https://doi.org/10.1016/j.ecolind.2016.05.050
Ferrigno, F., Bianchi, C. N., Lasagna, R., Morri, C., Russo, G. F., & Sandulli, R. (2016). Corals in high diversity reefs resist human impact. *Ecological Indicators*, *70*, 106-113.

Corals in high diversity reefs resist human impact

F. Ferrignoa∗, C.N. Bianchib, R. Lasagnab, C. Morrib, G.F. Russoa, R. Sandulliaa

DiST, Università di Napoli “Parthenope”, CoNISMa ULR, Centro Direzionale, Is. C4, 80143 Napoli, ItalybDiSTAV, Università di Genova, Corso Europa 26, 16132 Genova,

Keywords: Scleractinia Coral disease Human stressors Scuba diving Indonesia

A B S T R A C T

Coral reefs are amongst the most diverse ecosystems in the biosphere. However, they also represent oneof the most threatened marine systems. Apart from global change, especially fishing and tourism affectcoral reefs either with mechanical damage or with increase of pollution and sedimentation. Recently,the increase of disturbances has induced extensive changes in community structure and composition ofcoral reefs. Well-balanced and rich communities can better resist disturbances and show a more rapidrecovery, compared to less biodiverse systems.This study assesses the status of coral reefs subjected to several anthropogenic pressures, using amodified version of Coral Condition Index (CCI) that takes into account all Acropora and Pocillopora growthforms and considers a further category of coral damage: the presence of disease. The investigations werecarried out at Bangka Island (North Sulawesi, Indonesia), where some of the most flourishing reefs inthe country are present. The CCI takes into account the extent of different damages on coral colonies,particularly of the genera Acropora and Pocillopora, being among the most widespread bioconstructorsof local coral reefs and very sensitive to anthropogenic disturbances. The aim of the present work is totest whether the CCI is a reliable index in different coral reefs, and to evaluate if highly biodiverse reefsshow a better resistance to several human stressors.Data showed high values of CCI (0.9 on average) at all the investigated sites and at the two depths (3and 9 m) for each site, with the most abundant category represented by “healthy coral colonies”. Thesedata indicate a reasonably good health status of the reef in the study area (CCI > 0.8). The presence ofdifferent types of human pressure in the study area was evaluated through the use of metric proxies.Results do not seem to show any significant influence of such human activities on reef coral status, asshown by the low values of correlation between CCI values and the distances of the study sites from thethree main sources of stress (Villages, Resorts and Other). Moreover, the present data seem to confirmthat highly biodiverse and well-structured assemblages can resist disturbances more efficiently and thathuman pressure in the study area is sustainable. Compared to fishing activities, the impact of Scuba divingon coral reef is lower, resulting more sustainable and ecologically non-destructive.CCI summarizes many kinds of information and can be applicable in various areas with different pres-sures. It is a useful tool that might help to assist and guide management decisions towards alternativedevelopment models.

IntroductionCoral reefs represent one of the most threatened marine ecosys-tems, due to either natural or anthropogenic disturbances, onboth global and local scale (Lasagna et al., 2014). Global warm-ing is resulting in widespread bleaching and mass mortality events∗Corresponding author.E-mail address: federica.ferrigno@uniparthenope.it (F. Ferrigno).(Baker et al., 2008; Morri et al., 2015); similarly, ocean acidifica-tion is hampering coral growth and survival (Kleypas and Yates,2009). On local scale, especially fishing and tourism affect coralreefs either with mechanical damage or with pollution and sed-imentation (Bryant et al., 1998). The recent increase in scale andfrequency of disturbances has resulted in extensive changes incommunity structure and composition of coral reefs (Done, 1992;Knowlton, 2001; Montefalcone et al., 2011), which dramaticallydecrease their recovery potential (Dudgeon et al., 2010). Some stud-ies have also suggested that anthropogenic impacts can prevent

Fig. 1. Study area (black circle, top right) and study sites (black dots) around Bangka Island (North Sulawesi, Indonesia).

