PhD Thesis

The behaviour of tropical tuna around floating objects: From the study of individual and collective behaviour to the ecological trap hypothesis

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INTRA-INDIVIDUAL BEHAVIORAL VARIABILITY DISPLAYED BY TUNA AT FISH AGGREGATING DEVICES (FADS)

By Marianne Robert , Laurent Dagorn, John Filmalter, Jean Louis Deneubourg, David Itano and Kim Holland

Robert et al. Under Review. *MEPS*

State of the art

Active and passive acoustic tracking studies of tuna around anchored FADs

wide range of residence times of tunas at FADs
=> few minutes up to several months

Holland 1990, Brill el al 1999, Klimley and Holloway 1999, Otha and Kakuma 2005, Dagorn et al 2007

Objective

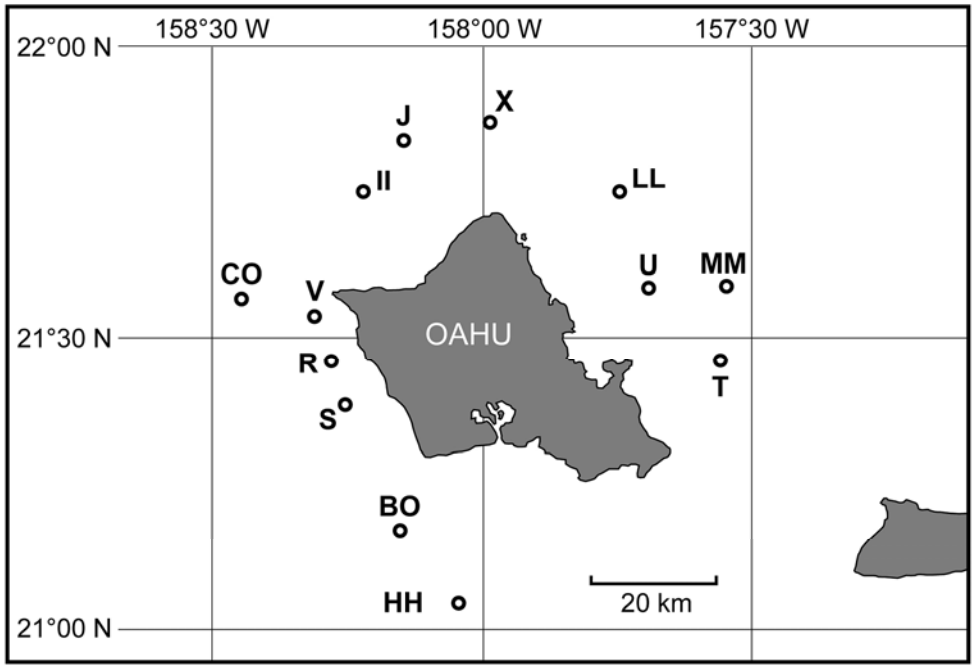
Investigate the variability : single or multiple behavioral modes ?

Determine the rules governing the decisions made by fish to leave or join a FAD

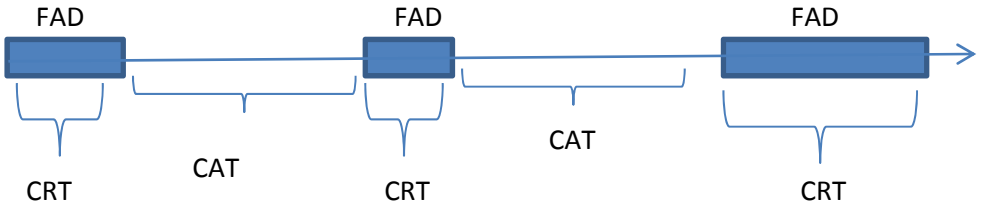
In the array of 13 anchored FADs around Oahu (Hawaii)

72 yellowfin tuna (59 -95 cm FL) acoustically tagged

All FADs were equipped with a listening station (VR2) from 2002 to 2005



Presence/absence data set



Residence time

at FAD (Continuous Residence Time - CRTs)

between two associations at a FAD (Continuous Absence Time - CATs)

