Extraction of daily activity pattern and vertical migration behavior from the benthic fish, *Lophius americanus*, based on depth analysis from data storage tags

smast UMassD BFAFi

…by J. Gröger

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2. A few words on fishery issues
3. The tagging experiment
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Introduction

- We distinguish between 3 species of *Lophiidae* in the North Atlantic area
  - *Lophius Americanus*
  - *Lophius piscatorius*
  - *Lophius budegassa*
- *Lophiidae* are commonly known as goosefish, monkfish, anglerfish, Devilfish

Introduction

Introduction

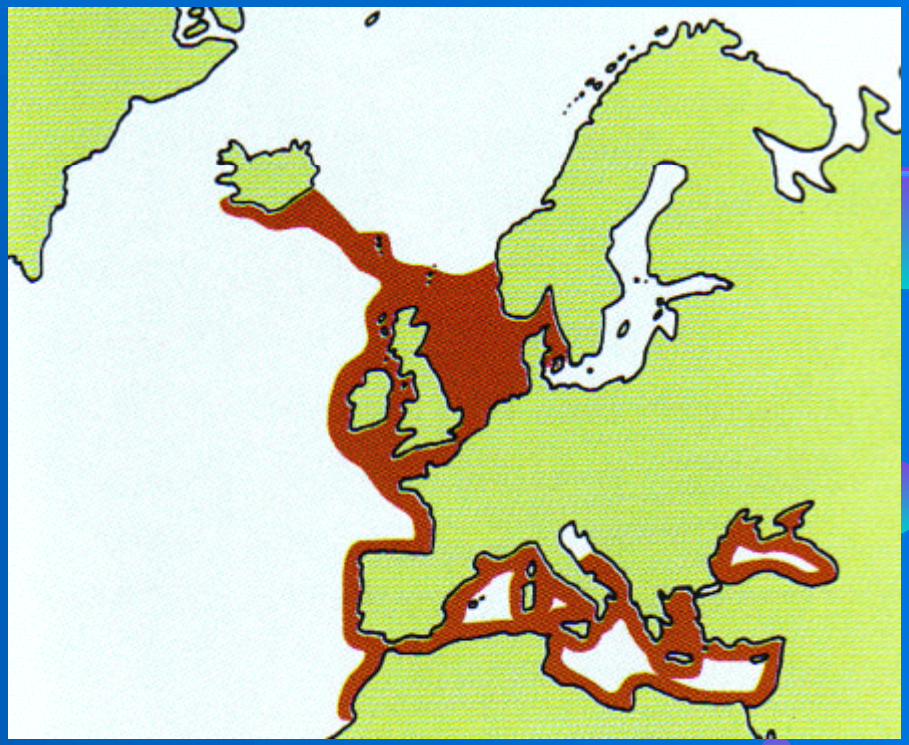
- Ideally suited to a benthic lifestyle
  - Lack of a swim bladder
  - Large, dorso-ventrally-flattened head
  - Angling appendage: illicium (= dorsal spine)
  - Strong, Leg-like pectoral fins
- Slow moving solitary bottom fish
  - Thought to be sluggish bottom dwelling ambush predator (Unique predatory behavior)
  - Behavior and ecology poorly understood

Introduction

- Habitats
  - pelagic and demersal waters
  - saltmarsh creeks, seagrass beds, mudflats and open bay areas
  - mud, sand and structured habitat that contains sponges and other biota
  - NEFMC 2004
    - more densely congregated in mud and sandy bottom

Introduction

Geographical Distribution of *Lophius piscatorius* (Europe)

