true dolphin location. Note: only good quality FastGPS locations are included.

Figure 1 shows that for data from both LocSolve versions appear to be most accurate when we consider tag data that was received less than 10 seconds from an observed dolphin surfacing (Table 3). As the time between the dolphin surfacing and location transmitted increases, so does the distance between the estimated distance between the dolphin and the tag location. This is likely related to the dolphins movements between

surfacings and the likelihood that the surfacing observed is the surfacing that was used to generate a location on the tag.

Table 3: Summary statistics for good quality data that has a temporal difference between the reported tag time and the focal follow observation of less than 10 seconds

LocSolve	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
Old	9	22.450	23.521	15.142	2.10394	41.722
New	17	17.543	19.173	10.902	0.96406	37.387

There were many 'poor' quality locations that actually seem to be quite accurate, particularly with the new LocSolve (Figures 2 and 3).Does our definition of 'good' quality hold with this new LocSolve or should we/can we relax it?

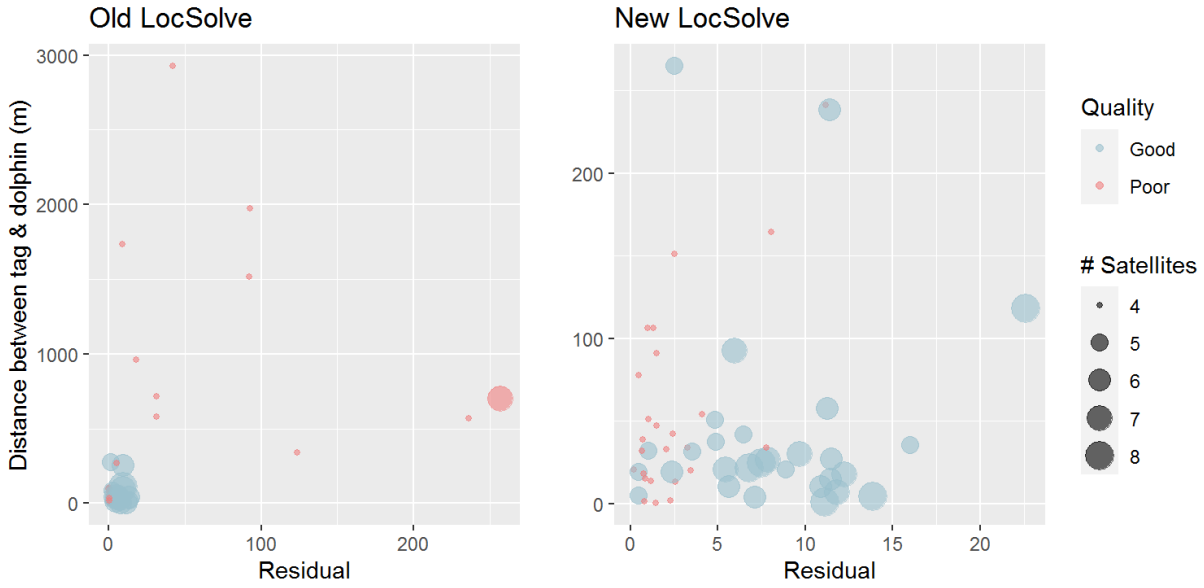

Figure 2. The relationship between the distances estimated between the tags and dolphins and the resdual of the tag location. The number of satellites is referencd by point size. Our definition of good and poor quality locations is referenced by point color.