Method

Define statistical units (SUs)

series of CRTs that occurred at a single FAD during a given period

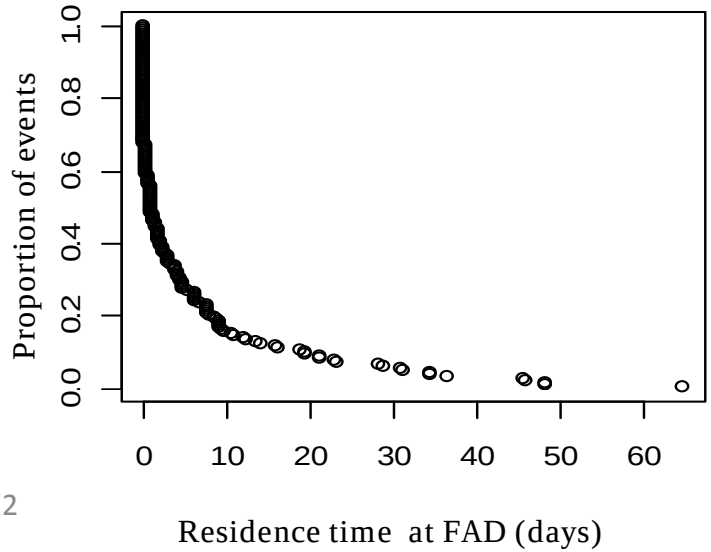
series of CATs that occurred during a given time period

Create survival curve of each SU

Comparison of survival curves of SUs

Cox Regression Model

=> identify homogeneous families of SUs



Method

Models fitting

On each homogeneous families of SUs (for both CRTs and CATs)
3 models were fitted and compared

⇒reveal the underlying behavioral process

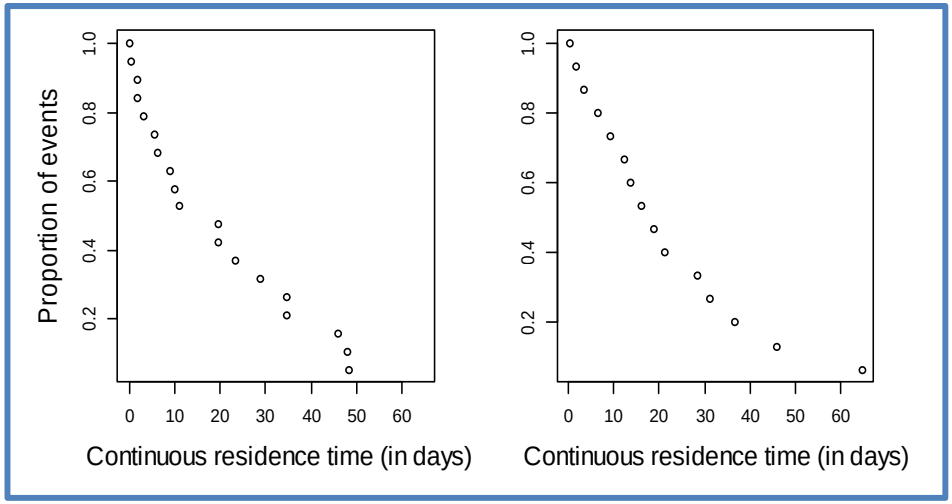
Exponential law
- single
- sum of two exponential

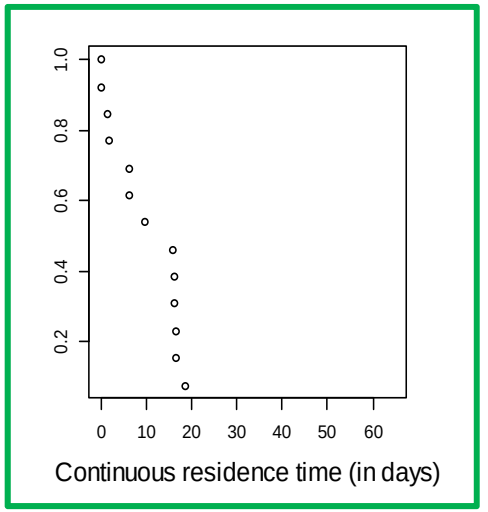
} Memory-less phenomenon
Probability is constant over time

