Smartphones and Digital Tablets: Emerging Tools for Fisheries Professionals

Lee F. G. Gutowsky

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, 1125 Colonel By Drive, Carleton University, Ottawa, ON, Canada, K1S 5B6. E-mail: leegutowsky@gmail.com

Jenilee Gobin

Environmental and Life Sciences Graduate Program, Trent University, Peterborough, ON, Canada

Nicholas J. Burnett, Jacqueline M. Chapman, Lauren J. Stoot, and Shireen Bliss

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON, Canada

ABSTRACT: *Smartphones and digital tablets are used to collect data for agricultural, geographical, and medical research. Science professionals find these devices attractive because they contain many useful hardware accessories (e.g., camera, Global Positioning System [GPS], accelerometer) and the capacity to access and customize software applications (apps). To enhance student learning, some educators are also integrating tablets into curricula for both indoor and outdoor course work. Recently, fisheries professionals have begun using these devices for data collection and public outreach and awareness. With new waterproofing technology, cases, and peripheral adapters, smartphones and digital tablets are continually becoming more relevant for data collection and education in fisheries. Here, we synthesize some of the available information on smartphone and tablet use for data collection and education and explore some current uses and future opportunities for these devices in fisheries. Overall, our objective is to demonstrate that smartphones and digital tablets are useful tools for fisheries professionals, including technicians, managers, and educators.*

Teléfonos inteligentes y tabletas digitales: herramientas emergentes para profesionales de las pesquerías

RESUMEN: *Los teléfonos inteligentes y las tabletas digitales se utilizan para colectar datos geográficos, de agricultura y de investigaciones médicas. Los profesionales de la ciencia encuentran atractivos estos dispositivos porque contienen accesorios útiles de hardware (p.e. cámaras, sistemas de posicionamiento geográfico –GPS-, acelerómetros, etc.) y además son capaces de brindar acceso y configurar aplicaciones de software (apps). Con el fin de mejorar el aprendizaje de los estudiantes, algunos educadores están integrando las tabletas digitales en las matrículas tanto dentro como fuera de los salones de clases. Recientemente, los profesionales de las pesquerías han comenzado a usar estos dispositivos para colectar datos, para difusión y concientización. Con nueva tecnología submarina, cubiertas y adaptadores periféricos, los teléfonos inteligentes y las tabletas digitales están volviéndose cada vez más relevantes para educación y para colectar datos pesqueros. En este estudio se resume parte de la información disponible en lo tocante al uso de teléfonos inteligentes y tabletas digitales con fines educativos y de recolecta de datos. También se exploran algunos usos actuales y oportunidades futuras que guardan estos dispositivos para la ciencia pesquera. El principal objetivo es demostrar que los teléfonos inteligentes y las tabletas digitales son herramientas útiles para los profesionales de las pesquerías, incluyendo técnicos, manejadores y educadores.*

INTRODUCTION

Touchscreen technology was first introduced publicly with the Palm Pilot in 2001 (Varshney and Vetter 2001). A decade later, Internet-capable smartphones (i.e., phones with advanced computing capability compared with traditional mobile phones) and digital tablets outsold personal computers (Al-Hadithy et al. 2012). In 2009, roughly half of the developed world owned a traditional mobile phone (Kwok 2009), and smartphone ownership has been projected to exceed one billion by 2013 (Dufau et al. 2011). Smartphones have also been predicted to possess 30% of the mobile market share by 2014 (Cochrane and Bateman 2010) and will undoubtedly continue to play a key role in global connectivity and communications.

Smartphones and digital tablets (herein referred together as SPTs) are probably best known as devices for web surfing, e-mail, instant messaging, two-dimensional bar codes (i.e., Quick Response [QR] codes, where an SPT is used as a scanner to convert a bar code into a website URL), and electronic commerce transactions (i.e., digital wallet). In addition to these more popular functions, SPTs are used as teaching tools (Rieger and Gay 2002; Kukulska-Hulme and Traxler 2005; Stewart et al. 2011) or a means to collect data (Kwok 2009; Raento et al. 2009; Dufau et al. 2011). For instance, teachers, social scientists, and health professionals are taking advantage of SPT popularity and their ability to immediately retrieve information (Kwok 2009; Benedict and Pence 2012; Chang et al. 2012). Given the combined functionality of a camera/video recorder, accelerometer, notepad, Global Positioning System (GPS), high-capacity memory storage (>8 GB), powerful processors, and native and web-based software apps, SPTs are an attractive alternative to carrying multiple devices. It is not surprising that today these devices are being used by professionals who teach and work outdoors in fields such as geology (Weng et al. 2012), agriculture (Mesas-Carrascosa et al. 2012), and fisheries (Nierenburg et al. 2011).

