Vertical and horizontal movements of opah (*Lampris guttatus*) electronically tagged with pop-up archival satellite tags

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Background

- Studied species : opah *(Lampris guttatus)*
- Pelagic species
- Longline bycatch
- Around 13000 opahs caught in 2005
- Valued by local restaurants, economic importance

picture : courtesy of Don Hawn

-> need to know more about the species

Pop-up archival satellite tags

- Electronic devices which record depth, water temperature and light level (-> geolocation)
- Archive those data, and transmit them to satellites after pop-up
- All the tags came off before programmed release times (6 months) and no tag was recovered

  -> **only binned data** were transmitted to satellites

  -> no detailed time series

Tags summary

trip	Argos #	days out	days of data	problem
1	6269	24	0	Low battery
1	6288	154	0	Low battery
2	30568	37	24	
2	30571	14	12	
2	30579	7	4	Too short
2	30601	17	8	
2	30628	11	8	
3	30588	2	2	Too short
3	30637	3	3	Too short
3	30646	20	19	
3	30649	?	0	No pop-up
3	40610	51	47	
4	41863	32	7	
4	41867	24	22	
4	41868	169	168	
4	41869	138	138	
6	52494	22	22	High Res.

17 tags deployed by Don Hawn, on commercial longline vessels

Tags summary

trip	Argos #	days out	days of data	problem
2	30568	37	24	
2	30571	14	12	
2	30601	17	8	
2	30628	11	8	
3	30646	20	19	
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17 tags deployed :
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17 tags deployed :
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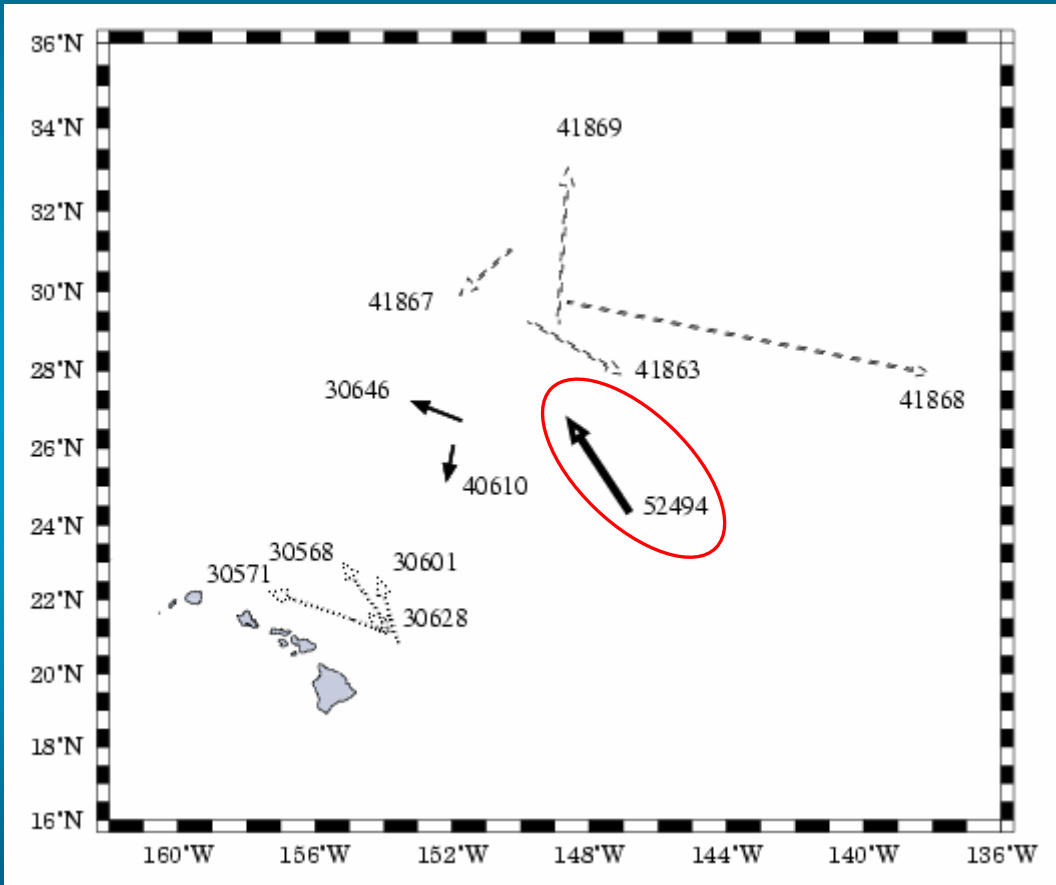
two timeseries are much **longer** than the other ones

Experiment



4 cruises :

