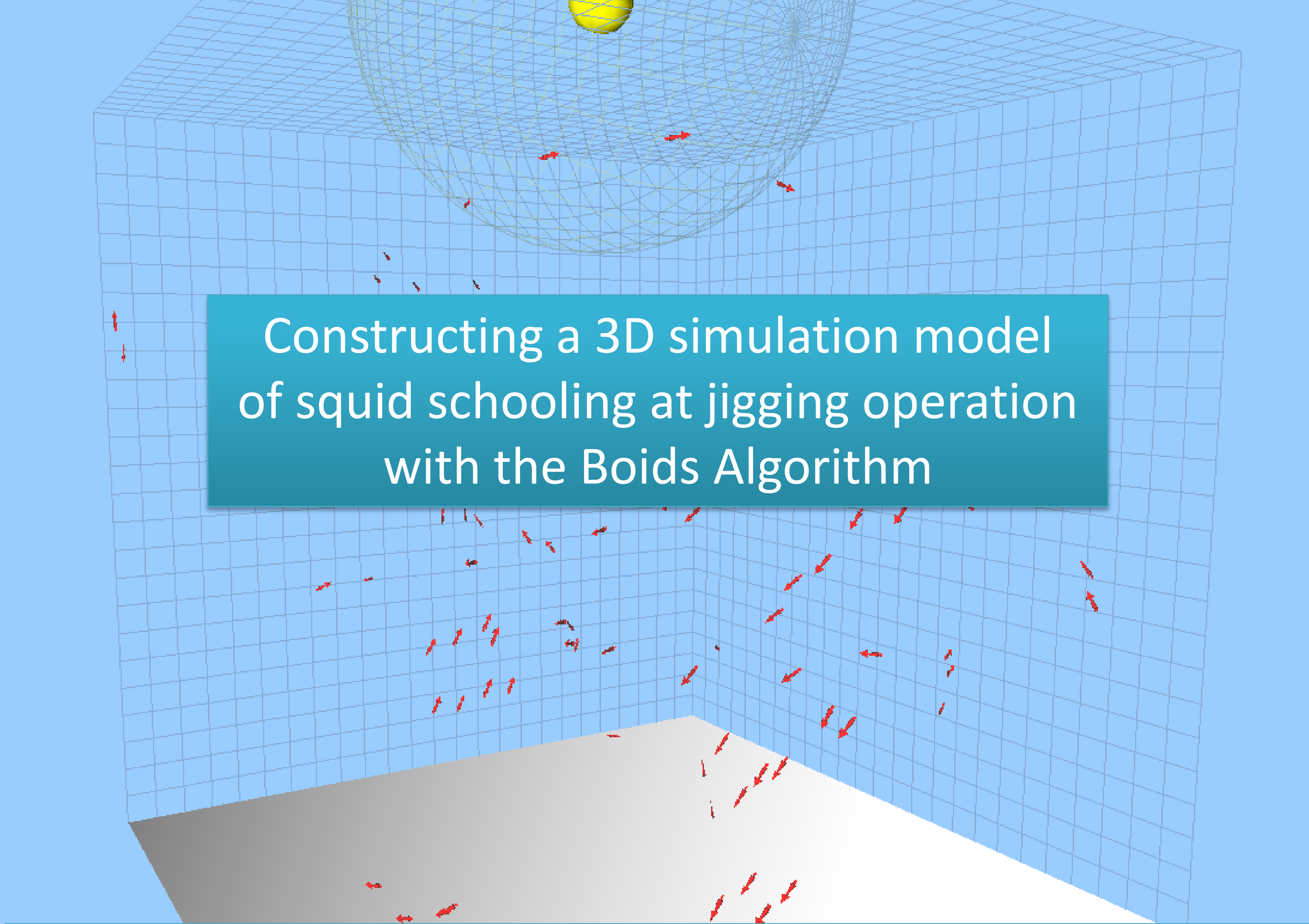


Constructing a 3D simulation model of squid schooling at jigging operation with the Boids Algorithm

○Osamu Tamaru, Go Takayama, Hideo Takahara and Toshihiro Watanabe (FRA)

Outline of this presentation

Background / Purpose

Methods - Squid jigging simulation

Results – Movie of the simulation

Discussion - Verifying the simulation

Conclusion / Future works

Background

Field experiment	⟷	Tank experiment
Indirect (echo-sounder)	Observation	Direct (video camera, eyesight)
Same	Action	Different
To observe conditions is difficult	Condition	To set condition is difficult

(Shaded box) means demerit

Results from these 2 types of EXP are sometimes different.

