Eastern Taiwan Strait *Sousa* Technical Advisory Working Group (ETSSTAWG)

Peer review 09-01:

"Does the proposed L-DEO seismic survey (US Federal Register 73(246) Dec 22 2008 p. 78294; planned for March –July 2009), in part to be carried out in the Eastern Taiwan Strait, present a risk to the Critically Endangered ETS Indo-Pacific humpback dolphins or other species?"

Eastern Taiwan Strait
Sousa Technical Advisory Working Group

Dr Peter S. Ross
Chairman, ETSSTAWG
PO Box 2429
Sidney BC V8L 3Y3
Canada

***Reviewer 1*:**

Activity in Question

As noted in the FR Notice[1], the National Marine Fisheries Service (NMFS) proposes to authorise, through an Incidental Harassment Authorization (IHA) pursuant to the Marine Mammal Protection Act (MMPA), L-DEO to incidentally take, by Level B harassment only, small numbers of marine mammals during the, incidental to conducting, a marine seismic survey, the Taiwan Integrated Geodynamics Research (TAIGER) survey, in Southeast (SE) Asia during March-July 2009.

The proposed survey will encompass the area 17 30'-26 30' N, 113 30'-126 E within the Exclusive Economic Zones (EEZ) of Taiwan and other nations, as well as on the high seas, between March 21 to July 14, 2009. The fourth leg around Taiwan is scheduled to occur from 21 June 14 July.

Important Note

It should be noted that, while LDEO are applying for the appropriate authorisation under US law, many seismic surveys are conducted in the Taiwan region every year without (to my knowledge) requesting IHAs. The actions of private O&G companies within the EEZ's of other countries is beyond the jusridiction of the MMPA, thus they need no such *U.S.* authorisations. However, this means that LDEO could become a scapegoat for all survey operation in the region, purely because they have to apply for authorization, as they will clearly be operating partly on the high seas (and thus fall under MMPA jurisdiction) and as they have government funding. This is acknowledged, but until such time as NMFS enforcement confirms the locations and tracks of every survey undertaken globally this situation is unlikely to change.

Questions to Raise

The Langseth will deploy an 8-km long streamer for most transects requiring a streamer; however, a shorter streamer (500 m to 2 km) will be used during surveys in Taiwan (Formosa) Strait (EA[2]). Do the effective source levels offered in the EA (259 dB re 1 μPa – m, with dominant frequencies at 2–188 Hz) pertain to the longer or shorted streamers? There are likely to be differences.

What is the frequency range of the PAM system? Is it suitable for detecting signals produce by all the marine mammals within the area?

[1] Federal Register Notice dated 22nd Dec 2008 - 2008 FR 73(246): 78294-78317
[2] LGL 2008. Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in Southeast Asia, March–July 2009

Have LDEO applied for the relevant permits and authorisations under the laws of the various countries where they will be conducting the survey.

General Comments

The lack of separate consideration of the genetically distinct Eastern Taiwan Strait (ETS) population of Sousa is, of course, a concern. One of the most effective ways to protect cetaceans and their habitat from the impacts of noise (and the cumulative and synergistic impacts in combination with other stressors) is through spatio-temporal restrictions, including marine protected areas (Weilgart, 2006).

There are a huge number of other threats facing this population[3], meaning that the potential for cumulative impacts equally huge and making the potential for non-linear synergistic impacts high. Given the above, and the fact that this genetically distinct population (somewhat akin to the Southern Resident killer whales) is small and probably declining, the part of the 4th leg running along the western coast of Taiwan should be removed from the survey.

Recent studies examining airgun noise have shown that, contrary to predictions, received levels can decrease between 5 km and 9 km, but then increase at distances between 9 km and 13 km (Madsen et al., 2006). The researchers stated that received levels "can be just as high at 12 km as they are at 2 km…beyond where visual observers on the source vessel can monitor effectively" (Madsen et al., 2006). Thus, no surveys should be conducted within at least 13 km and perhaps a more precautionary 15 km of the ETS Sousa population – meaning up to around 20 km from shore.

In short – despite a lack of data on the potential cumulative and synergistic impacts, the risk is high and the population is highly at risk, so the most precautionary measures are warranted.