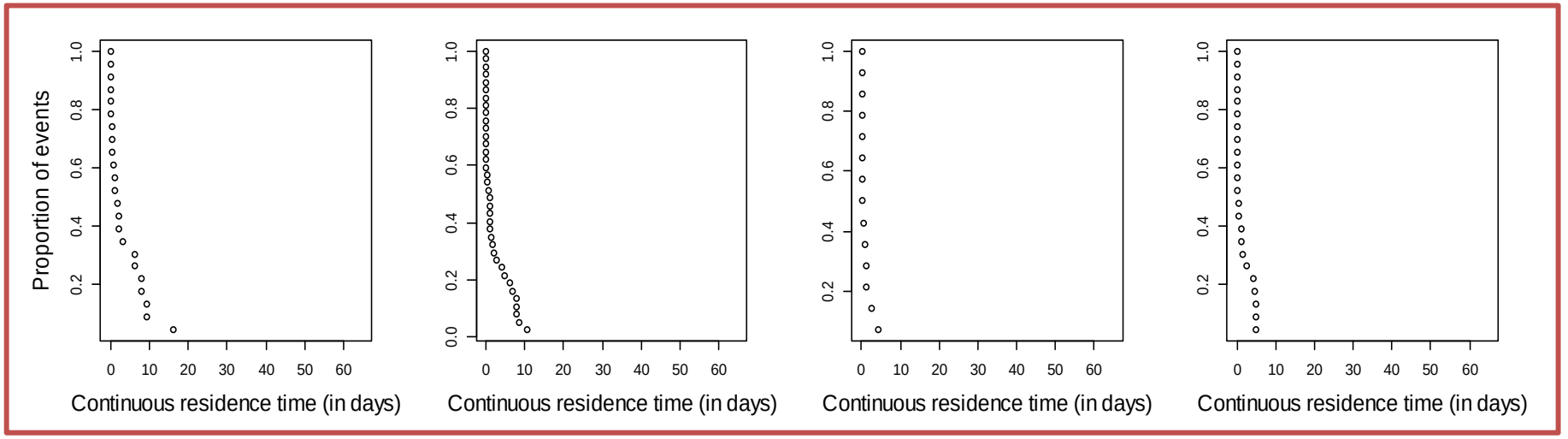
Power law

} Probability is time dependent

Three homogeneous families of SUs



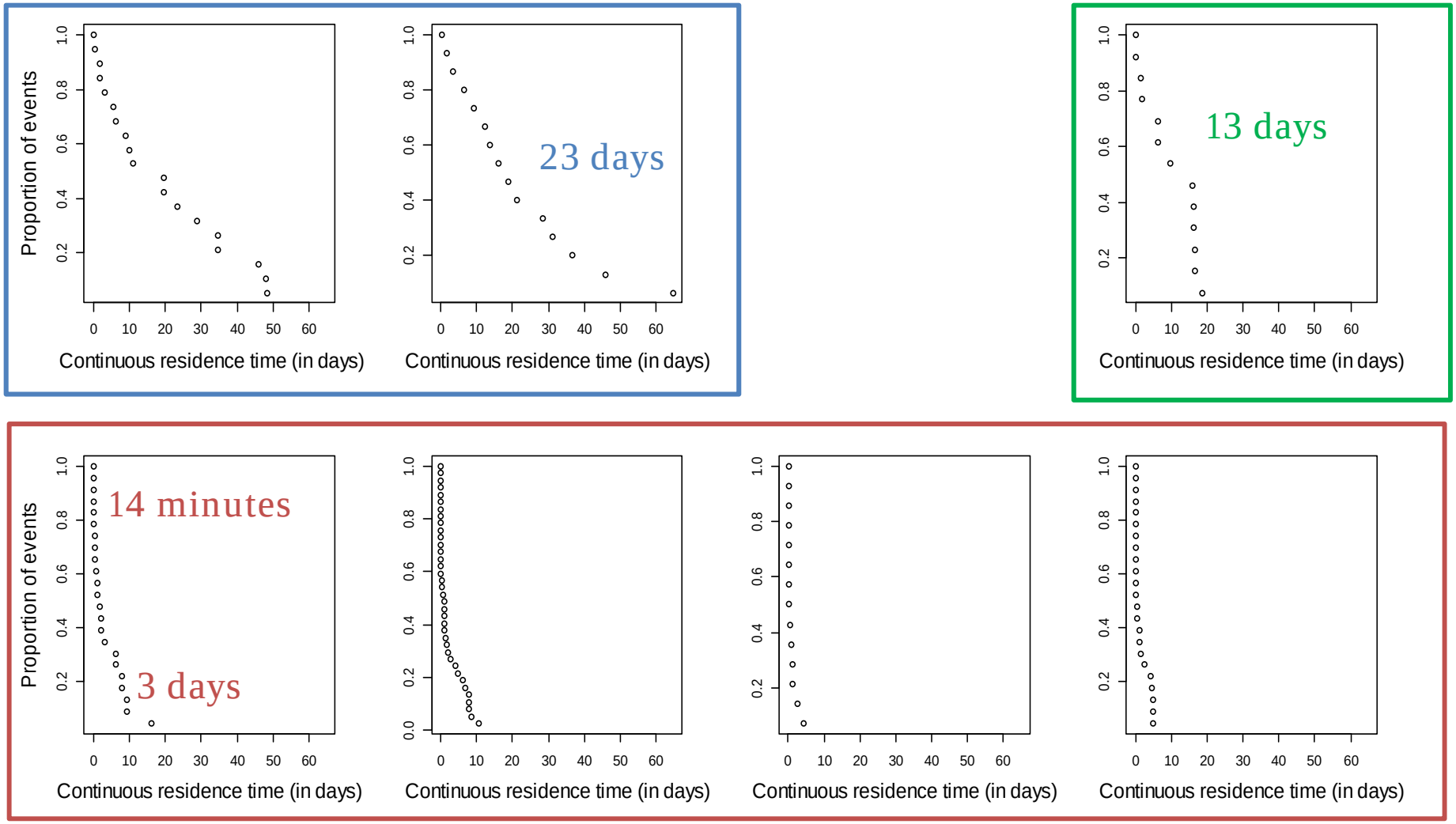




Distribution of residence times were best fitted with **exponential law**

The estimated parameters allow characterizing the behavioral modes
: mean residence times (1/k)

Four behavioral modes



Distribution of residence times are best fitted with **exponential law**