Why simulation?

Field EXP

Operating conditions fluctuate from hour to hour.

➡ To clear up the reasons of catch fluctuation is difficult.

Tank EXP

Squids action is not the same

➡ To make use of the results at R&D of fishing-lamps is difficult.

Simulation

We can set conditions freely and the results are visible.

Purpose

To construct 3D simulation model of squid schooling behavior at squid jigging operations

Overall of the Squid Jigging fisheries Simulation

Individual Squid SIM

Squid Schooling SIM
(with the Boids Algorithm)

Squid Jigging SIM

Obtain parameters from Tank EXPs

Underwater Light Condition SIM
(with the Snell's Law)

Fisheries Management SIM

- Economical ship speed
- Performance requirement of LED fish-lamps

Squid Trade Price SIM

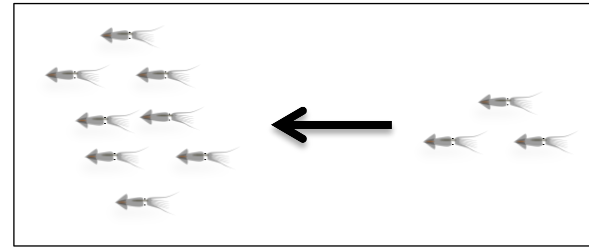
Process of squid jigging operation

Far
(over 1mile)

Near
(50m)

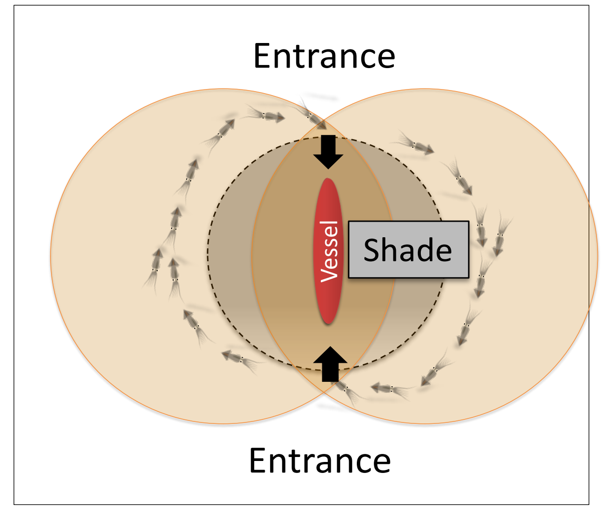
Under Vessel
(0m)

Fishing-lamps attract squids



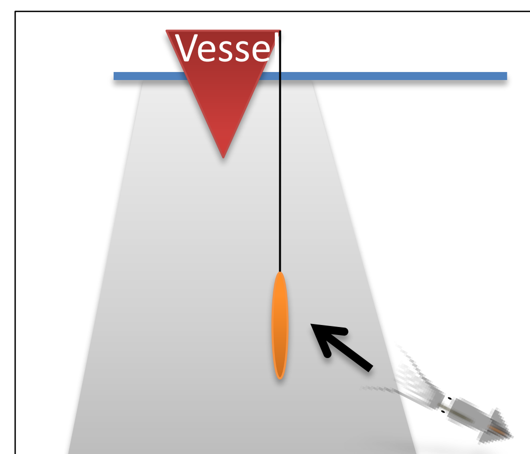
Make school

Make a round of the vessel



Enter the shade area

Attack jigging hooks



Be caught!

Schooling behavior

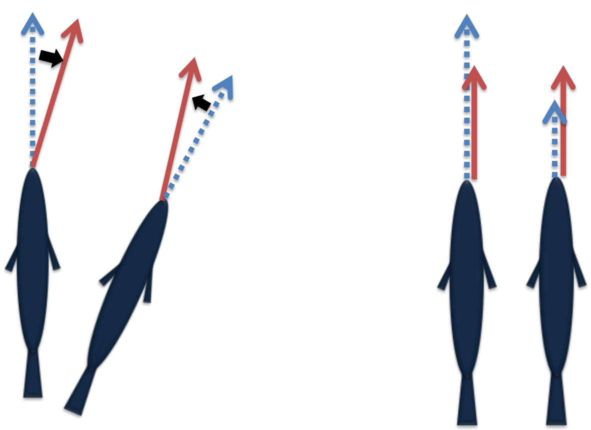
Fish makes their school with rules such as **no leader**, **parallel-orientation**, **speed adjusting** and **holding individual distance**.