Mitigation

The mitigation procedures offered (especially the use of visual detection at night) are known to be insufficient and ineffective. To make the most of the limited effectiveness, and thus offer the greatest protection, I recommend that:

1) surveys in the Taiwan Strait (and throughout the operation) shut down at night.
2) a minimum of two MMOs be used at all times, with one of those having considerable prior experience as a MMO (preferably within the area of Taiwan).
3) the MMO operating the PAM system (which should be in addition to the other two at all times) should have considerable experience working with the acoustic signals of many of the marine mammal taxa that are likely to be encountered in the survey.
4) the predicted protection ranges (AKA safety zones) should be confirmed in the field at each point in the survey that the bottom geography changes substantially. The results should be reported to NMFS immediately and safety zone sizes should be adjusted accordingly.
5) that the more precautionary 15 dB difference be employed in converting the SEL-based safety zones to SPL-based safety zones. (From the EA: "At the distances where rms levels are 160–190 dB re 1 μPa, the difference between the SEL and SPL values for the same pulse measured at the same location usually average ~10–15 dB, depending on the propagation characteristics of the location (Greene 1997; McCauley et al. 1998, 2000a; Appendix B). In this EA, we assume that rms pressure levels of received seismic pulses will be 10 dB higher than the SEL values predicted by L-DEO's model. Thus, we assume that 170 dB SEL ~ 180 dB re 1 μPa rms.") Thus 180 dB rms SPL would be reached with a SEL of 165 dB.

[3] The EA acknowledges this: "There are numerous threats to cetaceans in SE Asia including vessel traffic, habitat loss, oil and gas industry, pollution, fisheries, and hunting."

6) Since empirical data is not available for LDEO operations (and what is available at deep and shallow was from shorter arrays) in intermediate distances, the extrapolation in the EA ("On the expectation that results would be intermediate between those from shallow and deep water, a correction factor of 1.1 to 1.5x was applied to the estimates provided by the model for deep-water situations to obtain estimates for intermediate-depth sites.") should be much more precautionary. Perhaps a mean between the shallow and deep water ranges, rather than adjusted by the apparently arbitrary correction factor. See Table 1.
7) See also Weir & Dolman, 2007. (Note the EA states "However, currently the procedures are based on best practices noted by Pierson et al. (1998) and Weir and Dolman (2007)". However, this is clearly not the case since Weir and Dolman (2007) call for, among other things the avoidance of sensitive areas – e.g., the western Taiwan coastline; suspension of airgun use at night; and additional restrictions in adverse weather conditions. For example, the EA states that "when at all possible, seismic surveying will only take place at least 8–10 km from the Taiwanese coast, particularly the central western coast (~from Taixi to Tongshiao), to minimize the potential of exposing these threatened dolphins to SPLs >160 dB". The use of the term "when at all possible" is not reassuring.

Alternatives

It should be noted that, under the National Environmental Protection Act (NEPA), resources should not be committed until the EA/EIS process is complete. LGL admit that LDEO have done this within the EA "If the IHA is issued for another period, it could result in significant delay and disruption not only of the proposed cruise, but of subsequent geophysical studies that are planned by L-DEO for 2009 and beyond."

Disturbance Reactions, Tolerance and Masking

The idea that behavioural tolerance is a proxy for no impact has no scientific merit. In fact, some fairly sizable impacts have been reported in various species despite a lack of behavioural response. A recent panel of experts also noted that an apparently unresponsive animal may still be undergoing a chronic and/or severe acute stress response, with associated physiological and psychological consequences. These can result from exposure directly, or through masking and other phenomenon indirectly. Thus, taking is entirely possible without observable behavioural disturbance reactions and this needs to be accounted for. For a discussion of this issue and reviews of the available literature, see Beale (2007), Bateson (2007), Wright et al. (2007 a,b) and refs therein).

Hearing Impairment and Other Physical Effects

The EA notes that Southall et al. (2007) stated that TTS is not injury. However I believe that they have overstated their conclusions. It is true that Southall et al. (2007) state: "[impacts resulting in]…TTS rather than a permanent change in hearing sensitivity…are within the nominal bounds of physiological variability and tolerance and do not represent physical injury (Ward, 1997)." However, they also note that "at present, however, there are insufficient data to allow formulation of quantitative criteria for non-auditory injuries" and later acknowledge that, while they believe that "strong behavioral responses to single pulses…are expected to dissipate rapidly enough as to have limited long-term consequence" there are occasions where such responses may "secondarily result in injury or death (e.g., stampeding)" (Southall et al. 2007).

