On possible uses of Spinosaurus' sail

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The spinosaurus sail has always been a bit of a mistery, from thermal regulation, to fat storage, to mate signalling and individuals recognition it has always been a debated topic.
In this paper i am going to analyze two additional ways spinosaurus could have used its sail for its own benefit: luring and trapping.

Note that i'll use the term sail even if it was a hump as many suggest. The same conclusions can be inferred in the case of a hump nonetheless.

Swimming Spinosaurus life restoration[1]

We can see from this reconstruction[2] how tall the sail is in its highest point and how tall overall the spinosaurus would have been while swiming. Also notice the position of nostrils not at the tip of the snout.

1. Luring

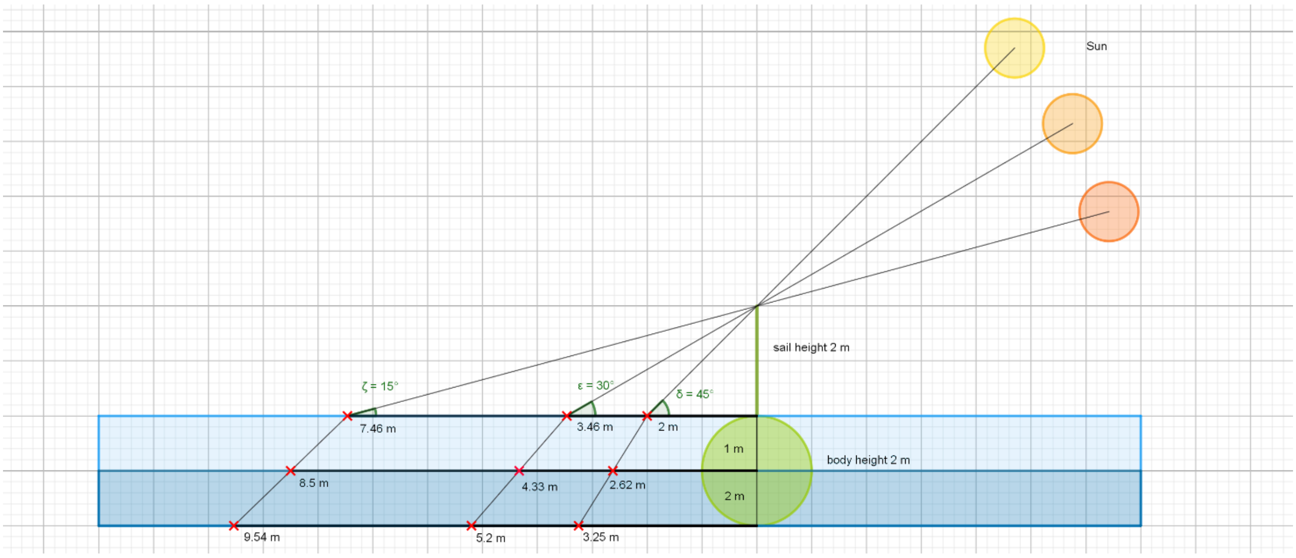
Spinosaurus Aegyptiacus could have used its sail to cast long shadows in the water, aligning its sail properly towards the sun. This would prove especially effective at dawn or sunset, when shadows are quite elongated. The shadow would become a lure for fishes that would try to find repair in it.
This method is inspired by the way the black heron (Egretta Ardesiaca) uses its wings to cast shadows in the water and lure prey in.

Black Heron (Egretta Ardesiaca) hunting [3]