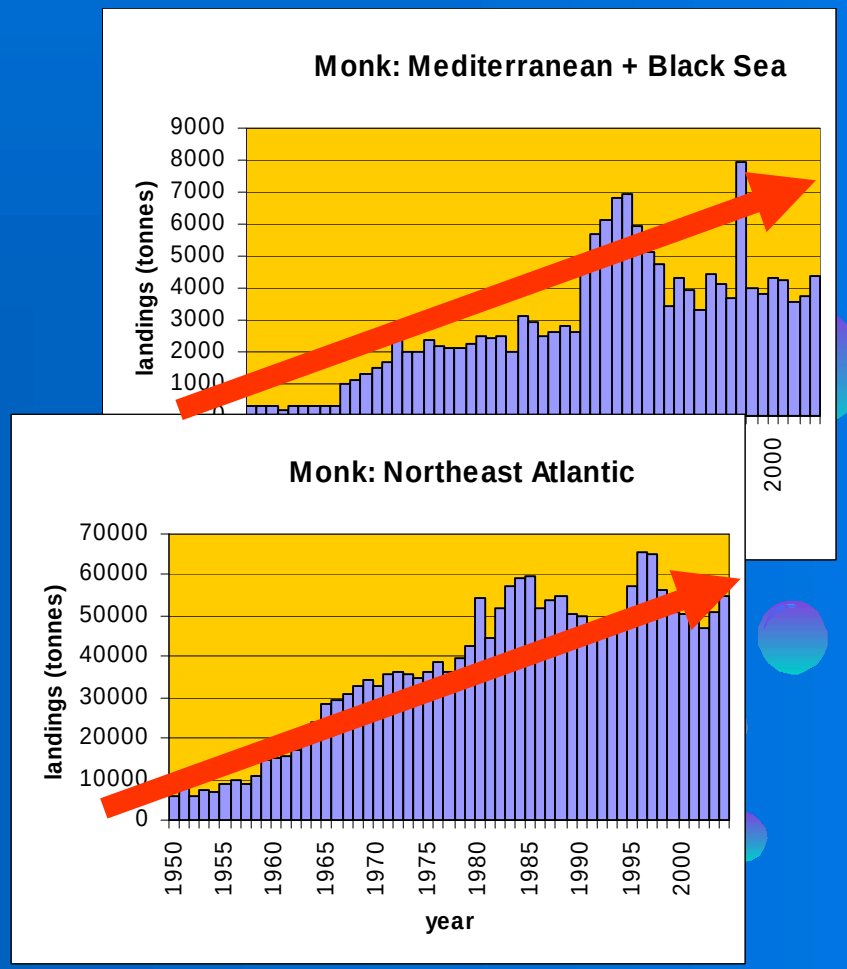


A few words on fishery issues …

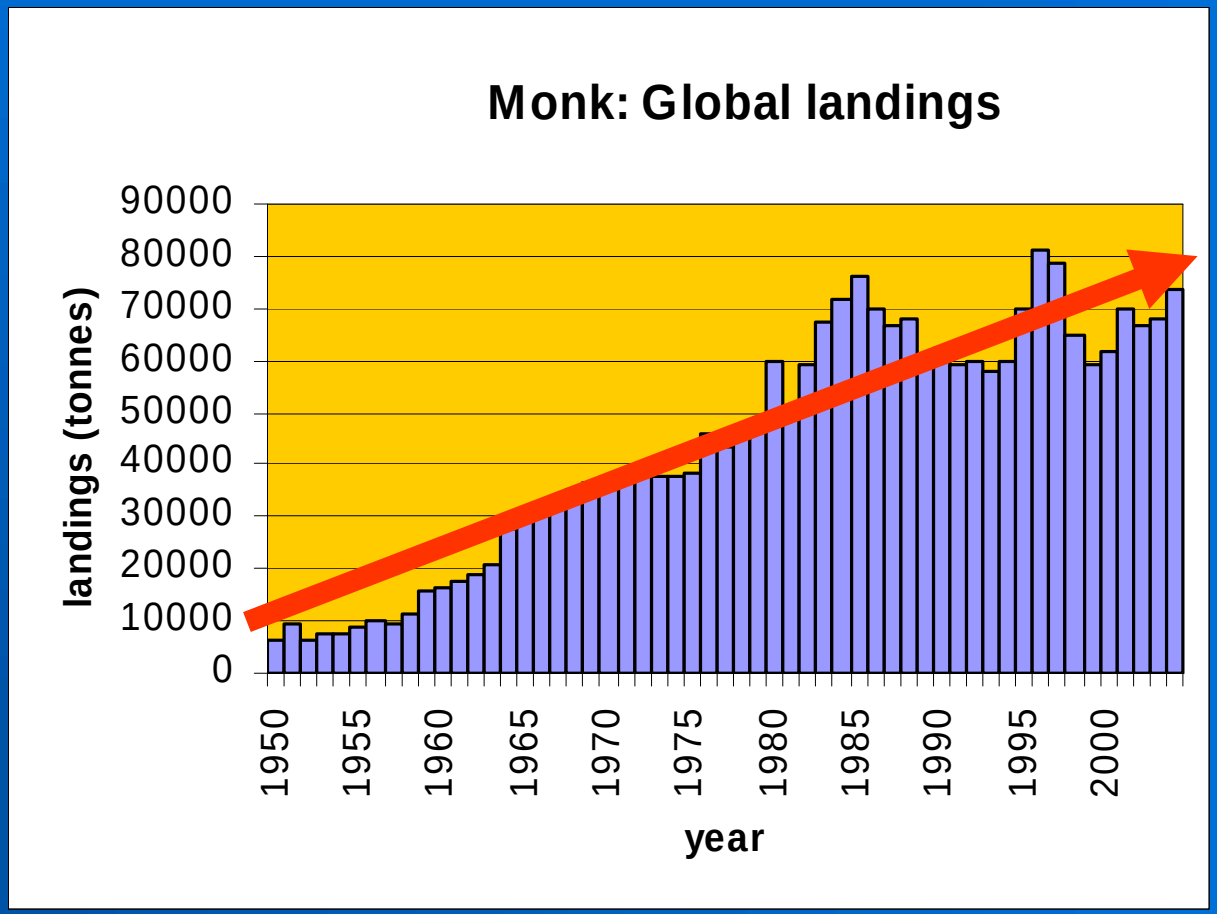
History of Monkfish Fishery

- Traditionally caught as bycatch and discarded until the 1980s
- The majority are caught in gillnet and trawl fisheries
- Market demand for the species first grew in Asia and Europe
- Rapid growth of the fishery
  - Monkfish on the overfished species list

Monkfish Fishery in Europe



Worldwide Monkfish Landings 1950-2004



1st half 2006
www.fishingnews.co.uk

20 January 2006

Monkfish action gets into top gear

27 January 2006

Monks hopes

Hopes rising on monkfish TAC

Skipper lands albino monk

Monkfish TAC talks next week

EU Quotas in 2005

Zone	TAC	BE	DK	DE	ES	FR	IE	NL	PT	SE	UK
IIa(1), IV(1)	10314	365	804	393		75		276		9	8392
IV (Norwegian waters)	NA	53	1343	21				19			314
Vb(1), VI, XII, XIV	4686	168		192	180	2073					1442
VII	26456	2445		273	971	15688	2005	317			4757
VIIIabde	7462				1137	6325					
VIIIc, IX, X, CECAF 34.1.1(1)	1955				1629	2			324		
TOTAL	50873	3031	2147	879	3917	24163	2474	774	324		14905