Southall et al. (2007) also add the following caveat with regards to their report:

> *Finally, we emphasize that exposure criteria for single individuals and relatively short-term (not chronic) exposure events, as discussed here, are insufficient to describe the cumulative and ecosystem-level effects likely to result from repeated and/or sustained human input of sound into the marine environment and from potential interactions with other stressors. Also, the injury*

criteria proposed here do not predict what may have been indirect injury from acoustic exposure in several cases where cetaceans of mass stranded following exposure to mid-frequency military sonars.

Thus, since they did not attempt to consider all possible methods of injury in their deliberations and thus their final figures, they should not be directly applied to management decisions that must, by law, consider the full suite of potential impacts. Direct application of their criteria would thus not be precautionary enough to meet the required legal standards.

In any case, it should be noted that repeated TTS can lead eventually lead to PTS, which would not be classed as injury under these criteria. Other potentially injurious impacts have also been shown to occur below levels that would cause TTS in humans. For example, impaired reading comprehension and recognition memory in children is linked to aircraft noise at exposure levels considerably less than 75 dB (Stansfeld et al., 2005), which, according to the U.S. National Institute on Deafness and Other Communication Disorders (NIDCD), are unlikely to cause hearing loss (temporary or otherwise) even after long exposure (NIDCD, 2007).

Similarly, the EA noted that "captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2000, 2002, 2005). However, the animals tolerated high received levels of sound before exhibiting aversive behaviors."

It should be noted, however, that the animals in the abovementioned Navy studies (Finneran et al., 2000, 2002, 2005) were reported by Nowacek et al. (2007) to be generally "tested in a context where they were being rewarded for tolerating high levels of noise" and were "usually 'punished' in some way…for failing to return to the experimental station for additional exposures". This was not a problem for their main results as the focus of the work was on to TTS, but the setup does invalidate any conclusions base on the behavioural responses reported in the same studies. For further discussion of the need for precaution in the use of captive studies to set exposure criteria for wild animals, see Parsons et al. (2008) and Wright et al. (In Press).

Non-auditory Physiological Effects

It is strange that an entire special issue devoted to noise-related stress responses in marine mammals resulting from a multi-disciplinary panel of experts does not get a single mention in this section, even though a discussion of likely impacts is offered in Wright et al 2007a, b and the other papers within (all of which are cited therein). The papers are cited in Southall et al., 2007, which the authors have obviously read. I will not repeat the conclusions here, but suggest they are included within the EA (or more likely an EIS) before this survey goes forward.

Numbers of Marine Mammals that Could be "Taken by Harassment"

This will be largely dependent upon abundance and other factors I am not familiar with and so I have decided to leave this to those more familiar with the populations in the area. However, I will mention that, according to the tables within the EA, more Sousa will be impacted than there actually are Sousa in the area. I am unclear on how this meets the 'small number' criteria. This number would, of course, go up further if the distances reported by Madsen et al. (2006 – noted above) were taken into account. Of course, these distances would increase the take numbers for all animals in the area.

Indirect Effects on Marine Mammals, Sea Turtles, and Their Significance

The most comprehensive study undertaken on the impacts of seismic surveys on the fishing industry in Norway in 1996 showed that fishing catches were impacted to as far as 33 km from seismic testing[4]. I can only assume this is also not good for marine mammals who have a limited range, such as Sousa.

Cumulative Effects

The discussion of cumulative impacts in the EA is lacking. It often refers to behavioural tolerance, which has already been dismissed as an inappropriate metric above, and uncertainty in the level of impact. However, the EA does note that "Indo-Pacific humpback dolphin is unknown…may be particularly at risk" from habitat loss/destruction.