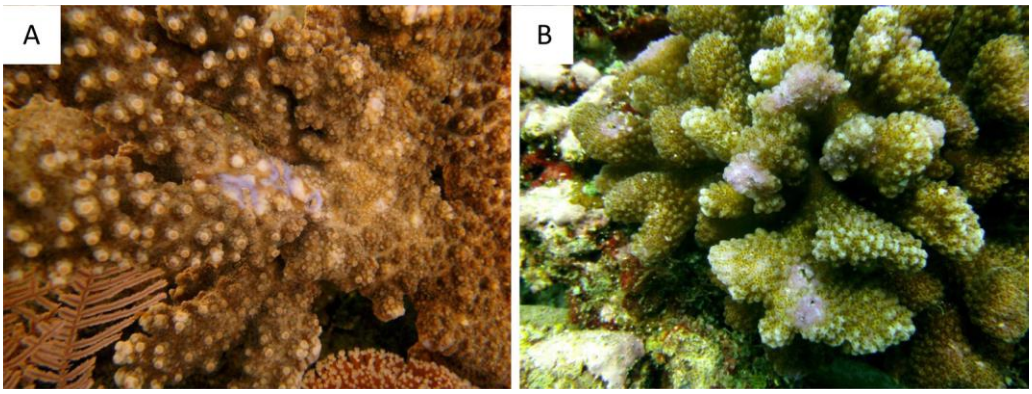


Fig. 2. Examples of diseased Acropora (A) and Pocillopora (B) colonies (DIC)

Recovery of coral assemblages from natural disasters (Hughes andConnell, 1999), and it is usually difficult to discern the differentstressors increasing coral reef damage, since they act synergically(Nyström et al., 2000).Reducing local stressors could mitigate the impacts of globalstressors, such as climate change. On the other hand, it has beensaid that continued degradation caused by local stressors inducescoral communities to become dominated by tolerant species, mak-ing them more resilient to climate disturbance (Côté and Darling,2010). Nonetheless, there is growing evidence that, following arange of disturbances, protected or less degraded reefs return morequickly to their original state than unprotected or more degradedreefs (Mumby and Harborne, 2010). Well-balanced communitiescan not only sustain their own resilience but also contribute tothe resilience of other “downstream” communities (West and Salm,2003; McClanahan et al., 2012).Coral reefs seem to shift their general structure in relation tophysical disturbances leading to a loss of three-dimensional struc-tural complexity, negatively affecting ecosystem functioning (Favaet al., 2009). For example, it was observed that loss of fast-growingbranching corals of the families Acroporidae and Pocilloporidaeinduces a decrease of resilience of coral reef; particularly, highlydiverse assemblages of Acropora exhibit rapid recovery after distur-bance and prevent the shift of the ecosystem into a more vulnerablesituation (Roff and Mumby, 2012). Other studies demonstratedthat while extreme waves are needed to inflict damage on robustcoral communities, much lesser forces can decimate fragile coralcommunities (Madin and Connolly, 2006). The threshold in stressintensity capable of causing severe loss in coral cover on undis-turbed sites is approximately half that reported to cause coral loss indisturbed sites (Fabricius et al., 2008); particularly, in sites affectedby a multitude of disturbances, resulting in low coral cover and sim-ple framework structures, vulnerability of reefs increases (Gardneret al., 2003).The present paper evaluates the health status of corals thriv-ing in reefs subjected to several human activities, using a modifiedversion of the Coral Condition Index (CCI), originally developed byLasagna et al. (2014) for Maldivian reefs. The study was carriedout in Indonesia, a country with a recent and substantial growthand consequent urban development, but with also a high levelof marine biodiversity, being part of the so-called Coral Triangle(Tomascik et al., 1997). The CCI, an extension of the Coral DamageIndex (CDI) of Jameson et al. (1999), takes into account the extentof different damages on coral colonies, particularly of the generaAcropora and Pocillopora, because they are among the main andwidespread bioconstructors of Indo-Pacific coral reefs and are sen-sitive to anthropogenic disturbances (Penin et al., 2007; Lasagnaet al., 2010; Bigot and Amir, 2012).Indonesia is known to host 350 scleractinian coral species (Bestet al., 1989), that is nearly the double of the 180 scleractiniancoral species inventoried for the Maldives (Pichon and Benzoni,2007).The present work aims at using the CCI in order to explore the