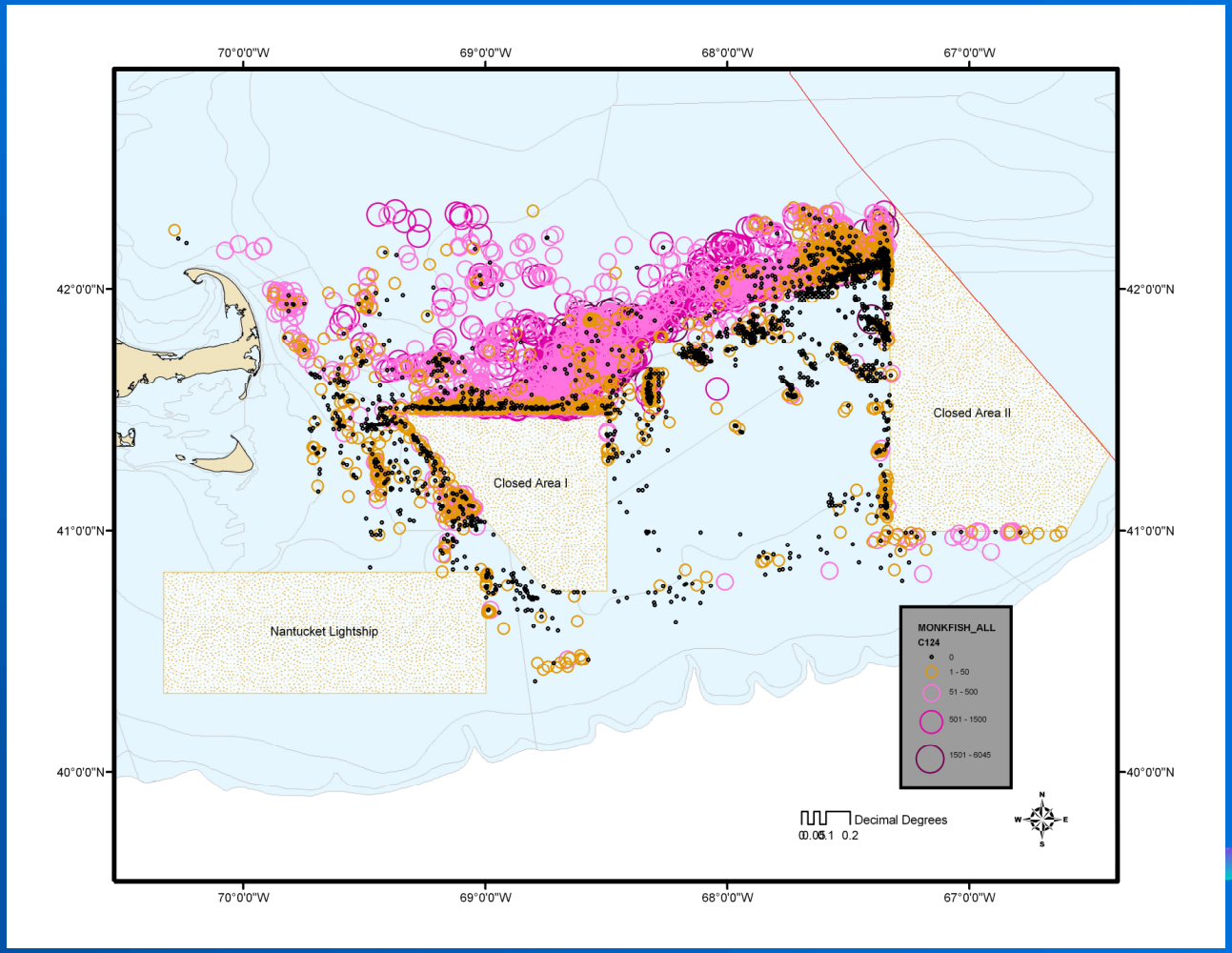
~80%

Monkfish Fishery in the US

- 7th most valuable fishery in New England and 17th US Nationwide (US$ 33 Million)
- Managed in two separate areas
  - the Northern Fishery Management Area (NFMA), which extends from Maine to Massachusetts and
  - the Southern Fishery Management Area (SFMA), which includes areas south of there
- Both populations were found to be overfished in 1999
  - so the species is under a rebuilding plan

The Tagging Experiment …

SMAST Industry-Based Trawl Survey 2000-2004



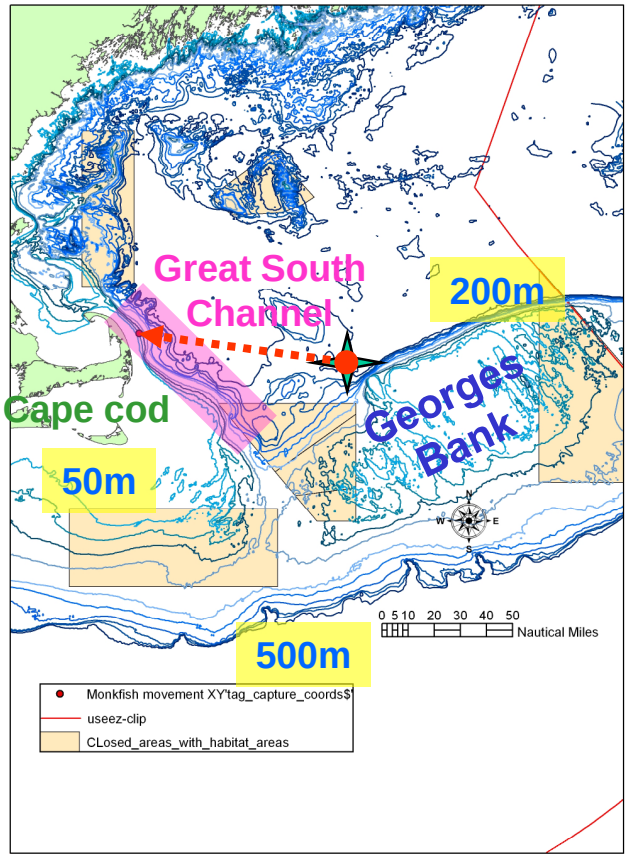
Dominant catch in SMAST Trawl Survey

Scientific name	Mean CPUE (lbs / tow h)	SE
Rajidae	311	9.7
Melanogrammus aeglefinus	100	12.0
Lophius americanus	88	1.9
Gadus morhua	87	5.4
Pleuronectes americanus	51	2.0
Pleuronectes ferrugineus	35	1.3
Hippoglossoides platessoides	16	0.4
Glyptocephalus cynoglossus	15	0.3
Homarus americanus	11	0.4
Pollachius virens	10	1.2
Squalus acanthias	8	1.2
Raja laevis	6	0.8
Urophycis sp	6	0.3
Hemitripterus americanus	6	0.3
Cottidae	5	0.3

Motivation for a monkfish tagging experiment

- No previous tagging efforts in western Atlantic (related species tagged in eastern Atlantic)
  - Geographic distribution known only from catch distribution patterns
  - Anecdotical observations of individuals occurring near the surface
  - Selected tidal transport mechanisms?
- Why potential migrations ?
  - Possible inshore-offshore seasonal movements (Specific Spawning behavior, Specific Foraging behavior, Specific Predator avoidance)

Tag recapture location



- As a by-product of an SMAST cod tagging program 13 goosefish were tagged using unused surplus tags
- 22 to 75 cm TL
- Nov & Dec 2003