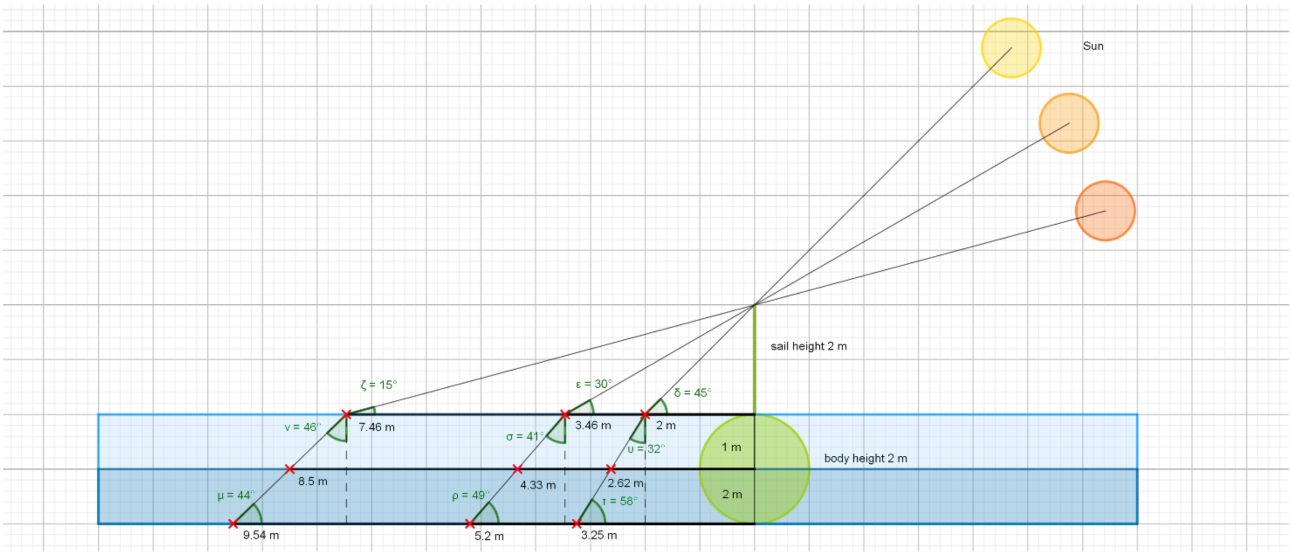
This method of hunting would save a lot of energy and would also allow the spinosaurus aegyptiacus to let the sail exposed to the sun, warming its body even if it wasn't its primary function. After all the times we will take in consideration as said previously are dawn and sunset, so an additional heat input could've been beneficial to the dinosaur.
The method proposed is the following:

- The spinosaurus stands still, floating or resting on its arms and legs while in water, depending on the specific situation. The head is probably out of the water or partially submerged, with nostrils and eyes outside of the water, looking in it. (Again notice the position of the nostrils not towards the snout, it may hint at a swimming or waiting posture with the eyes and nostrils outside, the water while the snout was probably already submerged, to close distances).
- A fish hides in its shadow, looking for safety or to prepare an ambush to its prey.
- The spinosaur notices it and strikes, taking advantage of the short distance between itself and the prey.

With a sail 2 metres tall and 3 metres wide the shadow casted with the sun at an height of 45° on the horizon would be aproximately a 2 metres x 3 metres rectangle, but at 30° it would become a 3,46 metres x 3 metres rectangle and at 15° a 7.46 metres x 3 metres rectangle. More than enough to fit a slightly large onchopristis.



In this image (made with GeoGebra) we can see different lenghts of the shadow casted by the sail of a spinosaurus at different times and at different depths. The refraction phenomenon is taken into account when determining the shadows in the water.