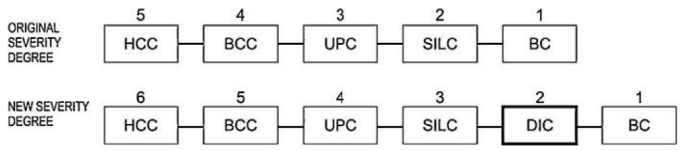
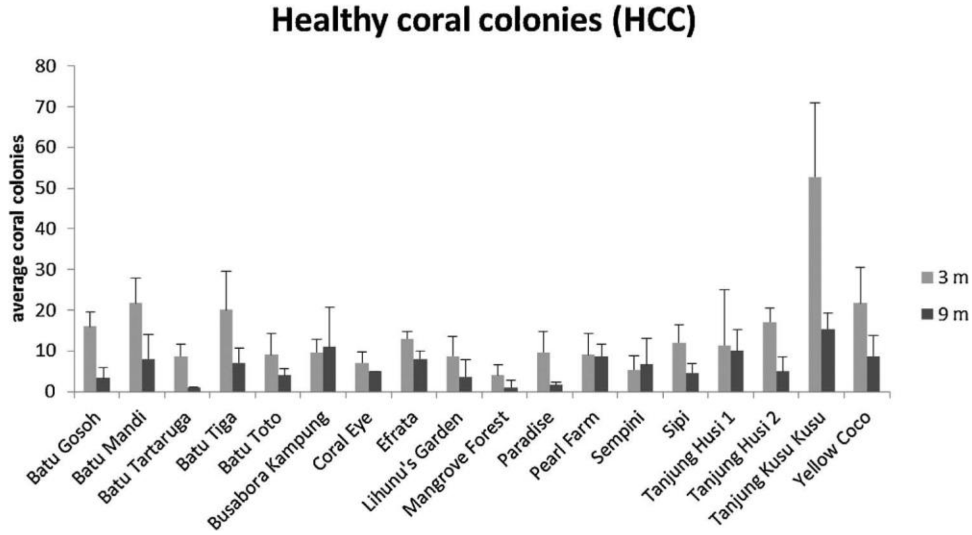


Fig. 3. Original (above) and new damage severity degree (below) for each CCI cat-egory. For explanation of abbreviations see text.

idea that corals in high diversity reefs resist several human stressorsbetter than in comparatively low diversity reefs.2. Materials and methods2.1. Study areaIndonesia is part of the Coral Triangle, which covers 5.7 millionsquare kilometers of ocean waters, has some of the world's largestcoral reefs and is recognized as the global center of marine biodi-versity (Tomascik et al., 1997). Unfortunately, Indonesia also hostsa very high number of species threatened with extinction (Ross andWall, 1999).The big island of Sulawesi gathers a mixture of Australian andAsian species with also many endemic species. Particularly, NorthSulawesi holds the greatest level of endemism, due to its long geo-logical history of mountain and water barriers, and island bridgesfrom north east and west (Whitten et al., 2002). The climate isgreatly influenced by the system of monsoon winds that stronglyinfluence the movement of water and productivity of coastal andmarine systems. The general patterns of circulation of the seas arelocally led by strong tidal regimes. Moreover, high seismic andvolcanic activity plays a fundamental role in modeling land mor-phology (Tomascik et al., 1997).North Sulawesi is one of the six Sulawesi's provinces, withabout 2,400,000 inhabitants (Badan Pusat Statistik, http://www.bps.go.id/). Its economy is mainly based on small-scale agricul-ture, particularly clove to produce cigarettes; other important andgrowing activities are coastal fishing farms, copper and gold min-ing, and tourism (Indahnesia, http://indahnesia.com/indonesia/SULECO/economy.php).Bangka Island owns rich and diverse reefs, which are not toopopular yet to Scuba diving. Thus, it may be an ideal site to testthe validity of CCI. However, in the last few years, this island hasbeen undergoing a continuous increase of anthropic developmentand its monitoring could help to understand the effects of humanactivities on the environment and, possibly, to protect it.2.2. Field activitiesSurveys were carried out in October and November 2014, atBangka Island (North Sulawesi, Indonesia) (Fig. 1), by Scuba div-ing. Data were collected according to the methods for hard bottomdescribed by Bianchi et al. (2004), at two different depths, cor-responding to reef flat (3 m) and reef slope (9 m), along threereplicates 20 × 2 m belt transects, parallel to the coastline. Theinvestigation included 18 georeferenced sites with different typesof potential human pressure (Table 1), randomly selected aroundthe island, for a total of 108 transects.Since collecting quantitative data is often difficult, time-consuming and expensive, the use of proxies must be considered,whenever applicable. In this case, distance in kilometers from themajor stress sources was used as a proxy for human pressure withinthe study sites (Hawkins et al., 1999; Parravicini et al., 2012). Thethree major stress distance proxies chosen were: Villages (fishing),Resorts (Scuba diving) and Other (see below).Villages (fishing): fishing villages can cause breaking andupturning of coral colonies with fishing gears and anchors, orsmothering, diseases and bleaching due to release of pollutants andsediments in the water.Resorts (Scuba diving): the resorts, with their diving centers,could stress the reef through tourism activities of snorkeling anddiving that can mainly cause mechanical damage as breaking andupturning of coral colonies.Other: activities related to metal mining cause smothering, dis-eases and bleaching due to release of pollutants and sediments inthe water, whereas fixed fishing structures and a pearl farm maycause breaking and upturning of coral colonies.Only Acropora and Pocillopora colonies with diameters higherthan 15 cm were counted in each transect, because they can beeasily identified and are potentially sexually mature (Babcock et al.,2003; Lasagna et al., 2010). In the modified version of CCI, suggestedhere, all the morphologies of Acropora were considered, while theoriginal CCI accounted only for tabular Acropora colonies.2.3. Data managementAccording to Lasagna et al. (2014), Acropora and Pocilloporacolonies were classified into the following categories: healthy coralcolonies (HCC), broken coral colonies (BCC), upturned coral colonies(UPC), smothered coral colonies (SILC), bleached coral colonies (BC)and recently dead corals (RDC). An important change of this newversion of the index is the addiction of another category, for amore complete overview of all possible damages of corals: diseased