Trip 2 : November 2002

Trip 3 : March 2003

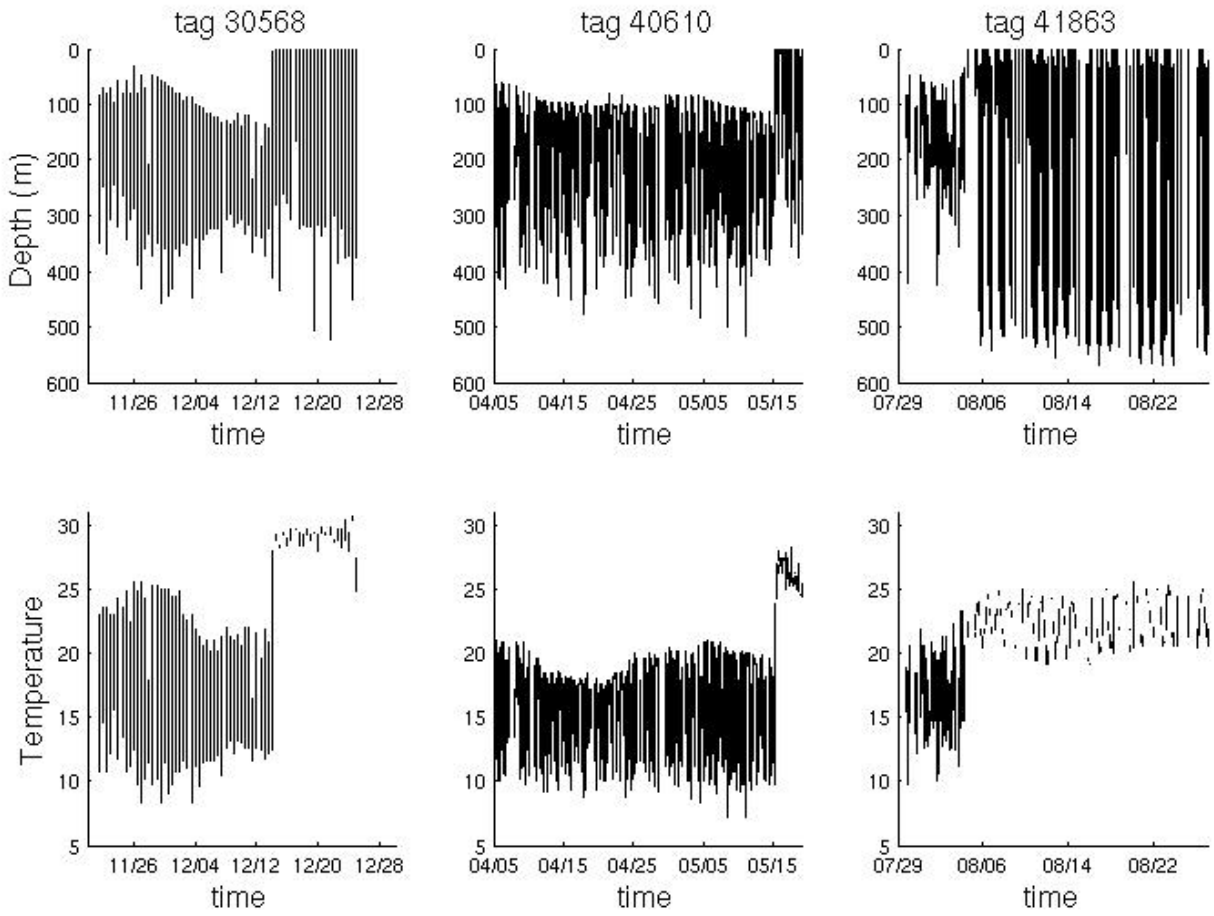
Trip 4 : July 2003

Trip 6 : July 2005

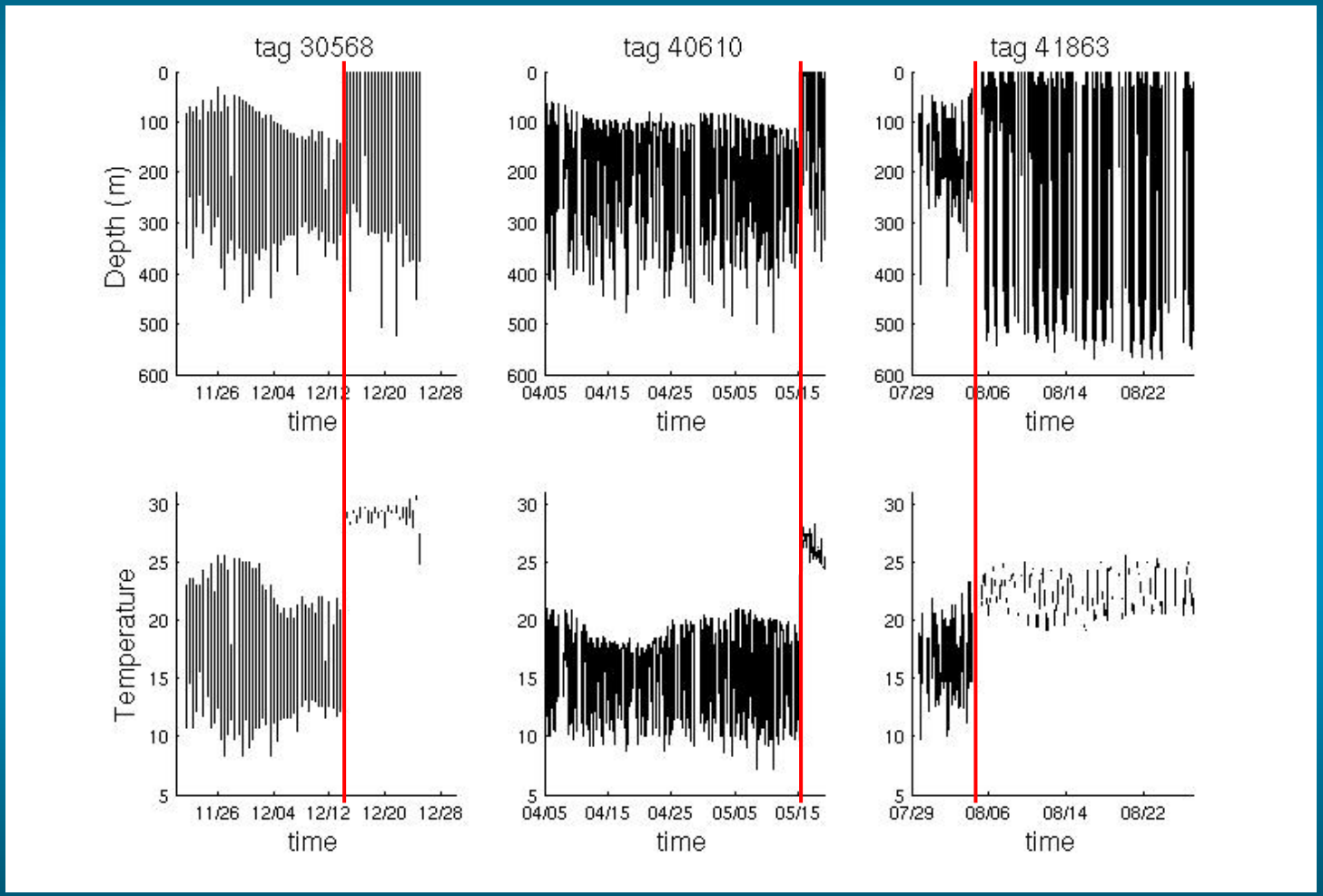
2 types of tags :

- MicroWave Telemetry : high resolution tag
- Wildlife Computers

Predation


tag 30568
tag 40610
tag 41863
Depth (m)
0
100
200
300
400
500
600
11/26 12/04 12/12 12/20 12/28
04/05 04/15 04/25 05/05 05/15
07/29 08/06 08/14 08/22
time
Temperature
30
25
20
15
10
5

Predation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07/29 08/06 08/14 08/22
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Temperature
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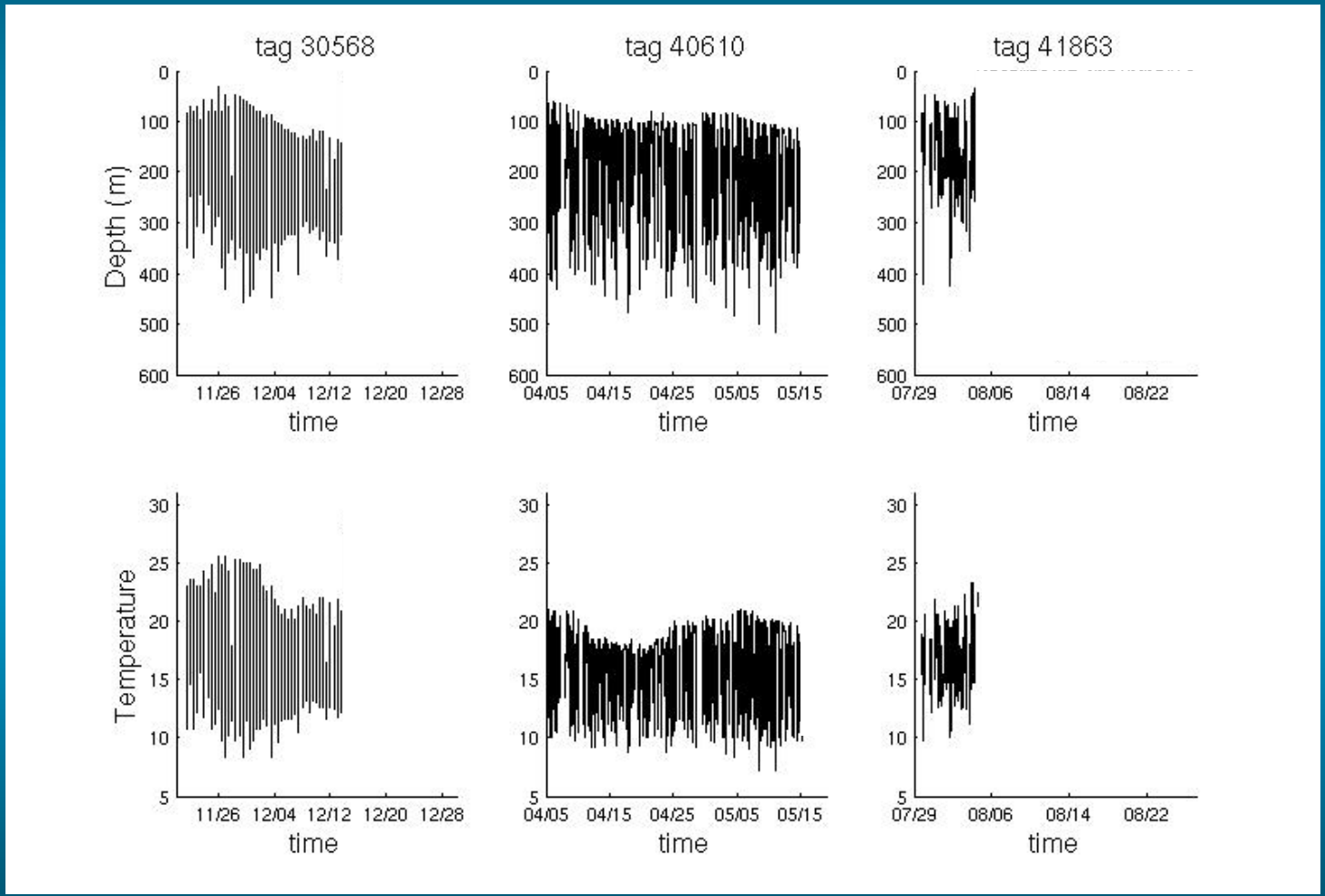
25
20
15
10
5