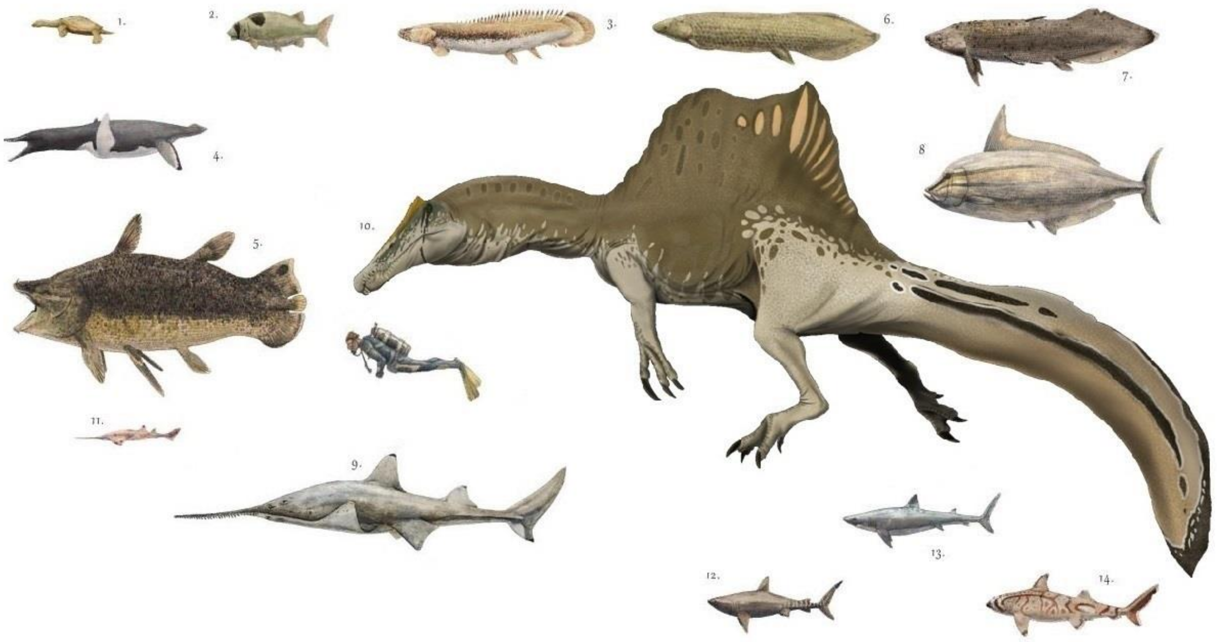


The angles ν, σ, υ have been calculated using the Snell's law, for example in the case of ν:

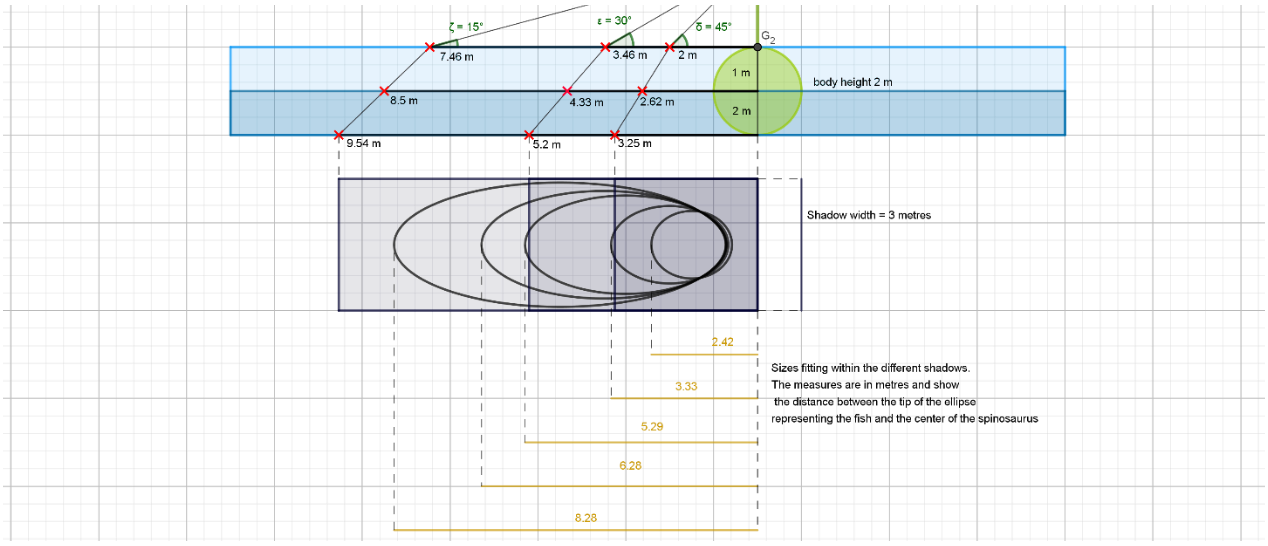
$$sin(\nu) = \frac{n_1 * sin(\zeta)}{n_2}$$

Where n_1 is the refractive index for air equal to 1.00 and n_2 is the refractive index for water equal to 1.33.

The same la wis used for the other two angles.



Notice the size of the spinosaurus and of other animals that lived in its environment [3] and that probably were part of its diet. Almost all of them fit easily inside the area of the sail and therefore would fit without problems in the shadow projected by it as the next image shows.