Healthy coral colonies (HCC)
average coral colonies
80
70
60
50
40
30
20
10
0
3 m
9 m
Batu Gosoh
Batu Mandi
Batu Tartaruga
Batu Tiga
Batu Toto
Busabora Kampung
Coral Eye
Efrata
Lihunu's Garden
Mangrove Forest
Paradise
Pearl Farm
Sempini
Sipi
Tanjung Husi 1
Tanjung Husi 2
Tanjung Kusu Kusu
Yellow Coco

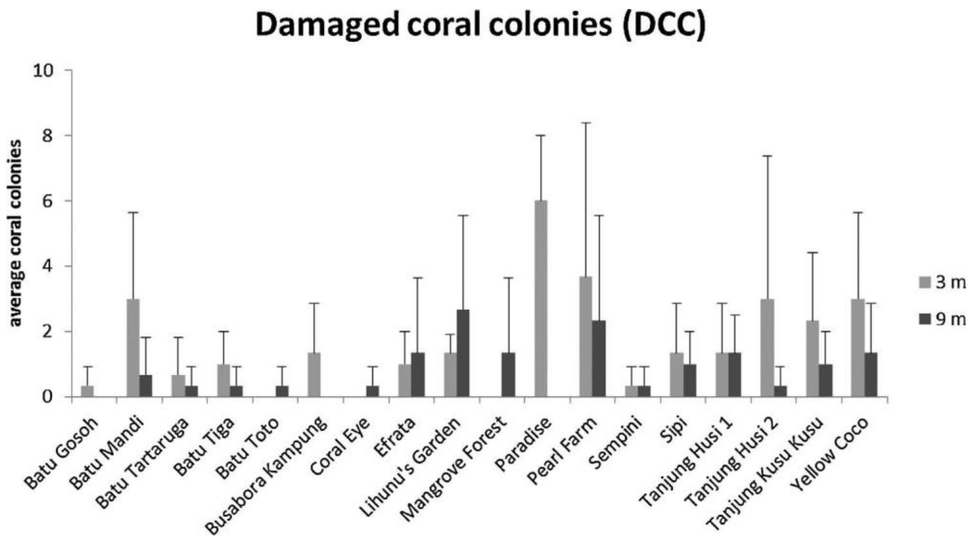

Damaged coral colonies (DCC)
average coral colonies
10
8
6
4
2
0
3 m
9 m
Batu Gosoh
Batu Mandi
Batu Tartaruga
Batu Tiga
Batu Toto
Busabora Kampung
Coral Eye
Efrata
Lihunu's Garden
Mangrove Forest
Paradise
Pearl Farm
Sempini
Sipi
Tanjung Husi 1
Tanjung Husi 2
Tanjung Kusu Kusu
Yellow Coco

Fig. 4. Average number (±SD) of healthy coral colonies (HCC), at each site.

Fig. !