TL: 62 cm

Release depth: 74m

Released: 9 Dec 2003

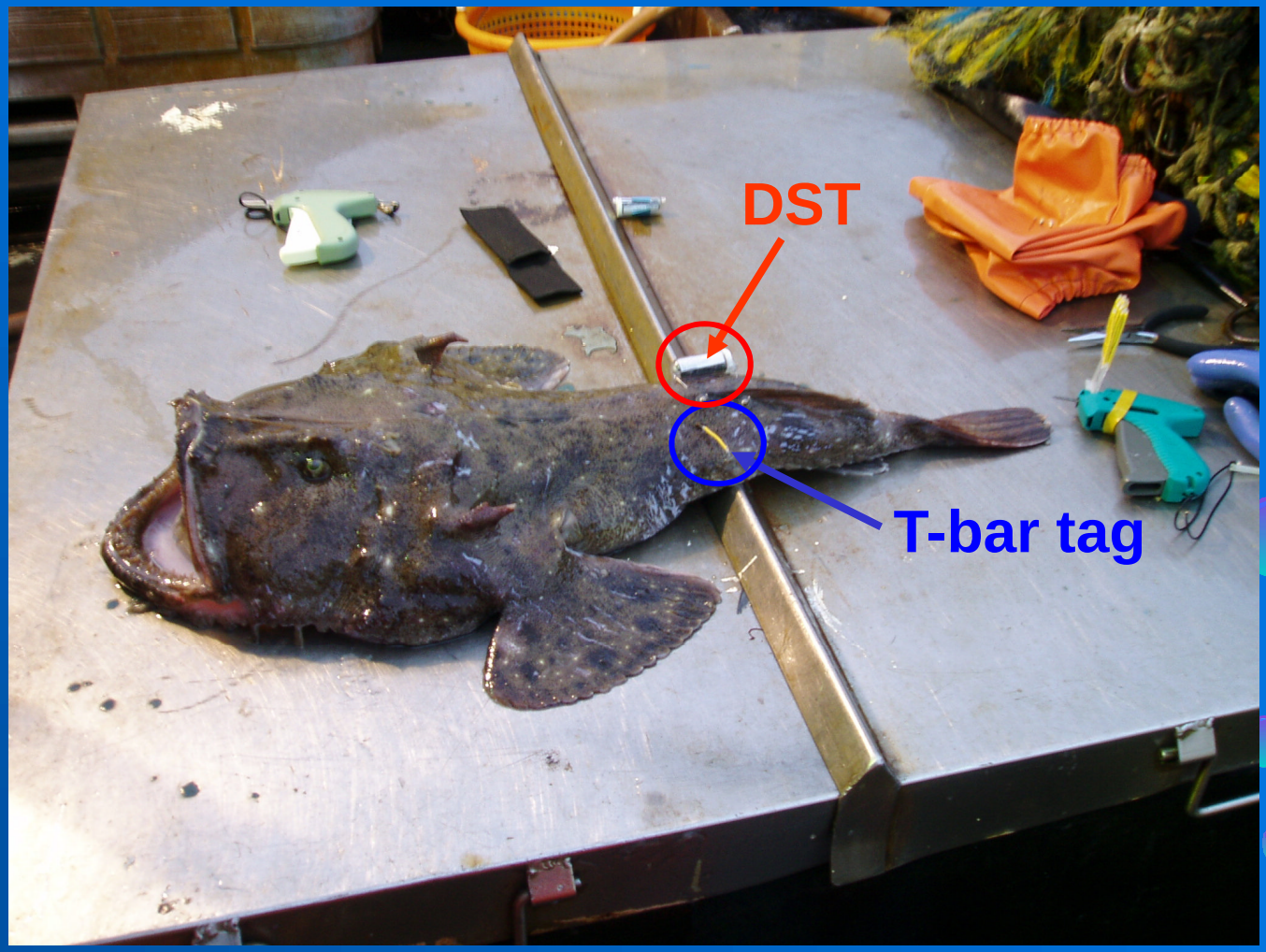
Recaptured: 18 June 2004

Days at large: 192

Travel: 113 km

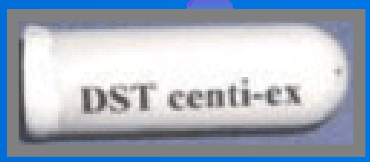
Av. Speed: 0.6 km/day

Tagged Monkfish



Star Oddi DST Features

Size	15mm x 46mm
Weight	19g (In Air), 12g (In Water)
Memory Capacity	87,167 Measurements (Standard)
Memory Management	Custom Programming, Primary and Secondary Parameter
Data Resolution	12 Bit
Data Retention	25 Years
Temperature Range	-1°C to 40°C (30°F to 104°F)
Resolution Temperature	0.032°C (0.058°F)
Accuracy Temperature	±0.1°C (0.18°F)
Depth Range	2000 Meters
Resolution Depth	0.075% of full scale (FS)
Response Time Depth	Immediate Response
Clock	Real Time Clock. Accuracy ±1 min/month
Sampling Interval	48 Minutes
First Recording	At Once Or At Any Future Time (User Defined)
Battery Life	5 Years (Sampling Rate of 1 Minute)
Attachment Hole	0.9mm (Diameter)