Given the increasing use of SPTs in data collection and education, we explore the opportunities that these devices present to fisheries professionals and synthesize this information in a descriptive mini review (Donaldson et al. 2011). Because many fisheries professionals are often directly involved with research and education (e.g., mentoring, delivering university courses, outreach, and public awareness), we investigate where SPT technology is currently applied in these two areas outside of fisheries. We then discuss how SPTs are being used specifically in fisheries. Finally, we discuss some possible opportunities for fisheries professionals who are interested in SPTs.

SPTs for Data Acquisition and Research Outside of Fisheries

Recent developments in hardware and software have transformed SPTs into powerful research tools (Aanensen et al. 2009; Dufau et al. 2011). New technologies allow SPTs to collect a wide variety of data types. For example, some smartphones are equipped with numerous hardware devices, including a digital barometer, altimeter, magnetometer, ambient light sensor, accelerometer, and gyroscope (e.g., Motorola Xoom and Samsung Galaxy Nexus). There are also external hardware accessories that could be used for collecting environmental data, such an infrared thermometer that measures ambient temperature to one decimal place (Medisina ThermoDock, Medisina/Neuss, Germany; Table 1). High-resolution SPT cameras are already used for geotagging (Welsh et al. 2012) and, with the aid of a mounted peripheral camera and biosensors, SPTs have even been used to collect data on moving objects (e.g., eye movement to assess driver alertness; B. Lee and Chung 2012). In addition, the camera, GPS, accelerometer, and notepad functions in a single smartphone have been used to collect geology data (Weng et al. 2012) or land use data for agricultural subsidies (Mesas-Carrascosa et al. 2012).

SPTs offer a variety of stand-alone and web-based (online only) applications (apps) designed for data collection, information sharing, or education. Whereas stand-alone apps are tailored specifically to a particular operating system and machine firmware, web-based apps download software each time they are run and can be accessed on any web-capable SPT (Luo 2010). Today, web-based apps have access to device hardware (e.g., accelerometers and gyroscopes) and long-term evolution networks that provide fast Internet browsing (up to 100 mbps). Despite the increasing utility of web-based apps, current data collection on SPTs is often accomplished by combining the performance of stand-alone apps with an Internet connection so that geolocated data can be accessed by third parties in near real-time. For example, with a geotagged photograph and some optional typed details, individuals can voluntarily report observations of invasive species (whatsinvasive.com), report an oil spill (oilreporter.org), or document wildlife (projectnoah.org). These kinds of apps promote citizen science that is educational (e.g., Project Noah) and informative to managers who can evaluate observations in an online database (e.g., What's Invasive; WA PestWatch; Table 1). For project managers, the web-based program called EpiCollect allows users (e.g., technicians) to upload data forms into a manager-defined project. As with the previously described apps, EpiCollect data are geotagged (with an error estimate and elevation) and may also include a photograph (Table 1). With an Internet connection, data can be instantly uploaded to an online database (Aanensen et al. 2009). In addition to data collection software, inexpensive (~US$5) geographic information system (GIS)-based mapping software is available to provide geospatial information about a study site (e.g., ArcGIS by Esri, iPhone GIS by Integrity Logic).

Although water damage, impact, and battery life are thought to be limitations to using SPTs in the outdoors, there are options that address these potential issues. At the 2013 World Mobile Congress in Barcelona, several manufacturers exhibited waterproofing technology and waterproof devices. For example, Liquipel offers an inexpensive (~US$70) nanotechnology that effectively waterproofs the inside and outside of SPTs (Table 1). Several other companies have developed devices that are manufactured waterproof; for example, the Panasonic Eluga, Samsung Galaxy S4 Active, and Sony Xperia Z. To avoid physical damage to devices, tough tablets (e.g., Armour tablets) or specialized cases can be purchased (Table 1). In remote areas, low batteries can be recharged with solar power chargers that are available for practically all SPTs (e.g., solio.com/chargers). Data can also be backed up by software (e.g., EpiCollect), micro SD cards, or manually through cloud computing online storage systems such as Dropbox, SugarSync, SkyDrive, or Google Drive. Together, these safeguards reduce the chance of device damage and data loss. To address screen glare in bright outdoor conditions, some manufacturers install antireflective technology directly into their products (e.g., ClearBlack display in the Nokia Lumina 900); however, matte screen protectors and visors are inexpensive alternatives to counter screen glare on any SPT.