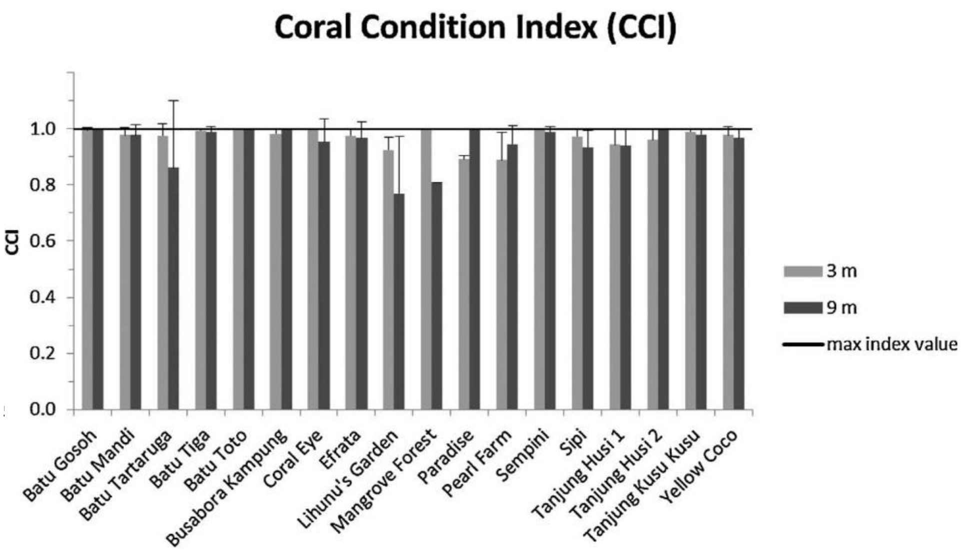
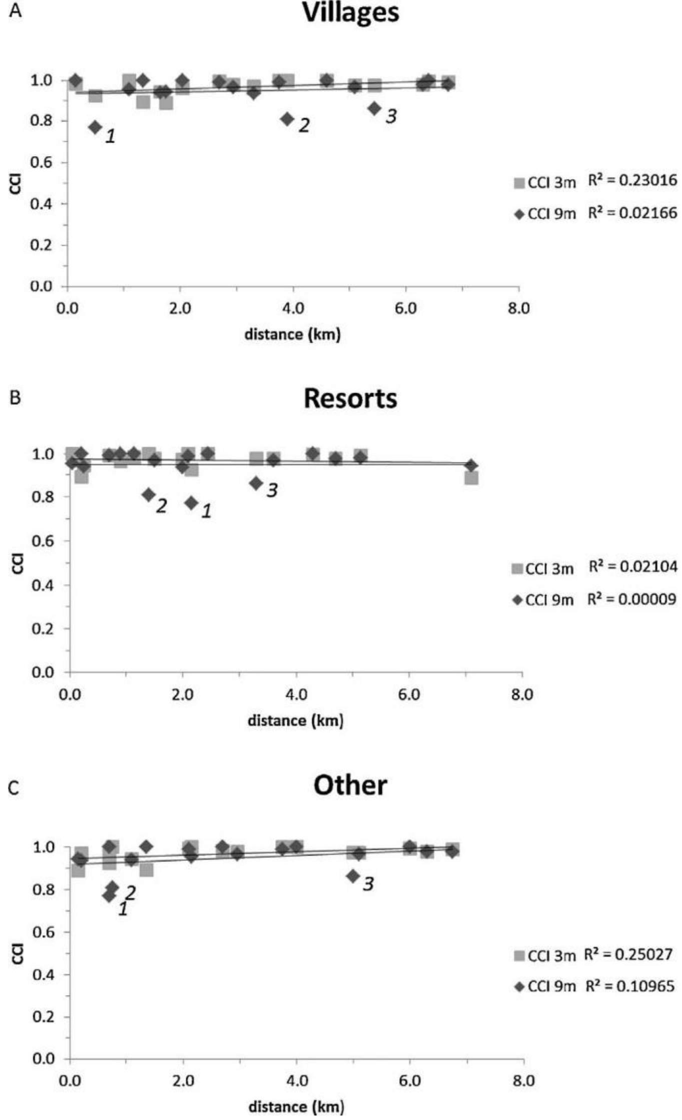


Fig. 6. Average values (±SD) of Coral Condition Index (CCI), at each site.coral colonies (DIC), including those colonies that exhibited evidentabnormal pigmentation (Fig. 2).