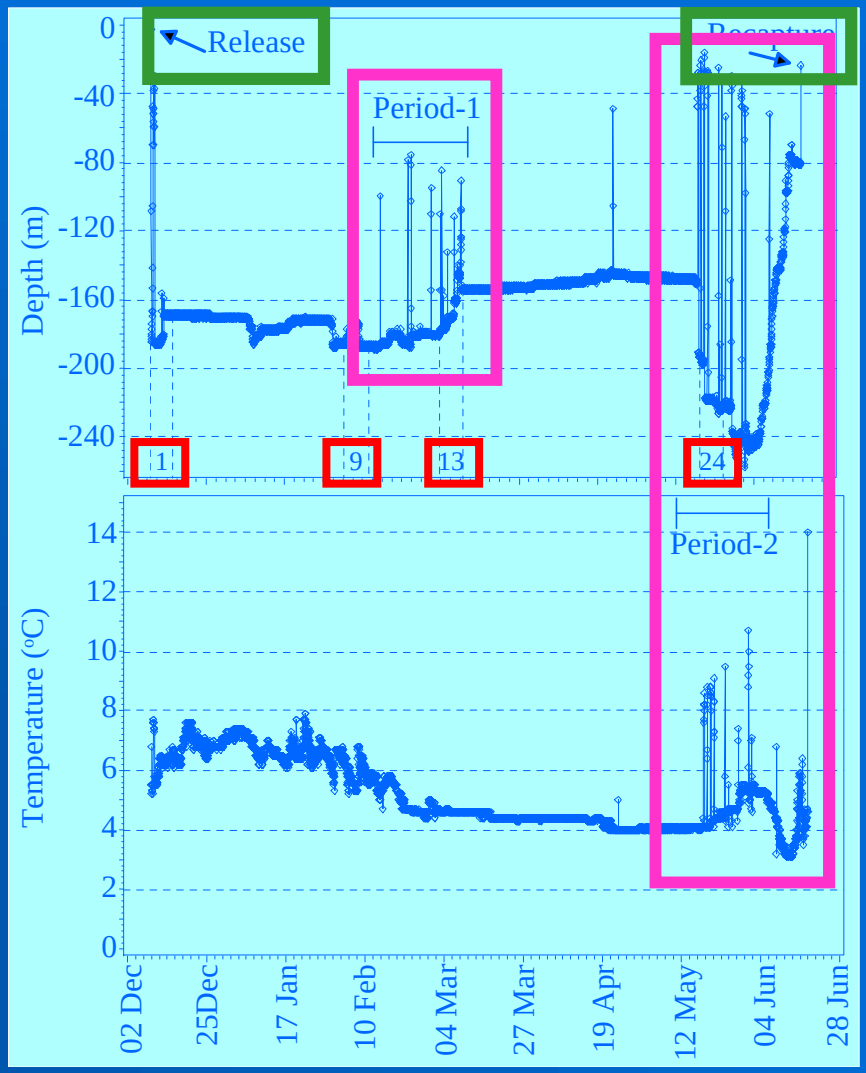
Geolocation

- Due to DST Specification no Geolocation possible
  - 48 minutes sampling interval
  - 1.50 m depth resolution
  - swimming speed unknown

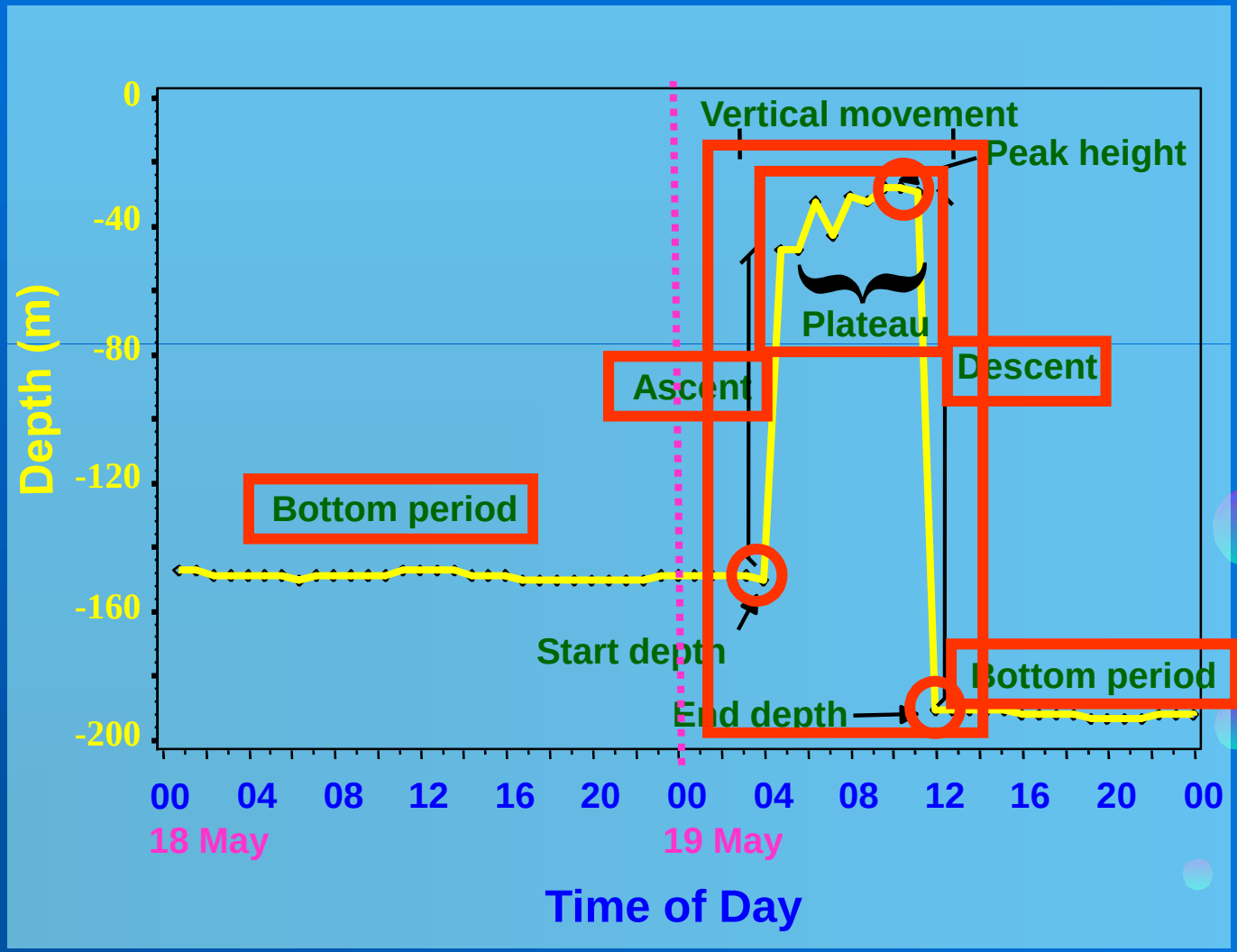
Depth and temperature profile recorded on the DST

Depth

Temp.