SPTs for Education Outside of Fisheries

SPTs have become popular tools among professional educators (Busis 2010; Cochrane and Bateman 2010; Benedict and Pence 2012). To introduce students to the some of the newest information management tools, iPads are being integrated into curricula at Briar Cliff University (2011) and Boreal College (2012; Thompson 2011). Libraries are also beginning to provide digital tablets to enhance student learning. For example, Wake Forest University, University of West Florida, Virginia Tech University, and Concordia University have begun loaning iPads at their libraries (Thompson 2011). In addition, there are several education programs where SPTs are implemented for student learning. Biology and chemistry educators are engaging students by incorporating SPTs into their course curricula (J. Lee et al. 2011; Benedict and Pence 2012). Specifically, biology students explore a field site, photograph flora and fauna, and acquire more information by using their smartphone to scan QR codes on field sheets (J. Lee et al. 2001). Chemistry students share videos and photo blogs of their experiments via QR codes that allow their classmates to view the experiments online (Benedict and Pence 2012). Medical educators also take advantage of SPTs. For example, at the University of Manitoba,

Table 1. A summary of selected SPT hardware and software technologies relevant to fisheries.*

Technologies and applications	Current uses	Benefits	Links or references
Smartphones and digital tablets for education or data collection	Hands on education experience in field courses Field and lab data collection	Field-based software availability Built-in camera, GPS, and sensors Quick data entry	drsarmor.com
Medisina ThermoDock	Measure ambient temperature	Quickly and accurately (10th/mm) measure ambient temperature	medisana.com/en/Health+control/Thermometer/ThermoDock+Infrared+Thermometer+Module.html
Pocket microscope accessory	First industrial and consumer models available March 2012	Accurate to 100th/mm Compact and user-friendly Photos can be taken and 3D images can be created	vtt.fi/news/2012/02152012_Finnish_research_organisation_VTT_combines_mobile_phone_technology_and_microscopy.jsp?lang=en
Protective cases and waterproofing	Available as a consumer product and can be used by anyone	Helps protect SPTs from cracks, scratches, or water	goballisticcase.com otterbox.com photojojo.com/store/awesomeness/iphone-scuba-suit liquipel.com p2i.com
EpiCollect	Collect multiple data entries from a mobile phone and upload to a central database	Users define their own project (specify the data to be collected) Data can be monitored and verified in real time	epicollect.net
Fishing	Used by anglers to ID fish, check regulations, and locate vendors	Increases angler knowledge of regulation Improves user fish ID accuracy Creates easy link to regulation hotlines and police	itunes.apple.com/au/app/fishing/id493874267?mt=8
MFP Fishing Log	Used by anglers to keep track of fishing trips and record catch information	Anglers can share their catches with family and friends and monitor their catch successes Simple and easy to use	itunes.apple.com/ca/app/mfp-fishing-log-catch-reports/id523631349?mt=8
Rectext	Used by marine recreational fisherman and charter captains to update real-time information on catch and fishing effort via text messaging	The website archive is password protected More current information is collected by various people for several areas of research, such as fishing pressures	rectext.org ncseagrant.org/home/coastwatch/coastwatch-articles?task=showArticle&id=7014
What's Invasive, WA PestWatch, and Project Noah	For smartphones that allow a GPS location and sample observations to be sent to a server Mainly used by researchers, naturalists, and citizen scientists	The general public can help to generate a database of specific biotic sightings, such as invasive or at-risk species Simple and easy to use	whatsinvasive.com projectnoah.org/mobile itunes.apple.com/au/app/wa-pestwatch/id610940171?mt=8
Ocean Wise	Guide to eating seafood	Current consumer information on sustainable seafood	oceanwise.ca/iphone-app
Freshwater Fish ID South	Identify a number of freshwater fishes in the Southern United States	Identify fish species with illustrations and descriptions No Internet connection required	quikiphoneproducts.com
Fish Culture Section Dissolved Oxygen (DO) Solubility Calculator and Fish Culture Section Drug Treatment Calculator	Calculate DO solubility and drug treatments at aquaculture facilities	Perform on-the-spot calculations	sites.google.com/site/fishculturesection/resources/android-apps