Coral diseases could induce tissuedegradation and skeleton exposure, potentially resulting in colonydeath (Richardson, 1998; Weil, 2004; Kumaraguru et al., 2005).The modified CCI was computed according to the new severitydegree scale suggested (Fig. 3):where TCC is the total number of coral colonies. The sum ofall damaged (BCC, UPC, SILC, DIC and BC) and recently dead coralcolonies (RDC) is the category damaged coral colonies (DCC). Cat-egories were assigned a different degree of severity (1–6), basedon literature information about the putative recovery capacity fol-lowing damage (Wittenberg and Hunte, 1992; Anthony et al., 2009;Maina et al., 2011 Anthony et al., 2009; Maina et al., 2011), wherelower degree corresponds to higher damage (Fig. 3).CCI results can be represented by values ranging from 0 to 1,where lower values suggest the impact of large scale disturbances,and comparatively higher values suggest the impact of local scaledisturbances; a value of 1 indicates a state of optimal health of reef.Finally, linear regressions between the distance from thesources of stress and CCI values were calculated.3. ResultsOn a total of 1241 colonies of Acropora and Pocillopora, themajority (69%) was found at 3 m depth. At both depths, most coralcolonies were in healthy condition (90% at 3 m and 88% at 9 mdepth) and the main damage was UPC (5% at 3 m and 7% at 9 m),followed by BCC (2%) at 3 m and SILC (2%) at 9 m (Table 2). Only0.2% of coral colonies resulted diseased (DIC) at 3 m depth, whileno diseased colony was found at 9 m depth.At 3 m depth, coral colonies in healthy conditions (HCC) wereon average 14.24 ± 4.26, with the lowest value in Mangrove Forest(4.00 ± 2.65) and the highest in Tanjung Kusu Kusu (52.67 ± 18.18);at 9 m depth, coral colonies were on average 6.26 ± 2.46, with thelowest value in Batu Tartaruga (1.00 ± 0.00) and Mangrove Forest(1.00 ± 1.73), and the highest in Tanjung Kusu Kusu (15.33 ± 4.04)(Fig. 4). At 3 m depth, damaged coral colonies (DCC) were on aver-age 1.65 ± 1.36, with the lowest value in Batu Toto, where nodamaged coral colony was found, and the highest value in Par-adise (6.00 ± 2.00); at 9 m depth, damaged coral colonies were onaverage 0.83 ± 0.97, with the lowest value in Batu Gosoh, BusaboraKampung and Paradise, where no damaged coral colony was found,and the highest value in Lihunu's Garden (2.67 ± 2.89) (Fig. 5).The calculation of CCI was then performed on the 18 sites ateach depth (3 and 9 m) (Fig. 6). The values ranged from a minimumof 0.77 to a maximum of 1.00, which corresponds to a good healthstatus of the coral reef. Particularly, at 3 m depth, the average valuewas 0.97 ± 0.03, with the lowest value in Paradise (0.89 ± 0.01) andPearl Farm (0.89 ± 0.10), and the highest value (1.00 ± 0.00) in BatuToto, Coral Eye, Mangrove Forest and Sempini; at 9 m depth, theaverage value was 0.95 ± 0.07, with the lowest value in Lihunu'sGarden (0.77 ± 0.20), Mangrove Forest (0.81 ± 0.01) and Batu Tar-taruga (0.86 ± 0.24), and the highest value (1.00 ± 0.01) in Batu