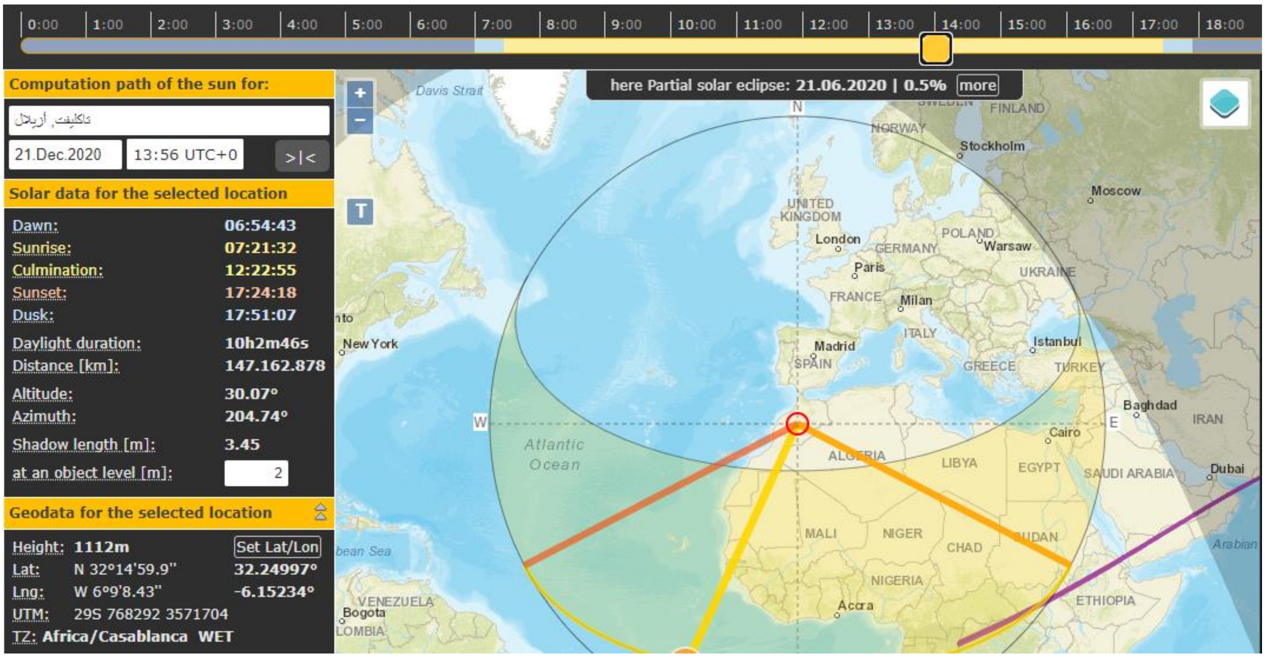


I showed the distance from the spinosaurus body because it is relevant for the purpose of it being able to more easily lunge to catch the fish. Especially with the 15° altitude of the sun we can notice how much space there is for even a large prey to hide in.

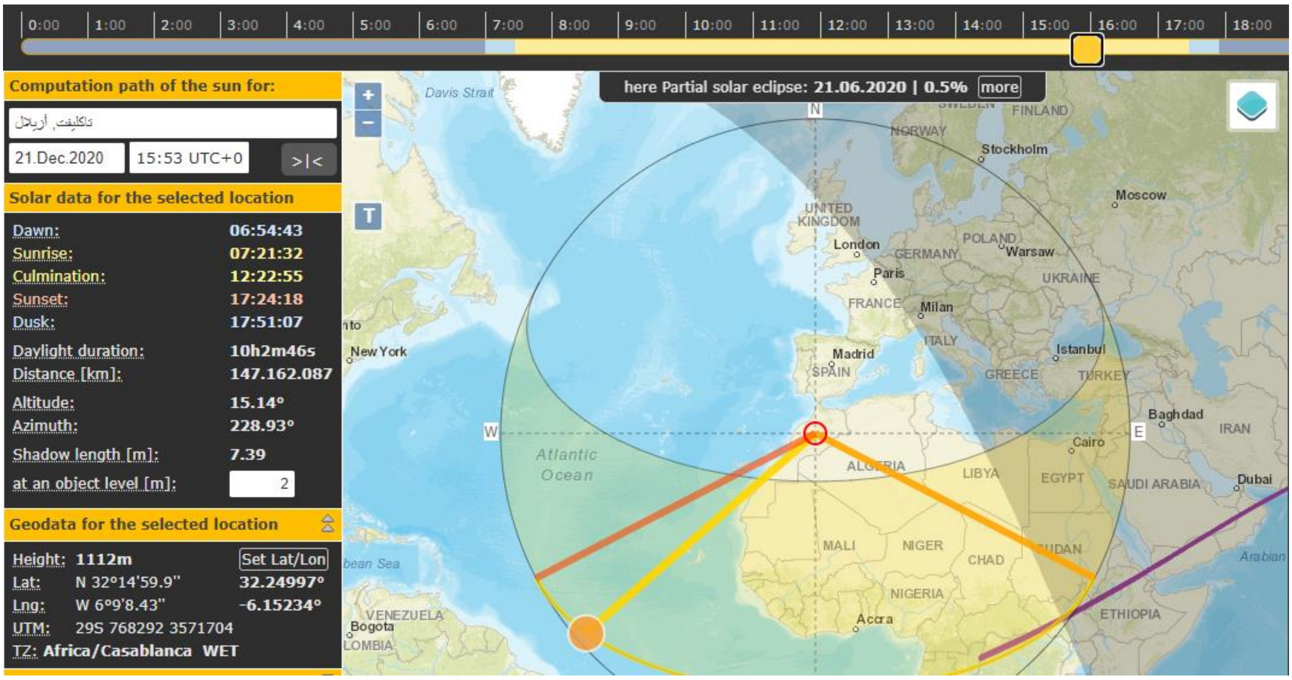
It should be noted that at such an hour the smaller fishes could hide further away from the spinosaurus, instead that occupying the portion of space closer to it.