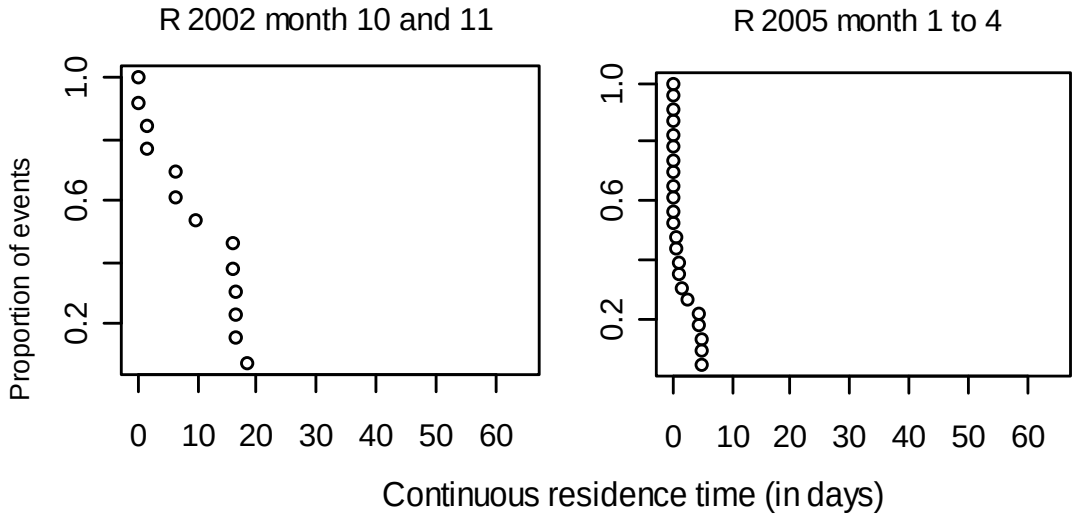
→ The estimated parameters allow characterizing the behavioral modes
: mean residence times (1/k)

Mean residence times at FADs	14 minutes / 3 days	13 days	23 days
Continuous absence times	3 days	Infinite /very long	

→ The probability that the event occurs (arriving and departure from a FAD) is time independent

How to explain the existence of the distinct behavioral modes observed ?