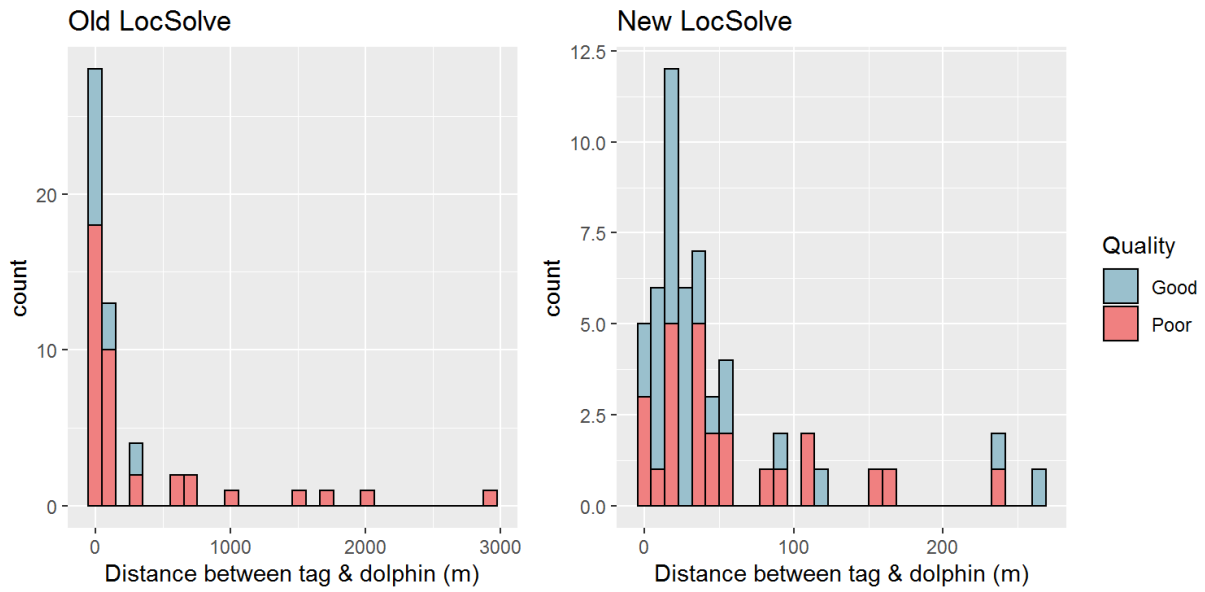

Figure 3. Histogram of distances estimated between the tags and dolphins with reference to good and poor quality locations.

The 8 poor tag location records that were highly unlikely or implausible (*e.g.*, points on land or far from where dolphins were known to be) before were 'fixed' with the new LocSolve processing, with 6 of the 8 points now being 'good' quality and reasonable estimates.

FastGPS Analysis - Bench Test

Before we deployed these tags, we performed a 'bench test' to make sure the tags were functioning properly, whereby we activated them and placed them on a boat behind our offices for several hours. We can use the results of this test to compare how the different LocSolve versions performed in estimating the tag's true location (27.335677, -82.576490). For this comparison, I excluded all poor quality data ($\leq$ 4 satellites used and residuals $>$ 35) and calculated the distance between the tag's true location and respective estimated locations using the same methods as described above.

Table 4. Summary statistics for good quality data from the bench test using old and new LocSolve processing.

LocSolve	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
Old	30	25.839	22.685	33.942	1.58671	192.59
New	30	26.613	24.602	24.668	0.67792	129.73