After detailing all the treats and outlining the uncertainties, the EA concludes that:

> *Because human activities in the area of the proposed seismic survey are high, additional impacts on marine mammals by the TAIGER seismic survey are expected to be no more than minor and short–term. Although the airgun sounds from the seismic survey will have higher source levels than do the sounds from most other human activities in the area, airgun operations will be intermittent during the program. In contrast, sounds from shipping have lower peak pressures but occur continuously over extended periods.*

Although this may appear logical, cumulative impacts do not work in this way. Any additional stressor may be the one that pushes the overall energetic demand beyond the capabilities of the animals involved. Similarly, the more stressors acting, the more likely synergistic impacts are. And finally, short-term stressors can lead to long-term impacts, especially in foetuses and newborns if they are exposed directly or through their mothers. It may well be that the small addition does not reach these physiological thresholds or lead to deleterious impacts as a result of synergism, but the argument that "it's only a little bit more – no-one will notice" is not a valid one.

These effects, and others, are outlined in Wright et al. (2007 a,b and references therein) and I ***strongly*** recommend NMFS consider those effects and the conclusions of the panel before accepting the IHA application and the EA upon which it is based.

Other Species

The impacts of masking (including the physiological and psychological consequences potentially resulting from masking) are likely to be greatest for baleen whales throughout the survey area. Pregnant females and/or newborns will be a greatest risk from exposure to stressors (see Wright et al. 2007a and references therein), so calving grounds at breeding season should be avoided.

According to the EA, the Multibeam Echosounder & Sub-bottom Profiler have outputs up to 204 dB re 1 µPa – m, at the dominant frequency of 3.5 kHz. This is perilously close to the US Navy's AN/SQS-53C tactical mid-frequency sonar system implicated in many of the mass strandings of beaked whales and other cetaceans, which produces 'pings' primarily in the 2.6–3.3 kHz range. Another LDEO survey has been associated with a stranding (as acknowledged in the EA: "…association of mass strandings of beaked whales with naval exercises and, in one case, an L-DEO seismic survey (Malakoff 2002)"). There may thus also be concern for beaked whales and other animals, because, while "[t]here is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys" (EA), there is also no conclusive evidence that seismic surveys *do not* lead to strandings or death either.

[4] The paper can be found in Norwegian at http://www.fiskeribladetfiskaren.no/filarkiv/vedlegg/96.pdf and there is an English summary around page 8.

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		190 dB			180 dB			170 dB			160 dB		
		LGL	Mean	% Mean larger than LGL	LGL	Mean	% Mean larger than LGL	LGL	Mean	% Mean larger than LGL	LGL	Mean	% Mean larger than LGL
Single Bolt airgun 40 in3	Deep	12			40			120			385		
	Int	18	81	450%	60	168	280%	180	310	172%	578	718	124%
	Shallow	150			296			500			1050		
36 airguns 6600 in3 6-7 deep	Deep	220			710			2100			4670		
	Int	330	910	276%	1065	1736	163%	3150	3877	123%	5189	5449	105%
	Shallow	1600			2761			5654			6227		
36 airguns 6600 in3 6-9 deep	Deep	300			950			2900			6000		
	int	450	1241	276%	1425	2322	163%	4350	5354	123%	6667	7000	105%
	Shallow	2182			3694			7808			8000		

Table 1. This illustrates the lack of precaution in the LGL extrapolations for the intermediate depths from their deep-water empirical data. If they were to take a mean of the data-supported ranges at which their signals reach certain dB levels shallow and deep water, the resulting ranges in intermediate depths would be substantially higher in most cases, especially at the higher levels of exposure.

Review 2:

It was with great concern that I read the proposal for extensive seismic survey off the coast of Taiwan by Lamont-Doherty Earth Observatory (**Federal Register** 73 (246) Monday, December 22, 2008 at p. **78294**).