Predation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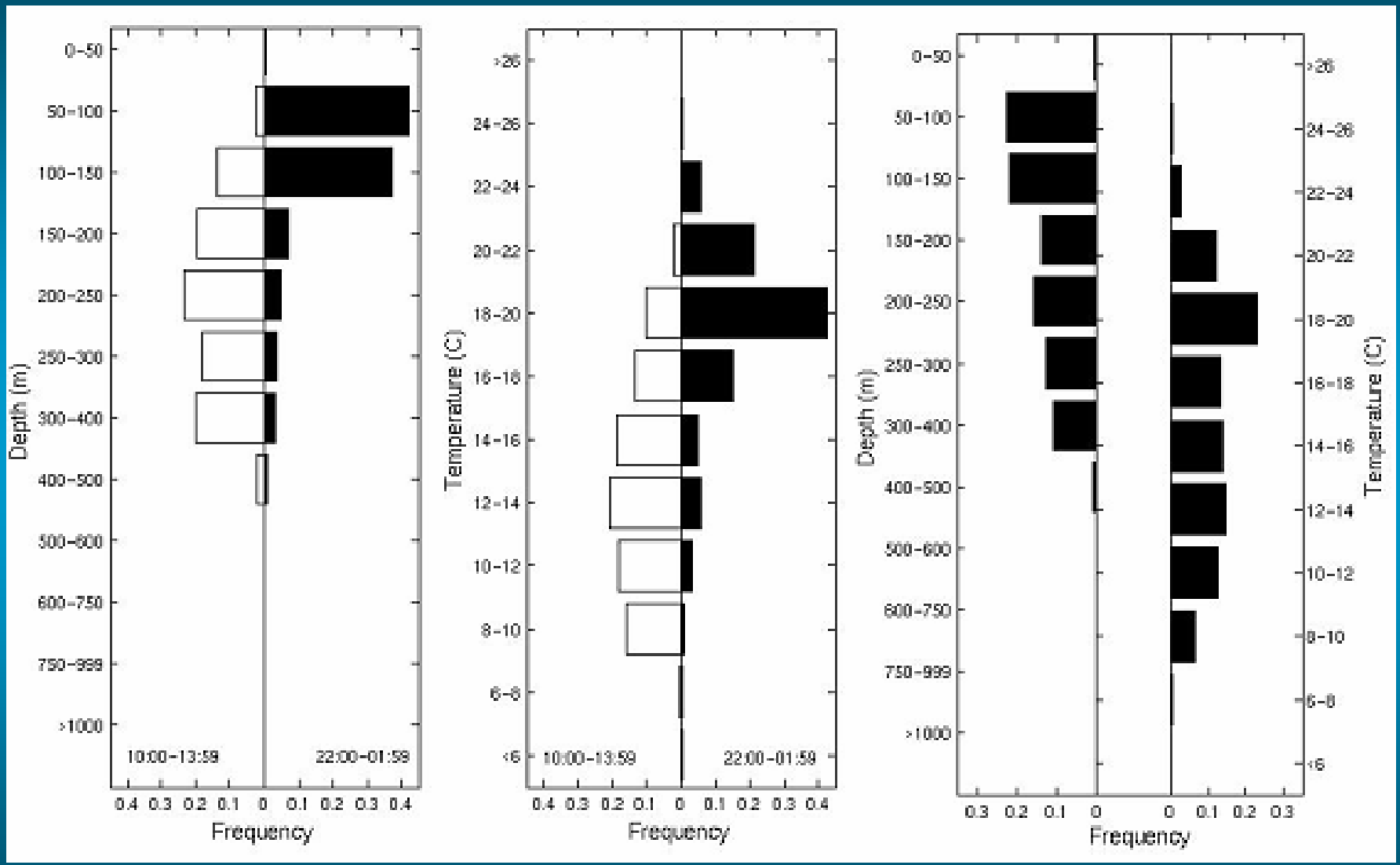
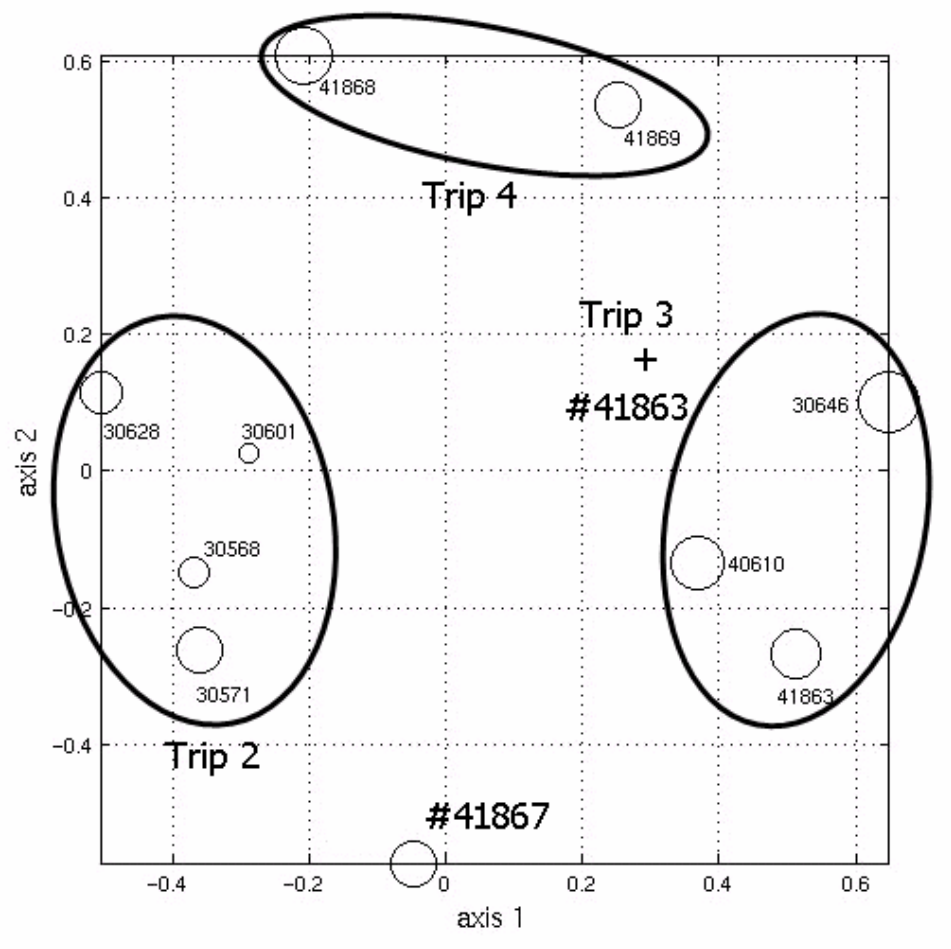
04/05 04/15 04/25 05/05 05/15
07/29 08/06 08/14 08/22
time
Temperature
30
25
20
15
10
5

