生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	用口哨彌補水下的聲音失真 (Whistles Compensate for Underwater Sound Distortion)
生物系統 LIVING SYSTEM	哺乳動物(Mammals)
功能類別 FUNCTIONS	#傳送聲音訊號 #來自環境的感覺聲音和其他震動 #協調活動 #在同一物種內合作 #Send Sound Signals #Sense Sound and Other Vibrations From the Environment #Coordinate Activities #Cooperate Within the Same Species
作用機制標題	海豚發出寬頻口哨聲和咔嗒聲以防止資訊在水下被扭曲。 (Dolphins send out broadband whistles and bursts of clicks to prevent messages from being distorted underwater.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 

作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

當人類透過將空氣推過我們喉嚨中的振動組織來產生聲音時，海豚的鼻腔通道中有振動組織，稱為“聲音嘴脣”。 他們發出的聲音通常分為三類：口哨、咔嗒聲和脈衝爆（快速串咔嗒聲）。 點選主要用於回聲定位和狩獵，頻率範圍狹窄。 口哨和突發脈衝更多地用於海豚之間的通訊，跨越了廣泛的頻率，從低到高，甚至在人類聽力範圍之外。 這些口哨和突發脈搏的“寬頻”性質實際上有助於確保海豚的資訊在傳遞給預期收件人時不會被扭曲。

假設你是一隻在淺水的原始水域游泳的海豚，試圖向海豚同伴傳遞食物位置的訊號。 你發出一個聲音，一個在水中傳播的波浪，可以被你的同齡人拾起。 然而，你發出的聲波會向各個方向傳播：它也會傳播到水面和海底，從兩者身上彈開，最終與波浪的其他部分碰撞。 這被稱為干擾，它只是任何試圖理解水下聲音訊號的生物體所面臨的眾多問題之一。 然而，研究人員證實，寬頻訊號彌補了這種干擾。 如果訊號的一部分在一個頻率上受到干擾，它仍然可能在另一個頻率上透過，並且整個訊息可以在不扭曲意義的情況下傳輸。

While humans produce sound by pushing air past vibrating tissues in our throat, dolphins have vibrating tissues in their nasal passages, called “phonic lips.” The sounds they produce typically fall into three categories: whistles, clicks, and burst pulses (rapid series of clicks). Clicks are used mainly for echolocation and hunting, and span a narrow range of frequencies. Whistles and burst pulses are used more for communication between dolphins, and span a wide range of frequencies, low to high, even outside the range of human hearing. The “broadband” nature of these whistles

and burst pulses can actually help ensure a dolphin's message is not distorted as it travels to its intended recipient.

Suppose you're a dolphin swimming through shallow, pristine waters, trying to get a signal to a fellow dolphin about the location of food. You emit a sound, a wave that propagates through the water and can be picked up by your peer. However, the sound wave you emitted propagates in all directions: it also travels to the surface of the water and the ocean floor, bouncing off of both and eventually colliding with the other parts of the wave. This is called interference, and it is just one of many problems posed for any organism trying to make sense of a sound signal underwater. Researchers have confirmed, however, that broadband signals compensate for this interference. If a portion of a signal gets interfered with at one frequency, it may still get through at another, and a whole message can be transmitted without distortion of meaning.

文獻引用 (REFERENCES)

我們的結果顯示，這兩種海豚的口哨和突發脈衝比傳統上報道的海豚的頻率範圍更廣。雖然它們口哨的基本頻率輪廓主要出現在人類可聽的範圍內（通常假設），但它們的諧波通常達到 50 千赫及以上。 此外，牠們的突發脈衝訊號主要是超聲波訊號，通常能量很少或沒有低於 20 千赫。(美國聲學會雜誌 | Lammers, M. O.，Au，W. W., & Herzing, D.)

Our results reveal that the whistles and burst pulses of these two species of dolphin span a broader frequency range than is traditionally reported for delphinids. Although the fundamental frequency contours of their whistles occur mostly in the human-audible range (as is typically assumed), their harmonics routinely reach 50 kHz and beyond. In addition, their burst pulse signals are predominantly ultrasonic, often with little or no energy below 20 kHz.(The Journal of the Acoustical Society of America | Lammers, M. O., Au, W. W., & Herzing, D. L.)

參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**

Clicks, whistles and pulses: Passive and active signal use in dolphin communication

Acta Astronautica | Herzing, D. L.

https://www.researchgate.net/publication/273862693_Clicks_whistles_and_pulses_Passive_and_active_signal_use_in_dolphin_communication

The broadband social acoustic signaling behavior of spinner and spotted dolphins

The Journal of the Acoustical Society of America | Lammers, M. O., Au, W. W., & Herzing, D. L.

https://asa.scitation.org/doi/10.1121/1.1596173

Dolphin sounds-inspired covert underwater acoustic communication and micro-modem

Sensors | Qiao, G., Zhao, Y., Liu, S., & Bilal, M.
https://www.mdpi.com/1424-8220/17/11/2447

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