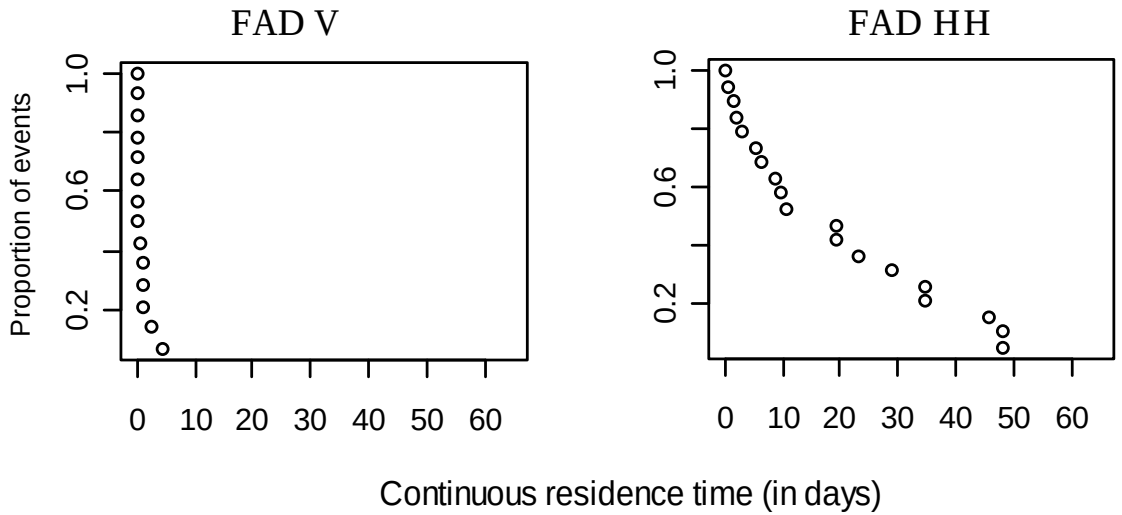
By the intrinsic characteristics of the FADs ? NO



Distribution of residence times under the same FAD (R) are different between two distinct periods

How to explain the existence of the distinct behavioral modes observed ?

By the time period ? NO



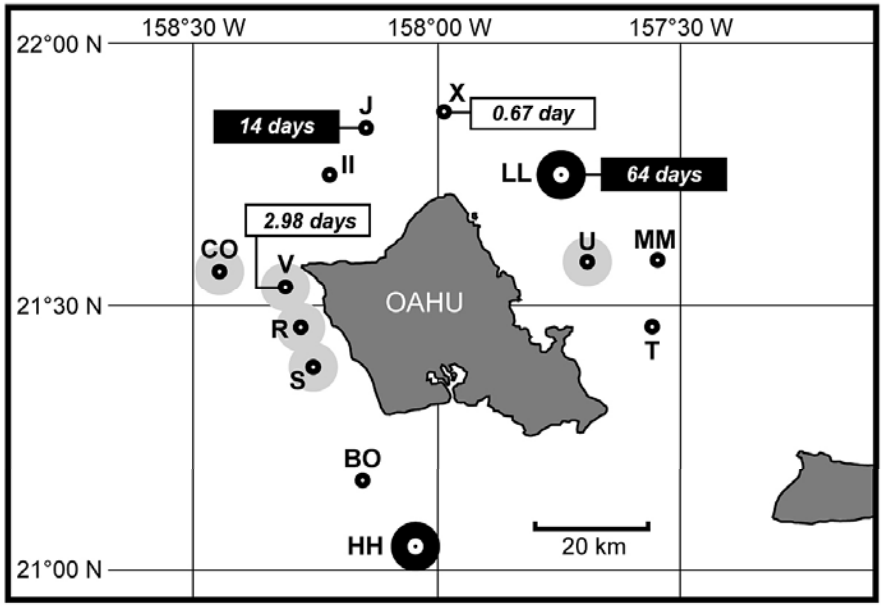
For a same time period (March-June 2003), distribution of residence times are different between distinct FADs of the network (FAD V and HH)

How to explain the existence of the distinct behavioral modes observed ?