Vertical movements

Distributions



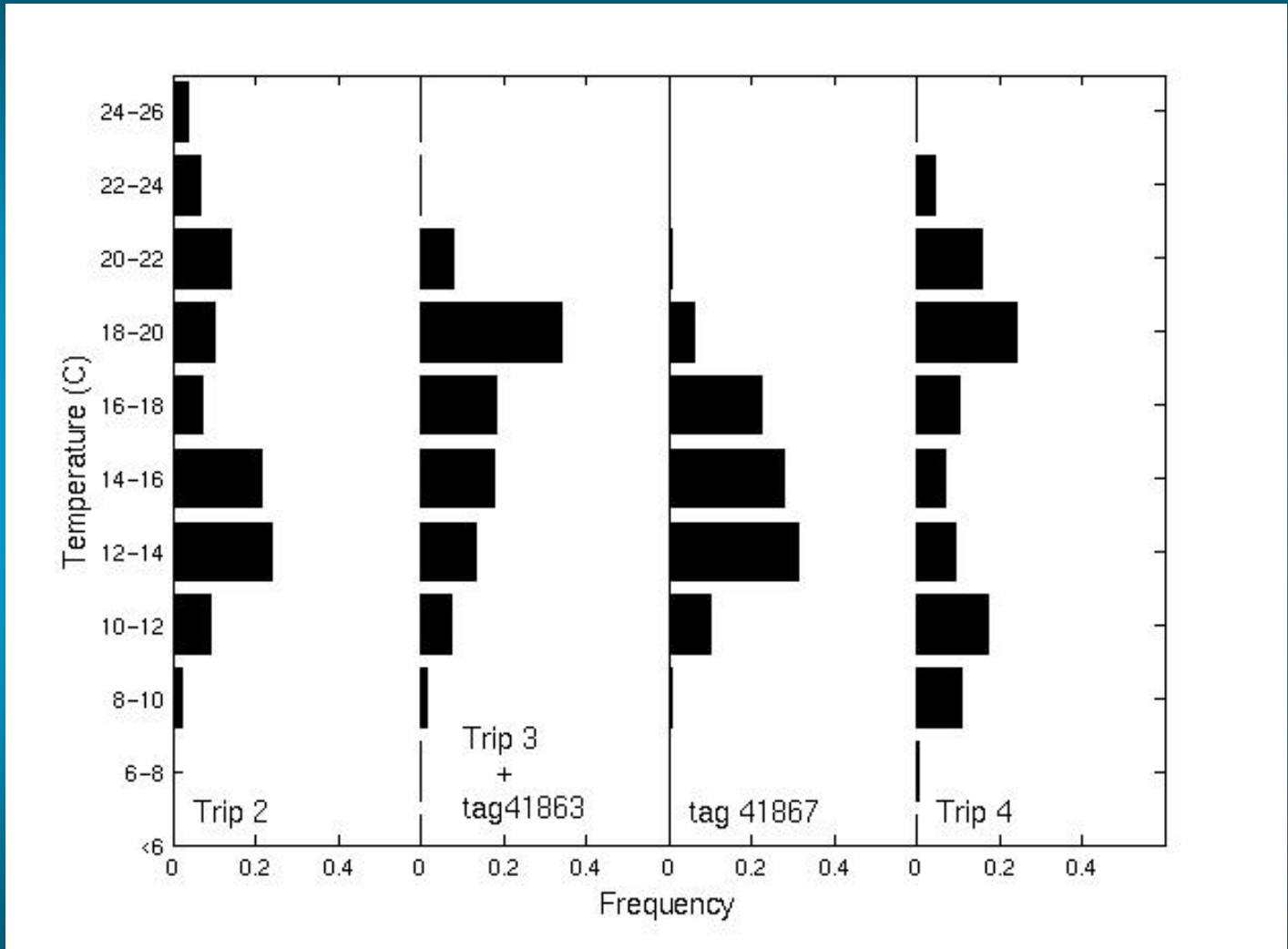
Factor analysis



Computed on the mean daily time-at-temperature distribution.

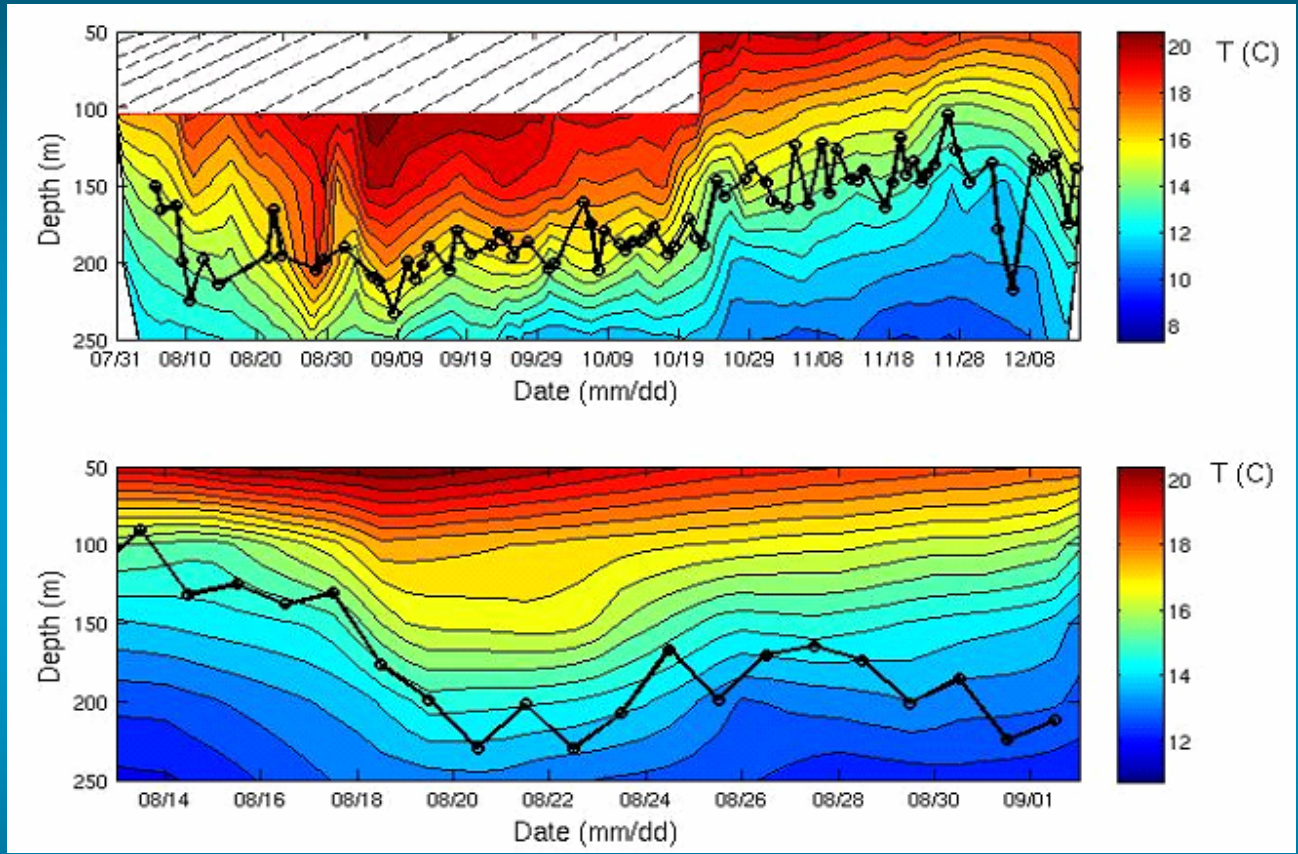
The first 2 factors explain 71% of the variation between tags.