The sounds produced by seismic surveys are the most intense of all anthropogenic sound sources and have been detected more 3000 miles (c. 5000 km) from their source (Nieukirk et al., 2004). Moreover, researchers trying to record cetaceans in the mid-Atlantic found that whale calls were frequently being smothered and "masked" by the high levels of continuous sound produced by these seismic surveys (Nieukirk et al., 2004). Clark and Gagnon (2006) also observed large scale effects, noting that observed that fin whales in the vicinity of seismic surveys cease vocalizing over spatial scales on the order of 10,000 nm^2 or greater. Animals have also been documented reacting to seismic surveys sounds; for example, sperm whales have been observed exhibiting a "startle" reaction 2 km away from a seismic survey vessel (Stone, 2003). McCauley and Duncan (2001) stated that airguns could elicit behavioural changes at a range measured in tens of km in blue whales and probable avoidance at 3-20 km. Miller et al. (1995) describe similar results for beluga whales and McCauley et al. (2000b) also discovered that humpback whales, off Exmouth, Australia, responded to seismic testing in various ways and at distances that were not observable from the survey vessel – females with calves were particularly sensitive and were reported to show aversive reactions at 7 to 12 km from seismic vessels (McCauley et al., 1998). The longest-term study of cetacean and seismic interactions began in the Alaskan Beaufort Sea in the 1980s. Data collected since then have shown that behavioural responses in bowhead whales, have occurred as far away as 30 km from the source (where received levels were 107-126 dB re 1 μPa rms; Richardson et al., 1999). Thus, there are numerous published studies showing impacts of seismic surveys on cetaceans at significanty distances from seismic vessels – greater that the distanced noted by the Federal register notice.

Moreover, recent studies on seismic survey sounds received by tagged whales have, however, altered our understanding of noise transmission in the sea as the received sound levels did not match predictions. (Madsen et al., 2006). In that case, sound levels from a seismic survey decreased between 5 km and 9 km from the sound source, but then *increased* at distances between 9 km and 13 km (Madsen et al., 2006). The researchers stated that sperm whales in the Gulf of Mexico "could be impacted at ranges of more than 10 km from seismic survey vessels" (Madsen et al., 2006, p. 2376.) and impacts would occur "beyond where visual observers on the source vessel can monitor effectively" (Madsen et al., 2006, p. 2376) It was also assumed that the seismic source only emitted low frequency pulses, however evidence demonstrates that air-gun arrays can generate significant sound energy at frequencies many octaves higher than the frequencies of interest for seismic exploration, which increases concern of the potential impact on odontocetes hearing at higher frequencies. (Madsen et al., 2006).

There are substantive populations of beaked whales off the coast of Taiwan, and these animals are known to be particularly susceptible to acoustic disturbance: there have been numerous strandings of these animals associated with high intensity noise events coupled with symptomatic emboli and lesions similar to those produced during decompression sickness (see Parsons et al., 2008 for a review). It is now widely believed that these stranding events are the result of behavioural responses to sound (i.e. surfacing too rapidly, or being forced to stay near the surface; see Cox et al., 2006) that can occur as exposure levels far below those levels that can cause acoustic injury such as temporary and permanent (TTS & PTS) threshold shifts, with strandings in the Bahamas being believed to have been the result of received levels of sound of 145-155 dB (see Parsons et al., 2008 for a review). Thus, at least for beaked whales, 180 or 190 dB exposure levels would be inappropriate safety guideline levels.

Seismic surveys have been linked to several whale stranding events. For example, in 2002, two Cuvier's beaked whales stranded on the Isla San Jose (Gulf of California, Mexico) coincident with seismic surveys from the research vessel Lamont-Doherty Earth Observatory Maurice Ewing (Malakoff, 2002) although there is as yet no scientific confirmation of this. It has also been speculated by scientists that seismic surveys have caused cetacean strandings in other areas, such as the Galápagos Islands (Palacios et al., 2004). Scientists did find, however, that cetacean diversity off the coast of Brazil dropped from 1994 to 2004, with a conspicuous decrease in 2000-2001 when there were a greater number of seismic surveys (Parente et al., 2007). Other oceanographic parameters such seawater temperature, salinity and density, showed no relationship to the decline, and thus weren't considered a factor in the decrease of species; seismic surveys were the most likely factor (Parente et al., 2007).

Marine mammals aren't the only marine life affected by seismic surveys. Norway's Institute of Marine Research showed that trawl catch rates of haddock and cod fell by 45-70% over a 2,000 square mile area, while seismic surveys were being conducted (Engas et al., 1993). Caged squid, fish and turtles have all shown an alarm response, avoidance and altered behaviour in seismic experiments (McCauley et al., 2000). Seismic survey sounds can also cause significant damage to fish hearing structures (McCauley et al., 2003). Furthermore, unusual numbers of giant squid were found dead and stranded on beaches at the same time seismic surveys were being conducted in the Bay of Biscay (MacKenzie, 2004). Thus, the impacts of seismic surveys may ultimately be found to be more extensive than previously thought on potential prey species of cetaceans and commercial fisheries – a major industry off the coast of Taiwan.