***This list is not exhaustive or meant to endorse any particular brands or products.**

nurse educators use Android operating system–based SPTs to teach students how to digitally document patient wounds (as an alternative to paper-based documentation; Vivanco et al. 2011). In Botswana, residents are using smartphone-based mobile learning to provide immediate access to information, which has important implications for physicians in remote areas (Chang et al. 2012).

SPTs can be used for outdoor learning, as shown by universities that offer field courses that incorporate SPTs into exercises to collect course-related data (Rieger and Gay 2002; Stewart et al. 2011). In the Introduction to Environmental Science course at Lawrence University (Appleton, Wisconsin) course instructors provide students with digital tablets that contain remote GPS receivers. Using the tablet's GPS system in combination with GIS and aerial photographs, students are able to enter temperature, pH, dissolved oxygen, and water conductivity at their geospatial coordinates. From this information, students then immediately analyze data, observe trends, and ask questions that relate directly to the surrounding geography (Stewart et al. 2011). In a field course through the University of Chester, UK, geography students use smartphones to collect data from geotagged photographs (time and geospatial coordinate; Welsh et al. 2012). Students who have taken the courses at either Lawrence University or the University of Chester have reported an increased ability to interpret results and geospatial data, prepare lab reports, create conceptual models (Stewart et al. 2011), and recount an overall positive experience with the use of geotagging (with smartphones) to collect field data (Welsh et al. 2012).

SPTs in Fisheries

Although still relatively uncommon, there are several published examples where SPTs were used to acquire data and conduct research in fisheries (e.g., Nierenburg et al. 2011). In a recent issue of *Fisheries*, Bowker (2012) briefly mentioned a smartphone app designed to calculate drug treatment rates and dissolved oxygen solubilities in aquaculture. This Android operating system app, designed by Fish Culture Past President and President-Elect Jesse Trushenski, can be found at the newly designed Fish Culture Section website (sites.google.com/site/fishculturesection). In France, a field ID book is under development to help field specialists identify native and nonnative crayfish (De Vaugelas et al. 2011). This project was originally developed by students and is now in the final stages of completion (De Vaugelas et al. 2011; J. De Vaugelas, Université de Nice-Sophia Antipolis, personal communication).

There are government fisheries agencies that enlist SPTs for collecting and visualizing data for the purposes of research and management. In Ontario, the Ministry of Natural Resources Northwest Science and Information Branch recently (2012) began a pilot project to capture fisheries data with digital tablets. The agency is trying these devices because they combine data recording, GPS, and a camera in a single unit, thus eliminating the need to carry multiple electronic devices (J. Wright, Northwest Science and Information Branch, personal communication). Digital tablets allow the user to organize files such as bathymetry maps, aerial survey maps, net sampling locations, and fish tallies into digital folders that can be uploaded (provided Internet accessibility) immediately to a server for instant access by managers (e.g., Aanensen et al. 2009). By minimizing time spent reentering data, there is less potential for human error. Among the cons are the initial purchase cost, tablet durability, employee training, and battery life while in remote locations (J. Write, Northwest Science and Information Branch, personal communication).

In addition to using SPTs for data collection by government employees, some state- and federally run natural resource agencies have begun using this technology to disseminate fishing regulation (e.g., Texas Hunt and Fish, Colorado Hunting and Fishing) and gather data from anglers in the United States (Hancock 2012). According to Hancock (2012), there are currently more than 100 Android and iOS apps designed for recreational anglers, with several of these apps (stand-alone and web-based) designed specifically to allow government agencies to gather data that have been recorded by anglers using their smartphones. SPT technology is also being employed by government agencies outside of the United States. For instance, today the Alberta and British Columbia (BC) governments maintain apps to disseminate fishing information to resident and nonresident resource users (Alberta Outdoor Adventure Guide iPhone app and BC Fishing).