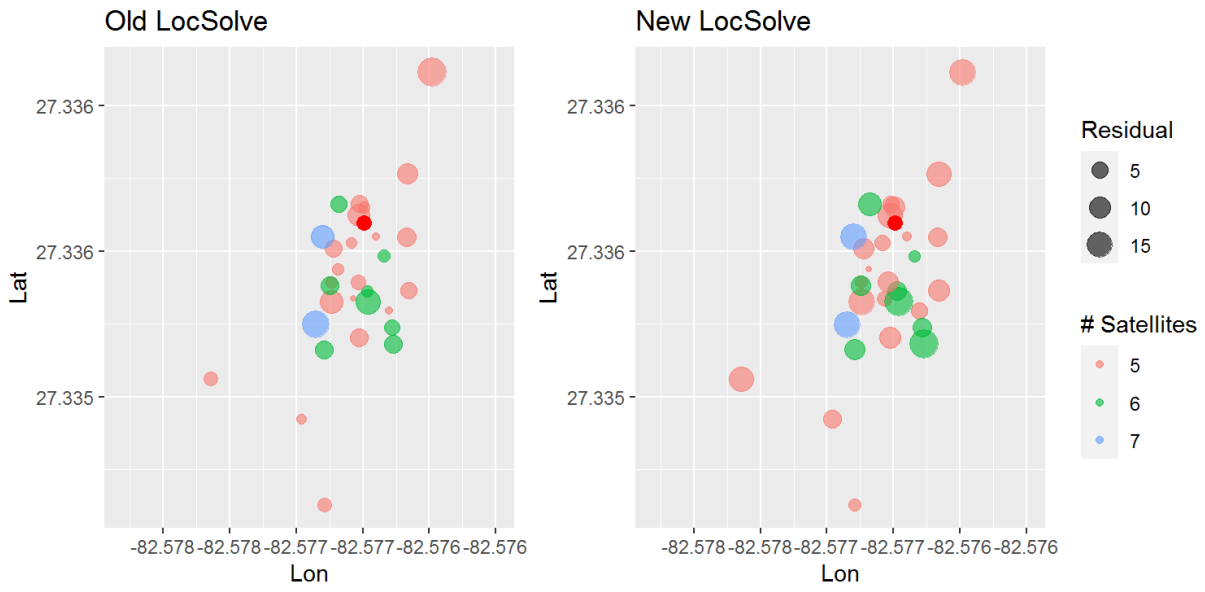

Figure 4. The true location of the tag (red circle) with the 'good' location estimates from the old and new LocSolve processing (triangles)

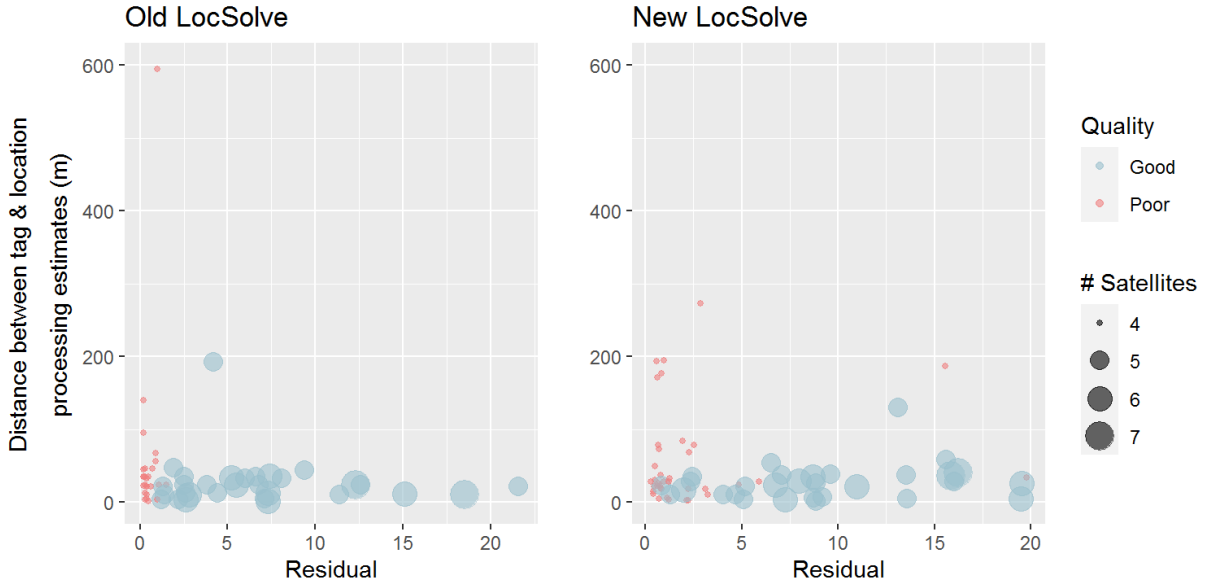

Figure 5. The relationship between the distances estimated between the tag's true location and the resdual of the tag location for each method. The number of satellites is referencd by point size. Good and poor quality locations are referenced by point color.