Compared to fishing activities, Scubadiving has a lower impact on coral reefs and is less harmful to coralhealth, being therefore more sustainable (Walters and Samways,2001).Nevertheless, unsustainable rates of attendance and inappro-priate behavior of diving tourists may cause changes in the marineenvironment, mainly through mechanical damage (Medio et al.,1997; Barker and Roberts, 2004). This study showed that this activ-ity is underexploited in the study area and can be consideredsustainable. Indeed, the number of dives per site per year, accord-ing to the data provided by the local Scuba diving centers, does notexceed the value of 1000. This figure is lower than the 6000 divesper site and per year, estimated by Hawkins and Roberts (1997)as impacting on coral reefs. The threshold of 6000 dives per siteand per year has been established for the Caribbean Sea and theRed Sea (Tratalos and Austin, 2001; Zakai and Chadwick-Furman,2002), two coral reef areas characterized by lower biodiversity thanthe Coral Triangle (Tomascik et al., 1997).The number of Scuba dives in the area might therefore be sensi-bly increased, provided effective monitoring programs are carriedout. Monitoring the effects of Scuba diving on the reef is necessaryto protect the ecosystem and also to direct the entire socio-economic sector towards sustainable management approaches.Additionally, small-scale management strategy aimed at the pro-tection of territory and maintenance of ecosystems, could resultalso in a larger scale protection from global disturbances.The measure beyond which community begins to change as aresponse to stress, is hard to assess but it is necessary to knowfor the conservation of high biodiversity areas. Estimate the toler-ability threshold of ecosystem to each disturbance is mandatory.For example, a way to estimate the sustainable level of divingtourism attendance by a marine ecosystem is to calculate its div-ing “carrying capacity” (Davis and Tisdell, 1995). However, inorder to fully understand the ecosystem functioning of a reef, itis necessary to consider the influence of multiple stressors actingtogether, because this might increase coral reef damage (Nyströmet al., 2000). Studying single events in isolation can be misleading,therefore a longer term approach is necessary to understand theresponses of reef corals to multiple stressors (Hughes and Connell,1999). Co-occurrence of different damage types could produce anincrease of instability and fragility of the entire reef framework(Bellwood et al., 2004).5. ConclusionsA modified version of Coral Condition Index was applied toassess the ecological status of coral colonies in a high diversity coralreef, taking into account also the effects of different stressors. Themodified index gives additional information on reef coral healththan the original version, by adding an additional coral damage(disease), and also with respect to other measures based only onlive coral cover. Diseases are in fact known to be an early signalof coral stress (Harvell et al., 1999). In this study several possibledamages on the corals were considered, obtaining a more completeoverview of the effects of human pressure on rich and sensitivecommunities. CCI is a very fast and easy method; it supplies valu-able information on various types of damage at different severitydegrees, and, finally, does not require highly specialized operators.The index, previously tested in some reefs of Maldives (Lasagnaet al., 2014) and in Indonesia (present study), implies the use oftwo of the main and widespread genera of hard coral of the Indo-Pacific and sensitive to anthropogenic disturbances (Penin et al.,2007; Lasagna et al., 2010; Bigot and Amir, 2012). The positive out-come shows that it might work also in other reefs where the twogenera are amongst the dominant. Different kinds of human pres-sures were considered in the study. Particularly, distances of stresssources from study sites were used as proxies and correlated to CCIvalues. The results