There are few examples where SPTs are used to collect commercial fisheries data. In 2011, the American Fisheries Society annual meeting in Seattle hosted a workshop that explored electronic fisheries information systems (Steinberg et al. 2012). The participants found that existing systems were ill suited to small fishing vessels and were typically restricted to dry conditions. Despite these challenges, an SPT system has been developed for at-sea, on-the-deck use by small-vessel commercial salmon fishers (Lavrakas et al. 2012). Specifically, a system comprised of a Nook tablet reader, an Android smartphone, Bluetooth and wireless technology, and various SPT embedded sensors is being tested for the collection of near real-time salmon harvest data, oceanographic conditions, and vessel movement and altitude (Lavrakas et al. 2012; Figures 1 and 2). If successful, this system could be employed to collect data in a number of commercial fisheries, including those in freshwater.

We were unable to find any examples where SPTs are being used for formal fisheries education; however, SPTs are currently used for outreach, public awareness programs, and citizen science in fisheries, e.g., the Ocean Wise guide to eating sustainable seafood (Table 1). In Australia, the Department of Primary Industries has recently designed a free recreational fishing guide application called Fishing for Victoria's Waterways (Table 1). Alongside color illustrations of resident species for identification, the app lists size and catch limits, fishing seasons, and legal fishing equipment. The app called Fishing also offers a direct link to both the illegal fishing report line and water police in Victoria, which raises awareness of illegal fishing and simplifies the reporting process. The application is free and available online for both Android and iOS devices (Table 1). Although

Figure 1. Components of the three-device, at-sea SPT system for small-vessel commercial salmon fishers: Barnes and Noble Nook tablet, MiFi Hotspot, and Samsung Precedent smartphone (Lavrakas et al. 2012). Photo credit: John Lavrakas.