（Shaw 1978）

Boids Algorithm

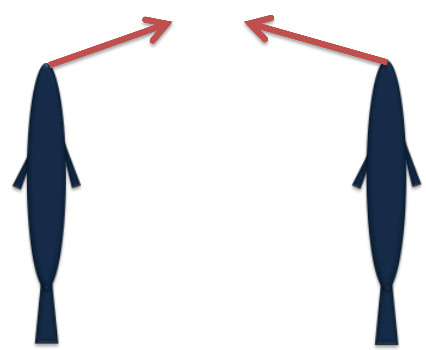
Schooling Algorithm developed by Craig Reynolds

1. Alignment

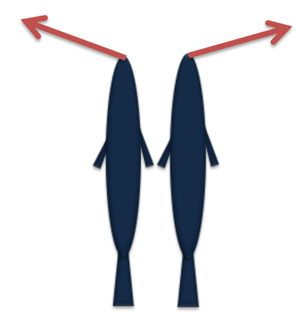


same direction　　same speed

2. Cohesion



3. Separation



Same individual distance

Reaction toward light and hook of Japanese common squid

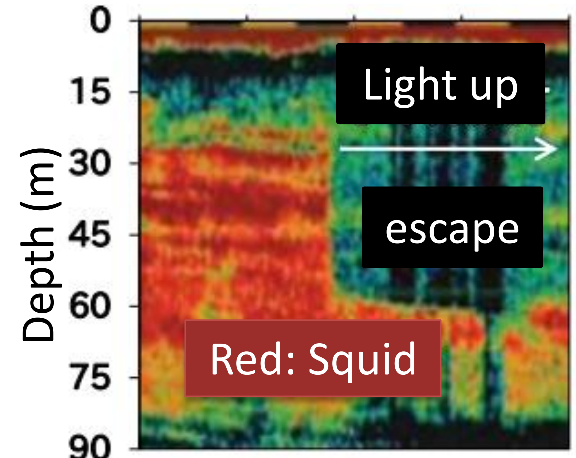
Toward lights

1. Be attracted by fishing-lamps, from over 1 mile
   (Tank and field EXPs) (Pinger data)

2. Escape from high light intensity area (Field and Tank EXPs)

3. Locate a boundary area between shade and bright
   (Tank Exps)

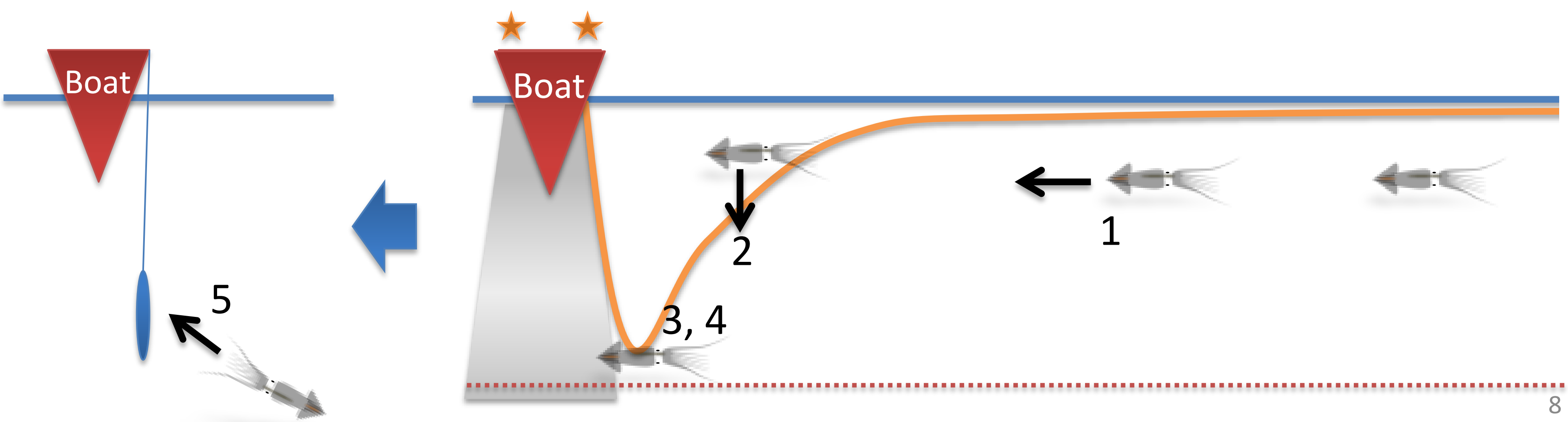
4. Move to a place they can directly see the light source
   (Tank Exps)