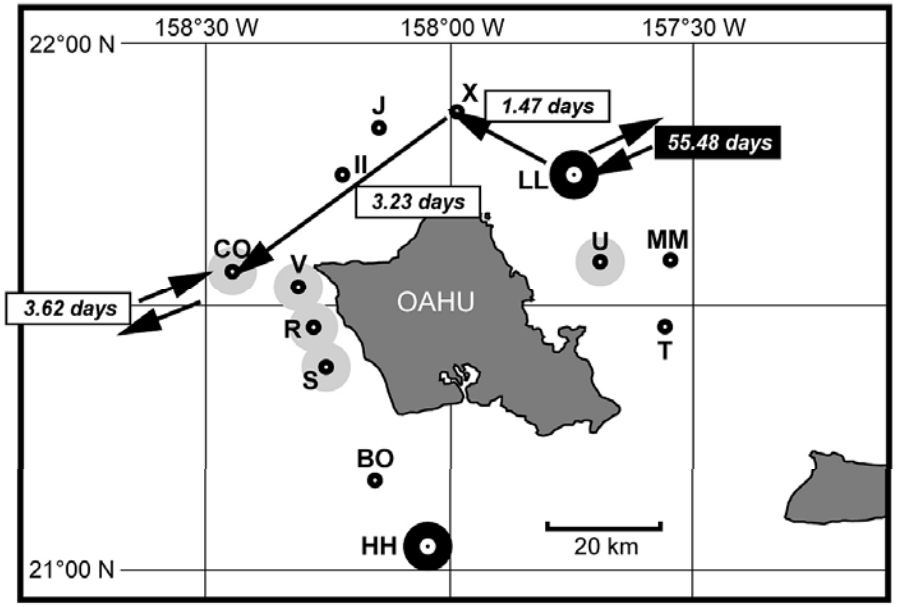
By the existence of distinct phenotypes within the population ? NO

=> 48% of the tagged tuna displayed both short and long residence times at FADs

(a)

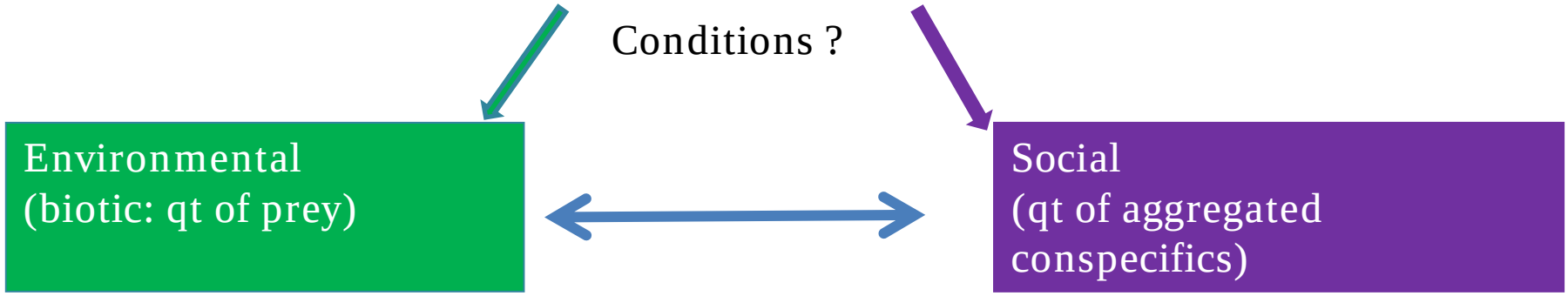


(b)



A same individual can display distinct behavioral mode while in a network of FADs

Hypothesis :
The conditions surrounding a FAD influence the duration of residency



Collection of simultaneous data is now required

=> Exhibit the need to develop new technologies

Our results question the ecological trap hypothesis

Ecological trap hypothesis implies that

> tuna has the same probability of associating with a FAD irrespective of the quality of the surrounding oceanic environment
>
> As such if FADs are embedded in a poor habitat they could have deleterious impacts on fish that remain associated with them Marsac et al 2000; Hallier and Gaertner 2008

However, our results show that a tuna's response to a FAD is not constant (intra-individual behavioral variability) and depends on local conditions

=> challenging the common hypothesis of a single behavioral pattern exhibited by tuna when associated with a network of FADs