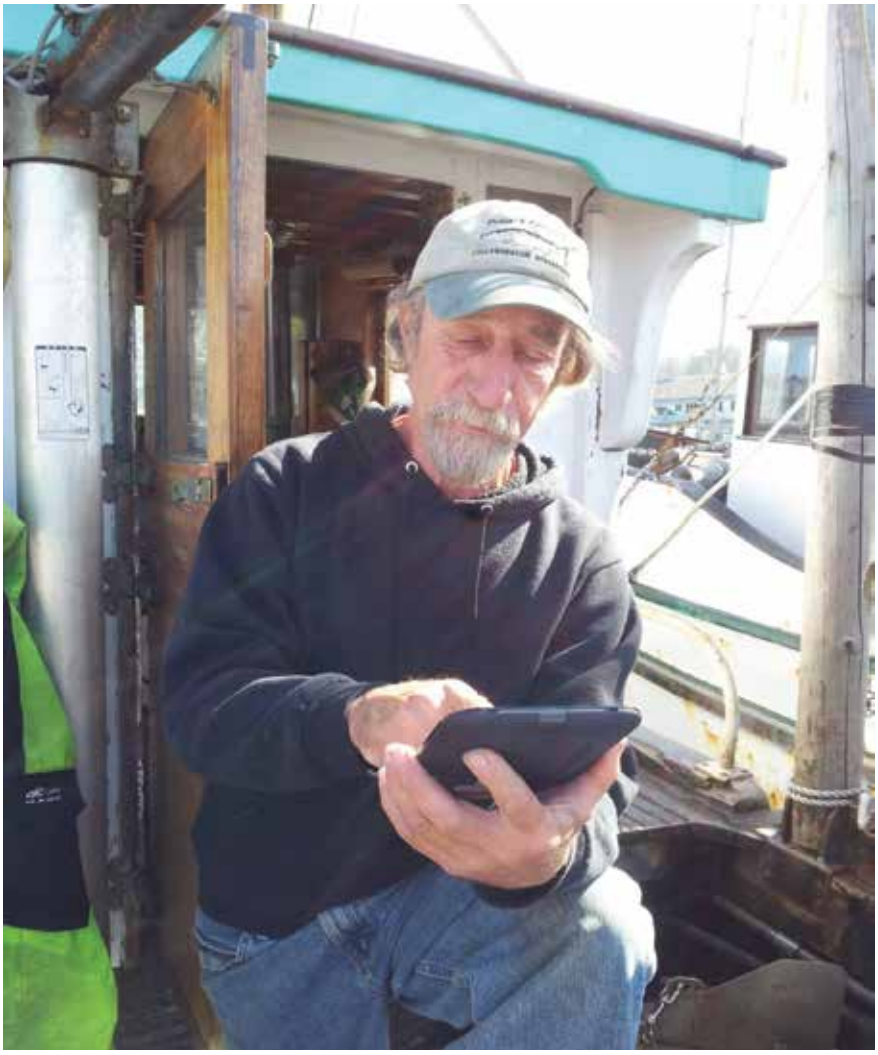

Figure 2. Oregon commercial salmon fisherman Kevin Bastien trying out the at-sea SPT system developed by Lavrakas et al. (2012). Photo credit: John Lavrakas.

Figure 3. A Blackberry smartphone used for collecting data and reporting red tides in Florida. Photo credit: Kate Kohler.

not exclusive to smartphones and digital tablets, Baker and Oeschger (2009) developed a catch reporting program (RecText; Table 1) through which recreational fishers and charter captains in southeastern North Carolina can send texts of their daily catches to managers who then upload the information to an online database via Twitter—an online social networking and microblogging service that enables its users to send and read text-based messages. Constructed as user-friendly software, the RecText system is intended to bridge the gap between anglers and scientists while providing managers with a more complete picture of fishing pressure and catch rates (Baker and Oeschger 2009). During a trial study in 2010, angler participation was 14.8% of tournament entrants, a number that is expected to increase with mobile phone use among resource users (P. Smith 2011). This type of two-way information sharing system between anglers and managers will continue to evolve with technologies such as SPTs (Dresler 2012). In Florida, Nierenburg et al. (2012) described the progression of an outreach and public awareness campaign about red tides (caused by dinoflagellate algae), which have direct negative consequences to human and fish health. The program began in 2000 with press releases, TV media coverage, and educational materials, such as shirts, pamphlets, and signs. The program evolved rapidly, and by 2006 full-time lifeguards and biologists began using smartphones to provide real-time geotagged photos and information about red tides (Mote Marine Laboratory's Environmental Health Program 2013; Figure 3).

STP Opportunities for Fisheries Professionals

SPTs can already be used for the collection of environmental data (temperature, barometric pressure, light levels) and for data visualization. With respect to the latter, Hydroacoustic Technology Inc. now offers a way to use a smartphone to monitor the tracks of tagged fish (htisonar.com/acoustic_tags.htm). Additionally, it may be possible to develop apps for field identification of fishes, such as fish ID eBooks that allow users to quickly "key out" unknown species captured during sampling. A similar application called Freshwater Fish ID South is currently available for iOS devices (Table 1), and although the full version could be useful, the app still only covers species found in the Southern United States. As described at the 2012 American Fisheries Society annual meeting (Loftus et al. 2012), fish ID eBooks could also include visual recognition software that automatically keys out the specimen (at least to family) based on a photograph. Such technology has already been developed by researchers from Columbia University, the University of Maryland, and the Smithsonian Institute and integrated into the free app called Leafsnap (leafsnap.com). Finally, fish ID apps could have uses in formal education, where SPTs already offer a great way to access and annotate eBooks and PDF copies of papers that are recommended for reading in courses on fish and fisheries related topics.

CONCLUSION

SPTs are becoming increasingly popular among the general public, researchers, and educators (e.g., Dufua et al. 2011; A. Smith 2012). The technologies embedded in SPTs have made them ideal for collecting a variety of data types and waterproofing technologies and shock-absorbent cases provide damage resistance. SPTs may not offer a replacement for all of the sophisticated tools available to fisheries professionals; however, as demonstrated in other professions, SPTs do provide a means for data collection and student learning. With advances in technology and ever increasing global connectivity, SPTs certainly present opportunities for creative and innovative fisheries professionals.

ACKNOWLEDGMENTS

Thanks to Steven Cooke, Nick Lapointe, and Sarah Gutowsky for commenting on early versions of our article. We also thank two anonymous reviewers for their constructive

feedback. The idea for this article may have never been imagined among the authors if not for productive conversations at the 2012 Annual Meeting of the Ontario Chapter of the American Fisheries Society.

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