(Shikata 2013)

Toward jigging hooks

5. Chase jigging hooks (Fish finder data)



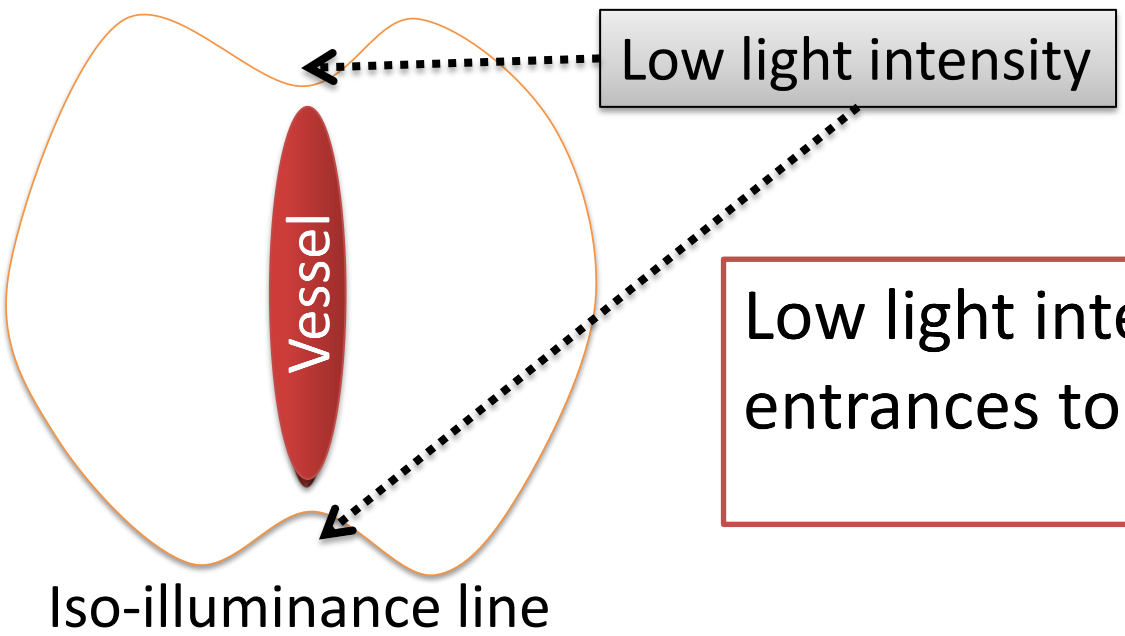
Behavior around a jigging vessel

Make a round of a vessel (sonar data)

Enter an area under a vessel from stem and stern of a vessel (sonar data)