Event measurements



4 Types of vertical movements

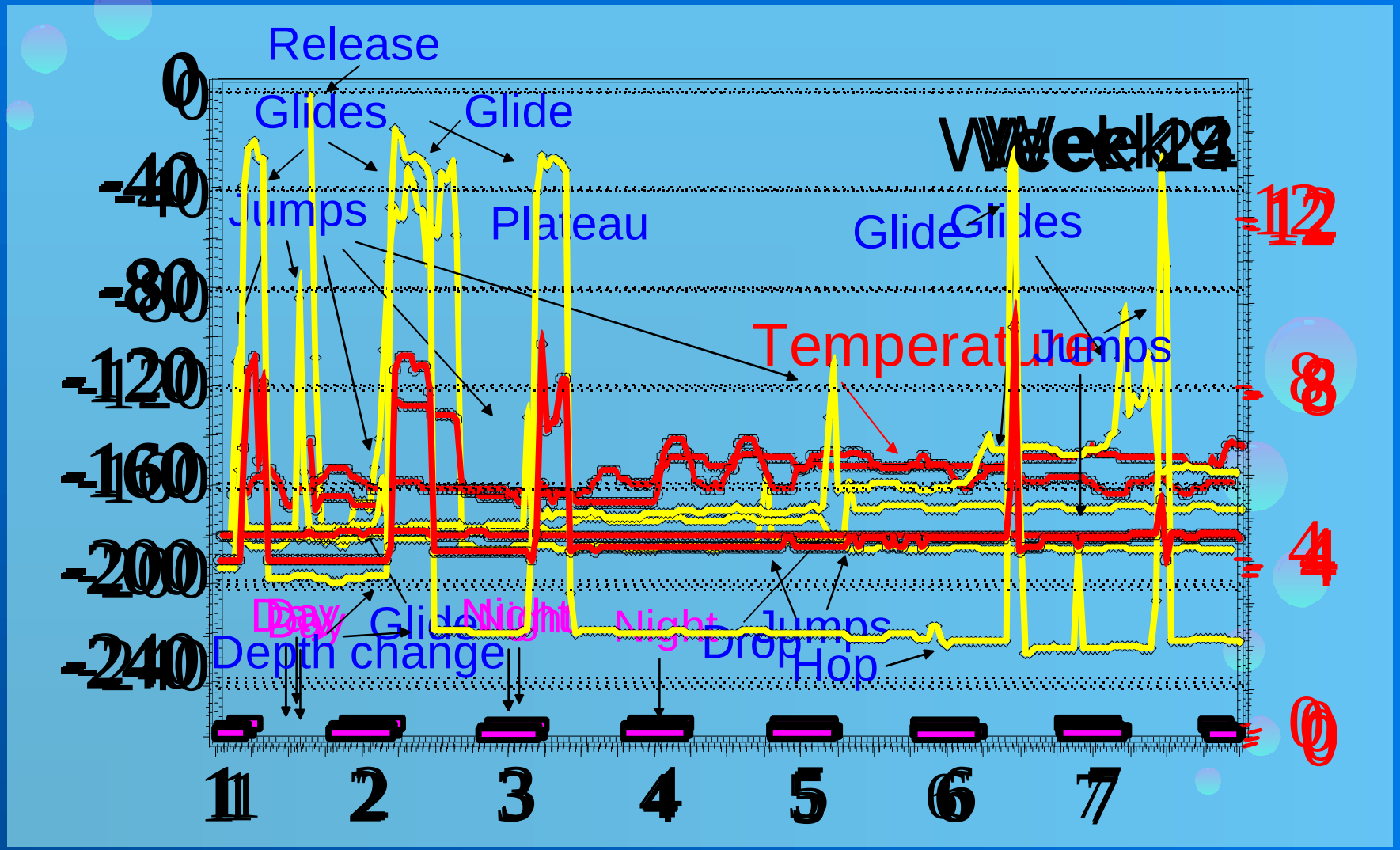
- Only vertical events > 4 m

- Drops
  = rapid changes in depths, no apparent rise from the starting point
- Hops
  = vertical rises of < 10 m and 240 minutes
- Jumps
  = rapid rises > 10 m, no apparent plateau
- Glides
  = prolonged jumps > 240 minutes, clear plateau