« Clusters »


Temperature (C)
24–26
22–24
20–22
18–20
16–18
14–16
12–14
10–12
8–10
6–8
<6
Trip 2
Trip 3
+
tag41863
tag 41867
Trip 4
0
0.2
0.4
Frequency

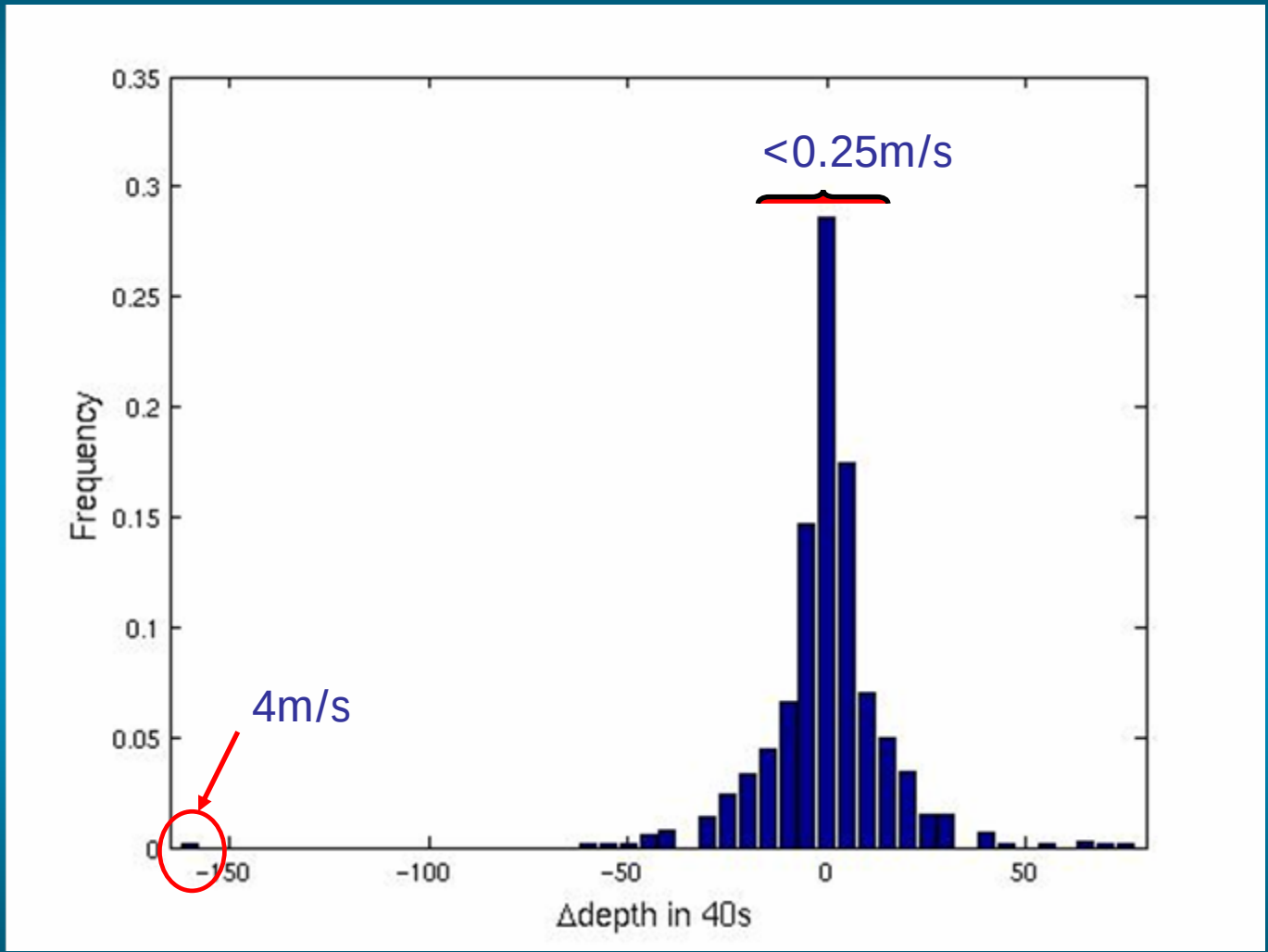
cluster	trip2	trip3 + # 41863	# 41867	trip4
mean 24h depth (m)	225	171	175	181
std (m)	34	32	40	28
mean 24h T (C)	**16.3**	**16.5**	14.7	**16**
std (C)	1.6	1	0.8	1.2

Mean daily depth



The fish adjust their mean daily depth in response to changes in the water column in order to maintain their mean daily temperature fairly constant