Fig. 7. Linear regression between the Coral Condition Index (CCI) and the distanceof sites from the source of anthropogenic stress Villages (A), Resorts (B) and Others(C), at both depth of 3 m and 9 m. 1: Lihunu's Garden; 2: Mangrove Forest; 3: BatuTartaruga.Gosoh, Batu Toto, Busabora Kampung, Paradise and Tanjung Husi2.Distances of the study sites from the three main sources ofanthropogenic stress ranged from a minimum of 50 m to a maxi-mum of 7 km. No correlation between CCI and distance from stresssources, at either 3 m or 9 m depth, was detected at almost all sites(Fig. 7). However, Lihunu's Garden, Mangrove Forest and Batu Tar-taruga, at 9 m depth, may be considered outliers showing lower CCIvalues. Coral damage at the first site consists in smothered coralcolonies (SILC), upturned coral colonies (UPC) and bleached coralcolonies (BC); at the second site the damage consists in upturnedcoral colonies (UPC), and at the third site it consists in bleachedcoral colonies (BC).4. DiscussionCompared to the original version (Lasagna et al., 2014), themodified CCI suggested here gives information on the status ofindividual coral colonies, and, according to the use of ecologicalindicators (Dale and Beyeler, 2001; Jameson et al., 2001), pro-vides a tool for an even earlier detection of change. Unlike themost commonly used metrics of reef health, such as percent-age live coral cover (Clarke et al., 1993; McManus et al., 1997;Sweatman et al., 2011), CCI gives more detailed information, takinginto account the effects of various stress and at different severitydegree to understand better the real possible damage and how toact when a reef is endangered. Moreover, it is a very fast and easymethod to be applied based only on field activities to collect data(directly by Scuba diving), and does not require extensive taxo-nomic knowledge, since the two coral genera used as indicators(Acropora and Pocillopora), are very common and easily recogniz-able. Furthermore, the two genera have been chosen because theyare representative of Indo-Pacific hard coral, being among the mainbioconstructors of coral reefs and being sensitive to human pres-sure (Penin et al., 2007; Lasagna et al., 2010; Bigot and Amir, 2012).In this study, a modified version of the index was applied toassess the ecological status of coral colonies in a high diversitycoral reef and to test whether they resist several human stressorsbetter than in less diverse reefs. In this new version of the CCI, asmentioned above, all Acropora and Pocillopora forms were consid-ered, and the presence of disease was evaluated. CCI was modifiedaccording to the types of damage and re-assigning a suitable sever-ity degree.Considering as many as possible coral damages might allow toobtain a more complete overview of human pressure causes andeffects. So, the integration of the category "diseased coral colonies"(DIC) in the index calculation, provides important information andmight be useful for a better understanding of the health statusof reefs. Diseases are an early signal of coral stress; indeed, itwas observed that both climate and human activities may inducephysiological stress, compromising host resistance and increasingfrequency of opportunistic diseases (Harvell et al., 1999). Anthro-pogenic pollutants, habitat degradation and overfishing have ledto a recent increase in disease outbreaks in many reef ecosystemsand organisms (Harvell et al., 2007). The several stressors affectingcoral reefs, particularly along heavily urbanized coastlines, as wellas introductions of new species to distant reefs by global trans-port, are contributing to concerns about extinction risks and lossof biodiversity (Peters, 2015). More anthropic areas may be threat-ened by acute stresses, including destructive fishing practices, aswell as anchor damage and ship groundings, and chronic stresses,including sewage pollution, increased sedimentation, nearshoreeutrophication, and industrial pollution (Edinger et al., 1998).In the present study, data showed high values of CCI (0.9 onaverage) in all the investigated sites and at the two depths for eachsite, with the most abundant category represented by healthy coralcolonies (HCC). These data translate into a good health status ofthe reef corals in the study area (CCI > 0.8). The lowest CCI valuewas detected at Lihunu's Garden, a site stressed by the nearbyvillage with its run-off that causes sedimentation and bleachingof coral colonies, and with anchoring and transition of boats thatmay induce upturning of coral colonies. The other lower CCI val-ues were detected at 9 m depth at Mangrove Forest with upturnedcoral colonies probably due to fishing activities, and at Batu Tar-taruga with bleached coral colonies, even if few hard coral colonieswere present while soft corals were dominant.Quantitative and accurate data for evaluation of human pressureare often difficult to obtain, due to the interaction of multiple fac-tors; in this study, the distances of stress sources from study siteswere used as proxies of human pressure. Proxy metrics are usedto reduce time and money required for data collection (Richards,2013) and are representative of trends in biodiversity and signif-icant challenge for ecology and conservation issues (Baillie et al.,2008). There are also new methodologies, used for evaluation ofthe environmental impact, such as the Multiple Criteria Data Envel-opment Analysis (MCDEA), a model to rank and select the bestalternative considering both qualitative and quantitative criteria(Zhao et al., 2006). Other data-driven models, including MachineLearning (ML) techniques, have been employed to identify theecologically significant variables, allowing to predict some eco-logical damages (Muttil and Chau, 2007), even though they mightappear more time-consuming and less direct approaches in thiscontext. Although different kinds of human pressures are presentin the study area, they do not seem to exert a marked influenceon reef coral health, as indicated by the low values of correla-tion between CCI and the distances of sites from the three mainsources of stress (Villages, Resorts and Other). This could mean thattime and/or intensity of disturbances are not enough to affect coralhealth (Done, 1992; Knowlton, 2001; Montefalcone et al., 2011);on the other hand, these results suggest corals in high diversityreefs are less prone to damage, as Indonesia lies at the center of theworld's tropical biodiversity and has extremely rich and diversecoral reefs (Veron, 1993). Thus, the present work may providean indication that corals in highly biodiverse and well-structuredassemblages can resist disturbances more efficiently and have amore rapid recovery, compared to less biodiverse environments(Tomascik et al., 1997; McClanahan et al., 2012).CCI can be applied to coral reefs of different areas, to assessthe possible impact that human activities may produce accord-ing to the socio-economic context. Comparing the present datafrom Indonesia with those from the Maldives by Lasagna et al.(2014), Indonesian corals result in a healthier status, which isconsistent with a general lower population density of Indonesia,about 135 inhabitants per square kilometer, compared with theMaldives, about 1213 inhabitants per square kilometer (UnitedNations Population Division, http://www.un.org/en/development/desa/population/theme/trends/).Overall, the human pressure in the study area seems to be sus-tainable, even if the growing population is placing greater pressureon the services from the environment, e.g. fisheries, and contributeto increased pollution, damage to habitats and illegal practices(DeVantier et al., 2004). Besides fishing activities, tourism is becom-ing of increasing interest for local economy, particularly Scubadiving, one of the main touristic activities in tropical seas and itis a significant source of income for the most flourishing coral reefsites (Brown et al., 2001). Well-planned tourism provides economicand political incentives for management and conservation, andmay bring additional benefits to local communities and regionaleconomies (Agardy, 1993).