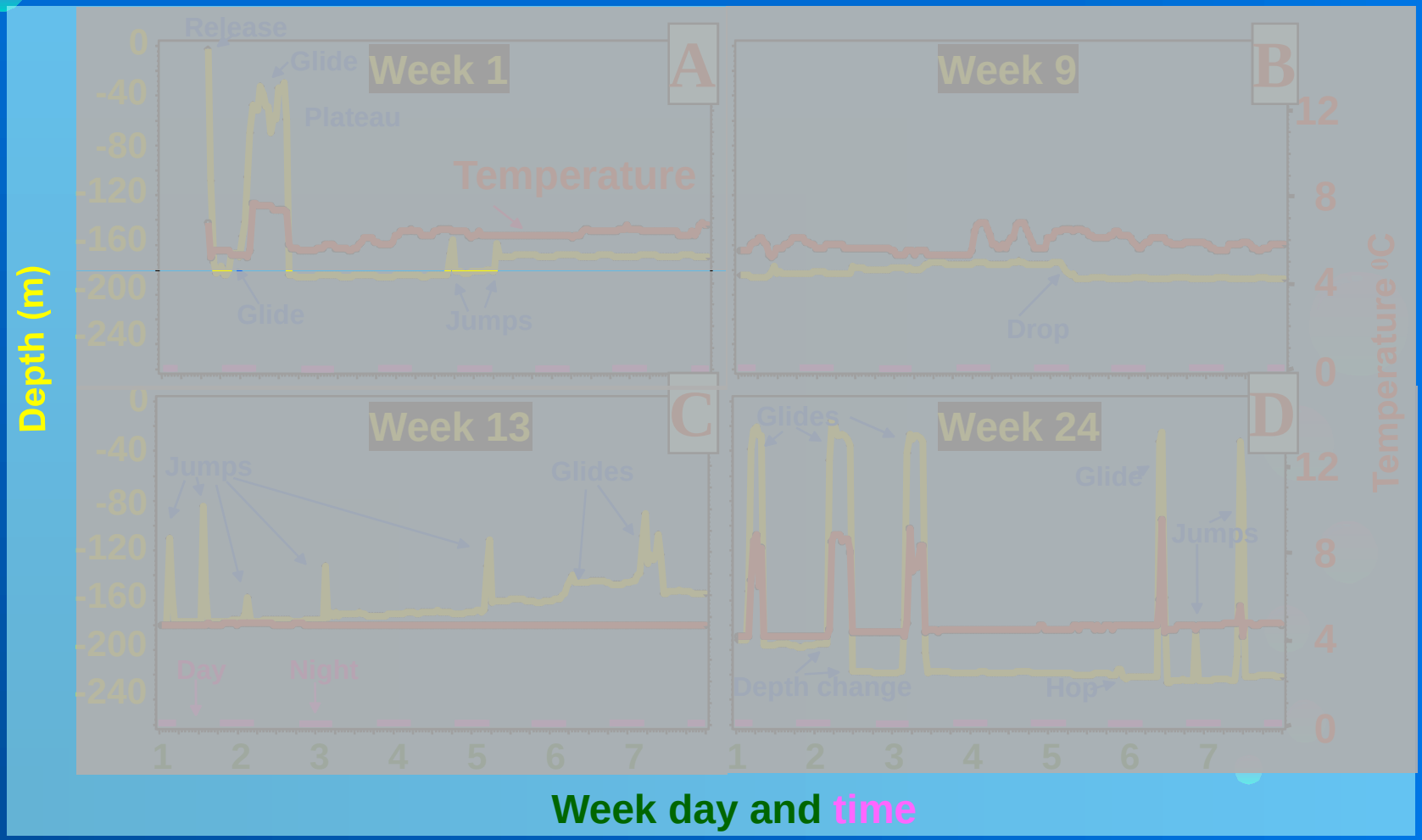
Some descriptive statistics of …

1. Vertical events
2. Bottom events
3. Between period comparisons
4. Daily events

Vertical movement behavior



Vertical movement behavior



Vertical movement statistics

Event attribute	N	Minimum	Maximum	Mean	Standard deviation
Duration (minutes)	43	48	864	177	162
Total height of movement (m)	43	0	209	75	73
Rate of ascent (m/minute)	40	0.079	3.958	0.994	0.915
Plateau height (m)	40	26	216	108	59
Plateau duration (minutes)	40	0	576	70	130
Rate of descent (m/minute)	43	0.014	4.208	1.199	1.295
Bottom depth change (m)	43	-41	24	-1	10
Absolute bottom depth change (m)	43	0	41	6	8
Rate of bottom change (m/hour)	43	0.000	7.5	1.7	1.604

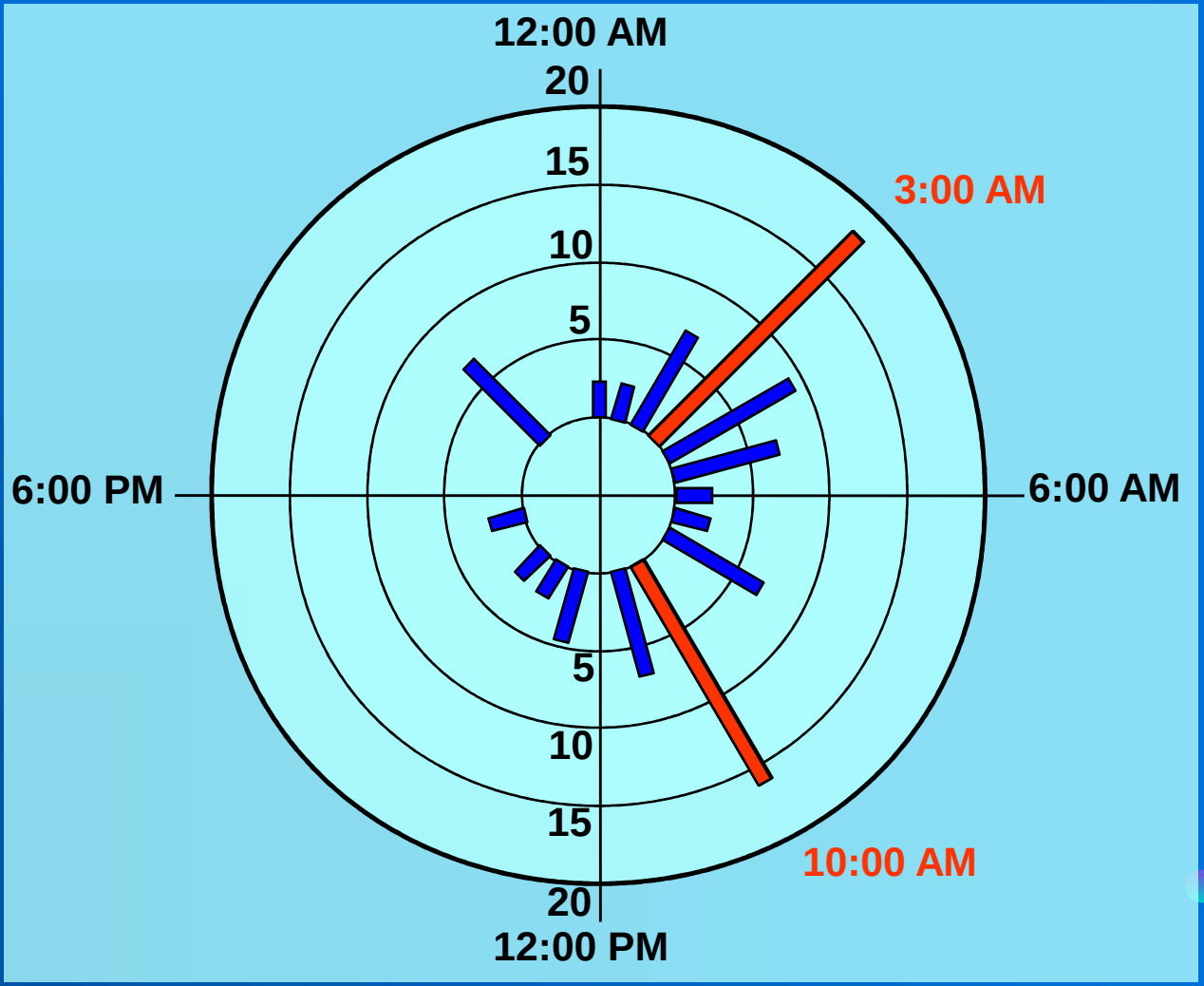
Bottom event statistics

Event attribute	N	Minimum	Maximum	Mean	Standard deviation
Duration (minutes)	41	384	64368	6413	12687
Absolute depth range (m)	41	0	91	6	16
Slope (m/hr)	41	-0.69	0.74	0.02	0.19
Absolute slope (m/hr)	41	0.00	0.74	0.07	0.18
Events with significant gradients					
Duration (m)	16	912	64368	13472	18372
Depth range (m)	16	-18	91	12	26
Absolute depth range (m)	16	3	91	17	23
Slope (m/hr)	16	-0.69	0.74	0.06	0.03
Absolute slope (m/hr)	16	0.00	0.74	0.18	0.25