Vertical swimming speed



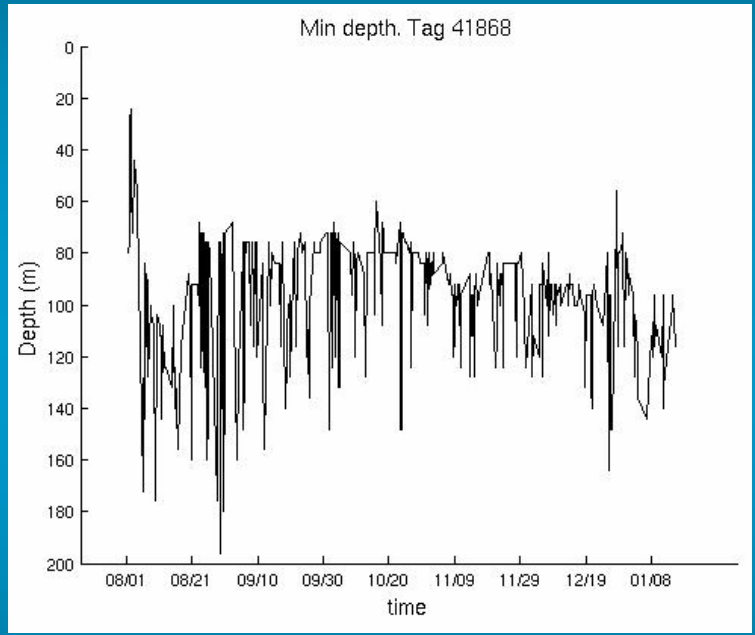
Horizontal movements

Geolocation

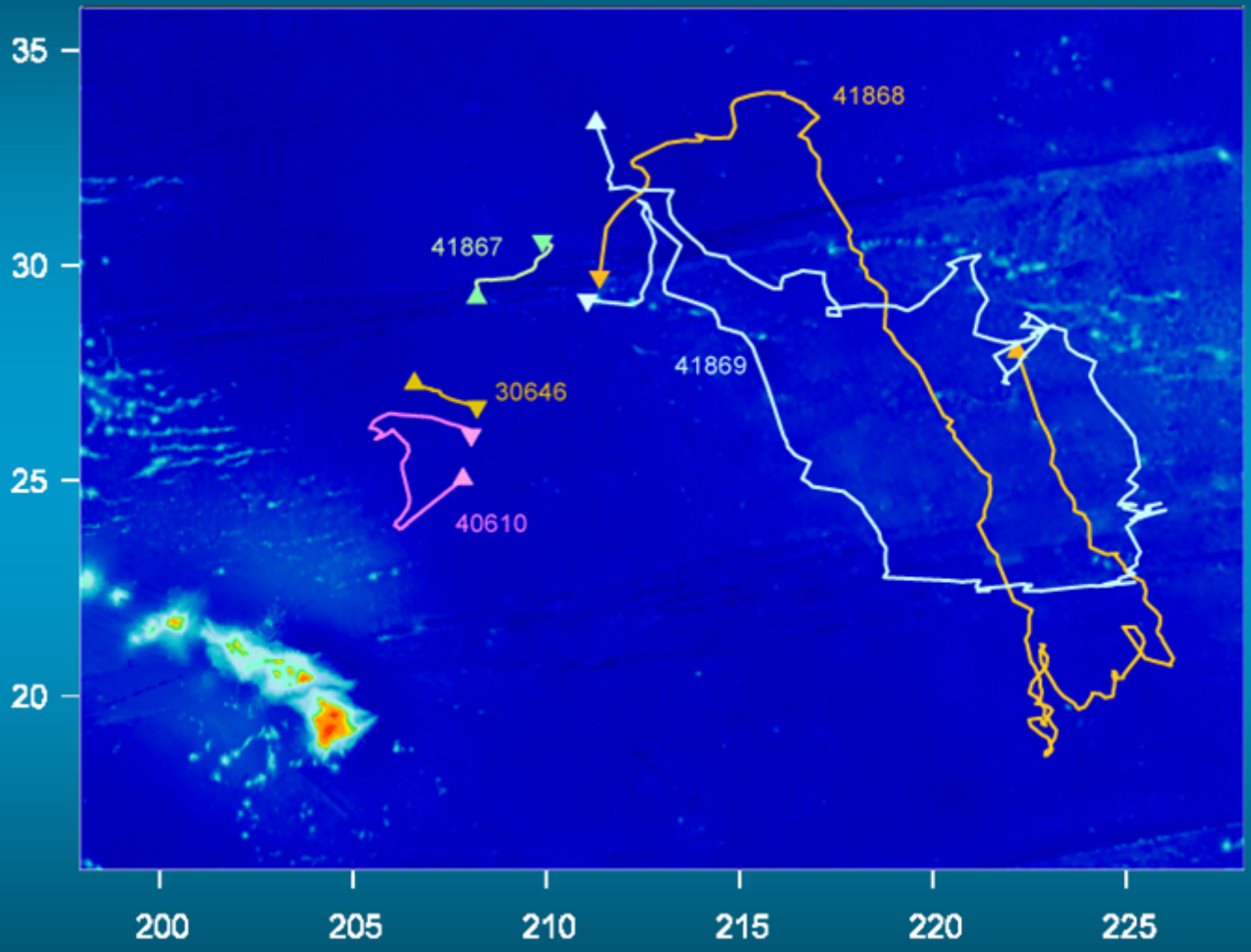
Use of Anders Nielsen's **trackit** package.

Based only on light levels

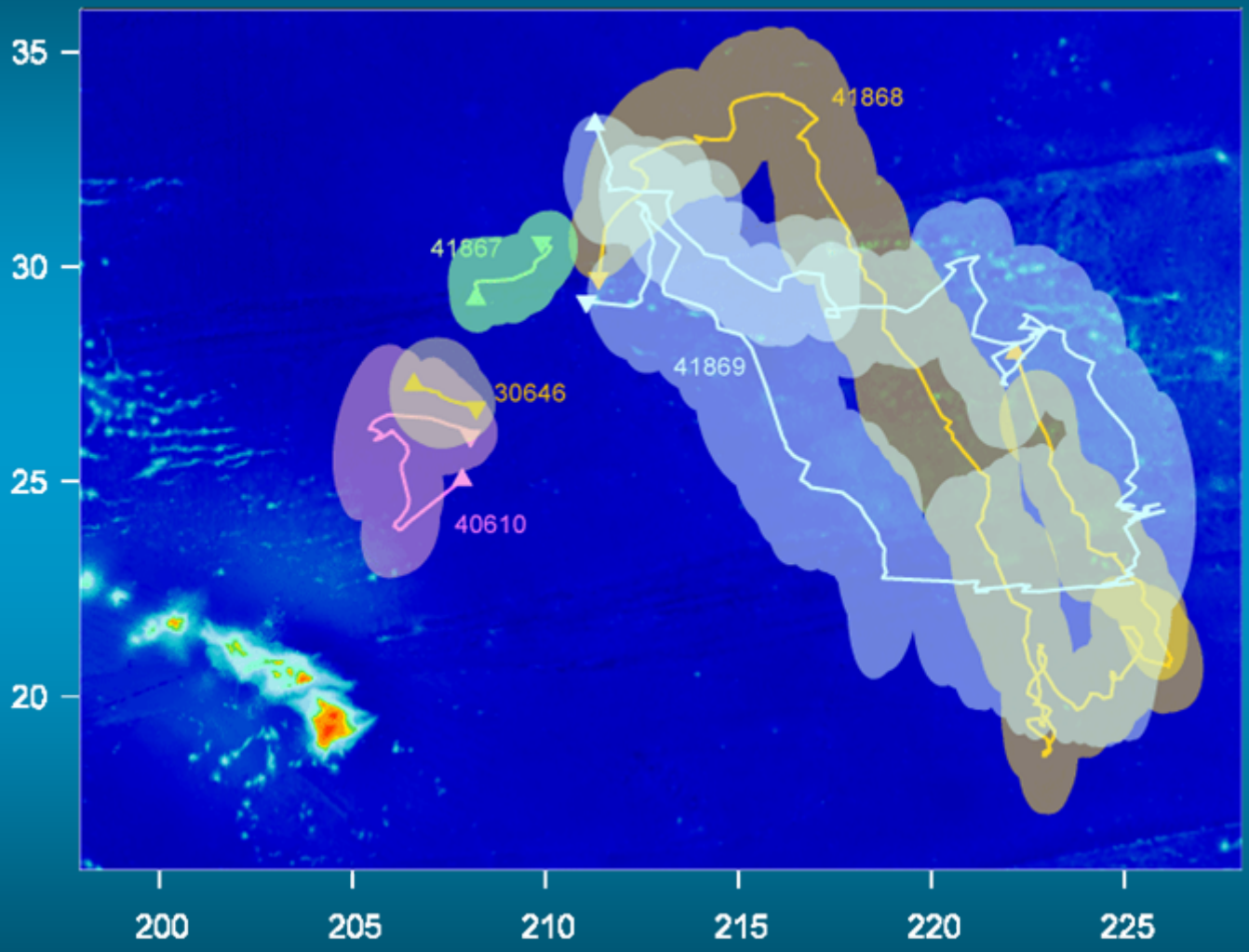
Earlier tags have much worse built-in depth corrections, which impedes us from having a good geolocation