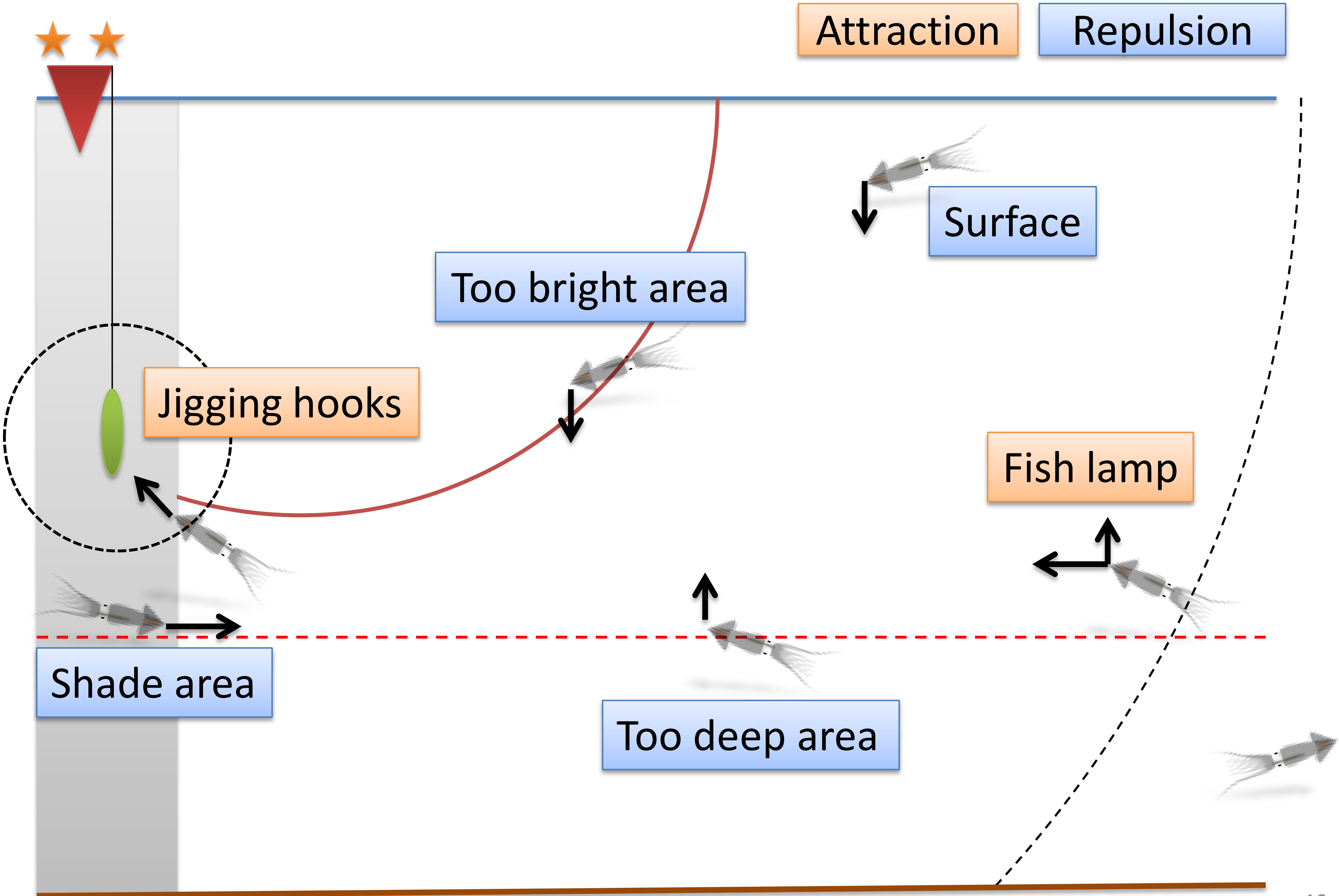
Light intensity of stem and stern area are low (Illuminomater data)