Between-period comparison of vertical events

Period 1	Number	Maximum	Mean
Duration (minutes)	19	480	131
Plateau duration (minutes)		240	19
Total height (m)		112	41
Period 2			
Duration (minutes)	16	432	198
Plateau duration (minutes)		384	108
Total height (m)		209	132

Daily pattern of vertical movements



Summary

- Depth and temperature DST measurements were examined from a single Atlantic goosefish
  - Tagged on Georges Bank on 9 December 2003 and recaptured on June 18, 2004 (192 days, 113 km)

Summary cont'

- A total of 43 vertical movements were recorded (1.6 movements per week)
  - Range: 4 to 209 m (mean = 75 m)
  - Duration: 96 to 912 minutes (mean = 225 minutes)

- At least 3 modes of movements:
  - gradual movements along the bottom contour
  - more rapid movements involving short vertical hops of less than 10 m height
  - large vertical movements involving vertical jumps of 10-200 m and durations of 8 hours

Summary cont'

- Two periods of frequent daily movements
  - first period
    - six weeks in February and March during a transition from deep (180 m) to shallow water (150 m)
  - second period
    - Occurred as the fish descended into the Great South Channel and then ascended up the western slope into the inshore waters of Cape Cod over a five week period in May and June

Summary cont'

- Vertical movements during the second period were consistently longer in duration and higher in elevation than those in the first period
  - mean duration = 246 minutes / 132 m (mean duration = 179 minutes / 41 m)
  - The rate of ascent and descent were similar with means of 1.0 m/minute and 1.2 m/minute, respectively

- Vertical movements occurred primarily between 00.00 h and 12.00 h (81 %)
  - peaks at 03.00 h and 10.00 h

Conclusions & speculation

- The two periods of high vertical activity pattern suggest extensive use of tidal transport mechanisms for horizontal migration
- 2nd period close to spawning season: part of spawning event?

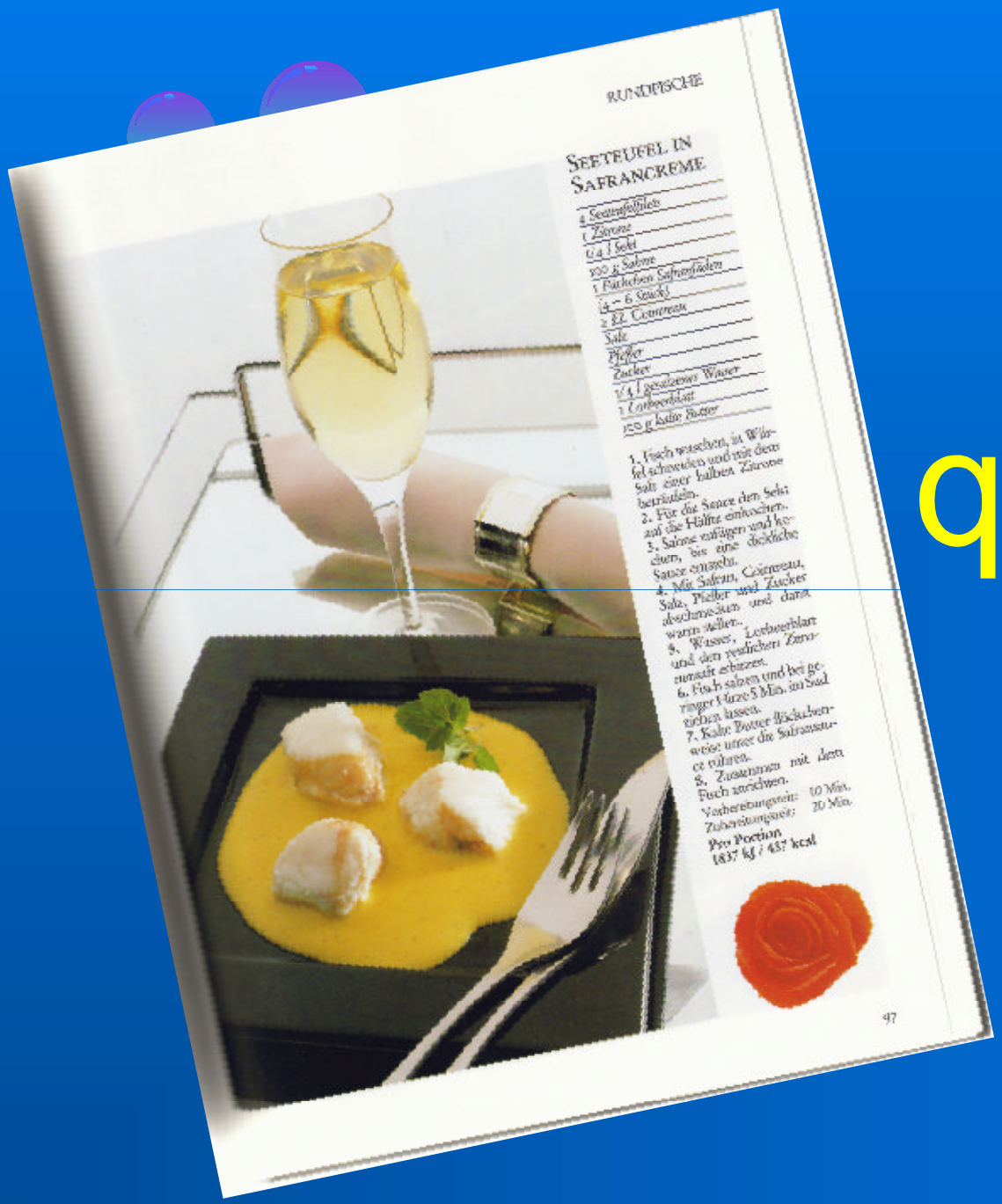
Future

- Geolocation
- Automatic Behavior Identification Algorithm

Acknowledgements

- New Bedford Fishermen
- Darin Jones and Ross Kessler

- Funding under the SMAST Cod Tagging Project supported by the Massachusetts Fisheries Recovery Commission; NMFS, NOAA, DOC, Cooperative Research Partners Initiative; and by NASA NAG 5-9752, 13-02042 and 13-03021



Thank you
Any questions ?