Tracks


35
30
25
20
200
205
210
215
220
225
41868
41867
41869
30646
40610

Tracks


35
30
25
20
200
205
210
215
220
225
41868
41867
41869
30646
40610

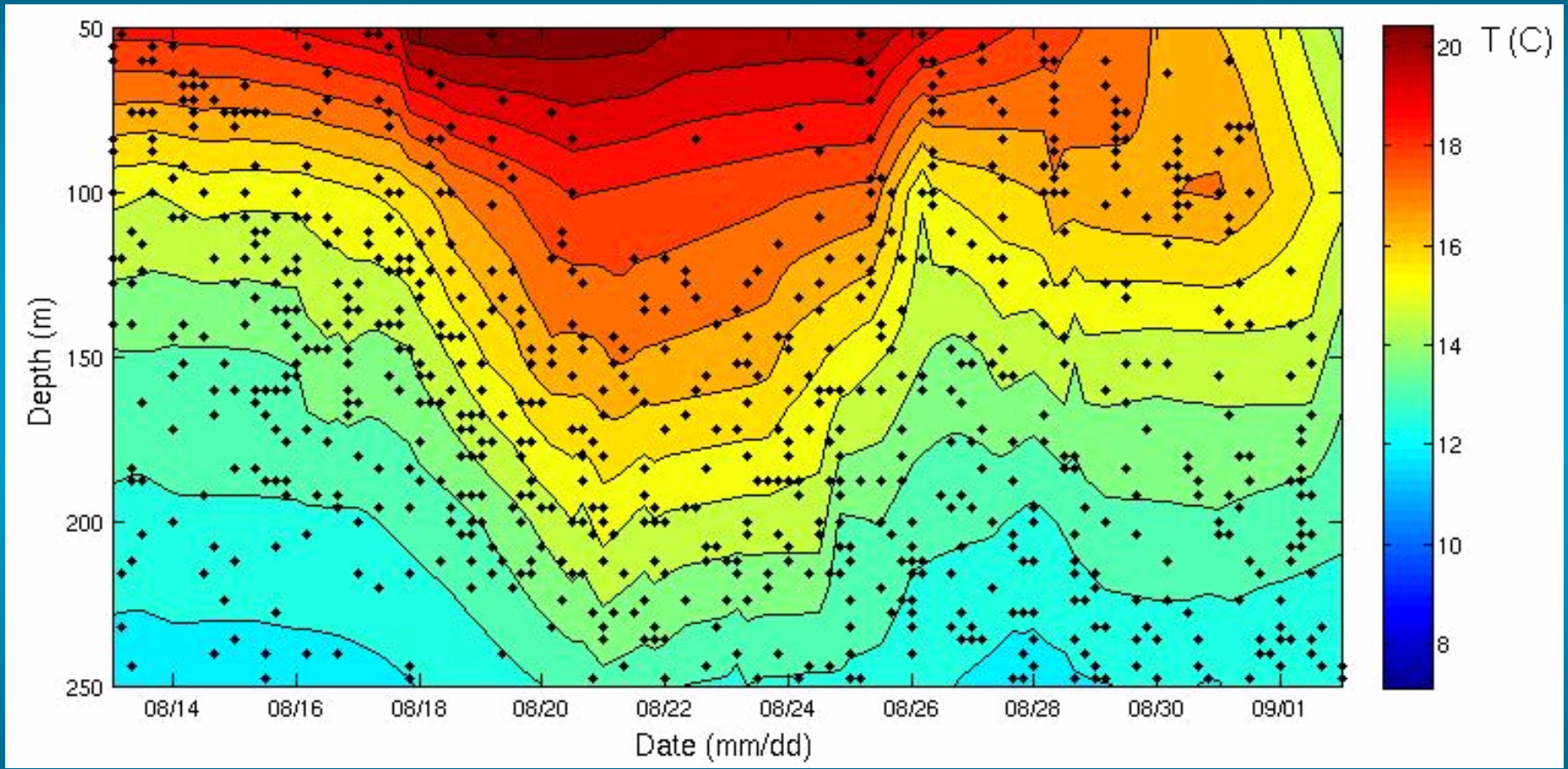
Speed over ground

Based on the most probable track from trackit

tag #	mean v (km/h)	std v (km/h)	total length of track (km)
30646	0.52	0.30	269
40610	0.88	0.69	1097
41867	0.61	0.33	344
41868	2.18	1.34	8908
41869	2.88	2.02	9768
Total average	1.42		

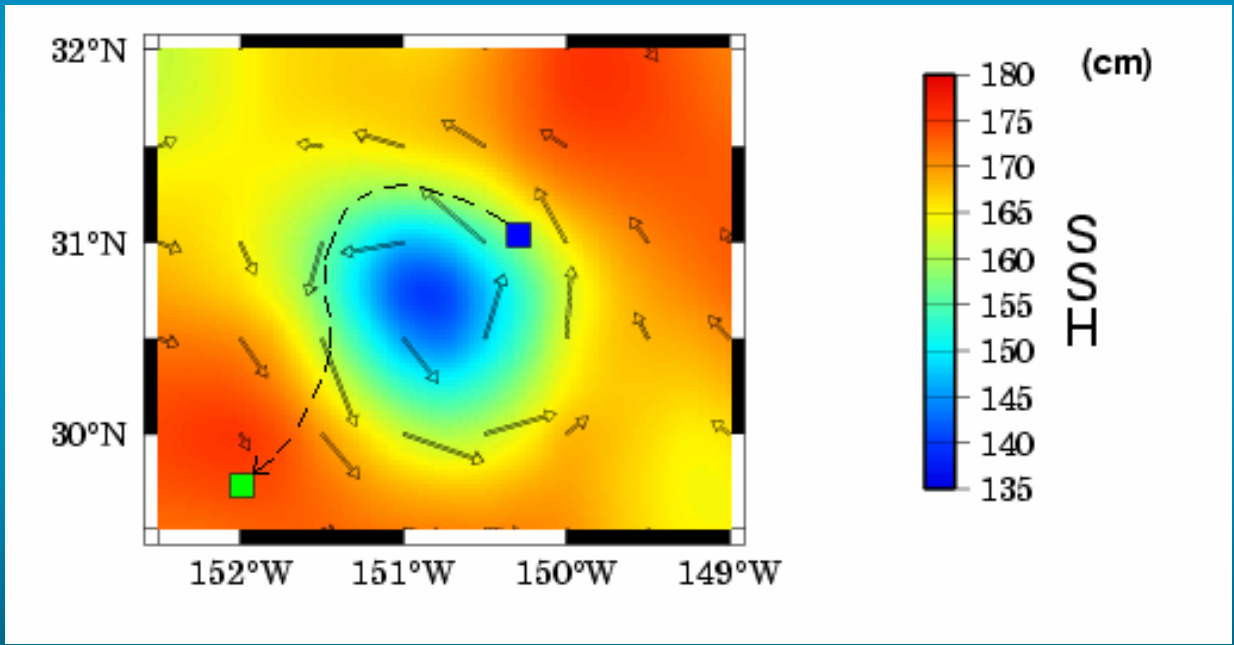
Turtles :	1.2 km/h	(Polovina et al., 2000)
Bluefin tuna :	1.5 – 5 km/h	(Royer, 2005)
Yellowfin tuna :	2.6 – 5.5 km/h	(Brill et al., 1999)
Bigeye tuna :	3.2 – 8.3 (day) km/h	(Dagorn et al., 2000)

Tag 41867 : Eddy ?