Moreover, I believe proposed mitigation measures to be insufficient. For example, for the visual survey methodology proposed, although there will be three marine mammal visual observers on board, at most times there will only be one present. Dedicated cetacean surveys usually use two teams of two to three observers who survey the sea simultaneously – and still animals are not observed (hence the need for the g0 calculation – the likelihood that animals would be observed under a set of environmental conditions when directly in front of a survey vessel, in order to estimate missed animals). Thus, the number of MMOs should be increased and a maximum length for observer shifts should be reduced from 4 to 2 hours to prevent observer fatigue.

There is no consideration of factors which effect visibility and the likelihood of cetacean detection, for example fog, rain or rough seas. Scientific surveys for cetaceans are often not conducted in sea states greater than Beaufort 3 or 5, depending on the study species, as rough weather severely reduces the ability to see cetaceans. Further, there are no prohibitions on conducting seismic surveys at night, when visual surveys are almost completely useless - even the use of night-vision glasses is rendered ineffective by lights on board seismic survey vessels At a minimum, when relying on observers as a mitigation measure in sea states greater than Beaufort 5, during fog or heavy precipitation, or at night, cetaceans may well be in the zone of impact despite having visual observers present, and thus animals cannot be protected from seismic survey noise during these conditions. Moreover, in areas where beaked whales are likely to be encountered (e.g. canyons and continental shelf edges) the likelihood of sighting animals even though they are present is extremely low. US government scientists have noted that the probability of observers actually sighting a beaked whale in the zone of acoustic impact is generally less than 1% (Barlow & Gisiner, 2006), even in the best conditions, with virtually a zero chance of detection beyond 1km or less than perfect conditions. This makes visual surveys for such acoustically vulnerable, deep-diving species largely ineffective. Thus, encroachment of seismic surveys sounds should be avoided in all likely beaked whale habitat.

Appropriate experience is an important criterion in the selection of visual observers, as shown by the British government's own research (Stone, 2003). When marine mammals were detected within the 500 m zone of impact by dedicated, experienced MMOs, the guidelines were followed and the survey was delayed 70% of the time. This figure fell to 0% when non dedicated, inexperienced observers or ship's crew were used (Stone, 2003). Thus, any visual observers should have multiple years of cetacean observation experience, ideally with cetaceans from SE Asia, in conditions similar to those off the coast of Taiwan.

PAM has great potential for detecting cetacean species that vocalise frequently such as sperm whales, which would reduce a number of the concerns noted above for visual surveys. However, PAM can only detect cetaceans when they vocalise and no species vocalises constantly (Gordon & Tyack, 2002). One study on common dolphins in the UK showed that although vocalisation rates were relatively high at night, they decreased for portions of the day (Wakefield, 2001).

Also, anthropogenic sounds have, on occasion, been shown to cause cetaceans to cease vocalising. For example, as noted above, fin whales ceased all vocalisation during seismic surveys and did not resume vocalising for hours or days afterward (Clark & Gagnon, 2006). Sperm whales have also decreased vocalisations or become completely silent in response to seismic surveys (IWC, 2007), as well as in the presence of pinger sounds (Watkins & Schevill, 1975), mid-frequency military sonar signals (Watkins et al., 1985), and low-frequency anthropogenic sounds (Bowles et al., 1994). Nevertheless, real-time PAM should be used in conjunction with visual observation, to maximize the probability of detection.

In summary, based on the best available science, the safety distances and mitigation measures proposed cannot guarantee that cetaceans will not be impacted by seismic surveys, and the number of takes would likely be much greater than those proposed in the Federal Register notice. Several important and key studies related to seismic survey impacts and the impacts of noise on cetaceans have not been mentioned in the FR notice, showing at best incomplete research, and at worst selective use of published scientific data. In particular, beaked whales could likely be impacted more heavily than stated. The most effective mitigation measure for these animals would be spatial exclusion zones in important habitats, which are not esonified by seismic surveys.

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