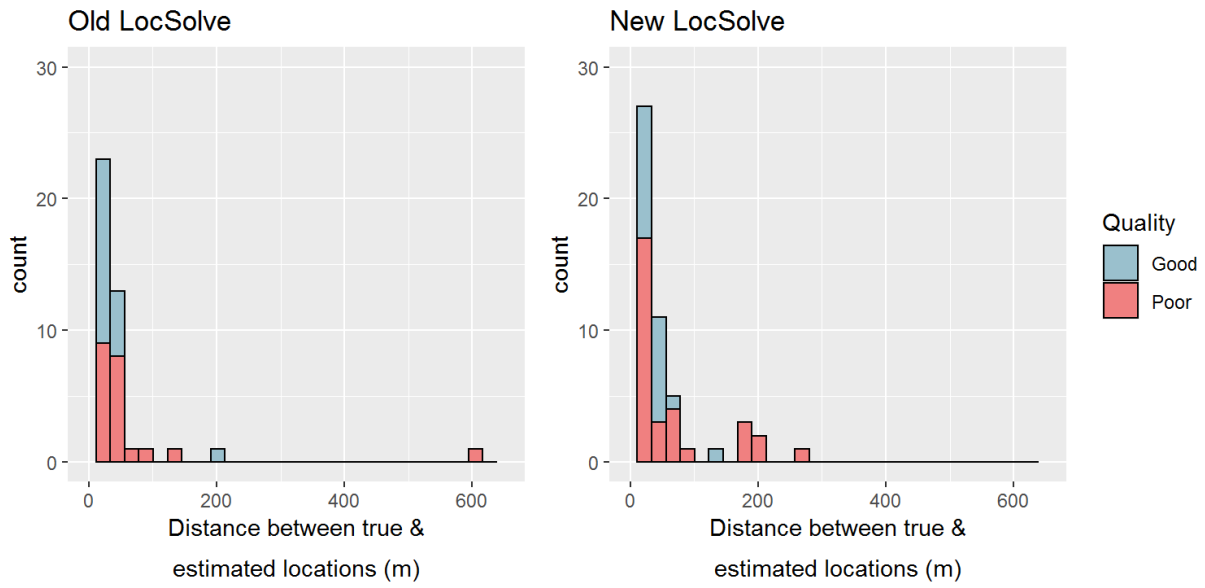

Figure 6. Histogram of distances estimated between the tags and dolphins with reference to good and poor quality locations.

Interestingly, the data from the old LocSolve appears to be more accurate and precise than the data derived using the new LocSolve for this bench test. Is it possible that the effect of buildings is more influential with the new LocSolve than the previous version? If so, perhaps we should scrap this test from our manuscript...

Argos - Field Tests

Argos locations were analysed the same was as the FastGPS locations. I did not do any extra processing of these locations yet - for now I just used the locations provided in the outputs from the data portal. We had 25 Argos 'snaps' (*i.e.*, matching records) within 2 minutes of the focal follow observations (179062 = 8, 179063 = 13, 179064 = 4). Five distances of dolphin locations were estimated with a range finder, all others were estimated by eye.

Table 5. Summary statistics of distances for all Argos snaps

Quality	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
3	6	601.07	578.12	229.96	306.80	924.72
2	5	638.77	291.46	980.30	49.67	2383.26
1	4	642.01	583.93	558.51	49.29	1350.90
0	4	1322.18	1043.40	979.67	495.21	2706.72
A	2	2224.51	2224.51	2842.94	214.26	4234.77
B	4	2910.51	2260.92	2581.14	567.59	6552.63

Table 6. Summary statistics of distances for all Argos snaps broken down by PTT ID for LCs: 3, 2, and 1

Quality	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
179062						

3	1	797.85	797.85	NaN	797.85	797.85
2	3	988.92	292.04	1207.53	291.46	2383.26
1	1	389.99	389.99	NaN	389.99	389.99
179063						
3	3	441.91	420.80	146.80	306.80	598.12
2	1	49.67	49.67	NaN	49.67	49.67
1	3	726.02	777.86	652.35	49.29	1350.90
179064						
3	2	741.42	741.42	259.22	558.13	924.72
2	1	177.44	177.44	NaN	177.44	177.44

The distances estimated between the dolphins 'true' location and the location generated by Argos are much larger than the FastGPS locations for all location classes (as we would expect).

The difference in the times reported by Argos and those used from our focal follow observations and boat tracks to estimate dolphin locations did not affect the estimated distances between the dolphin and tag locations as significantly as for the FastGPS estimates (Figure 7). This is probably related to how the Argos location is created during a pass and how the timestamp reported by Argos for each location is dependent on the length of the pass (which can be > 10 min) (Matt - please correct me if I am wrong).