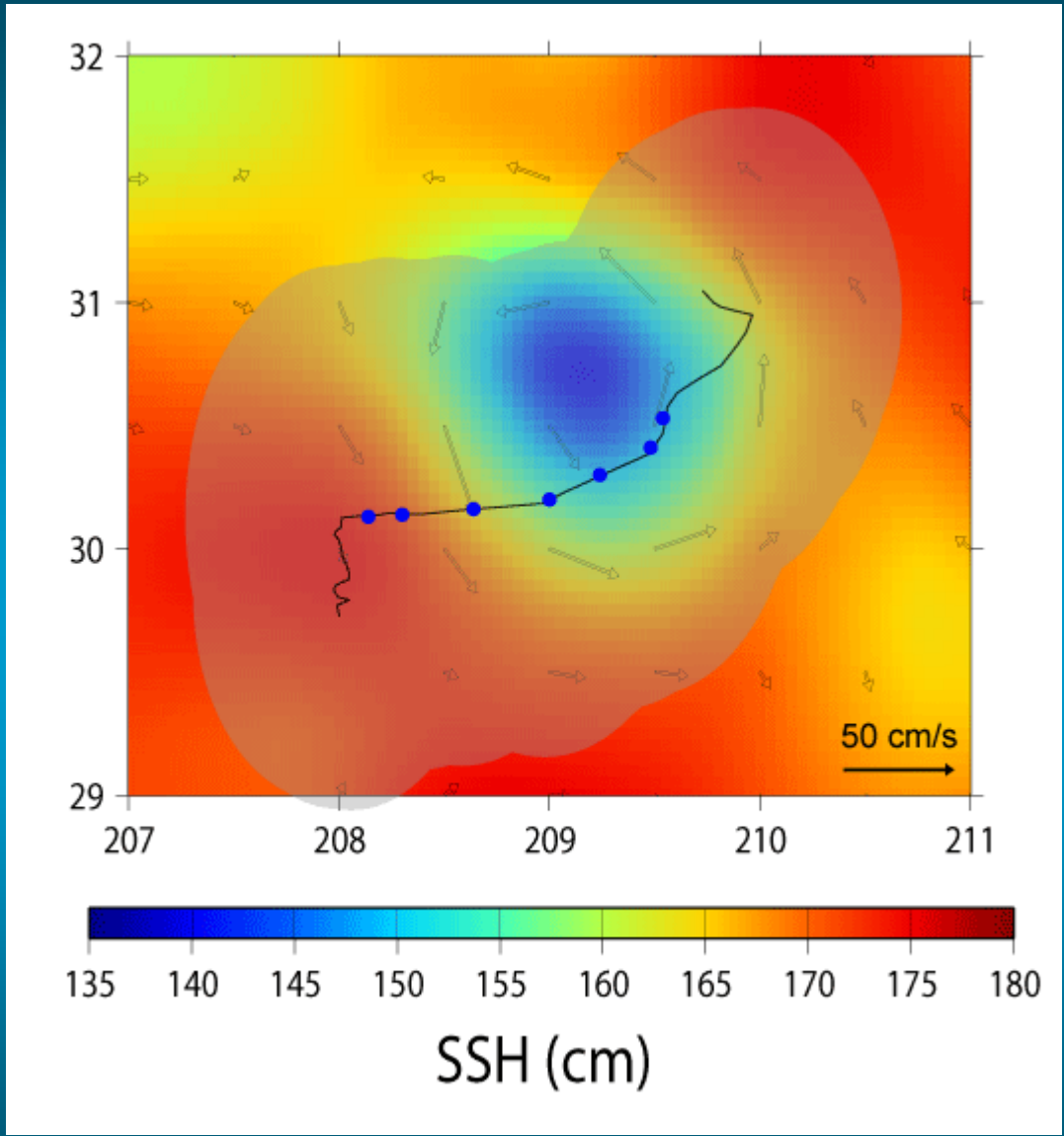
Eddy

- Data : SSH from Aviso
- Arrows : estimates of the geostrophic currents (cm/s)



Aug. 18-24, 2003

Mean speed :
0.61 km/h



Conclusions

- Opah often exhibited vertical behavior like many other large pelagic visual predators, like swordfish and bigeye tuna : deeper day and shallower night depth distributions.
- Opah rarely occupied depths < 50 m probably to reduce encounters with predators using the surface layer at night.
- Opah tagged close together in location and time generally had similar time-at-temperature distributions.
- Nevertheless, opah's use of its vertical habitat can vary in response to changes in local oceanography to maintain a fairly constant mean daily temperature
- The suggested use of the edge of a cyclonic eddy by the opah was consistent with the hypothesis that new production generated from water vertically upwelled at the center would be concentrated at the eddy's edge to support a food web

Limitations

- Very short timeseries and only 11 tags ....
  -> we can't really draw general conclusions about opah
- No tag was recovered : no detailed timeseries
- Geolocation : confidence intervals still too big to obtain a fine description of opah's behavior

References

- **Polovina, J.J., Hawn, D., Abecassis, M.** (2007). Vertical movement and habitat of opah (*Lampris guttatus*) in the central North Pacific recorded with pop-up archival tags. Marine Biology, Online First
- **Nielsen, A. and Sibert, J.R.** (2007). State-space model for light-based tracking of marine animal. Can. J. Fish. Aquat. Sci. 64(8):1055-1068
- **Polovina, J.J., Kobayashi, D.R., Parker, D.M., Seki, M.P., Balazs, G.H.** (2000). Turtles on the edge : movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998. Fish. Oceanogr. 9, 71-82
- **Royer, F.** (2005). Contribution à l'étude de la dynamique du thon rouge Atlantique, PhD thesis.
- **Brill, R.W., Block, B.A., Boggs, C.H., Bigelow, K.A., Freund, E.V., Marcinek, D.J.** (1999). Horizontal movements and depth distribution of large adult yellowfin tuna (*Thunnus albacares*) near the Hawaiian Islands, recorded using ultrasonic telemetry: implications for the physiological ecology of pelagic fishes. Marine Biology, 133: 395-408
- **Dagorn, L., Bach, P., Josse, E.** (2000). Movement patterns of large bigeye tuna (*Thunnus obesus*) in the open ocean, determined using ultrasonic telemetry. Marine Biology, 136: 361-371