The angle of 15° is obtained around one hour before the sunset, but the 30 ° one is reached much before, around 3 hours before. And of course there are other 3 hours after dawn to take into account.

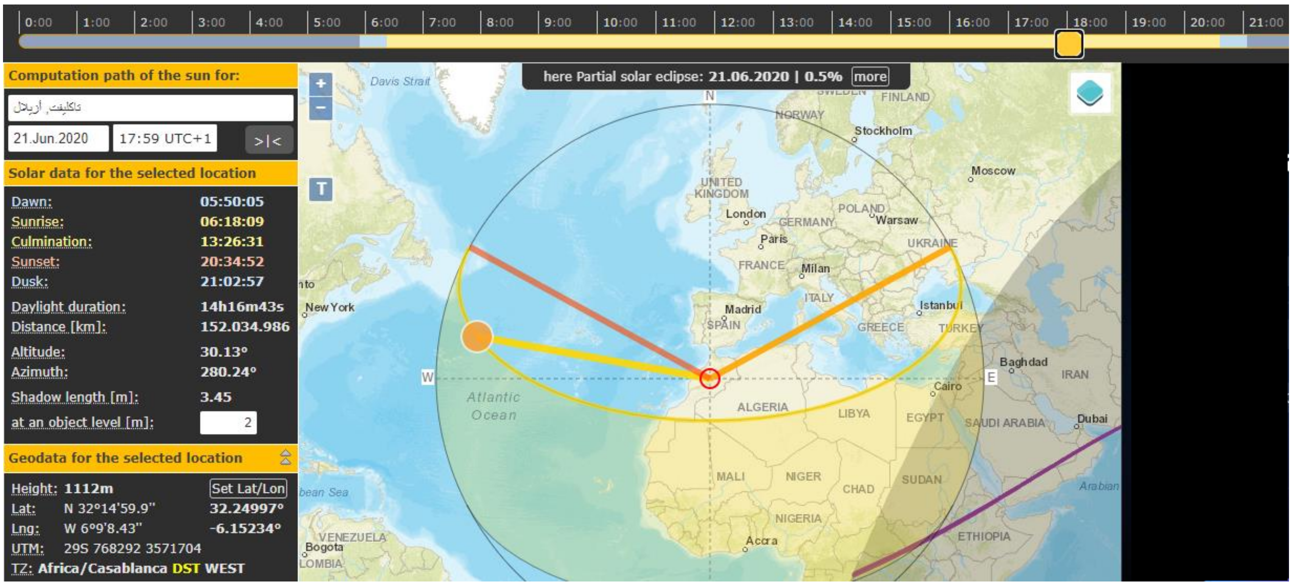
This gives an application time for this hunting strategy of 6 hours per day, that is $\frac{6}{24} = \frac{1}{4}$ of the day and around one half – one third of daytime.