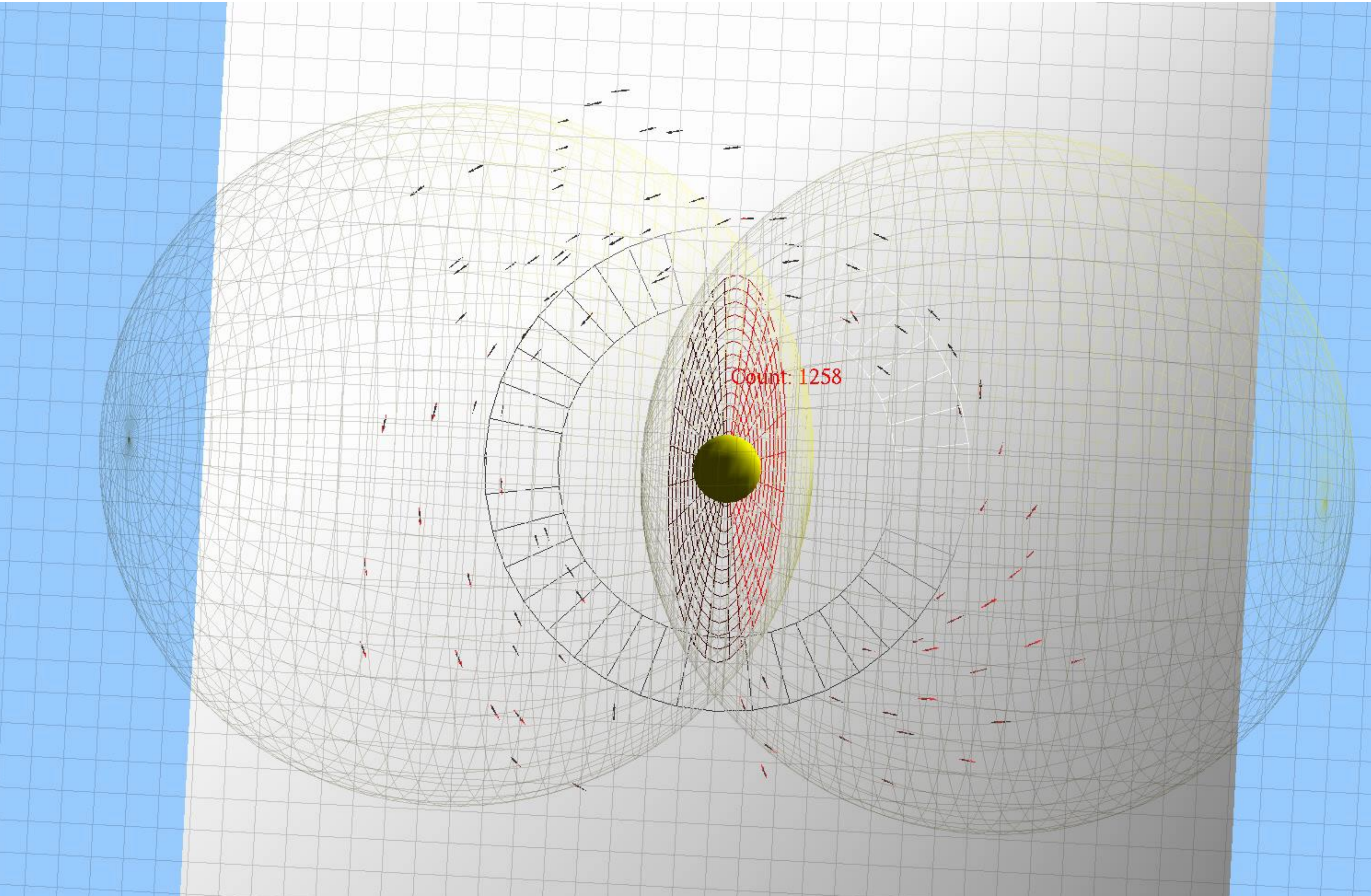
Jigging machines placed stem and stern begin to catch (Field Exps)