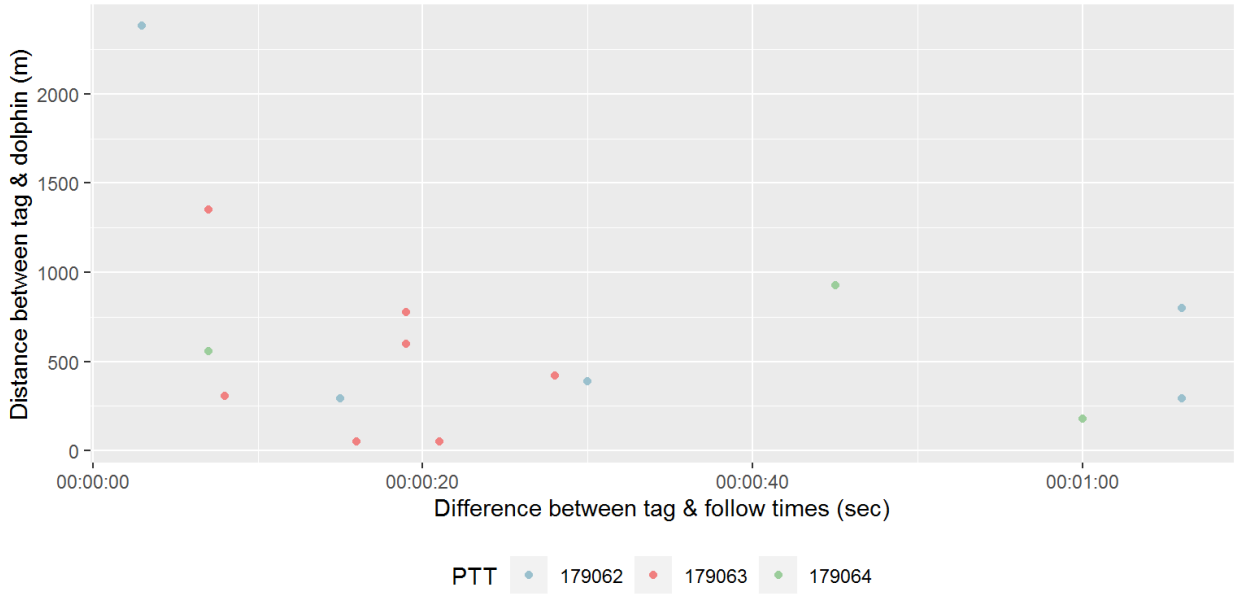

Figure 7. The relationship between the lag in time between the data transmitted by the tag and that recorded during our focal follow observations to the distances estimated between the tag and true dolphin location. Note: only Argos LCs: 3, 2, and 1 are included.

If desired, I can run these data through crawl or foieGras to interpolate each tag's movement path and predict locations that are close to our focal follow observation times.

Argos - Bench Test

I calculated the distances between the true location of the tag during the bench tag with the tag's estimated location based on Argos estimates using the same methods described above. Estimated error for Argos

location classes are as follows:

LC 3: < 250m
LC 2: 250m < < 500m
LC 1: 500m < < 1500m
LC 0: > 1500m
LC A: unbounded
LC B: unbounded

Table 7 shows that our estimated distances are just outside the estimated errors suggested by Argos service for each LC.

Table 7. Summary statistics of distances for all Argos snaps for the bench test

Quality	N	mean.distance	median.distance	sd.distance	min.distance	max.distance
3	10	278.34	263.45	152.77	136.62	655.03
2	11	737.19	493.82	723.79	101.79	2458.36
1	10	1871.53	1888.23	1390.78	113.91	3961.34
A	3	902.54	642.28	508.70	576.63	1488.72
B	5	2652.80	1323.13	2876.41	258.10	6531.11

Things to decide for the manuscript:

- Do we include results from both location processing techniques (old and new), or just one?
- Do we include comparisons with Argos locations as well, or just focus on the Fastloc locations?
- Do we include the bench test results?
- Decide Target Journal: Methods in Ecology and Evolution (possibly good followup to Dujon paper depending on what we decide to include), Movement Ecology, Animal Biotelemetry, or other