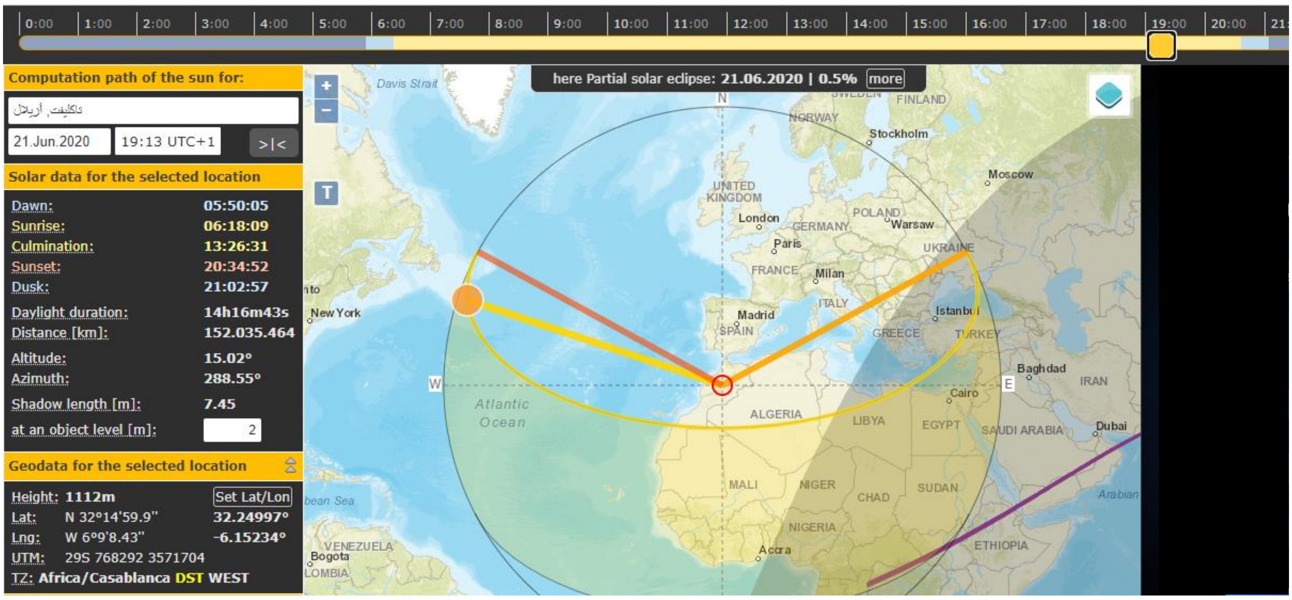
Sun altitude at 13:56 UTC the 21 December (www.suncalc.org)



Sun altitude at 15:53 UTC the 21 December (www.suncalc.org)



Sun altitude at 17:59 UTC the 21 June (www.suncalc.org)



Sun altitude at 19:13 UTC the 21 June (www.suncalc.org)

In these images we can see the altitude of the sun expressed in degrees on the left. I picked a location in nowadays Morocco during the winter solstice and the summer solstice.

Such location wasn't at an higher latitude than nowadays, while other locations were closer to the equator 110 millions of years ago. Nonetheless closer to the equator a location is, longer the daytime during the year is, therefore we don't have to further analyze more datas about other locations, because we can already enstablish that in case the spinosaurus would have benefitted from more hours of daylight and an increase in opportunities to use the sail to lure the prey.

2. Trapping

Sailfishes (Istiophorus) use their dorsal fin to hunt. They keep it raised when they are close to the school of fish they are predating because it allows for sharper turns and increases their agility in the quick movements required to snag the single individuars.

The dorsal fin of a sailfish (Istiophorus) allows for sharp and fast maneuvers.[5]

But they also keep it raised to push the fish towards the surface and to not allow any escape over their back. In this sense the sai lis a barrier that increases the space occupied by the fish and allows the sailfish to direct the school it is attacking where it wants it, to the surface, where it can't escape anymore.

Sailfish blocking the path of a school of fishes.[6]

It is proposed here that the Spinosaurus could do the same, thanks to its long and tall tail and especially its tall sail it could easily force its prey in a ball of food (in the case of many smaller fishes) or just trap it while trying to bite it successfully. Other than the sail we have to consider the height of the body of spinosaurus, that is around the same height of the sail, so we reach an height slightly inferior than 4 meters [2], more than enough to deny the passage of middle to big sized fishes. This process would've been facilitated by the shallower waters where spinosaurus' prey lived in.

A variant

A variant of this predation technique could have been adopted in really shallow waters. The spinosaurus could confine the movements of its prey, cornering it in waters shallower and shallower, reducing its movements and its ability to escape, pushing it towards the land. It is known that fully aquatic animals, like orcas and dolphins do this, as well as seals and sea lions, so it is not that far-fetched to think that an animal like spinosaurus, that retained the ability to walk and move on land could adopt such an hunting strategy.

Two Galapagos sea lions “herding” a tuna towards land.[6]

Dolphins beaching themselves to catch fishes previously pushed towards land [7]

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3. Joschua Knüppe
4. Shawn Heinrichs
5. Pete Oxford
6. Tui De Roy, the tuna herders
7. BBC Earth: The Hunt, episode 4