Low light intensity areas are entrances to under-vessel area.
(Shikata et al. 2011)

Flow chart of the squid's actions in the simulation

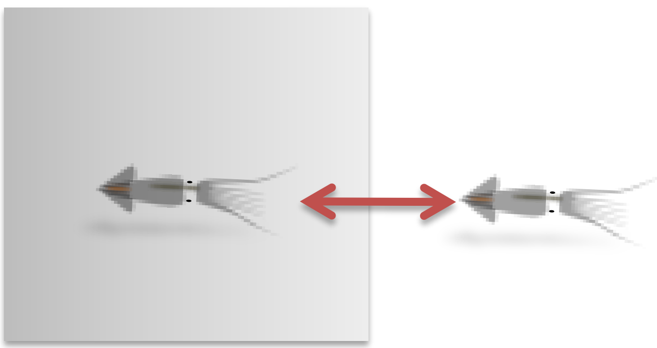



Count: 1258

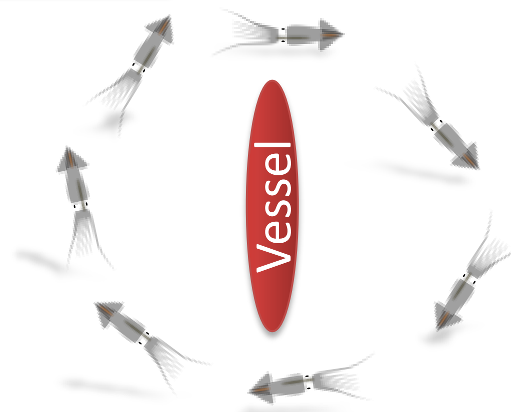
Verifying the simulation results

1. Compare to results of simulation and 2 types of experiments

Tank EXP — Locate a boundary area

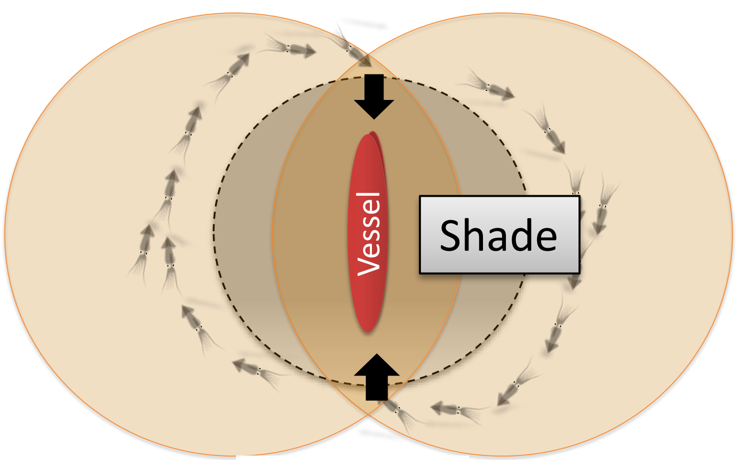


Field EXP — Make a round of boat



2. Compare to jigging process of simulation and field experiment

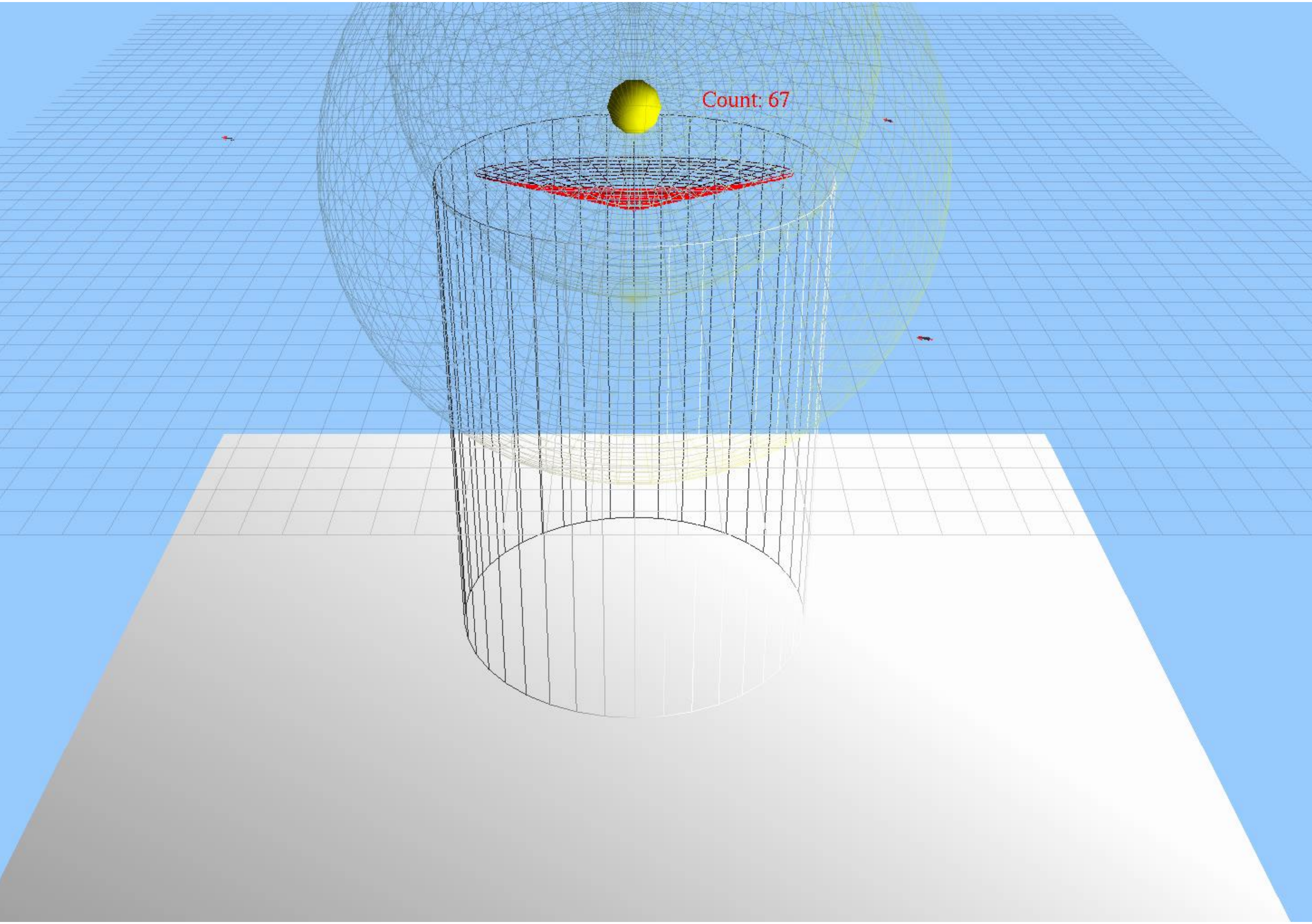
Entrance

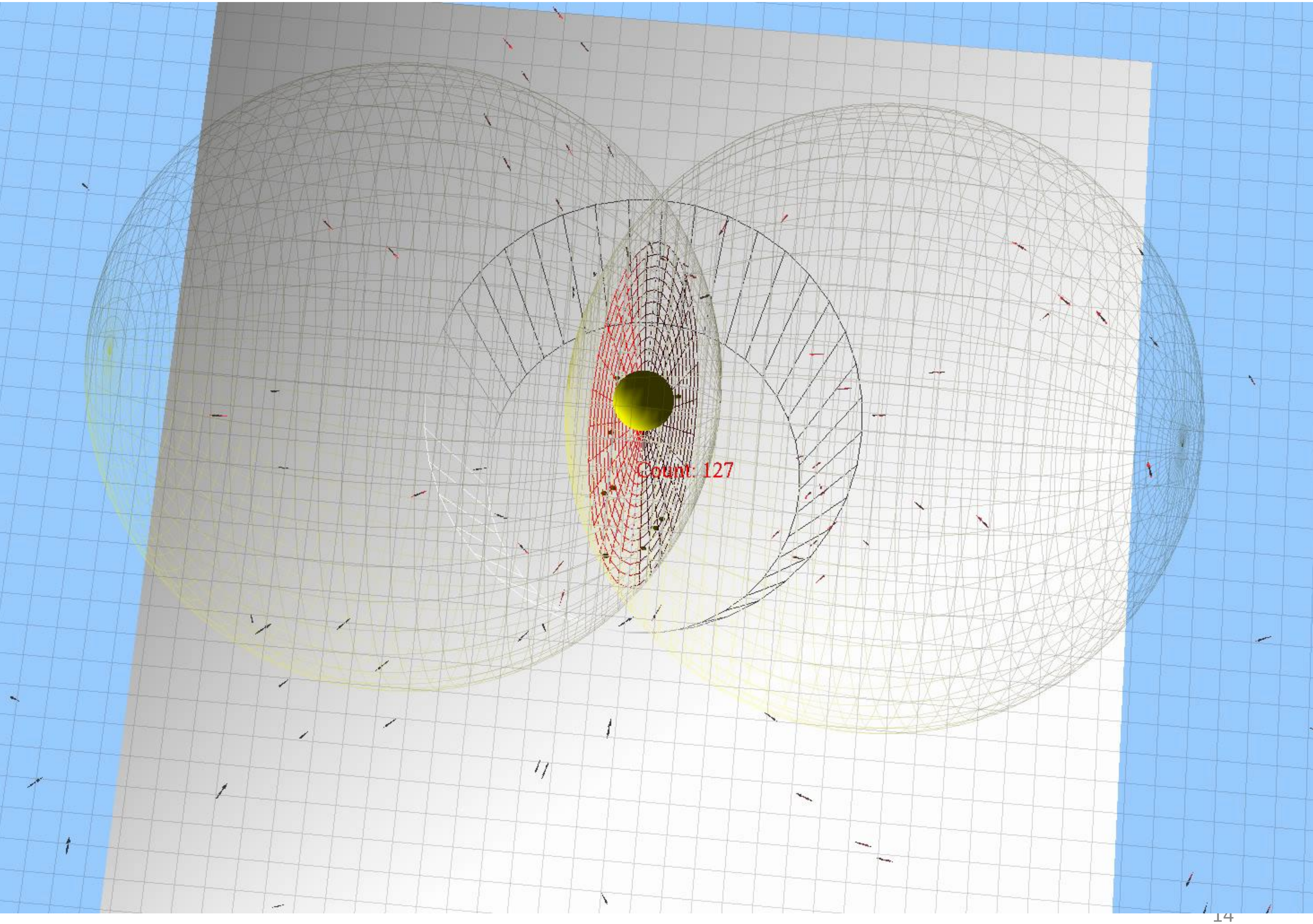


Entrance

Enter under vessel area from stem and stern of a vessel or NOT

Jigging machines at stem and stern tend to begin to catch at first or NOT


Count: 67


Count: 127

Conclusion

The simulation results are same as the results of 2 types of experiment.

➡ Differences of results of field and tank EXPs are due to difference of individual reaction and schooling behavior.

Shade areas on the stem and stern are entrances to under vessel area.

➡ Designing better shade area makes squid catch larger

This simulation model is useful in designing fishing-lamps.

Future works

Survey for obtaining other parameters

Verify the simulation results in other situations